Stantec Consulting Services Inc.
11687 Lebanon Road, Cincinnati, OH 45241

October 14, 2021
File: 175531033
Revision 0

Indiana-Kentucky Electric Corporation
3932 U.S. Route 23
P.O. Box 468
Piketon, Ohio 45661

RE: Periodic Safety Factor Assessment
Landfill Runoff Collection Pond
EPA Coal Combustion Residuals (CCR) Rule
Clifty Creek Station
Madison, Jefferson County, Indiana

1.0 PURPOSE

This letter documents Stantec's certification of the safety factor assessment for the Indiana-Kentucky Electric Corporation (IKEC) Clifty Creek Station's Landfill Runoff Collection Pond. The EPA CCR Rule requires a new certification to be performed on a five-year periodic interval under 40 CFR 257.73(f). The initial certification of the safety factor assessment was placed in the operating record in October 2016.

2.0 INITIAL SAFETY FACTOR ASSESSMENT

The initial safety factor assessment is attached. The assessment calculated factors of safety for the following loading conditions:

- Long-term, maximum storage pool,
- Maximum surcharge pool,
- Seismic / pseudo-static, and
- Liquefaction / post-earthquake.

Stantec compiled and reviewed available historical site, topographic, and geotechnical data for the Landfill Runoff Collection Pond as part of the initial assessment. The critical sections were analyzed for the loading conditions specified in 40 CFR 257.73(e)(1)(i) through (iv). The results demonstrated that the Landfill Runoff Collection Pond met the requirements for the initial safety factor assessment.

3.0 CURRENT SAFETY FACTOR ASSESSMENT

Stantec reviewed the result of the initial safety factor assessment and the changes in site conditions that have occurred in the past five years. The following operational changes and other factors were considered in this periodic assessment:

Re: **Periodic Safety Factor Assessment**
Landfill Runoff Collection Pond
EPA Coal Combustion Residuals (CCR) Rule
Clifty Creek Station
Madison, Jefferson County, Indiana

1. Cross-sectional geometry of the dam embankment has not changed.

2. Annual and weekly inspections conducted since 2015 were reviewed as part of this assessment. There were no observations of deficiencies that would negatively affect the result of the safety factor assessment.

3. Typical operating pool and Ohio River water levels have remained unchanged.

4. Ground motion parameters were compared to the initial seismic assessment using the USGS website. The current parameters are representative of the initial seismic assessment.

Based on our review, there are no conditions that have changed in the past five years that would have a negative effect on the initial safety factor assessment.

4.0 SUMMARY OF FINDINGS

Based on a review of the initial safety factor assessment and the items listed in Section 3.0, the result of this periodic safety factor assessment is that the Landfill Runoff Collection Pond at Clifty Creek Station meets the requirements of §257.73(e) of the EPA CCR Rule.

Re: **Periodic Safety Factor Assessment**
Landfill Runoff Collection Pond
EPA Coal Combustion Residuals (CCR) Rule
Clifty Creek Station
Madison, Jefferson County, Indiana

5.0 QUALIFIED PROFESSIONAL ENGINEER CERTIFICATION

I, Jacqueline S. Harmon, being a Professional Engineer in good standing in the State of Indiana, do hereby certify, to the best of my knowledge, information, and belief:

1. that the information contained in this certification is prepared in accordance with the accepted practice of engineering,

2. that the information contained herein is accurate as of the date of my signature below, and

3. that the safety factor assessment for the IKEC Clifty Creek Station's Landfill Runoff Collection Pond meets the requirements specified in 40 CFR 257.73(e).

SIGNATURE Jacqueline S Harmon DATE 10/14/2021

ADDRESS: Stantec Consulting Services Inc.
11687 Lebanon Road
Cincinnati, Ohio 45241

TELEPHONE: (513) 842-8200

ATTACHMENTS: Clifty Creek Station Landfill Runoff Collection Pond Initial Safety Factor Assessment

JACQUELINE S. HARMON
REGISTERED
No. 10911138
STATE OF
INDIANA
PROFESSIONAL ENGINEER

Report of CCR Rule Stability Analyses
AEP Clifty Creek Power Plant
Boiler Slag Pond Dam and Landfill Runoff Collection Pond

Madison, Jefferson County, Indiana

Stantec

Prepared for:
American Electric Power
Columbus, Ohio

Prepared by:
Stantec Consulting Services Inc.
Cincinnati, Ohio

February 16, 2016

Table of Contents

LIST OF TABLES

Executive Summary

The Clifty Creek Power Station's Boiler Slag Pond Dam, owned and operated by the Indiana and Kentucky Electric Corporation (IKEC), is located in the city of Madison, Indiana along the northern bank of the Ohio River. The Boiler Slag Pond currently serves as a settling facility for sluiced bottom ash produced at the plant. In addition to the process flows from the plant, approximately 510 acres drain to the facility. The pond is formed by natural grade to the north, east, and west; as well as a southern dike that runs along the bank of the Ohio River.

The Landfill Runoff Collection Pond serves as a collection pond for the Coal Combustion Byproducts Landfill. The pond is formed by natural grades to the north, east, and west; as well as a southern dam that runs along the bank of the Ohio River. The drainage area of the pond is approximately 443 acres. The Indiana Department of Natural Resources (IDNR) has designated this dam as No. 39-12, which was registered as a High Hazard Structure in 2010.

Stantec Consulting Services Inc. (Stantec) was contracted to perform a geotechnical exploration, stability analysis, and liquefaction assessment of the dike for these facilities in 2009 (Landfill Runoff Collection Pond) and in 2010 (Boiler Slag Pond Dam). The intent of the explorations was to develop subsurface data at cross-sections along the dike for the Boiler Slag Pond and the dam for the Landfill Collection Runoff Pond and to perform conventional seepage and stability analyses, assessing the performance of the facilities. The potential for liquefaction was to be evaluated according to simplified published methods. Reports from past geotechnical explorations were used to supplement subsurface data.

In response to the Coal Combustion Residual (CCR) rules mandated in the Federal Register on April 17, 2015, AEP contracted Stantec to perform stability analyses for the Boiler Slag Pond Dam and Landfill Runoff Collection Pond to estimate static, seismic, and liquefaction potential factors of safety. According to Section 257.73(e)(1)(i) through (iv), the factor of safety assessment CCR rules are:

(i) The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.

(ii) The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.

(iii) The calculated seismic factor of safety must equal or exceed 1.00

(iv) For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

The factors of safety obtained during the analyses for static and seismic load cases were greater than those required for Section 257.73 (e)(1)(i) through (iii). The average factor of safety for each soil horizon that was susceptible to liquefaction was greater than that required in Section 257.74 (e)(1)(iv).

The results of the 2010 analyses can be found in Section 6.1.1 for the Boiler Slag Pond Dam and Section 6.1.2 for the Landfill Runoff Collection Pond. The results of the 2015 CCR review can be found in Section 6.1.2 for the Boiler Slag Pond Dam and Section 6.2.2 for the Landfill Runoff Collection Pond.

1.0 INTRODUCTION

The Clifty Creek Power Station's Boiler Slag Pond Dam, owned and operated by the Indiana and Kentucky Electric Corporation (IKEC), is located in the city of Madison, Indiana along the northern bank of the Ohio River. The Boiler Slag Pond currently serves as a settling facility for sluiced bottom ash produced at the plant. In addition to the process flows from the plant, approximately 510 acres drain to the facility. The pond is formed by natural grade to the north, east, and west; as well as a southern dike that runs along the bank of the Ohio River.

The Landfill Runoff Collection Pond serves as a collection pond for the Coal Combustion Byproducts Landfill. The pond is formed by natural grades to the north, east, and west; as well as a southern dam that runs along the bank of the Ohio River. The drainage area of the pond is approximately 443 acres. The Indiana Department of Natural Resources (IDNR) has designated this dam as No. 39-12, which was registered as a High Hazard Structure in 2010.

Stantec Consulting Services Inc. (Stantec) was contracted to perform a geotechnical exploration, stability analysis, and liquefaction assessment of the dike for these facilities in 2009 (Landfill Runoff Collection Pond) and in 2010 (Boiler Slag Pond Dam). The intent of the explorations was to develop subsurface data at cross-sections along the dike for the Boiler Slag Pond and the dam for the Landfill Collection Runoff Pond and to perform conventional seepage and stability analyses, assessing the performance of the facilities. The potential for liquefaction was to be evaluated according to simplified published methods. Reports from past geotechnical explorations were used to supplement subsurface data.

In response to the Coal Combustion Residual (CCR) rules mandated in the Federal Register on April 17, 2015, AEP contracted Stantec to perform stability analyses for the Boiler Slag Pond Dam and Landfill Runoff Collection Pond to estimate static, seismic, and liquefaction potential factors of safety. According to Section 257.73(e)(1)(i) through (iv) of the CCR rules, the required factors of safety are as follows:

(i) The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.

(ii) The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.

(iii) The calculated seismic factor of safety must equal or exceed 1.00

(iv) For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

Table 1 summarizes the geometric characteristics of the embankments.

Table 1 Clifty Creek Facility Geometry

Facility Section	Height (feet)	Crest Width (feet)	Downstream Slope Grade	Upstream Slope Grade
Boiler Slag Pond Section A-A'	41	22	2.5H:1V*	1.75H:1V*
Boiler Slag Pond Section B-B'	31	30	2.5H:1V*	1.5H:1V*
Boiler Slag Pond Section C-C'	35	30	2H:1V*	2H:1V*
Landfill Runoff Collection Pond Section D-D'	61	20	2.5H:1V*	3H:1V*
Landfill Runoff Collection Pond Section E-E'	51	20	2.5H:1V*	4.5H:1V*

*Denotes horizontal to vertical ratio

2.0 GEOLOGY OF THE SITE

The site lies within the Muscatatuck Regional Slope Physiographic Region of Indiana. This gently sloping plain is made of bedrock that is mostly Devonian in age that has been dissected by streams. Along the Ohio River the uplands immediately to the north are rugged and stand in bold relief to the flood plain. The reaches of each drainageway typically contain accumulations of silt, clay, and sand that make up the flat-lying flood plains. The site topography is steep to moderately sloping toward natural drainage channels. Topographic relief between Clifty Creek Power Plant and the uplands to the north is on the order of 350 feet.

Published soils information for the site was obtained from the Soil Survey of Jefferson County, Indiana, (US Department of Agriculture [USDA], Natural Resources Conservation Service [NRCS], 1985). The soil survey indicated the side slopes of Devil's Backbone and the ridge flanks to the north of the site belong to the Eden-Caneyville complex (EgG). These soils are found on steep to very steep slopes ranging from 25 to 60 percent. The Eden-Caneyville complex consists of moderately deep and well-drained soils that formed on slopes facing the Ohio River and on back slopes facing adjacent to tributaries near the river.

Mapping of unconsolidated sediments obtained from Regional Geologic Map, Louisville Sheet, Part B (Indiana Department of Natural Resources [IDNR], 1972) indicates the lowland areas adjacent to the Ohio River are predominantly underlain by clay, silt, sand, and gravel deposited as alluvium, lacustrine and outwash deposits. The glacial deposits in the area are of the Illinoian and Wisconsinan Quaternary age and belong to the Atherton Formation. The overlying more recent alluvial deposits belong to the Martinsville Formation.

The Atherton Formation consists of coarse- to fine-grained, well-sorted sediments that were deposited by glacial outwash (sand and gravel deposited by glacial meltwater streams), lake sediments and loess. The Martinsville Formation consists of alluvial sediments of non-glacial origin that have been deposited in modern flood plains along the major drainage ways. This formation varies in thickness from a few inches up to 30 feet near rivers.

Available geologic mapping from Bedrock Geology of Indiana (Indiana Geological Survey [IGS] Miscellaneous Map 48, IGS, 1987) shows the site to be underlain by bedrock of the Maquoketa Group. The Maquoketa Group in Indiana is a westward-thinning wedge, 1,000 feet thick in southeastern Indiana and 200 feet thick in northwestern Indiana. Overall, the group consists principally of shale (about 80 percent) and limestone (about 20 percent), although limestone is dominant in some areas. The lower part of the group is almost entirely shale, and the lower part of the shale is dark brown to nearly black. These rocks were deposited during the Upper Ordovician Period.

3.0 FIELD EXPLORATIONS AND SITE RECONNAISSANCE

The borings for the 2009 and 2010 geotechnical exploration were advanced using 3¼-inch inside-diameter hollow-stem augers powered by a truck-mounted drill rig. Standard penetration tests (SPTs) were performed at 2.5-foot intervals in accordance with ASTM D 1586. Undisturbed Shelby tube samples were performed at selected intervals to obtain samples for consolidated-undrained (CU) triaxial compression (ASTM D 4767) and permeability testing (ASTM D 5084-90). Sample depths and recovery amounts are presented on the boring logs. Additionally, disturbed bag samples were collected from auger cuttings obtained from the boreholes.

A Stantec geotechnical engineer directed the drill crews, logged the subsurface materials encountered during the exploration and collected soil samples. During field logging, particular attention was given to each material's color, texture, moisture content, and consistency or relative density.

Following the field explorations, the Shelby tubes and bag samples were transported to Stantec's (or certified vendor's) laboratory for testing. Natural moisture content and unit weight testing were performed on samples extruded from the tubes. Testing consisting of sieve and hydrometer analyses (ASTM D 422) and Atterberg limits (ASTM D 4318) was performed on representative samples in order to classify the soil according the Unified Soil Classification System (USCS). Consolidated undrained triaxial compression tests (ASTM D 4767) and falling head permeability tests (ASTM D 5084) were also performed on Shelby tube samples. Standard Proctor moisture-density testing (ASTM D 698) was performed on disturbed soil bag samples collected from the auger cuttings.

3.1 BOILER SLAG POND DAM

3.1.1 2010 Geotechnical Exploration

Stantec advanced six borings at the dike of the Boiler Slag Pond Dam near the locations requested by AEP. The boring locations are shown in Appendix A. Borings B-1, B-3, and B-5 were positioned along the crest of the dike and Borings B-2, B-4, and B-6 were located along the downstream toe.

Upon completion of drilling, one-inch diameter standpipe piezometers were installed in four of the borings (Borings B-1, B-3, B-4, and B-5). In these, ten-foot long sections of polyvinyl chloride (PVC) well screen were placed in the borehole with the bottoms at approximate depths ranging from 30 to 40 feet. PVC riser tubing extended to the tops of the piezometers. Flush-mount well covers were installed along the crest of the dike (Borings B-1, B-3, and B-5) and an above-ground steel tube cover was used at the toe of the downstream slope (Boring B-4). Refer to Appendix C for piezometer installation details.

3.1.2 2015 CCR Mandate Site Reconnaissance

Representatives from Stantec visited the Boiler Slag Pond Dam for a site reconnaissance on August 25, 2015. The purpose of this visit was to confirm that physical conditions at the pond, such as geometry of the embankment, pool elevations, etc. had not changed since the completion of the analysis in 2010. The crest and exterior slopes of the pond were walked by Stantec personnel, while the interior slopes were observed from the crest. Evidence of alterations to the pond since 2010 were not observed during the reconnaissance.

3.2 LANDFILL RUNOFF COLLECTION POND DAM

3.2.1 Previous Explorations

Two historical exploration reports were used to develop subsurface profiles and engineering parameters for the onsite material. The Fly Ash Dam Raising Feasibility Report (AEP, 1985) was implemented to obtain geotechnical properties of the dams, dikes, and foundation material to perform a feasibility assessment of raising the dams by 30 feet. Approximately 22 borings with SPT sampling and 11 Cone Penetrometer Test (CPT) borings were performed for this study. This report was used to develop a subsurface profile of the dam and estimate soil properties and shear strength parameters.

The Hydrogeologic Study Report (Applied Geology and Environmental Science, Inc., 2006) summarized the piezometers and field permeability testing performed by various firms. This report was used to develop initial phreatic surfaces for the stability analyses, and the field permeability testing data were reviewed to assist in selecting hydraulic conductivity values for soil horizons in the seepage analysis.

A review of the existing data by Stantec revealed a lack of laboratory testing necessary to develop drained (long-term) shear strength parameters. Standard Proctor moisture-density testing was recommended to compare with in-situ total unit weights to estimate the apparent degree of compaction used during construction. The review of the existing data resulted in the additional exploration explained in Section 3.2.2.

3.2.2 2009 Geotechnical Exploration

Stantec advanced four additional borings along the southern dam on November 11 and 19, 2009 to collect undisturbed Shelby tube and disturbed bag samples for laboratory testing. The boring locations are shown in Appendix A. Borings B-7 and B-9 were positioned along the crest of the dam, and Borings B-8 and B-10 were located along the downstream toe of the dam embankment. The borings were numbered in sequence with the six borings drilled at the Boiler Slag Pond Dam, also advanced late in 2009.

3.2.3 2015 Geotechnical Exploration

An additional boring (B-12) was advanced on July 6-7, 2015 to confirm subsurface conditions. This boring was placed on the crest of the dam, between the two cross-sections. The location of the boring can be seen on the site plan in Appendix A. Standard Penetration Test samples were collected at five-foot intervals. These samples were taken to a Stantec laboratory for natural moisture content, hydrometer analyses, and Atterberg limits testing.

3.2.4 2015 CCR Mandate Site Reconnaissance

Representatives from Stantec visited the Landfill Runoff Collection Pond for a site reconnaissance on August 25, 2015. The purpose of this visit was to confirm that physical conditions at the pond, such as geometry of the embankment, pool elevations, etc. had not changed since the completion of the analysis in 2010. The crest and exterior slopes of the pond were walked by Stantec personnel, while the interior slopes were observed from the crest. Evidence ot alterations to the pond since 2010 were not observed during the reconnaissance.

4.0 RESULTS OF EXPLORATIONS

Logs of borings are provided in Appendix B and shown graphically on stability analysis cross sections in Appendix I for the 2009 and 2010 explorations. Results of natural moisture content tests and SPTs are provided on the logs adjacent to the appropriate sample. Summaries of engineering classification tests are provided in Appendix D.

4.1 BOILER SLAG POND DAM

4.1.1 2010 Geotechnical Exploration

4.1.1.1 Boring B-1

Boring B-1 was on the crest along cross-section A-A' of the Boiler Slag Pond Dam. The surface elevation of this boring was 473.4 feet.

Lean clay with sand was observed from the surface of the boring to a depth of 67.5 feet (Elevation 405.9 feet). From the surface of the boring to a depth of 37.5 feet (Elevation 435.9 feet), this material was described as light yellowish brown with light gray, damp to moist, and medium stiff to stiff. Natural moisture contents ranged from 15 to 23 percent and SPT N-values varied from 7 to 15 blows per foot (bpf). A liquid limit of 32 percent and a plasticity index of 13 percent were determined for a sample from this horizon. This sample was classified as CL, lean clay with sand, according to the Unified Soil Classification System (USCS) and A-6 (10) according to the Association of American State and Highway Transportation Officials (AASHTO) system. The average total unit weight of undisturbed samples was 131 pounds per cubic foot (pcf).

From a depth of 37.5 to 67.5 feet (Elevation 435.9 to 405.9 feet), the lean clay with sand was described as light yellowish brown with light gray, moist to wet, and very soft to medium stiff. Natural moisture contents ranged from 20 to 37 percent and SPT N-values varied from 2 to 7 blows per foot. A liquid limit of 28 percent and a plasticity index of 12 percent were determined for this soil. A Shelby tube sample yielded a total unit weight of 129 pounds per cubic foot. A representative sample from this layer classified as CL, lean clay with sand, according to the USCS and A-6 (8) according to the AASHTO system.

Bedrock, described as weathered gray shale, was encountered at a depth of 67.5 feet (Elevation 405.9 feet) and was augered to a boring termination depth of 71.5 feet (Elevation 401.9 feet). Groundwater was observed during the drilling at a depth of 40.0 feet (Elevation 433.4 feet) during drilling.

4.1.1.2 Boring B-2

Boring B-2 was advanced at the downstream toe along the same cross-section as Boring B-1 at a surface elevation of 444.0 feet.

From the surface of the boring to a depth of 51.5 feet (Elevation 392.5 feet), lean clay with sand was observed. The top 30 feet of this deposit was described as light yellowish brown with gray, moist to wet, and soft to very stiff. Moisture contents ranged from 17 to 32 percent and SPT N-values varied from 2 to 19 bpf, with an average of 7 blows per foot. The average total unit weight of the soil was 124 pounds per cubic foot.

The lower 21.5 feet of the lean clay with sand was described as gray, moist to wet, and soft to medium stiff. Natural moisture contents ranged from 25 to 35 percent and SPT N-values varied from 2 to 6 blows per foot. A liquid limit of 33 percent and plasticity index of 18 percent was determined for this material. A representative sample of this soil classified as CL, lean clay with sand according to the USCS and A-6 (13) according to the AASHTO system. Total unit weights of 117 and 121 pcf were determined for Shelby tube samples.

From a depth of 51.5 to 55.5 feet (Elevation 392.5 to 388.5 feet), well-graded gravel with silt and sand was observed. Bedrock was encountered below this material, described as shale, gray, hard, and medium bedded. Groundwater was observed at a depth of 22.5 feet (Elevation 421.5 feet) during drilling.

4.1.1.3 Boring B-3

Boring B-3 was positioned on the crest of the dike along cross-section B-B'. The surface elevation of the boring was 471.6 feet.

Lean clay with sand, described as light yellowish brown with light gray, was observed from the boring surface to a depth of 37.5 feet (Elevation 434.1 feet). The soil was further described as damp to moist and medium-stiff to very stiff. Moisture contents ranged from 15 to 22 percent and SPT N-values varied from 8 to 17 blows per foot. The average total unit weight was 131 pounds per cubic foot.

Gray lean clay with sand was observed below the upper soil horizon to the termination depth of 71.5 feet (Elevation 400.1 feet). This soil was described as moist and soft to very stiff. Moisture contents ranged from 20 to 40 percent and SPT N-values varied from 2 to 18 bpf, with an average of 6 blows per foot. The average total unit weight was 126 pounds per cubic foot.

Groundwater was observed at a depth of 40.0 feet (Elevation 431.6 feet) during drilling. Bedrock was not encountered.

4.1.1.4 Boring B-4

Boring B-4 was located along the downstream toe of the dike, downhill from Boring B-3, at a surface elevation of 444.0 feet.

Brown to dark gray lean clay with sand was observed from the surface of the boring to a depth of 15.0 feet (Elevation 429.0 feet). The soil was described as damp to moist and medium stiff to very stiff. Natural moisture contents ranged from 14 to 22 percent and SPT N-values varied from 7 to 16 blows per foot.

Gray lean clay with sand was encountered below the upper soil horizon to a depth of 57.5 feet (Elevation 386.5 feet) and was described as moist to wet and soft to stiff. Moisture contents varied from 21 to 35 percent and SPT N-values varied from 3 to 9 blows per foot. A representative sample yielded a liquid limit of 25 percent and a plasticity index of 8 percent. This material classified as CL, lean clay with sand, according to the USCS and A-4 (4) according to the AASHTO system.

Underlying the lean clay with sand, well-graded gravel with silt and sand was observed to a termination depth of 71.5 feet (Elevation 372.5 feet). This material was described as gray, wet, and dense to very dense. Moisture contents ranged from 9 to 13 percent and SPT N-values varied from 39 to over 50 blows per foot. A representative sample of this material tested as non-plastic and classified as GW-GM, well-graded gravel with silt and sand, according to the USCS and A-1-a (1) according to the AASHTO system.

Bedrock was not encountered in the boring. Groundwater was observed at a depth of 22.5 feet (Elevation 421.5 feet) during drilling.

4.1.1.5 Boring B-5

Boring B-5 was advanced from the crest of the dike on cross-section C-C'. The surface elevation was 468.7 feet.

Lean clay with sand was observed from the surface of Boring B-5 to a depth of 40.0 feet (Elevation 428.7 feet). The soil was described as light yellowish brown with light gray, damp to moist, and medium stiff to very stiff. Natural moisture contents ranged from 15 to 25 percent and SPT N-values varied from 6 to 19 blows per foot. The average total unit weight of the soil was 128 pounds per cubic foot.

Additional lean clay with sand was encountered below the uppermost layer to a depth of 47.5 feet (Elevation 421.2 feet). This material was described as gray, moist to wet, and soft. Natural moisture contents ranged from 23 to 25 percent and SPT N-values varied between 3 and 4 blows per foot. The total unit weight was 119 pounds per cubic foot.

Below the lean clay with sand, sandy silt was observed to the termination depth of 71.5 feet (397.2 feet). The sandy silt was described as light yellowish brown to gray, wet, and soft to stiff. Moisture contents ranged from 22 to 30 and SPT N-values varied from 2 to 13 bpf, with an average of 7 blows per foot. A representative sample from this horizon tested as non-plastic and classified as ML, sandy silt, according to the USCS and A-4 (0) according to the AASHTO system.

Bedrock was not encountered in the boring. Groundwater was encountered at a depth of 45.0 feet (Elevation 423.7 feet) during drilling.

4.1.1.6 Boring B-6

Boring B-6 was advanced from a surface elevation of 445.5 feet near the southeast toe of slope below Boring B-5.

Lean clay with sand was encountered from the surface to a depth of 27.5 feet (Elevation 418.0 feet). This material was described as brown to gray, damp to moist, and very soft to very stiff. Natural moisture contents ranged from 16 to 32 percent and SPT N-values varied from 0 to 18 bpf, with an average of 6 blows per foot. The average total unit weight was 117 pounds per cubic foot.

Sandy silt was observed below the lean clay with sand to the boring termination depth of 71.5 feet (Elevation 374.0 feet). This soil was described as gray, moist to wet, and very soft to stiff. Moisture contents ranged from 27 to 40 percent and SPT N-values varied from 1 to 11 bpf, with an average of 5 blows per foot. The total unit weight was 117 pounds per cubic foot.

Bedrock was not encountered in the boring. Groundwater was observed at a depth of 30.0 feet (Elevation 415.5 feet) during drilling.

4.1.1.7 Piezometers

Piezometers were installed on the crest in Borings B-1, B-3, and B-5, and at the downstream toe in Boring B-4. Details of piezometers installations are shown in Appendix C. Ten-foot long piezometers screens were installed with the tips at approximate depths of 40 feet along the crest and 30 feet at the downstream toe of slope. Table 2 summarizes the installations and first two readings performed on the piezometers.

Table 2 Summary of Piezometer Elevations for the Boiler Slag Pond Dam

Boring No.	Top of Piezometer (feet)	Tip of Piezometer (feet)	Piezometric Reading on 11/13/09 (feet)	Piezometric Reading on 02/01/10 (feet)
B-1	473.4	433.4	434.2	434.1
B-3	471.8	431.6	440.6	434.6
B-4	446.7	414.0	430.7	428.5
B-5	469.0	428.7	434.9	430.4

4.2 LANDFILL RUNOFF COLLECTION POND

4.2.1 2009 Geotechnical Exploration

4.2.1.1 Boring B-7

Boring B-7 was advanced from the crest of the dam along cross-section D-D'. The surface elevation of the boring was 503.4 feet. Approximately 0.5 feet of asphalt pavement and gravel base was observed at the surface of the boring.

Below the pavement and gravel base, lean clay was observed to a boring termination depth of 29.0 feet (Elevation 474.4 feet). The lean clay was described as yellow and light gray, moist, and stiff. Three undisturbed Shelby tube samples were obtained from a depth of 23.0 to 29.0 feet (Elevation 480.4 to 474.4 feet). Natural moisture contents of those samples ranged from 18 to 24 percent, and total unit weights varied from 128 to 133 pounds per cubic foot. A representative sample yielded a liquid limit of 28 percent and a plasticity index of 8. This sample classified as CL, lean clay, according to the USCS and A-4 (7) according to the AASHTO system.

Neither bedrock nor groundwater was encountered during drilling.

4.2.1.2 Boring B-8

Boring B-8 was located at the toe of slope downstream of Boring B-7. The surface elevation of the boring was 441.5 feet. From the surface of the boring to a depth of 16.0 feet (Elevation 425.5 feet), the soil was visually described as yellow and light gray, damp to moist, silty clay.

Below the silty clay, lean clay was encountered to a depth of 29.0 feet (Elevation 412.5 feet). The lean clay was described as yellowish brown to light gray and moist. Two undisturbed Shelby tube samples were taken from this horizon at depths of between 25.0 and 29.0 feet (Elevation 416.5 to 412.5 feet). Natural moisture contents ranged from 24 to 27 percent, and total unit weights ranged from 124 to 130 pounds per cubic foot. A representative sample of this material yielded a liquid limit of 38 percent and a plasticity index of 17 percent. The sample classified as CL, lean clay according to the USCS and A-6 (15) according to the AASHTO system.

Soil described as lean clay with sand was observed beneath the lean clay to the boring termination depth of 31.0 feet (Elevation 410.5 feet). The lean clay with sand was further described as yellowish brown and light gray and moist. Shelby tube samples yielded moisture contents of 22 and 24 percent and total unit weights of 126 and 129 pounds per cubic foot. This soil had a liquid limit of 45 percent and a plasticity index of 25 percent. The soil classified as CL, lean clay with sand according to the USCS and A-7-6 (20) according to the AASHTO system.

Neither bedrock nor groundwater was encountered during drilling.

4.2.1.3 Boring B-9

Boring B-9 was advanced along the crest of cross-section E-E' at a surface elevation of 504.3 feet. Asphalt pavement and gravel base was observed at the surface of the boring to a depth of 0.5 feet.

Lean clay was encountered below the pavement to the boring termination depth of 22.0 feet (Elevation 482.3 feet). The lean clay was described as yellow to light gray and damp to moist. Three undisturbed Shelby tube samples were obtained from a depth of 16.0 to 22.0 feet (Elevation 488.3 to 482.3 feet). Natural moisture contents ranged from 17 to 23 percent, and total unit weights varied from 119 to 135 pounds per cubic foot. A sample of this material yielded a liquid limit of 39 percent and a plasticity index of 19 percent. This sample classified as CL, lean clay, according to the USCS and A-6 (17) according to the AASHTO system.

Neither bedrock nor groundwater was encountered during drilling.

4.2.1.4 Boring B-10

Boring B-10 was positioned near the toe below Boring B-9. The surface elevation was 457.3 feet.

Silty clay with sand was observed from the surface of the boring to a depth of 13.2 feet (Elevation 444.1 feet) and from a depth of 16.0 feet to the termination depth of 18.0 feet (Elevation 441.3 to 439.3 feet). This soil was described as yellow to light gray and damp to moist. Two undisturbed Shelby tube samples were taken and natural moisture contents ranged from 21 to 28 percent. Total unit weights of the samples ranged from 116 to 124 pounds per cubic foot. A representative sample of this material yielded a liquid limit of 28 percent and a plasticity index of 7 percent. The sample classified as CL-ML, silty clay with sand according to the USCS and A-4 (5) according to the AASHTO system.

From a depth of 13.2 to 16.0 feet (Elevation 444.1 to 441.3 feet) a layer of silty sand was encountered and describe as gray-brown and damp to moist. One Shelby tube sample was taken from this layer. A representative sample of this soil classified as non-plastic SM, silty sand, according to the USCS and A-2-4 (0) according to the AASHTO system.

4.2.2 2015 Geotechnical Exploration

Boring B-12 was advanced on the crest of the dam between the analysis cross-sections. The ground surface elevation of the boring was estimated to be 503.9 feet. A layer of asphalt with gravel base was encountered at the surface of the boring to a depth of 0.4 feet (Elevation 503.5 feet).

Beneath the asphalt and gravel base, lean clay with sand was encountered to a depth of 40.0 feet (Elevation 463.9 feet). This material was described as gray, damp, and medium stiff to stiff.

The natural moisture contents ranged from 18 to 28 percent and the SPT N-values varied from 7 to 15 blows per foot. The liquid limit of this material ranged from 31 to 43 percent and the plasticity index varied from 13 to 22 percent. The material classified as CL, lean clay with sand, according to the USCS and A-6 (7) or A-7-6 (15) according to the AASHTO system.

Silty clay with sand was observed beneath the lean clay with sand to a depth of 50.0 feet (Elevation 453.9 feet). This material was described as brown, moist, and medium stiff to very stiff. The natural moisture contents ranged from 16 to 19 percent and the SPT N-values varied from 8 to 16 blows per foot. A representative sample of this material yielded a liquid limit of 26 percent and a plasticity index of 7 percent. The material classified as CL-ML, silty clay with sand, according to the USCS and A-4 (4) according to the AASHTO system.

Cohesionless material was encountered beneath the silty clay with sand to the depth of 90.0 feet (Elevation 413.9 feet). This material was silt, silt with sand, silty sand, or sand; and was described as brown or gray, damp to wet, and loose to medium dense. The natural moisture contents ranged from 15 to 28 percent and the SPT N-values varied from 6 to 28 blows per foot. Samples from these materials tested as non-plastic. The material classified as ML (sandy silt, silt, or silt with sand) or SM (silty sand) according to the USCS and A-4 (0) according to the AASHTO system.

Beneath the cohesionless material, lean clay was encountered to the boring termination depth of 101.5 feet (402.4 feet). This material was described as gray, moist, and medium stiff to very stiff. The natural moisture content ranged from 23 to 27 percent and the SPT N-values varied from 8 to 19 blows per foot. A representative sample from this material yielded a liquid limit of 42 percent and a plasticity index of 23 percent. The sample classified as CL, lean clay, according to the USCS and A-7-6 (20) according to the AASHTO system.

5.0 LABORATORY TESTING

Laboratory tests in addition to the natural moisture content, classification tests, and unit weight tests mentioned in Section 4 were conducted on samples taken from the Boiler Slag Pond Dam (2010 Geotechnical Exploration) and Landfill Runoff Collection Pond (2009 Geotechnical Exploration). The results from the additional testing are summarized in the following sections.

5.1 BOILER SLAG POND DAM

5.1.1 Consolidated-Undrained Triaxial Compression Testing

Three consolidated-undrained (CU) triaxial compression tests were performed on undisturbed samples collected from the borings. These tests were performed in accordance with ASTM D

4767, and detailed results of the tests are provided in Appendix E. The samples were described as lean clay with sand. Table 3 shows a summary of the CU triaxial tests performed.

Table 3 Summary of CU Triaxial Compression Testing for the Boiler Slag Pond Dam

Boring Nos.	Depth (feet)	Soil Description	Material	Effective Cohesion, c' (psf)	Effective Angle of Internal Friction, ϕ' (deg.)
B-3, B-5	8.1 – 11.2	Lean Clay with Sand	Embankment	330	33.2
B-2, B-4	18.2 – 24.3	Lean Clay with Sand	Foundation	320	27.2
B-1, B-3	43.1 – 48.7	Lean Clay with Sand	Foundation	170	30.2

5.1.2 Permeability Testing

Four permeability tests (ASTM D 5084, Falling-Head, Method C, Rising Tailwater) were performed on undisturbed samples. Detailed data sheets showing the results of the tests are provided in Appendix F. Vertical hydraulic conductivities ranged from $8.7\text{x}10^{-9}$ to $1.6\text{x}10^{-6}$ centimeters per second. The samples were described as lean clay with sand. Table 4 summarizes the results of the permeability tests.

Table 4 Summary of Permeability Testing for the Boiler Slag Pond Dam

Boring No.	Depth, feet	Soil Description	Material	Vertical Hydraulic Conductivity, cm/second
B-1	16.1 – 16.6	Lean Clay with Sand	Embankment	$1.44\text{x}10^{-7}$
B-2	42.6 – 43.1	Lean Clay with Sand	Foundation	$8.70\text{x}10^{-9}$
B-4	7.6 – 8.1	Lean Clay with Sand	Embankment	$1.58\text{x}10^{-6}$
B-6	17.6 – 18.1	Lean Clay with Sand	Foundation	$2.01\text{x}10^{-7}$

5.1.3 Moisture-Density Testing

Three standard Proctor moisture-density tests (ASTM D 698) were performed on bag samples taken from auger cuttings. The data sheets for these tests are provided in Appendix G.

Maximum dry densities ranged from 113.0 to 117.4 pcf and optimum moisture contents varied from 13.4 to 15.8 percent. The samples were described as lean clay with sand. Table 5 summarizes the results of the tests.

Table 5 Summary of Moisture-Density Testing for the Boiler Slag Pond Dam

Boring No.	Depth, feet	Material	Soil Description	Maximum Dry Density, pcf	Optimum Moisture Content, %
B-1	5.0 +/- 2.0	Embankment	Lean Clay with Sand	117.4	13.4
B-5	7.5 +/- 2.0	Embankment	Lean Clay with Sand	113.0	15.8

These moisture-density tests were performed to compare with natural moisture contents and unit weights of the soils. Within the embankment soils, natural moisture contents ranged from 15 to 25 percent with an average of 19 percent. Dry densities of the embankment soil ranged from 106 to 115 pcf, with an average of 110 pounds per cubic foot. The results of these tests indicate that the average natural moisture content of the embankment soil is 3 to 5 percent above optimum moisture and that the average percent compaction of the embankment soil is on the order of 94 to 97 percent of the standard Proctor maximum density.

5.2 LANDFILL RUNOFF COLLECTION POND

5.2.1 Consolidated-Undrained Triaxial Testing

Four CU triaxial compression tests were performed on undisturbed samples collected from the borings. These tests were performed in accordance with ASTM D 4767, and detailed results of the tests are provided in Appendix E. The samples were described as lean clay, lean clay with sand, or sandy clay. Table 6 shows a summary of the CU triaxial tests performed.

Table 6 Summary of CU Triaxial Compression Testing for the Landfill Runoff Collection Pond

Boring No.	Depth (feet)	Soil Description	Material	Effective Cohesion, c' (psf)	Effective Angle of Internal Friction, ϕ' (deg.)
B-7	25.8 – 29.0	Lean Clay	Embankment	430	29.3
B-8	25.8 – 30.9	Lean Clay with Sand	Foundation	410	28.0
B-9	17.4 – 21.4	Lean Clay	Embankment	360	25.7
B-10	13.4 – 18.0	Sandy Clay	Foundation	300	35.1

5.2.2 Permeability Testing

Four permeability tests (ASTM D 5084, Falling-Head, Method C, Rising Tailwater) were performed on undisturbed samples. Detailed data sheets showing the results of the tests are provided in Appendix F. Vertical hydraulic conductivities ranged from 3.4×10^{-8} to 1.4×10^{-7} centimeters per second. The samples were described as lean clay, lean clay with sand, or silt. Table 7 summarizes the results of the permeability tests.

Table 7 Summary of Permeability Testing for the Landfill Runoff Collection Pond

Boring No.	Depth, feet	Material	Soil Description	Vertical Hydraulic Conductivity, cm/second
B-7	27.4 – 27.7	Embankment	Lean Clay	8.4×10^{-8}
B-8	29.7 – 30.9	Foundation	Silt	3.4×10^{-8}
B-9	18.3 – 18.9	Embankment	Lean Clay	6.2×10^{-8}
B-10	16.4 – 16.7	Foundation	Lean Clay with Sand	1.4×10^{-7}

5.2.3 Moisture-Density Testing

One standard Proctor moisture-density test (ASTM D 698) was performed on a bag sample of embankment soil taken from auger cuttings. The data sheet for this test is provided in Appendix

G. The maximum dry density was 110.6 pcf and the optimum moisture content was 16.9 percent. The sample was described as lean clay. Table 8 summarizes the results of the tests.

Table 8 Summary of Moisture-Density Testing for the Landfill Runoff Collection Pond

Boring No.	Depth, feet	Material	Soil Description	Maximum Dry Density, pcf	Optimum Moisture Content, %
B-7	7.0 +/- 2.0	Embankment	Lean Clay	110.6	16.9

The moisture-density test was performed to compare with in-situ natural moisture contents and unit weights of the soils. Within the embankment soils, natural moisture contents varied from 17 to 24 percent with an average of 20 percent. Dry densities of the embankment soil ranged from 99 to 114 pounds per cubic foot, with an average of 108 pounds per cubic foot. The results of these tests indicate that the average natural moisture content of the embankment soil is about 3 percent above optimum moisture and that the average percent compaction of the embankment soil is approximately 98 percent of the standard Proctor maximum density.

6.0 ENGINEERING ANALYSIS

6.1 BOILER SLAG POND DAM

Based on the review of available information, results of the geotechnical exploration and results of laboratory testing, Stantec performed engineering analyses of the Boiler Slag Pond Dam in 2010. This included liquefaction, seepage, and slope stability analysis of three cross sections. The procedures used and the results of the analyses are presented in the following paragraphs. The results of the liquefaction analysis are shown in Appendix H, and the cross section drawings showing the results of the seepage and stability analyses are provided in Appendix I. Appendix J provides an explanation of derivations of shear strength, seepage, and liquefaction analysis parameters.

6.1.1 Engineering Analyses Performed in 2015 as Part of CCR Mandate

6.1.1.1 Liquefaction Analysis

The liquefaction analysis conducted in 2010 was revisited as part of the CCR Mandate. The details for this analysis are contained in Appendix H. Similar to the analysis performed in 2010, a screening process was used to determine if the cohesive material encountered in the borings has the potential for liquefaction. The screening process was conducted for four samples which had liquid limits below 37 percent. According to the Seed et al and Bray and Sancio plots supplied in Appendix H, one sample could be labeled as susceptible to liquefaction and another could be labeled as moderately susceptible to liquefaction.

The remaining cohesionless material encountered in the critical cross-sections was tested for liquefaction as a coarse–grained analysis similar to the one conducted in 2010. According to the CCR Mandate, for dikes constructed of soils that have a susceptibility to liquefaction, the calculated factor of safety must equal or exceed 1.20. Test data from Borings B-1 and B-2, representative of cross-section A-A', Boring Nos. B-3 and B-4, representative of cross-section B-B', and B-5 and B-6, representative of cross-section C-C' was used. Soil characteristics (grain size, plasticity, etc.) from SPT and Shelby tube samples were summarized to assess liquefaction potential. The copies of the spreadsheets used for the calculations appear in Appendix H and provide the soil, test data, and calculations used in the assessment.

It was assumed during the screening process for potential liquefaction that the steady-state water elevation consistent with that developed during the stability analysis would be used as the groundwater elevation. Unsaturated soils above this elevation were considered not liquefiable. Also the dike embankment materials, consisting of engineered fill, were not considered liquefiable.

Factors of safety against liquefaction were estimated for soil layers predicted to be potentially liquefiable during the screening process. As a result of recent industry publications that attempted to update certain correlations that had larger uncertainty that are used in the calculations for the factor of safety, slight differences in the factors of safety were obtained than those reported in 2010. Inputs such as depth, material properties, seismic accelerations, etc. have not been altered. Ranges and averages of these factors of safety for the potentially liquefiable soil layers are summarized in Table 9.

Table 9 Liquefaction Factor of Safety for the Boiler Slag Pond Dam, CCR Mandate

Boring No.	Depth (feet)	Elevation (feet)	Unified Soil Classification	Liquefaction FS, Range	Liquefaction FS, Average
B-2	51.5 – 56.0	392.5 – 388.0	GW-GM	10.00	10.00
B-4	57.5 – 71.5	386.5 – 372.5	GW-GM	10.00	10.00
B-5	47.5 – 71.5	421.2 – 397.2	ML	1.60 – 3.52	2.41
B-6	27.5 – 71.5	418.0 – 374.0	ML	1.08 – 2.64	1.73

The range of factors of safety for each soil horizon represents factors of safety calculated from each individual corrected N-value at that specific depth and overburden pressure. Due to the variable and somewhat unreliable nature associated with the SPT, it is recommended that the liquefaction factors of safety be evaluated according to the average values shown in Table 9. The average liquefaction factors of safety against liquefaction ranged from 1.73 to 10.00 and are considered acceptable.

6.1.1.2 Seepage Analysis

The seepage analysis conducted in 2010 was reviewed as part of the CCR Mandate. The seepage models used in the SEEP/W product were calibrated to recent piezometric data and visual field operations. Changes to the material properties developed in Appendix J of this report were not deemed necessary.

The 2010 analysis used a normal pool elevation of 442 feet to establish the piezometric line. During the 2015 site reconnaissance with AEP personnel, it was learned that the normal pool elevation is currently 448 feet and is not expected to change. As a result, a piezometric line has been adjusted for the current normal pool elevation of 448 feet, and has been used during the CCR Mandate review. The seepage analysis conducted at the critical cross-sections of A-A', B-B', and C-C' were reviewed.

The results of the seepage analysis were used to revise the stability cross-sections.

6.1.1.3 Stability Analysis

The stability analysis conducted in 2010 was reviewed as part of the CCR Mandate, using the results of the seepage analysis review in Section 6.1.1.2. Similar to 2010, SLOPE/W was the software used during the analysis. The drained shear strength parameters developed in 2010, located in Appendix J, were maintained for the updated analysis. Undrained shear strength parameters were not derived in 2010. These parameters were determined by CU test data for the Embankment Fill and Lean Clay with Sand. Undrained shear strength parameters for cohesionless materials were taken to be identical to the drained shear strength parameters.

Table 10 summarizes the drained and undrained shear strength parameters used in the analysis.

Table 10 Shear Strength Parameters for CCR Mandate Review

		Drained Shear Strengths		Undrained Shear Strengths	
Material	**Unit Weight (pcf)**	**ϕ' (deg.)**	**Effective Cohesion (psf)**	**ϕ (deg.)**	**Cohesion (psf)**
Embankment	130	33.2	165	13	600
Lean Clay with Sand	119	27.2	160	5	1,200
Gravel with Silt and Sand	130	35	0	35	0
Bottom Ash	115	28	0	28	0
Silty Sand	130	30	0	30	0

The upstream and downstream slopes of each cross-section were analyzed, incorporating the auto locate and entry/exit search routines to locate the critical slip surface. Once the potential failure surface with the lowest factor of safety was identified, the optimization routine was run.

When the surface slope is composed of a material with low effective cohesion, an infinite slope failure (shallow sliding parallel to the surface) will be critical. A minimum failure depth of ten feet was specified for each section, to eliminate the evaluation of surficial sloughing and erosional types of instability.

For this review, SLOPE/W was used to investigate one normal pool elevation, considered the maximum steady-state pool, and one PMF pool elevation:

- Current normal pool level of 448 feet.
- 50 Percent PMF pool level of 468.4 feet, applied as a steady-state load condition within SLOPE/W.

Using the drained and undrained strength parameters listed in Table 10, the existing dam was analyzed at the three critical cross sections selected for the CCR review. The undrained materials strengths were used in the seismic analyses.

A summary of the factors of safety are presented in Table 13 at the end of this section and printouts of the GeoStudio runs are presented in Appendix I.

6.2 LANDFILL RUNOFF COLLECTION POND

Based on the review of available information, results of geotechnical exploration and results of laboratory testing, Stantec performed engineering analyses of the Landfill Runoff Collection Pond in 2009. This included liquefaction, seepage, and slope stability analysis of two cross sections. The procedures used and the results of the analyses are presented in the following paragraphs. The results of the liquefaction analysis are shown in Appendix H, and the cross section drawings showing the results of the seepage and stability analyses are provided in Appendix I. Appendix J provides an explanation of derivations of shear strength, seepage, and liquefaction analysis parameters.

6.2.1 Engineering Analyses Performed in 2015 as Part of CCR Mandate

6.2.1.1 Liquefaction Analysis

The liquefaction analysis conducted in 2010 as part of the 2009 geotechnical exploration was revisited as part of the CCR Mandate. The details for this analysis are contained in Appendix H. Similar to the analysis performed in 2010, a screening process was used to determine if the cohesive material encountered in the borings has the potential for liquefaction. The screening process was conducted for nine samples, four of which had liquid limits below 37 percent. According to the Seed et al and Bray and Sancio plots supplied in Appendix H, none of the samples are considered susceptible to liquefaction.

The remaining cohesionless material encountered in the critical cross-sections was tested for liquefaction as a coarse–grained analysis similar to the one conducted in 2010. According to the CCR Mandate, for dikes constructed of soils that have a susceptibility to liquefaction, the calculated factor of safety must equal or exceed 1.20. Test data from historic Borings SS2-1 and SS2-4, representative of cross-section D-D’ and historic Borings SI-1, SS3-1, and SS3-4, representative of cross-section E-E’, were used. Soil characteristics (grain size, plasticity, etc.) from SPT and Shelby tube samples were summarized to assess liquefaction potential. The copies of the spreadsheets used for the calculations appear in Appendix H and provide the soil, test data, and calculations used in the assessment.

It was assumed during the screening process for potential liquefaction that the steady-state water elevation consistent with that developed during the stability analysis would be used as the groundwater elevation. Unsaturated soils above this elevation were considered not liquefiable. Also the dike embankment materials, consisting of engineered fill, were not considered liquefiable.

Factors of safety against liquefaction were estimated for soil layers predicted to be potentially liquefiable during the screening process. As a result of recent industry publications that attempted to update certain correlations that had larger uncertainty that are used in the calculations for the factor of safety, slight differences in the factors of safety were obtained than those reported in 2010. Inputs such as depth, material properties, seismic accelerations, etc. have not been altered. Ranges and averages of these factors of safety for the potentially liquefiable soil layers are summarized in Table 11.

Table 11 Liquefaction Factor of Safety for the Boiler Slag Pond Dam, CCR Mandate

Boring No.	Depth (feet)	Elevation (feet)	Unified Soil Classification	Liquefaction FS, Range	Liquefaction FS, Average
SI-1	14.0 – 26.0	442.6 – 430.6	ML	2.06 – 2.40	2.23
SI-1	26.0 – 36.0	430.6 – 420.6	SC	10.00	10.00
SI-1	36.0 – 41.0	420.6 – 415.6	SM	5.02	5.02
SI-1	41.0 – 79.5	415.6 – 377.1	ML	2.08 – 10.00*	4.87
SS2-1	61.0 – 66.0	443.5 – 438.5	ML	6.22	6.22
SS2-1	71.0 – 86.0	443.5 – 418.5	SM	2.41 – 10.00	6.31
SS2-4	16.0 – 21.0	423.8 – 418.8	SM	3.29	3.29
SS2-4	61.0 – 64.0	388.8 – 385.8	GC	3.50	3.50
SS3-1	36.0 – 46.0	468.5 – 458.5	ML	3.36 – 4.92	4.14
SS3-1	46.0 – 51.0	458.5 – 453.5	SP	5.34	5.34
SS3-1	51.0 – 56.0	453.5 – 448.5	SC	10.00	10.00
SS3-1	56.0 – 66.0	448.5 – 438.5	SP	3.28 – 3.84	3.56
SS3-1	66.0 – 71.0	438.5 – 433.5	SM	5.03	5.03
SS3-1	71.0 – 86.0	433.5 – 418.5	SP	2.93 – 10.00	6.25
SS3-1	86.0 – 96.0	418.5 – 408.5	SM	5.53 – 6.09	5.81
SS4-1	41.0 – 46.0	464.6 – 459.6	ML	3.28	3.28
SS4-1	46.0 – 66.0	459.6 – 439.6	SM	2.32 – 4.51	3.60
SS4-1	71.0 – 76.0	434.6 – 429.6	SC	1.83	1.83
SS4-1	76.0 – 94.0	429.6 – 411.6	ML	4.01 – 6.30	5.62

*Typical range is 2.08 – 2.93, typical average is 3.16

6.2.1.2 Seepage Analysis

The seepage analysis conducted in 2010 as a part of the 2009 geotechnical exploration was reviewed as part of the CCR Mandate. The seepage models used in the SEEP/W product were calibrated to recent piezometric data and visual field operations. Changes to the material properties developed in Appendix J of this report and the piezometric lines developed were not deemed necessary. The seepage analysis conducted at the critical cross-sections of D-D' and E-E' were reviewed.

The results of the seepage analysis were used to revise the stability cross-sections.

6.2.1.3 Stability Analysis

The stability analysis conducted in 2010 was reviewed as part of the CCR Mandate, using the results of the seepage analysis review in Section 6.2.1.2. Similar to 2010, SLOPE/W was the software used during the analysis. The drained shear strength parameters developed in 2010, located in Appendix J, were maintained for the updated analysis. Undrained shear strength parameters were not derived in 2010. These parameters were determined by CU test data for the Embankment and Lean Clay with Sand. The undrained shear strength parameters for the silty clay with sand layer were taken from established typical value tables. Undrained shear strength parameters for cohesionless materials were taken to be identical to the drained shear strength parameters.

Table 12 summarizes the drained and undrained shear strength parameters used in the analysis.

Table 12 Shear Strength Parameters for CCR Mandate Review

		Drained Shear Strengths		Undrained Shear Strengths	
Material	**Unit Weight (pcf)**	**ϕ' (deg.)**	**Effective Cohesion (psf)**	**ϕ (deg.)**	**Cohesion (psf)**
Embankment	129	27.5	198	21	1,400
Lean Clay with Sand	127	28	206	17	1,200
Sandy Silt	125	30	0	30	0
Silty Sand	94	30	0	30	0
Clayey Gravel with Sand	130	35	0	35	0
Fly Ash	115	25	0	25	0
Silty Clay with Sand	118	34	152	20	1,000

The upstream and downstream slopes of each cross-section were analyzed, incorporating the auto locate and entry/exit search routines to locate the critical slip surface. Once the potential failure surface with the lowest factor of safety was identified, the optimization routine was run.

When the surface slope is composed of a material with low effective cohesion, an infinite slope failure (shallow sliding parallel to the surface) will be critical. Failure was defined as any slip surface that begins in the crest with a reasonable depth of failure. A minimum failure depth was specified for each section, to eliminate the evaluation of surficial sloughing and erosional types of instability.

For this review, SLOPE/W was used to investigate one normal pool elevation and one PMF pool elevation:

- Current normal pool level of 485 feet.
- PMF pool level of 501.4 feet, applied as a surcharge load within SLOPE/W.

Using the drained and undrained strength parameters listed in Table 12, the existing dam was analyzed at the three critical cross sections selected for the CCR review. The undrained shear strength parameters were used in the seismic analyses.

A summary of the factors of safety are presented in Table 14 at the end of this section and printouts of the GeoStudio runs are presented in Appendix I.

Table 13 Summary of Computed Factors of Safety for the West Boiler Slag Pond Dam, 2015 CCR Mandate

Headwater Pool	Drainage	Incipient Motion	Seismic Load Case	Acceptance Criteria	Factor of Safety		
					A-A'	B-B'	C-C'
Normal Pool Elevation (448 feet)	Drained	Downstream	No	1.50	2.30	2.44	2.30
Normal Pool Elevation (448 feet)		Upstream		1.50	1.88	1.63	2.73
50% PMF Elevation(462.8 feet)		Downstream		1.40	2.30	2.44	2.18
50% PMF Elevation (462.8 feet)		Upstream		1.40	2.13	1.95	3.88
Normal Pool Elevation (448 feet)	Undrained	Downstream	Yes	1.00	1.35	1.30	1.53
Normal Pool Elevation (448 feet)		Upstream		1.00	1.34	1.30	2.25

Table 14 Summary of Computed Factors of Safety for the Landfill Runoff Collection Pond Dam, 2015 CCR Mandate

Headwater Pool	Drainage	Incipient Motion	Seismic Load Case	Acceptance Criteria	Factor of Safety	
					D-D'	E-E'
Normal Pool Elevation (485 feet)	Drained	Downstream	No	1.50	1.85	1.99
Normal Pool Elevation (485 feet)		Upstream		1.50	2.73	3.51
PMF Elevation Surcharge (501.4 feet)		Downstream		1.40	1.81	1.99
PMF Elevation Surcharge (501.4 feet)		Upstream		1.40	3.47	4.51
Normal Pool Elevation (485 feet)	Undrained	Downstream	Yes	1.00	1.42	1.64
Normal Pool Elevation (485 feet)		Upstream		1.00	1.94	2.28

February 16, 2016

7.0 CONCLUSIONS

7.1 PE CERTIFICATION

I, Stan Harris, being a Professional Engineer in good standing in the State of Indiana, do hereby certify, to the best of my knowledge, information, and belief that the information contained in this certification is prepared in accordance with the accepted practice of engineering. I certify that pursuant to 40 CFR 257.73(e)(2), the safety factor assessment for the AEP Clifty Creek Power Plant's Boiler Slag Pond Dam and Landfill Runoff Collection Pond demonstrates compliance with the factors of safety specified in 40 CFR 257.73(e)(1)(i) through (iv).

SIGNATURE Stan A. Harris DATE 2/16/16

ADDRESS: Stantec Consulting Services Inc.
11687 Lebanon Road
Cincinnati, Ohio 45241-2012

TELEPHONE: (513) 842-8200

STAN A. HARRIS
REGISTERED
No. PE-19700150
STATE OF INDIANA
PROFESSIONAL ENGINEER

7.2 GENERAL

The analyses presented herein are based on information gathered (from various sources) using that degree of care and skill ordinarily exercised under similar circumstances by competent members of the engineering profession. Subsurface profiles are generally based on straight-line interpolation between borings and no warranties can be made regarding the continuity of subsurface conditions between the borings.

The boring logs and related information presented in this report depict approximate subsurface conditions only at the specific boring locations noted and at the time of drilling. Conditions at other locations may differ from those occurring at the boring locations. This report may not be applicable if the facility is modified from what is described in this report or if the site conditions are altered. This report may require updating to reflect the different, modified facility specifics and/or the altered site conditions.

8.0 REFERENCES

1. Stantec, Report of Geotechnical Exploration, AEP Clifty Creek Power Landfill Runoff Collection Pond, May 2010

2. Stantec, Report of Geotechnical Exploration, AEP Clifty Creek Power West Bottom Ash Pond, May 2010

3. Stantec, Reservoir Routing Analysis Landfill Runoff Collection Ash Pond Report, February 2010

4. Applied Geology and Environmental Sciences, Inc (AGES), "Hydrogeologic Study Report, Clifty Creek Coal Ash Landfill, Clifty Creek Station," Report Date: November, 2006

5. ASCE, Foundation Engineering Handbook, Design and Construction with the 2006 International Building Code, Robert W. Day, 2005

6. Earthquake Engineering Research Center, Recent Advances in Soils Liquefaction Engineering: A Unified and Consistent Framework, R.B. Seed, K.O. Cetin, R.E.S Moss, A.M. Kammerer, J. Wu, J.M. Pestana, M.F. Riemer, R.B. Sancio, J.D. Bray, R.E. Kayen, A. Faris, 2003

7. USACE, EM 1110-2-1902 Engineering and Design - Slope Stability, 2003

8. Indiana Department of Natural Resources, General Guidelines for New Dams and Improvements to Existing Dams in Indiana, 2001

9. Virginia Polytechnic Institute and State University, Virginia Tech Center For Geotechnical Practice and Research, Performance and Use of the Standard Penetration Test in Geotechnical Engineering Practice October 1998

10. NAVFAC DM 7.2 - NAVFAC DM7-02 Foundations and Earth Structures, Table 1: Typical Properties of Compacted Soils (Page 39) September 1986

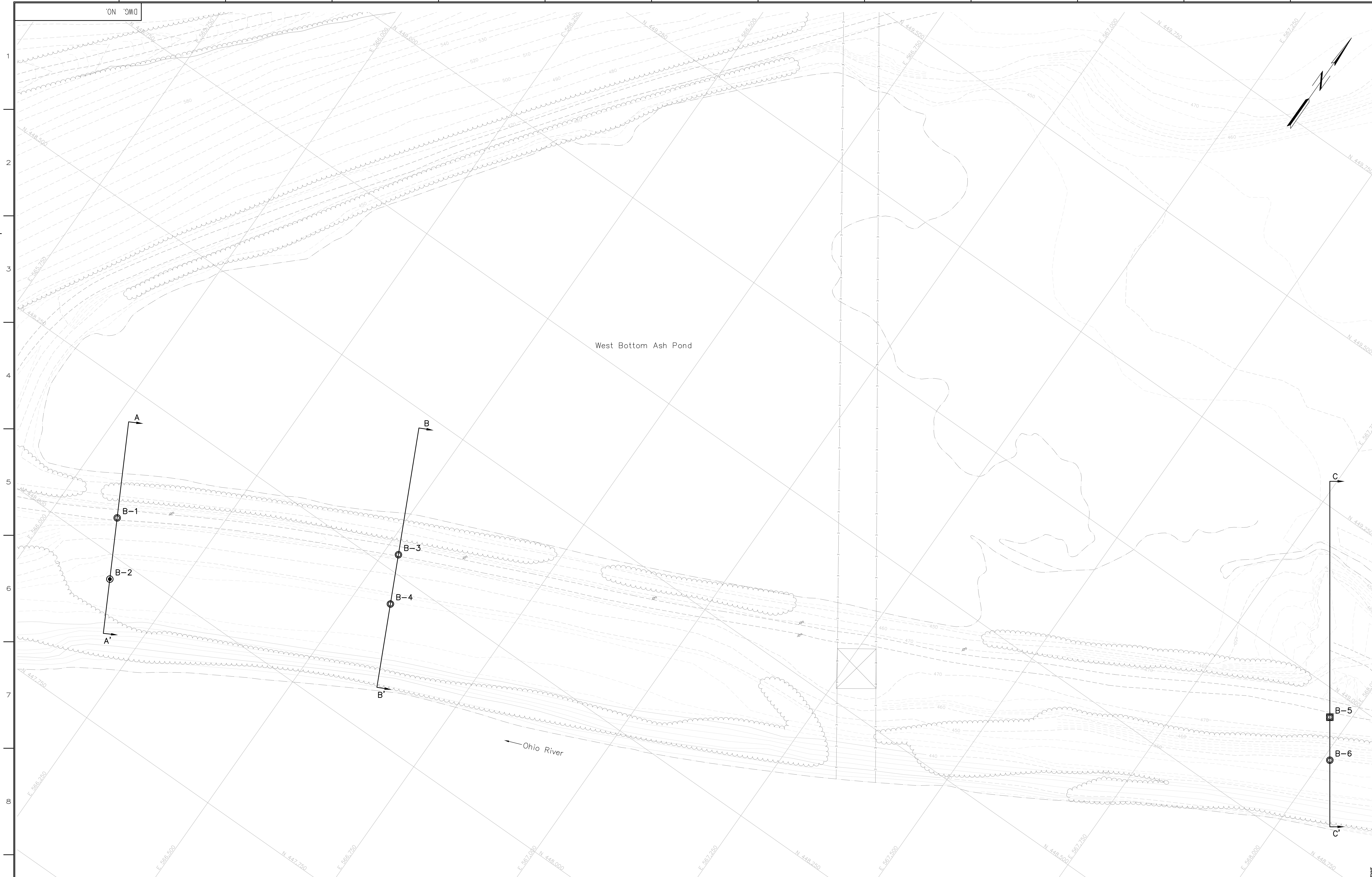
11. Indiana-Kentucky Electric Corporation, (IKEC), "Flyash Dam Raising Feasibility Report, Clifty Creek Plant," Report Date: January 31, 1985

12. US Department of the Interior, Bureau of Reclamation, Design of Small Dams, Second Edition, 1973

APPENDIX A

SITE PLANS

BOILER SLAG POND DAM



BORING LAYOUT

SCALE: 1"=60'

LEGEND

- Soil Boring with Undisturbed (Shelby) Tube Samples and/or Standard Penetration Tests
- Soil Boring with Undisturbed (Shelby) Tube Samples and/or Standard Penetration Tests and Rock Core

30 0 60 120 FEET

GRAPHIC SCALE

NOTES

REFERENCE DRAWINGS

DATE	NO.	DESCRIPTION	APPD.

REVISIONS

INDIANA – KENTUCKY ELECTRIC CO.

CLIFTY CREEK PLANT

MADISON INDIANA

GEOTECHNICAL EXPLORATION WEST BOTTOM ASH POND BORING LAYOUT

DWG. NO.

SCALE: | CIVIL ENGINEERING DIVISION

DR:
CH:
ARCH:
ENGR:
DATE:
APPROVED BY

AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

SCALE: AS SHOWN
DR: CW
CH: EMK
ENGR: CN
DATE: APR., 2010

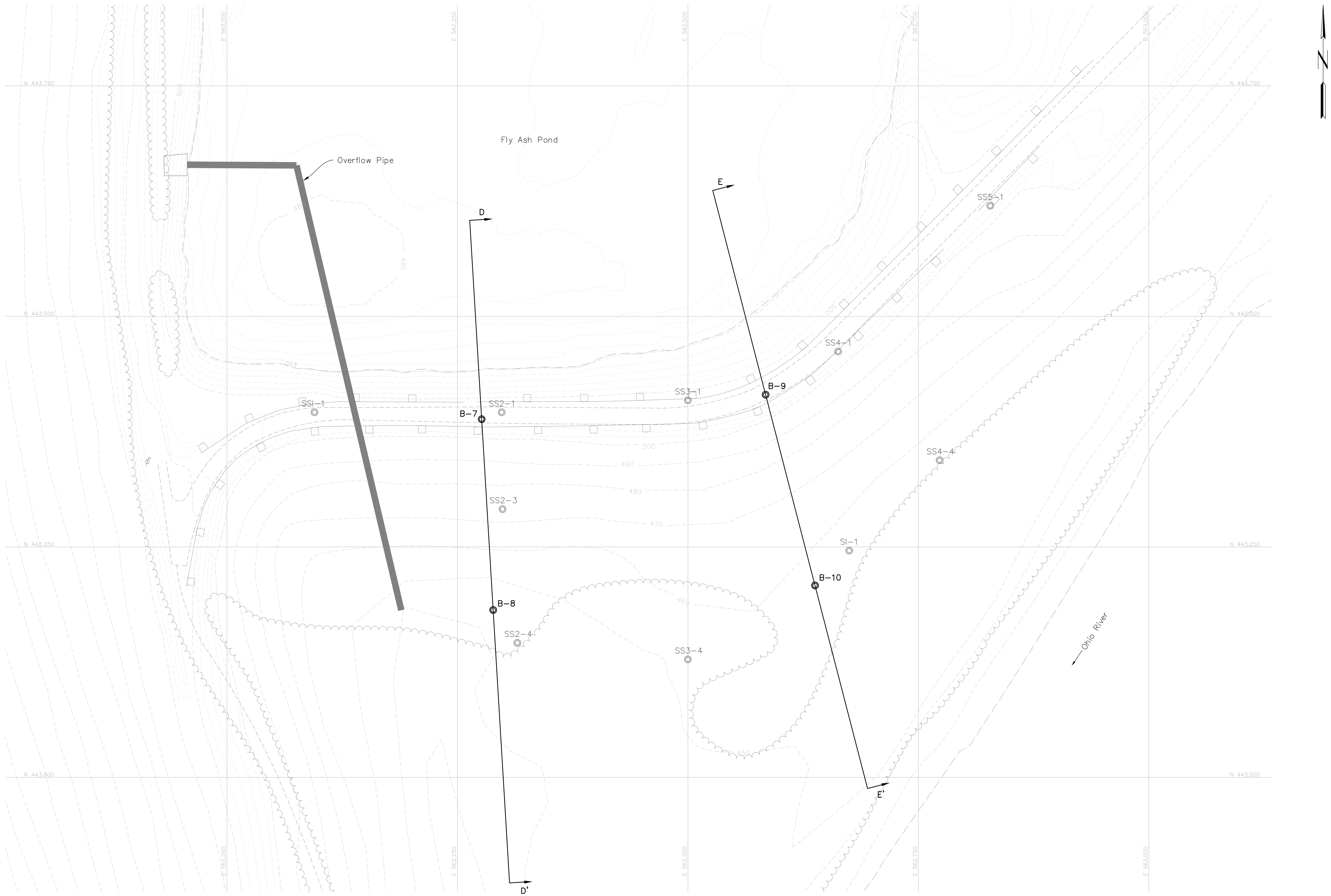
Stantec Consulting Services Inc.
11687 Lebanon Rd.
Cincinnati, Ohio
45241
513-842-8200
www.stantec.com

PLOT DATE: 04/12/2010 USER: WITHERS, CHEYENNE
V:\1755\ACTIVE\175539022\GEOTECHNICAL\DRAWING\39022B-101-BL1.DWG

LANDFILL RUNOFF COLLECTION POND

NOTES

REFERENCE DRAWINGS



BORING LAYOUT
SCALE: 1"=40'

20 0 40 80 FEET
GRAPHIC SCALE

LEGEND

- Soil Boring with Undisturbed (Shelby) Tube Samples and/or Standard Penetration Tests
- Historic Boring

DATE	NO.	DESCRIPTION	APPD.

REVISIONS

INDIANA – KENTUCKY ELECTRIC CO.

CLIFTY CREEK PLANT

MADISON INDIANA

GEOTECHNICAL EXPLORATION LANDFILL RUNOFF COLLECTION POND DAM BORING LAYOUT

DWG. NO.

SCALE: | CIVIL ENGINEERING DIVISION
DR:
CH:
ARCH:
ENGR:
DATE:
APPROVED BY

AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

PLOT DATE: 05/20/2010 USER: WITHERS, CHEYENNE
V:\1755\ACTIVE\175539022\GEOTECHNICAL\DRAWING\39022B-102-BL2.DWG

SCALE:	AS SHOWN
DR:	CW
CH:	EMK
ENGR:	CN
DATE:	MAY, 2010

Stantec Consulting Services Inc.
11687 Lebanon Rd.
Cincinnati, Ohio
45241
513-842-8200
www.stantec.com

APPENDIX B

BORING LOGS

BOILER SLAG POND DAM

SUBSURFACE LOG

Project Number	175539022	Location	West Crest: West Pond Dam
Project Name	AEP Clifty Creek / Ash Ponds	Boring No.	**B-1** Total Depth 71.5 ft
County	Jefferson, IN	Surface Elevation	473.4 ft
Project Type	Geotechnical Exploration	Date Started	11/3/09 Completed 11/4/09
Supervisor	C. Nisingizwe Driller M. Wethington	Depth to Water	40.0 ft Date/Time 11/4/09
Logged By	C. Nisingizwe	Depth to Water	39.2 ft Date/Time 11/13/09

Lithology Elevation	Depth	Description	Overburden / Rock Core	Sample # / RQD	Depth / Run	Rec. Ft. / Rec. Ft.	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
473.4'	0.0'	Top of Hole							
		Lean Clay With Sand, light yellowish brown with light gray, damp to moist, medium stiff to very stiff, Fill		SPT-1	2.5 - 4.0	1.2	6-5-6	17	N = 11
				SPT-2	5.0 - 6.5	1.3	5-5-5	15	N = 10
				ST-3	7.5 - 9.5	2.0		23	
				SPT-4	10.0 - 11.5	0.4	1-5-5	21	N = 10
				SPT-5	12.5 - 14.0	1.3	2-2-5	17	N = 7
				ST-6	15.0 - 17.0	2.0		20	
				SPT-7	17.5 - 19.0	1.5	5-6-9	19	N = 15
				SPT-8	20.0 - 21.5	1.5	3-5-10	15	N = 15
				SPT-9	22.5 - 24.0	1.5	3-7-7	17	N = 14
				SPT-10	25.0 - 26.5	1.2	3-3-5	17	N = 8
				SPT-11	27.5 - 29.0	1.3	3-4-8	20	N = 12
				SPT-12	30.0 - 31.5	1.4	4-4-7	19	N = 11
				SPT-13	32.5 - 34.0	1.3	2-4-5	18	N = 9
				SPT-14	35.0 - 36.5	1.1	2-5-5	17	N = 10
435.9'	37.5'								
				SPT-15	37.5 - 39.0	1.2	1-2-4	20	N = 6

Project Number	175539022	Location	West Crest: West Pond Dam
Project Name	AEP Clifty Creek / Ash Ponds	Boring No.	**B-1** Total Depth 71.5 ft

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	Remarks
		Lean Clay With Sand, light yellowish brown with light gray, moist to wet, very soft to medium stiff *(Continued)*		SPT-16	40.0 - 41.5	1.3	1-2-3	24	N = 5
				ST-17	42.5 - 44.5	2.0		22	
				SPT-18	45.0 - 46.5	1.5	1-1-1	30	N = 2
				SPT-19	47.5 - 49.0	1.5	1-1-2	23	N = 3
				SPT-20	50.0 - 51.5	1.1	1-1-3	28	N = 4
				SPT-21	52.5 - 54.0	1.5	1-1-1	27	N = 2
				SPT-22	55.0 - 56.5	1.5	1-2-2	25	N = 4
				SPT-23	57.5 - 59.0	1.1	1-1-3	28	N = 4
				SPT-24	60.0 - 61.5	1.4	1-2-3	28	N = 5
				SPT-25	62.5 - 64.0	1.3	1-2-4	37	N = 6
				SPT-26	65.0 - 66.5	1.2	2-2-5	34	N = 7
405.9'	67.5'								
		Gray, Weathered Shale, Augered		SPT-27	67.5 - 69.0	0.4	50+	14	50+
401.9'	71.5'			SPT-28	70.0 - 71.5	0.3	50+	5	50+
		No Refusal / Bottom of Hole							

STANTEC/FMSM_LEGACY 175539022 CLIFTY CREEK.GPJ FMSM-GRAPHIC LOG.GDT 5/20/10

Stantec

SUBSURFACE LOG

Project Number	175539022	Location	West Toe: West Pond Dam
Project Name	AEP Clifty Creek / Ash Ponds	Boring No.	**B-2** Total Depth 61.0 ft
County	Jefferson, IN	Surface Elevation	444.0 ft
Project Type	Geotechnical Exploration	Date Started	11/12/09 Completed 11/12/09
Supervisor	C. Nisingizwe Driller M. Wethington	Depth to Water	22.5 ft Date/Time 11/12/09
Logged By	C. Nisingizwe	Depth to Water	N/A Date/Time N/A

Lithology Elevation	Lithology Depth	Description	Overburden / Rock Core	Sample # / RQD	Depth / Run	Rec. Ft. / Rec. Ft.	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
444.0'	0.0'	Top of Hole							
		Lean Clay With Sand, light yellowish brown with gray, moist to wet, soft to very stiff		SPT-1	2.5 - 4.0	1.2	7-8-11	17	N = 19
				SPT-2	5.0 - 6.5	0.6	4-3-4	19	N = 7
				SPT-3	7.5 - 9.0	0.6	3-3-4	24	N = 7
				ST-4	10.0 - 12.0	1.6		22	
				SPT-5	12.5 - 14.0	1.2	2-2-3	25	N = 5
				SPT-6	15.0 - 16.5	1.2	2-2-2	28	N = 4
				SPT-7	17.5 - 19.0	1.5	1-1-1	30	N = 2
				SPT-8	20.0 - 21.5	1.5	1-2-2	32	N = 4
				ST-9	22.5 - 24.5	2.0		29	
				SPT-10	25.0 - 26.5	1.5	2-2-2	29	N = 4
				SPT-11	27.5 - 29.0	0.7	1-4-5	30	N = 9
414.0'	30.0'	Lean Clay With Sand, gray, moist to wet, soft to medium stiff		SPT-12	30.0 - 31.5	1.5	3-3-3	25	N = 6
				SPT-13	32.5 - 34.0	1.5	3-3-3	32	N = 6
				SPT-14	35.0 - 36.5	1.5	1-2-3	33	N = 5
				SPT-15	37.5 - 39.0	1.5	1-2-2	31	N = 4

Project Number	175539022	Location	West Toe: West Pond Dam		
Project Name	AEP Clifty Creek / Ash Ponds	Boring No.	**B-2**	Total Depth	61.0 ft

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	Remarks
		Lean Clay With Sand, gray, moist to wet, soft to medium stiff *(Continued)*		SPT-16	40.0 - 41.5	1.5	3-3-3	30	N = 6
				ST-17	42.5 - 44.5	1.5		33	
				SPT-18	45.0 - 46.5	1.5	1-1-1	35	N = 2
392.5'	51.5'			SPT-19	50.0 - 51.5	1.5	4-3-3	33	N = 6
388.5'	55.5'	Gravel With Silt And Sand, gray, wet, very dense		SPT-20	55.0 - 55.5	0.4	11-50+	10	Began Core N = 50+
383.0'	61.0'	Shale, gray, hard, medium bedded		45	5.5	5.5	100	61.0	

Bottom of Hole

Top of Rock = 56.0'
Elevation (388.0')

STANTEC/FMSM_LEGACY 175539022 CLIFTY CREEK.GPJ FMSM-GRAPHIC LOG.GDT 5/20/10

Stantec

SUBSURFACE LOG

Project Number	175539022	Location	Middle Crest: West Pond Dam
Project Name	AEP Clifty Creek / Ash Ponds	Boring No.	**B-3** Total Depth 71.5 ft
County	Jefferson, IN	Surface Elevation	471.6 ft
Project Type	Geotechnical Exploration	Date Started	11/4/09 Completed 11/5/09
Supervisor	C. Nisingizwe Driller M. Wethington	Depth to Water	40.0 ft Date/Time 11/4/09
Logged By	C. Nisingizwe	Depth to Water	31.0 ft Date/Time 11/13/09

Lithology Elevation	Lithology Depth	Description	Overburden / Rock Core	Sample # / RQD	Depth / Run	Rec. Ft. / Rec. Ft.	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
471.6'	0.0'	Top of Hole							
		Lean Clay With Sand, light yellowish brown with light gray, damp to moist, stiff to very stiff, Fill		SPT-1	2.5 - 4.0	0.7	4-5-6	15	N = 11
				SPT-2	5.0 - 6.5	1.1	3-4-4	17	N = 8
				SPT-3	7.5 - 9.0	1.1	3-3-7	16	N = 10
				ST-4	10.0 - 12.0	2.0		16	
				SPT-5	12.5 - 14.0	1.5	4-4-5	22	N = 9
				SPT-6	15.0 - 16.5	1.0	3-4-6	17	N = 10
				SPT-7	17.5 - 19.0	1.3	3-5-7	18	N = 12
				ST-8	20.0 - 22.0	2.0		18	
				SPT-9	22.5 - 24.0	1.5	3-5-7	17	N = 12
				SPT-10	25.0 - 26.5	1.3	3-4-5	18	N = 9
				SPT-11	27.5 - 29.0	1.5	6-7-8	16	N = 15
				SPT-12	30.0 - 31.5	1.5	5-5-5	18	N = 10
				SPT-13	32.5 - 34.0	1.5	4-7-10	17	N = 17
				SPT-14	35.0 - 36.5	1.5	5-7-9	22	N = 16
434.1'	37.5'								
				SPT-15	37.5 - 39.0	1.5	5-7-11	20	N = 18

STANTEC/FMSM_LEGACY 175539022 CLIFTY CREEK.GPJ FMSM-GRAPHIC LOG.GDT 5/20/10

Project Number	175539022	Location	Middle Crest: West Pond Dam		
Project Name	AEP Clifty Creek / Ash Ponds	Boring No.	**B-3**	Total Depth	71.5 ft

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	Remarks
		Lean Clay With Sand, gray to light brown, moist to wet, very stiff to very stiff *(Continued)*		SPT-16	40.0 - 41.5	1.5	1-2-2	24	N = 4
				SPT-17	42.5 - 44.0	1.5	1-2-2	23	N = 4
				SPT-18	45.0 - 46.5	1.3	2-3-3	25	N = 6
				ST-19	47.5 - 49.5	2.0		23	
				SPT-20	50.0 - 51.5	1.5	1-2-2	25	N = 4
				SPT-21	52.5 - 54.0	1.5	1-1-1	25	N = 2
				SPT-22	55.0 - 56.5	1.5	1-2-3	24	N = 5
				SPT-23	57.5 - 59.0	1.5	1-1-1	40	N = 2
				SPT-24	60.0 - 61.5	1.5	3-4-4	28	N = 8
				SPT-25	62.5 - 64.0	1.5	1-2-4	33	N = 6
				SPT-26	65.0 - 66.5	1.5	1-3-4	34	N = 7
				SPT-27	67.5 - 69.0	1.5	2-4-5	29	N = 9
400.1'	71.5'			SPT-28	70.0 - 71.5	1.5	3-3-5	31	N = 8
		No Refusal / Bottom of Hole							

SUBSURFACE LOG

Project Number	175539022	Location	Middle Toe: West Pond Dam
Project Name	AEP Clifty Creek / Ash Ponds	Boring No.	**B-4** Total Depth 71.5 ft
County	Jefferson, IN	Surface Elevation	444.0 ft
Project Type	Geotechnical Exploration	Date Started	11/10/09 Completed 11/11/09
Supervisor	C. Nisingizwe Driller M. Wethington	Depth to Water	22.5 ft Date/Time 11/10/09
Logged By	C. Nisingizwe	Depth to Water	16.0 ft Date/Time 11/13/09

Lithology Elevation	Depth	Description	Overburden / Rock Core	Sample # / RQD	Depth / Run	Rec. Ft. / Rec. Ft.	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
444.0'	0.0'	Top of Hole							
		Lean Clay With Sand, brown to dark gray, damp to moist, medium stiff to very stiff		SPT-1	2.5 - 4.0	1.3	8-8-8	14	N = 16
				SPT-2	5.0 - 6.5	1.4	6-7-8	16	N = 15
				ST-3	7.5 - 9.5	2.0		--	
				SPT-4	10.0 - 11.5	1.3	3-5-6	19	N = 11
				SPT-5	12.5 - 14.0	1.0	2-3-4	22	N = 7
429.0'	15.0'								
		Lean Clay With Sand, gray, moist to wet, soft to stiff		SPT-6	15.0 - 16.5	1.2	2-2-3	26	N = 5
				ST-7	17.5 - 19.5	2.0		--	
				SPT-8	20.0 - 21.5	1.5	2-2-2	26	N = 4
				SPT-9	22.5 - 24.0	1.5	1-2-3	27	N = 5
				SPT-10	25.0 - 26.5	1.5	2-2-4	26	N = 6
				SPT-11	27.5 - 29.0	1.5	1-2-3	27	N = 5
				SPT-12	30.0 - 31.5	1.5	1-1-2	28	N = 3
				SPT-13	32.5 - 34.0	1.5	1-2-2	35	N = 4
				SPT-14	35.0 - 36.5	1.5	2-4-5	31	N = 9
				ST-15	37.5 - 39.5	2.0		--	

SUBSURFACE LOG

Project Number	175539022	Location	Middle Toe: West Pond Dam
Project Name	AEP Clifty Creek / Ash Ponds	Boring No.	**B-4**
		Total Depth	71.5 ft

Lithology Elevation	Lithology Depth	Description	Overburden / Rock Core	Sample # / RQD	Depth / Run	Rec. Ft. / Rec. Ft.	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
		Lean Clay With Sand, gray, moist to wet, soft to stiff *(Continued)*		SPT-16	40.0 - 41.5	1.5	2-2-2	24	N = 4
				SPT-17	42.5 - 44.0	1.2	1-2-3	33	N = 5
				SPT-18	45.0 - 46.5	1.5	2-4-4	35	N = 8
				SPT-19	47.5 - 49.0	1.2	1-2-4	31	N = 6
				SPT-20	50.0 - 51.5	1.5	2-3-4	31	N = 7
				SPT-21	52.5 - 54.0	1.5	1-2-3	30	N = 5
386.5'	57.5'			SPT-22	55.0 - 56.5	1.5	2-3-4	21	N = 7
		Gravel With Silt And Sand, gray, moist, dense to very dense		SPT-23	57.5 - 59.0	1.5	10-17-22	13	N = 39
				SPT-24	60.0 - 61.5	1.5	16-28-18	9	N = 46
				SPT-25	65.0 - 66.5	0.7	26-50+	12	N = 50+
372.5'	71.5'			SPT-26	70.0 - 71.5	0.7	20-22-30	9	N = 52
		No Refusal / Bottom of Hole							

STANTEC/FMSM_LEGACY 175539022 CLIFTY CREEK.GPJ FMSM-GRAPHIC LOG.GDT 5/20/10

SUBSURFACE LOG

Project Number	175539022	Location	East Crest: West Pond Dam
Project Name	AEP Clifty Creek / Ash Ponds	Boring No.	**B-5** Total Depth 71.5 ft
County	Jefferson, IN	Surface Elevation	468.7 ft
Project Type	Geotechnical Exploration	Date Started	11/10/09 Completed 11/10/09
Supervisor	C. Nisingizwe Driller M. Wethington	Depth to Water	45.0 ft Date/Time 11/10/09
Logged By	C. Nisingizwe	Depth to Water	33.8 ft Date/Time 11/13/09

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	Remarks
468.7'	0.0'	Top of Hole							
		Lean Clay With Sand, light yellowish brown with light gray, damp to moist, medium stiff to very stiff, Fill		SPT-1	2.5 - 4.0	1.5	6-9-10	15	N = 19
				SPT-2	5.0 - 6.5	1.5	4-4-5	17	N = 9
				ST-3	7.5 - 9.5	1.6		17	
				SPT-4	10.0 - 11.5	1.3	6-7-8	23	N = 15
				SPT-5	12.5 - 14.0	0.0	3-4-6	--	N = 10
				SPT-6	15.0 - 16.5	1.3	1-3-4	16	N = 7
				SPT-7	17.5 - 19.0	1.0	5-7-9	16	N = 16
				SPT-8	20.0 - 21.5	0.6	1-2-5	18	N = 7
				ST-9	22.5 - 24.5	1.8		19	
				SPT-10	25.0 - 26.5	1.2	2-3-5	22	N = 8
				SPT-11	27.5 - 29.0	1.4	1-2-5	25	N = 7
				SPT-12	30.0 - 31.5	1.3	4-5-7	23	N = 12
				SPT-13	32.5 - 34.0	1.5	2-3-5	19	N = 8
432.2'	36.5'			SPT-14	35.0 - 36.5	1.5	4-6-10	18	N = 16
		Lean Clay With Sand, gray, moist, soft		SPT-15	37.5 - 39.0	1.5	2-3-3	21	N = 6

STANTEC/FMSM_LEGACY 175539022 CLIFTY CREEK.GPJ FMSM-GRAPHIC LOG.GDT 5/20/10

Project Number	175539022	Location	East Crest: West Pond Dam
Project Name	AEP Clifty Creek / Ash Ponds	Boring No.	**B-5** Total Depth 71.5 ft

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	Remarks
		Lean Clay With Sand, gray, moist, soft *(Continued)*		SPT-16	40.0 - 41.5	1.3	1-1-2	25	N = 3
				ST-17	42.5 - 44.5	2.0		23	
				SPT-18	45.0 - 46.5	1.5	1-1-3	25	N = 4
421.2'	47.5'								
		Sandy Silt, light yellowish brown to gray, wet, soft to stiff		SPT-19	47.5 - 49.0	1.5	1-1-3	28	N = 4
				SPT-20	50.0 - 51.5	1.5	1-1-5	24	N = 6
				SPT-21	52.5 - 54.0	1.0	1-1-1	22	N = 2
				SPT-22	55.0 - 56.5	1.3	1-2-2	23	N = 4
				SPT-23	57.5 - 59.0	1.5	1-2-3	26	N = 5
				SPT-24	60.0 - 61.5	1.5	2-3-4	22	N = 7
				SPT-25	62.5 - 64.0	1.5	2-3-6	27	N = 9
				SPT-26	65.0 - 66.5	1.5	2-5-6	28	N = 11
				SPT-27	67.5 - 69.0	1.5	2-4-5	28	N = 9
397.2'	71.5'			SPT-28	70.0 - 71.5	1.5	3-5-8	30	N = 13
		No Refusal / Bottom of Hole							

STANTEC/FMSM_LEGACY 175539022 CLIFTY CREEK.GPJ FMSM-GRAPHIC LOG.GDT 5/20/10

SUBSURFACE LOG

Project Number	175539022	Location	East Toe: West Pond Dam
Project Name	AEP Clifty Creek / Ash Ponds	Boring No.	**B-6** Total Depth 71.5 ft
County	Jefferson, IN	Surface Elevation	445.5 ft
Project Type	Geotechnical Exploration	Date Started	11/19/09 Completed 11/19/09
Supervisor	C. Nisingizwe Driller Danny Jessie	Depth to Water	30.0 ft Date/Time 11/19/09
Logged By	C. Nisingizwe	Depth to Water	N/A Date/Time N/A

Lithology Elevation	Depth	Description	Overburden / Rock Core Sample # / RQD	Depth / Run	Rec. Ft. / Rec. Ft.	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
445.5'	0.0'	Top of Hole						
		Lean Clay With Sand, brown to gray, damp to moist, stiff to very stiff						
			SPT-1	2.5 - 4.0	1.0	2-4-4	19	N = 8
			SPT-2	5.0 - 6.5	1.0	4-4-6	18	N = 10
			ST-3	7.5 - 9.5	2.0		25	
			SPT-4	10.0 - 11.5	1.2	5-7-11	16	N = 18
			SPT-5	12.5 - 14.0	1.1	2-2-2	21	N = 4
			SPT-6	15.0 - 16.5	1.3	1-1-2	31	N = 3
			ST-7	17.5 - 19.5	1.2		32	
			SPT-8	20.0 - 21.5	1.5	0-1-0	32	N = 1
			SPT-9	22.5 - 24.0	1.5	0-0-2	29	N = 2
			SPT-10	25.0 - 26.5	1.5	2-1-3	29	N = 4
418.0'	27.5'							
		Sandy Silt, gray, moist to wet, very soft to stiff	SPT-11	27.5 - 29.0	1.5	0-3-2	32	N = 5
			SPT-12	30.0 - 31.5	1.5	0-0-3	32	N = 3
			SPT-13	32.5 - 34.0	1.5	0-1-2	33	N = 3
			SPT-14	35.0 - 36.5	1.5	0-0-1	35	N = 1
			SPT-15	37.5 - 39.0	1.5	0-0-1	30	N = 1

STANTEC/FMSM_LEGACY 175539022 CLIFTY CREEK.GPJ FMSM-GRAPHIC LOG.GDT 5/20/10

Project Number	175539022	Location	East Toe: West Pond Dam		
Project Name	AEP Clifty Creek / Ash Ponds	Boring No.	**B-6**	Total Depth	71.5 ft

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	Remarks
		Sandy Silt, gray, moist to wet, very soft to stiff *(Continued)*		ST-16	40.0 - 42.0	1.1		31	
				SPT-17	42.5 - 44.0	1.5	0-1-1	35	N = 2
				SPT-18	45.0 - 46.5	1.5	0-0-1	40	N = 1
				SPT-19	47.5 - 49.0	1.5	0-0-1	40	N = 1
				SPT-20	50.0 - 51.5	1.5	0-2-3	39	N = 5
				SPT-21	52.5 - 54.0	1.5	0-5-6	27	N = 11
				SPT-22	55.0 - 56.5	1.5	4-3-4	31	N = 7
				SPT-23	57.5 - 59.0	1.5	4-4-5	35	N = 9
				SPT-24	60.0 - 61.5	1.5	5-5-6	28	N = 11
				SPT-25	65.0 - 66.5	1.5	4-5-4	28	N = 9
374.0'	71.5'			SPT-26	70.0 - 71.5	0.0	5-5-5	--	N = 10
		No Refusal / Bottom of Hole							

STANTEC/FMSM_LEGACY 175539022 CLIFTY CREEK.GPJ FMSM-GRAPHIC LOG.GDT 5/20/10

LANDFILL RUNOFF COLLECTION POND:
2009 GEOTECHNICAL EXPLORATION

Project Number	175539022	Location	Crest: LRCP Dam
Project Name	AEP Clifty Creek / Ash Ponds	Boring No.	B-7
		Total Depth	29.0 ft
County	Jefferson, IN	Surface Elevation	503.4 ft
Project Type	Geotechnical Exploration	Date Started	11/12/09
		Completed	11/12/09
Supervisor	C. Nisingizwe	Driller	M. Wethington
Depth to Water	Dry	Date/Time	11/12/09
Logged By	C. Nisingizwe		
Depth to Water	N/A	Date/Time	N/A

Lithology		Description	Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks
Elevation	Depth		Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	
503.4'	0.0'	Top of Hole							
502.9'	0.5'	Asphalt pavement and gravel base							
		Lean Clay, yellow and light gray, moist, stiff							
				ST-1	23.0 - 25.0	2.0		--	
				ST-2	25.0 - 27.0	2.0		20	
474.4'	29.0'			ST-3	27.0 - 29.0	2.0		20	
		No Refusal / Bottom of Hole							

STANTEC/FMSM_LEGACY 175539022 CLIFTY CREEK.GPJ FMSM-GRAPHIC LOG.GDT 4/16/10

Stantec

SUBSURFACE LOG

Project Number	175539022	Location	Toe: LRCP Dam
Project Name	AEP Clifty Creek / Ash Ponds	Boring No.	**B-8** Total Depth 31.0 ft
County	Jefferson, IN	Surface Elevation	441.5 ft
Project Type	Geotechnical Exploration	Date Started	11/19/09 Completed 11/19/09
Supervisor	C. Nisingizwe Driller Danny Jessie	Depth to Water	Dry Date/Time 11/19/09
Logged By	C. Nisingizwe	Depth to Water	N/A Date/Time N/A

Lithology Elevation	Lithology Depth	Description	Overburden / Rock Core	Sample # / RQD	Depth / Run	Rec. Ft. / Rec. Ft.	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
441.5'	0.0'	Top of Hole							
		Silty Clay, yellow and light gray, damp to moist							
425.5'	16.0'								
		Lean Clay, yellowish brown and light gray, moist							
				ST-1	25.0 - 27.0	2.0		25	
				ST-2	27.0 - 29.0	2.0		26	
412.5'	29.0'								
		Lean Clay With Sand, yellowish brown and light gray, moist		ST-3	29.0 - 31.0	2.0		23	
410.5'	31.0'								
		No Refusal / Bottom of Hole							

STANTEC/FMSM_LEGACY 175539022 CLIFTY CREEK.GPJ FMSM-GRAPHIC LOG.GDT 4/16/10

Stantec

SUBSURFACE LOG

Project Number	175539022	Location	Crest: LRCP Dam
Project Name	AEP Clifty Creek / Ash Ponds	Boring No.	**B-9** Total Depth 22.0 ft
County	Jefferson, IN	Surface Elevation	504.3 ft
Project Type	Geotechnical Exploration	Date Started	11/12/09 Completed 11/12/09
Supervisor	C. Nisingizwe Driller M. Wethington	Depth to Water	Dry Date/Time 11/12/09
Logged By	C. Nisingizwe	Depth to Water	N/A Date/Time N/A

Lithology Elevation	Lithology Depth	Description	Overburden / Rock Core	Sample # / RQD	Depth / Run	Rec. Ft. / Rec. Ft.	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
504.3'	0.0'	Top of Hole							
503.8'	0.5'	Asphalt pavement and gravel base							
		Lean Clay, yellowish brown and light gray, damp to moist							
				ST-1	16.0 - 18.0	2.0		22	
				ST-2	18.0 - 20.0	2.0		19	
482.3'	22.0'			ST-3	20.0 - 22.0	2.0		20	
		No Refusal / Bottom of Hole							

STANTEC/FMSM_LEGACY 175539022 CLIFTY CREEK.GPJ FMSM-GRAPHIC LOG.GDT 4/16/10

SUBSURFACE LOG

Project Number	175539022	Location	Toe: LRCP Dam		
Project Name	AEP Clifty Creek / Ash Ponds	Boring No.	**B-10**	Total Depth	18.0 ft
County	Jefferson, IN	Surface Elevation	457.3 ft		
Project Type	Geotechnical Exploration	Date Started	11/19/09	Completed	11/19/07
Supervisor	C. Nisingizwe Driller Danny Jessie	Depth to Water	Dry	Date/Time	11/19/07
Logged By	C. Nisingizwe	Depth to Water	N/A	Date/Time	N/A

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	Remarks
457.3'	0.0'	Top of Hole							
		Silty Clay With Sand, yellow and light gray, damp to moist							
444.1'	13.2'			ST-1	12.0 - 14.0	1.5		17	
		Silty Sand, gray to brown, damp to moist		ST-2	14.0 - 16.0	2.0		10	
441.3'	16.0'								
		Silty Clay With Sand, yellow and light gray, damp to moist		ST-3	16.0 - 18.0	2.0		25	
439.3'	18.0'								
		No Refusal / Bottom of Hole							

STANTEC/FMSM_LEGACY 175539022 CLIFTY CREEK.GPJ FMSM-GRAPHIC LOG.GDT 4/16/10

LANDFILL RUNOFF COLLECTION POND:
2015 GEOTECHNICAL EXPLORATION

Project Number	175553022	Location	Landfill Runoff Collection Pond Dam
Project Name	CCR Rule - AEP Clifty Creek	Boring No.	**B-12** Total Depth 101.5 ft
County	Jefferson, IN	Surface Elevation	503.9 (estimated)
Project Type	Geotechnical Exploration	Date Started	7/6/15 Completed 7/7/15
Supervisor	C. Nisingizwe Driller E. Caudill	Depth to Water	60.0 ft Date/Time 7/7/15
Logged By	C. Nisingizwe	Depth to Water	N/A Date/Time N/A

Lithology Elevation	Lithology Depth	Description	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	Remarks
			Overburden Rock Core / RQD	Run	Rec. Ft.	Rec. %	Run Depth	
503.9	0.0	Top of Hole						
(estimated)	0.4	Asphalt and base						
		Lean Clay With Sand, gray, damp, medium stiff to stiff	SPT-1	1.0 - 2.5	1.5	1-2-5	21	Pocket Penetrometer (PP) = 2.50 tsf
			SPT-2	5.0 - 6.5	1.5	3-3-4	20	PP = 2.50 tsf
			SPT-3	10.0 - 11.5	1.2	3-4-5	23	PP = 3.50 tsf
			SPT-4	15.0 - 16.5	1.0	3-3-5	19	PP = 2.50 tsf
			SPT-5	20.0 - 21.5	0.9	4-6-9	18	PP = 2.50 tsf
			SPT-6	25.0 - 26.5	1.1	3-5-7	18	PP = 4.25 tsf
			SPT-7	30.0 - 31.5	1.3	2-5-8	19	PP = 4.50 tsf
			SPT-8	35.0 - 36.5	0.9	WOH-3-4	18	PP = 4.00 tsf

Project Number	175553022	Location	Landfill Runoff Collection Pond Dam		
Project Name	CCR Rule - AEP Clifty Creek	Boring No.	**B-12**	Total Depth	101.5 ft

Lithology			Overburden	Sample #	Depth	Rec. Ft.	Blows	Mois.Cont. %	
Elevation	Depth	Description	Rock Core	RQD	Run	Rec. Ft.	Rec. %	Run Depth	Remarks
	40.0	Lean Clay With Sand, gray, damp, medium stiff to stiff *(Continued)*							
		Silty Clay With Sand, brown, moist, medium stiff to very stiff		SPT-9	40.0 - 41.5	1.5	6-8-8	16	
	50.0			SPT-10	45.0 - 46.5	1.5	1-3-5	19	
		Silt With Sand, grayish light brown, moist, medium stiff to stiff		SPT-11	50.0 - 51.5	1.5	2-3-3	22	
	58.0			SPT-12	55.0 - 56.5	1.0	2-5-8	20	
	63.5	Silty Sand, grayish light brown, damp, very stiff		SPT-13	60.0 - 61.5	1.4	3-11-17	15	
	70.0	Silt With Sand, grayish light brown, wet, stiff		SPT-14	65.0 - 66.5	1.5	2-3-8	28	
		Sand, mottled gray and brown, moist to wet, medium stiff to stiff		SPT-15	70.0 - 71.5	1.5	3-5-5	22	
	78.0			SPT-16	75.0 - 76.5	1.3	2-3-5	28	

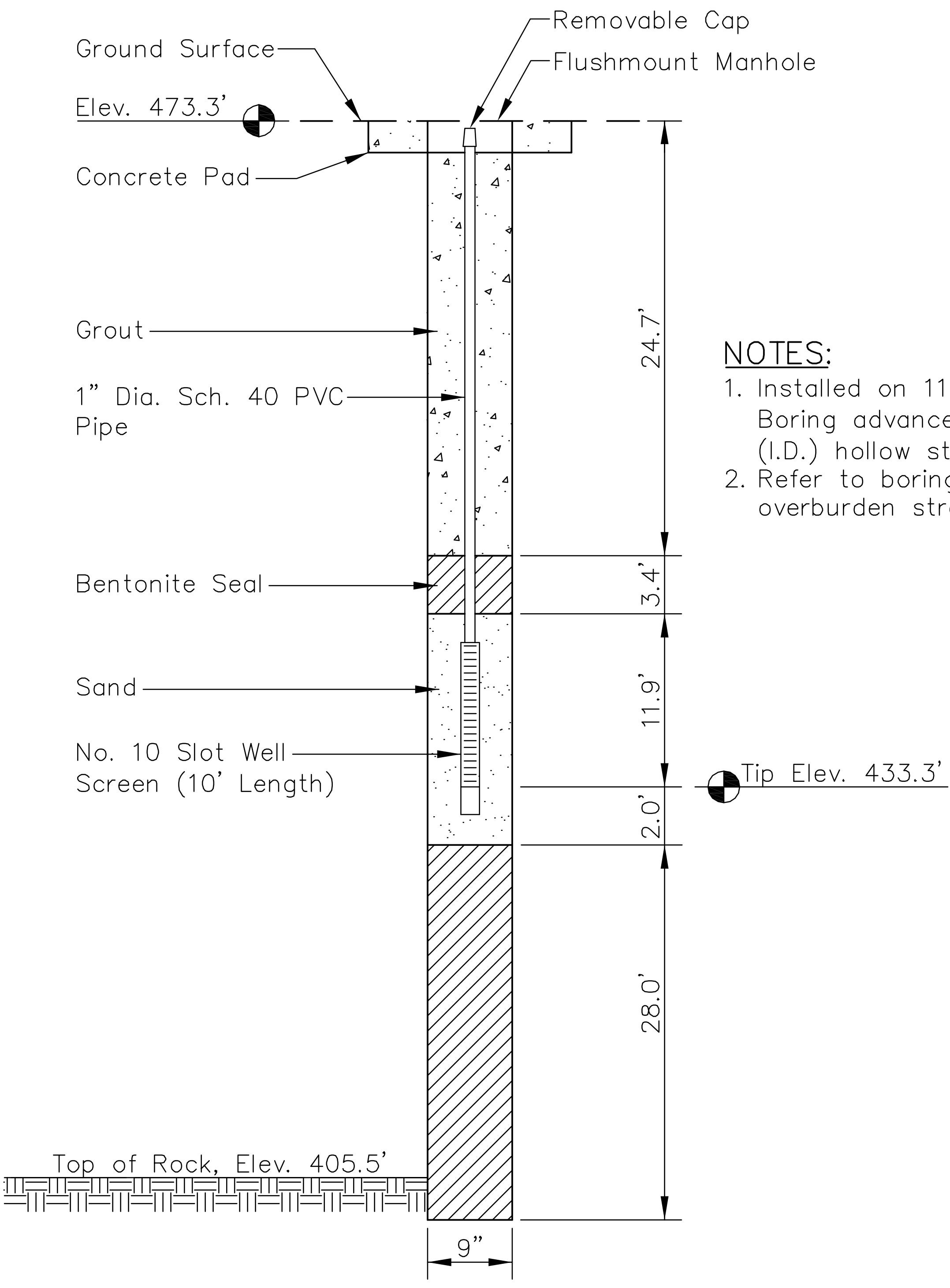
Project Number	175553022	Location	Landfill Runoff Collection Pond Dam
Project Name	CCR Rule - AEP Clifty Creek	Boring No.	**B-12** — Total Depth 101.5 ft

Lithology Elevation	Lithology Depth	Description	Overburden / Rock Core	Sample # / RQD	Depth / Run	Rec. Ft. / Rec. Ft.	Blows / Rec. %	Mois.Cont. % / Run Depth	Remarks
	90.0	Silt, gray, moist to wet, medium stiff to stiff		SPT-17	80.0 - 81.5	1.5	6-9-6	26	
				SPT-18	85.0 - 86.5	1.5	2-3-5	28	
	101.5	Lean Clay, gray, moist, medium stiff to very stiff		SPT-19	90.0 - 91.5	1.5	2-4-4	25	PP = 2.25 tsf
				SPT-20	95.0 - 96.5	1.5	5-8-11	23	PP = 3.75 tsf
				SPT-21	100.0 - 101.5	1.5	4-6-8	27	PP = 3.50 tsf
		No Refusal / Bottom of Hole							

APPENDIX C

PIEZOMETER DETAILS

BOILER SLAG POND DAM



NOTES:

1. Installed on 11/04/2009. Boring advanced with 4.25" (I.D.) hollow stem augers.
2. Refer to boring log for overburden stratigraphy.

PLOT DATE: 02/18/2010 USER: JENNINGS, MATTHEW
V:\1755\ACTIVE\175539022\GEOTECHNICAL\DRAWING\INSTRUMENTS\PZB1.DWG

LOCATION:

Northing: 448,055.94
Easting: 566,098.09
Ground Elevation: 473.3'

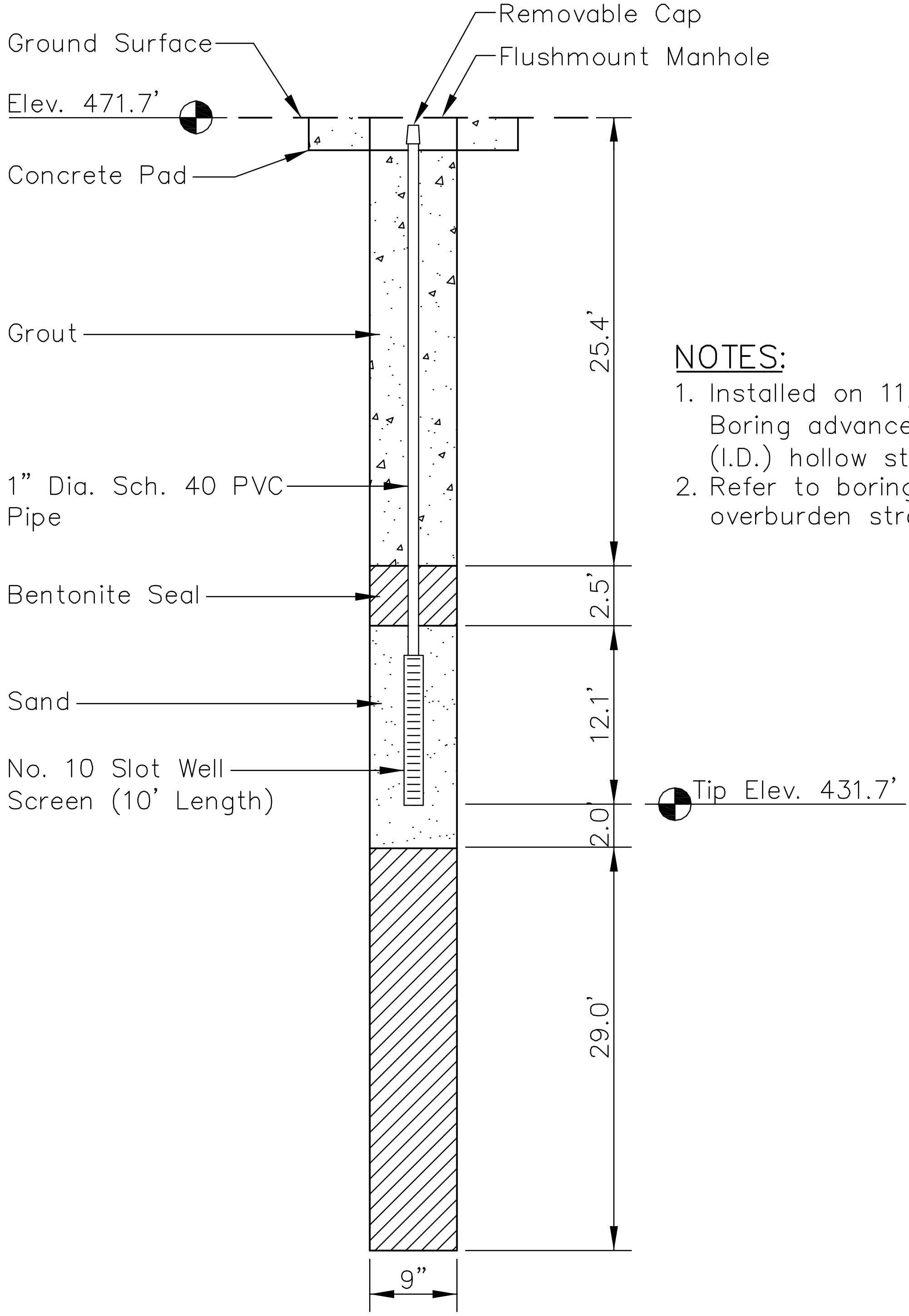
Horizontal Datum: NAD 27
Vertical Datum: NGVD88

PIEZOMETER B-1
WEST BOTTOM ASH DAM
CLIFTY CREEK PLANT

Stantec

Stantec Consulting Services Inc.
11687 Lebanon Rd.
Cincinnati, Ohio
45241-2012
513-842-8200
www.stantec.com

DRAWN BY	MJ	DATE	FEB., 2010	REVISED		SHEET
CHECKED BY	CN	PROJ. NO.	175539022	1.	3.	1 OF 1
CHECKED BY	EMK	SCALE	NTS	2.	4.	



NOTES:
1. Installed on 11/05/2009. Boring advanced with 4.25" (I.D.) hollow stem augers.
2. Refer to boring log for overburden stratigraphy.

PLOT DATE: 02/18/2010 USER: JENNINGS, MATTHEW
V:\1755\ACTIVE\175539022\GEOTECHNICAL\DRAWING\INSTRUMENTS\PZB3.DWG

LOCATION:
Northing: 448,278.25
Easting: 566,522.86
Ground Elevation: 471.7'

Horizontal Datum: NAD 27
Vertical Datum: NGVD88

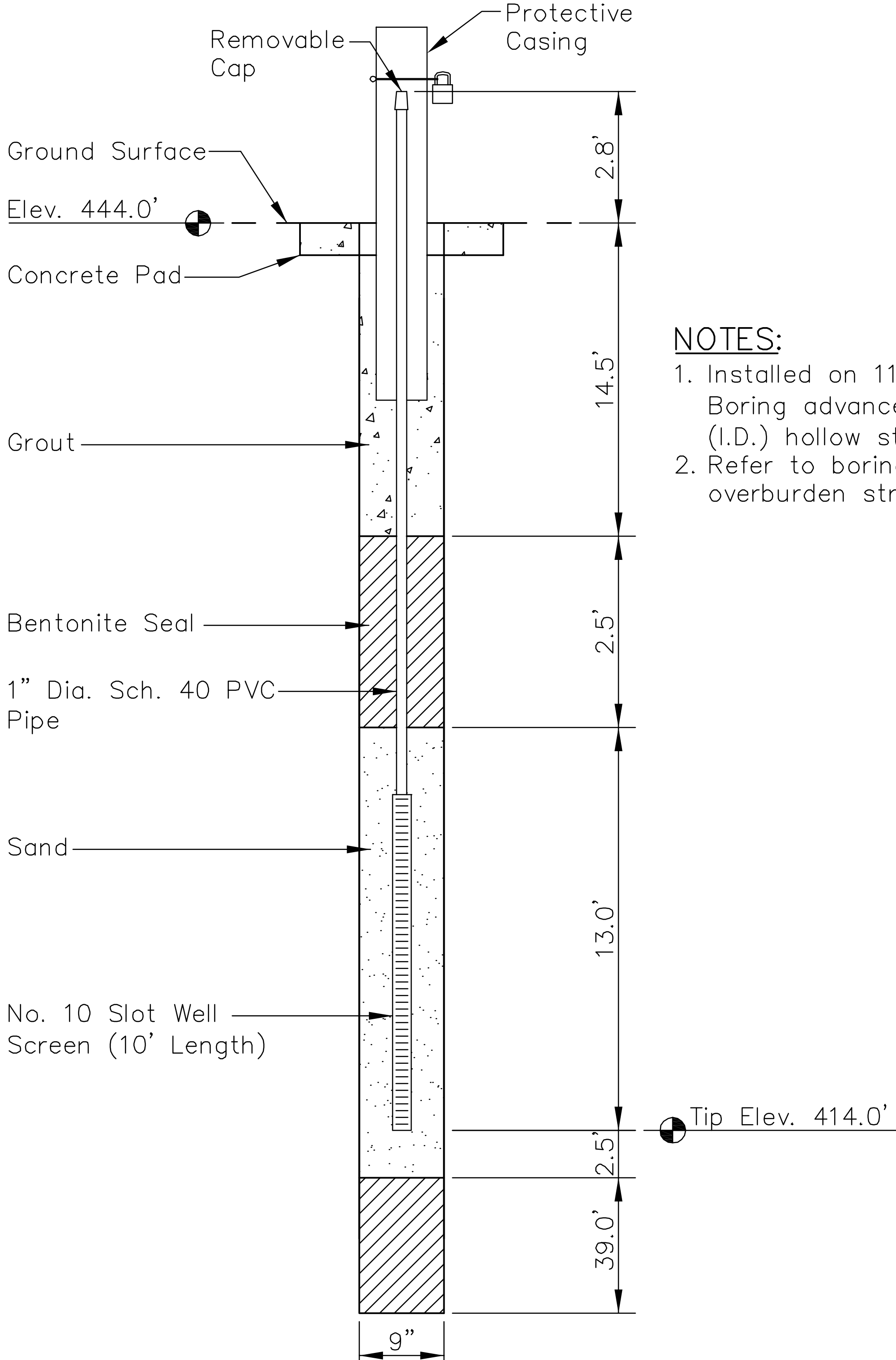
PIEZOMETER B-3
WEST BOTTOM ASH DAM
CLIFTY CREEK PLANT

Stantec

Stantec Consulting Services Inc.
11687 Lebanon Rd.
Cincinnati, Ohio
45241-2012
513-842-8200

www.stantec.com

DRAWN BY	MJ	DATE	FEB., 2010	REVISED			SHEET
CHECKED BY	CN	PROJ. NO.	175539022	1.	3.		1 OF 1
CHECKED BY	EMK	SCALE	NTS	2.	4.		



NOTES:
1. Installed on 11/11/2009. Boring advanced with 4.25" (I.D.) hollow stem augers.
2. Refer to boring log for overburden stratigraphy.

PLOT DATE: 02/18/2010 USER: JENNINGS, MATTHEW
V:\1755\ACTIVE\175539022\GEOTECHNICAL\DRAWING\INSTRUMENTS\PZB4.DWG

LOCATION:
Northing: 448,202.42
Easting: 566,559.67
Ground Elevation: 444.0'

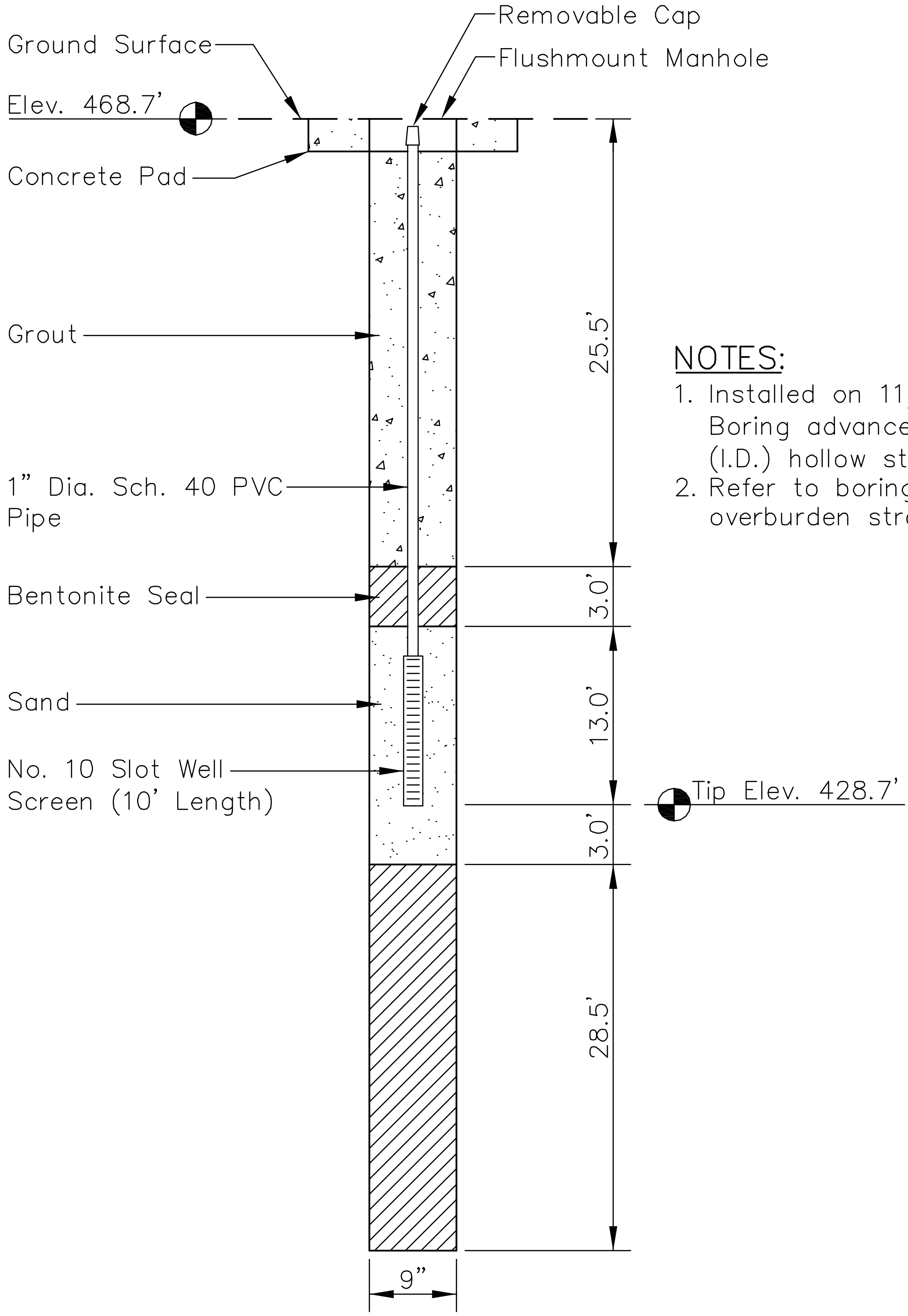
Horizontal Datum: NAD 27
Vertical Datum: NGVD88

PIEZOMETER B-4
WEST BOTTOM ASH DAM
CLIFTY CREEK PLANT

Stantec

Stantec Consulting Services Inc.
11687 Lebanon Rd.
Cincinnati, Ohio
45241-2012
513-842-8200
www.stantec.com

				REVISED		SHEET
DRAWN BY	CW	DATE	FEB., 2010			
CHECKED BY	CN	PROJ. NO.	175539022	1.	3.	1 OF 1
CHECKED BY	EMK	SCALE	NTS	2.	4.	



NOTES:
1. Installed on 11/10/2009. Boring advanced with 4.25" (I.D.) hollow stem augers.
2. Refer to boring log for overburden stratigraphy.

PLOT DATE: 02/18/2010 USER: JENNINGS, MATTHEW
V:\1755\ACTIVE\175539022\GEOTECHNICAL\DRAWING\INSTRUMENTS\PZB5.DWG

LOCATION:
Northing: 448,958.53
Easting: 567,968.94
Ground Elevation: 468.7'

Horizontal Datum: NAD 27
Vertical Datum: NGVD88

PIEZOMETER B-5
WEST BOTTOM ASH DAM
CLIFTY CREEK PLANT

Stantec

Stantec Consulting Services Inc.
11687 Lebanon Rd.
Cincinnati, Ohio
45241-2012
513-842-8200
www.stantec.com

DRAWN BY	MJ	DATE	FEB., 2010	REVISED		SHEET
CHECKED BY	CN	PROJ. NO.	175539022	1.	3.	1 OF 1
CHECKED BY	EMK	SCALE	NTS	2.	4.	

APPENDIX D

SOIL CLASSIFICATION SUMMARIES

BOILER SLAG POND DAM

Stantec

Summary of Soil Tests

Project Name: AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds
Project Number: 175539022
Source: B-1, 10.0'-11.5', 12.5'-14.0'
Lab ID: 4

County: Jefferson, IN
Date Received: 11-16-09
Sample Type: SPT Comp
Date Reported: 11-30-09

Test Results

Natural Moisture Content

Test Method: ASTM D 2216

Moisture Content (%): 19.1

Particle Size Analysis

Preparation Method: ASTM D 421

Gradation Method: ASTM D 422

Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
3"	75	
2"	50	
1 1/2"	37.5	
1"	25	
3/4"	19	
3/8"	9.5	
No. 4	4.75	100.0
No. 10	2	99.8
No. 40	0.425	98.4
No. 200	0.075	84.0
	0.02	49.1
	0.005	31.1
	0.002	23.7
estimated	0.001	22.1

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	0.2
Coarse Sand	0.2	1.4
Medium Sand	1.4	---
Fine Sand	14.4	14.4
Silt	52.9	60.3
Clay	31.1	23.7

Atterberg Limits

Test Method: ASTM D 4318 Method A

Prepared: Dry

Liquid Limit: 32

Plastic Limit: 19

Plasticity Index: 13

Activity Index: 0.54

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3): N/A

Maximum Dry Density (kg/m^3): N/A

Optimum Moisture Content (%): N/A

Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A

Compacted Dry Density (lb/ft^3): N/A

Compacted Moisture Content (%): N/A

Specific Gravity

Test Method: ASTM D 854

Prepared: Dry

Particle Size: No. 10

Specific Gravity at 20° Celsius: 2.70

Classification

Unified Group Symbol: CL

Group Name: Lean clay with sand

AASHTO Classification: A-6 (10)

Comments:

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name: AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface exp — Project Number: 175539022
Source: B-1, 10.0'-11.5', 12.5'-14.0' — Lab ID: 4

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: KR
Test Date: 11-20-2009
Date Received: 11-16-2009

Maximum Particle size: No. 4 Sieve

Sieve Size	% Passing
3"	
2"	
1 1/2"	
1"	
3/4"	
3/8"	
No. 4	100.0
No. 10	99.8

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on: Total Sample

Specific Gravity: 2.7

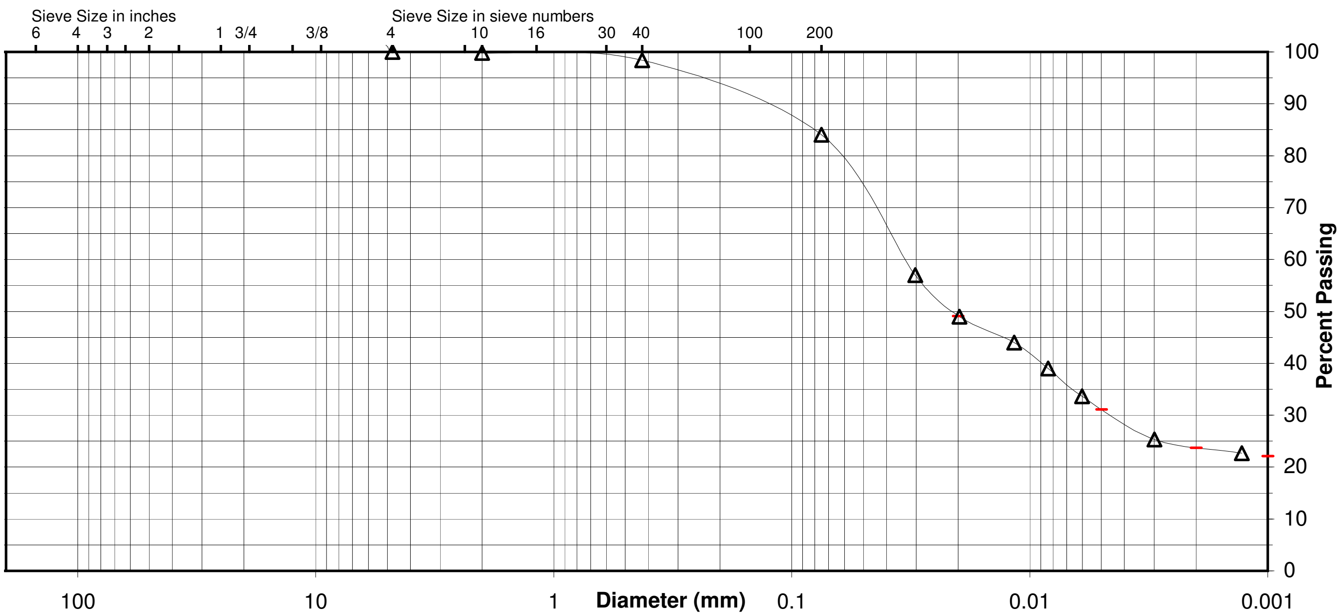
Dispersed using: Apparatus A - Mechanical, for 1 minute

No. 40	98.4
No. 200	84.0
0.02 mm	49.1
0.005 mm	31.1
0.002 mm	23.7
0.001 mm	22.1

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	0.2	1.4	14.4	52.9	31.1

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	0.2	1.4	14.4	60.3	23.7



Comments

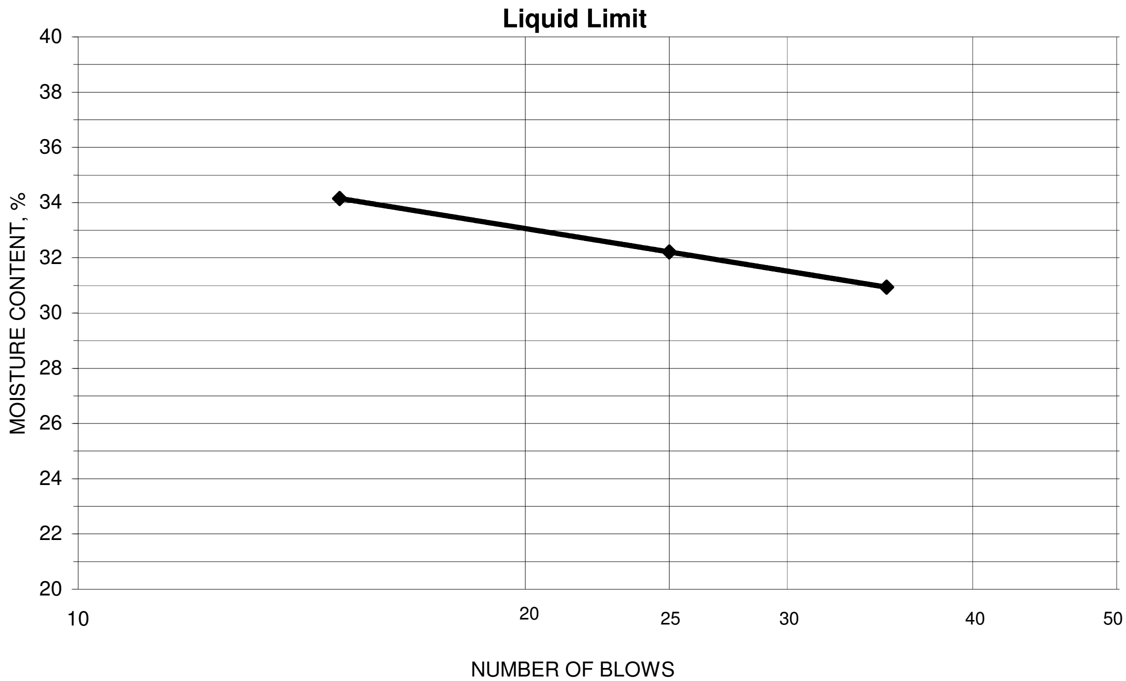
Reviewed By

Stantec

ATTERBERG LIMITS

Project	AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface e:	Project No.	175539022
Source	B-1, 10.0'-11.5', 12.5'-14.0'	Lab ID	4
		% + No. 40	2
Tested By	RG	Test Method	ASTM D 4318 Method A
Date Received	11-16-2009		
Test Date	11-23-2009	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
22.20	19.41	11.24	15	34.1	32
20.53	18.13	10.68	25	32.2	
22.58	19.87	11.11	35	30.9	



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
24.73	22.56	11.06	18.9	19	13
24.53	22.36	11.08	19.2		

Remarks:

Reviewed By

Summary of Soil Tests

Project Name: AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds Subs
Project Number: 175539022
Source: B-1, 47.5'-49.0', 50.0'-51.5'
Lab ID: 20

County: Jefferson, IN
Date Received: 11-16-09
Sample Type: SPT Comp
Date Reported: 11-30-09

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
Moisture Content (%): 25.3

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
3"	75	
2"	50	
1 1/2"	37.5	
1"	25	
3/4"	19	
3/8"	9.5	100.0
No. 4	4.75	100.0
No. 10	2	99.9
No. 40	0.425	99.7
No. 200	0.075	84.1
	0.02	54.5
	0.005	28.2
	0.002	20.4
estimated	0.001	17.1

Plus 3 in. material, not included: 0 (%)

	ASTM	AASHTO
Range	(%)	(%)
Gravel	0.0	0.1
Coarse Sand	0.1	0.2
Medium Sand	0.2	---
Fine Sand	15.6	15.6
Silt	55.9	63.7
Clay	28.2	20.4

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry
Liquid Limit: 28
Plastic Limit: 16
Plasticity Index: 12
Activity Index: 0.60

Moisture-Density Relationship

Test Not Performed
Maximum Dry Density (lb/ft^3): N/A
Maximum Dry Density (kg/m^3): N/A
Optimum Moisture Content (%): N/A
Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed
Bearing Ratio (%): N/A
Compacted Dry Density (lb/ft^3): N/A
Compacted Moisture Content (%): N/A

Specific Gravity

Test Method: ASTM D 854
Prepared: Dry
Particle Size: No. 10
Specific Gravity at 20° Celsius: 2.77

Classification

Unified Group Symbol: CL
Group Name: Lean clay with sand

AASHTO Classification: A-6 (8)

Comments:

Particle-Size Analysis of Soils
ASTM D 422

Project Name	AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface exp	Project Number	175539022
Source	B-1, 47.5'-49.0', 50.0'-51.5'	Lab ID	20

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: KR
Test Date: 11-20-2009
Date Received 11-16-2009

Maximum Particle size: 3/8" Sieve

Sieve Size	% Passing
3"	
2"	
1 1/2"	
1"	
3/4"	
3/8"	100.0
No. 4	100.0
No. 10	99.9

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on: Total Sample

Specific Gravity 2.77

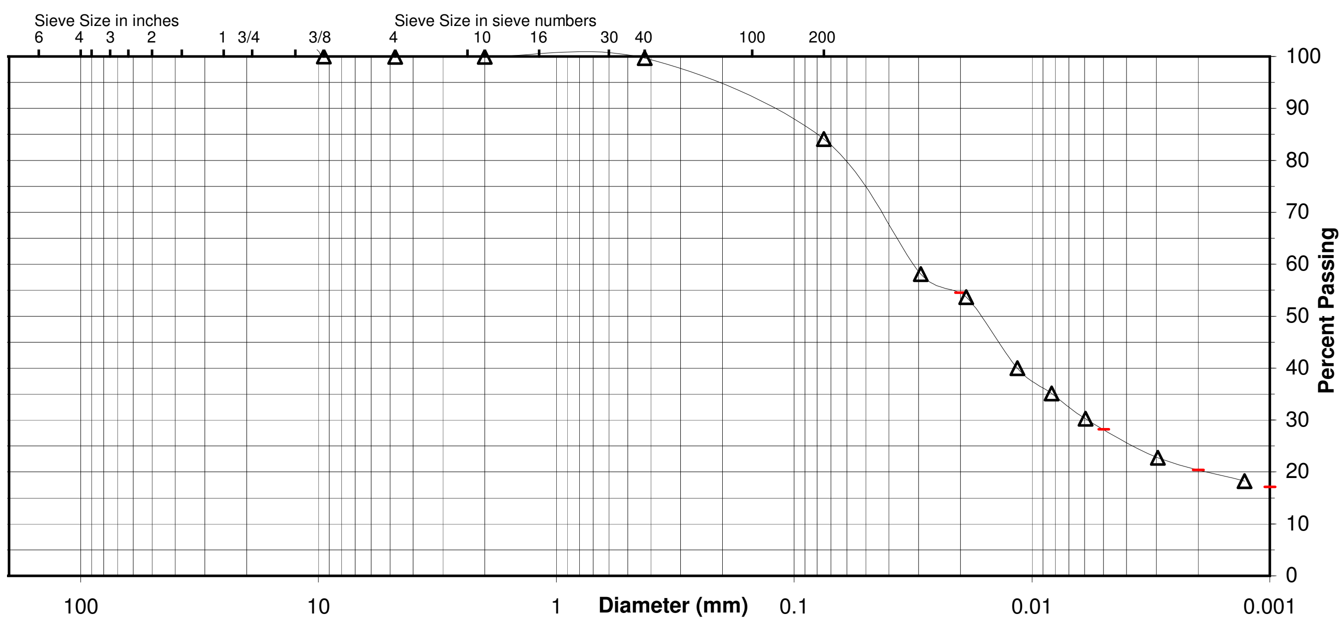
Dispersed using: Apparatus A - Mechanical, for 1 minute

No. 40	99.7
No. 200	84.1
0.02 mm	54.5
0.005 mm	28.2
0.002 mm	20.4
0.001 mm	17.1

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	0.1	0.2	15.6	55.9	28.2

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	0.1	0.2	15.6	63.7	20.4



Comments

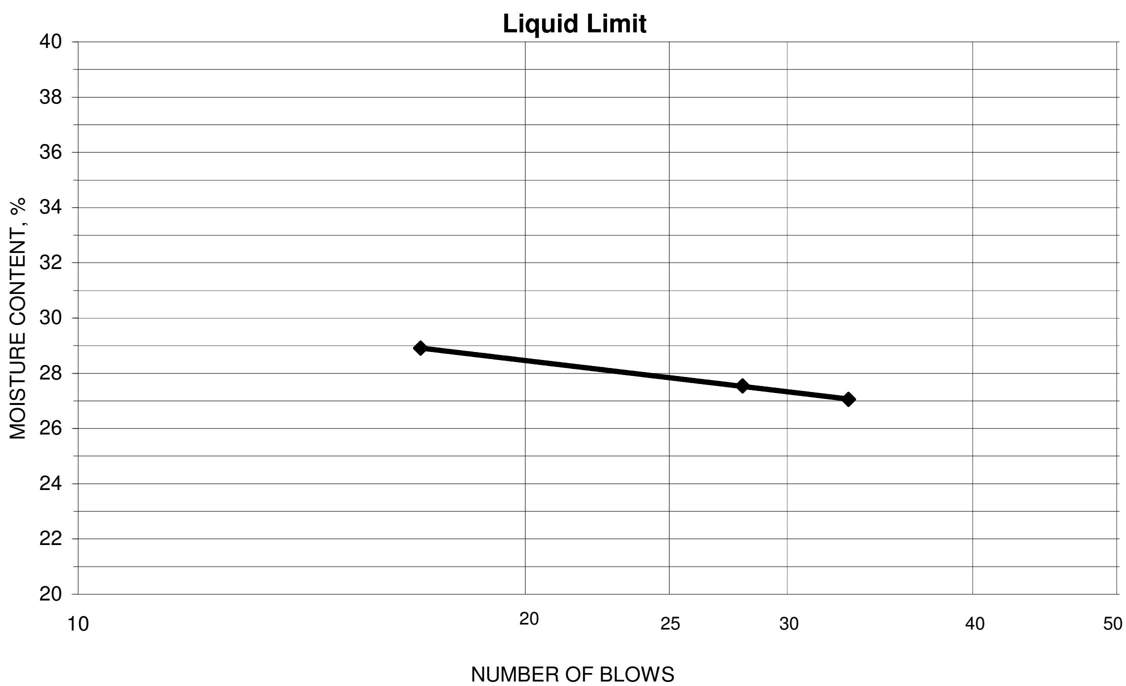
Reviewed By

Stantec

ATTERBERG LIMITS

Project	AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface e:	Project No.	175539022
Source	B-1, 47.5'-49.0', 50.0'-51.5'	Lab ID	20
		% + No. 40	0
Tested By	RG	Test Method	ASTM D 4318 Method A
Date Received	11-16-2009		
Test Date	11-23-2009	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
23.68	21.01	11.14	33	27.1	
23.20	20.50	11.16	17	28.9	
23.78	21.05	11.14	28	27.5	28



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
25.05	23.09	10.96	16.2	16	12
22.52	20.86	10.61	16.2		

Remarks:

Reviewed By

Stantec

Summary of Soil Tests

Project Name: AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds Subs
Project Number: 175539022
Source: B-2, 32.5'-34.0', 35.0'-36.5'
Lab ID: 43

County: Jefferson, IN
Date Received: 11-16-09
Sample Type: SPT Comp
Date Reported: 11-30-09

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
Moisture Content (%): 32.1

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
3"	75	
2"	50	
1 1/2"	37.5	
1"	25	
3/4"	19	
3/8"	9.5	100.0
No. 4	4.75	99.7
No. 10	2	99.7
No. 40	0.425	98.7
No. 200	0.075	79.7
	0.02	50.6
	0.005	28.1
	0.002	19.7
estimated	0.001	16.0

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.3	0.3
Coarse Sand	0.0	1.0
Medium Sand	1.0	---
Fine Sand	19.0	19.0
Silt	51.6	60.0
Clay	28.1	19.7

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry
Liquid Limit: 33
Plastic Limit: 15
Plasticity Index: 18
Activity Index: 0.90

Moisture-Density Relationship

Test Not Performed
Maximum Dry Density (lb/ft^3): N/A
Maximum Dry Density (kg/m^3): N/A
Optimum Moisture Content (%): N/A
Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed
Bearing Ratio (%): N/A
Compacted Dry Density (lb/ft^3): N/A
Compacted Moisture Content (%): N/A

Specific Gravity

Test Method: ASTM D 854
Prepared: Dry
Particle Size: No. 10
Specific Gravity at 20° Celsius: 2.72

Classification

Unified Group Symbol: CL
Group Name: Lean clay with sand

AASHTO Classification: A-6 (13)

Comments:

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface exp Project Number 175539022
Source B-2, 32.5'-34.0', 35.0'-36.5' Lab ID 43

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: KR
Test Date: 11-20-2009
Date Received 11-16-2009

Maximum Particle size: 3/8" Sieve

Sieve Size	% Passing
3"	
2"	
1 1/2"	
1"	
3/4"	
3/8"	100.0
No. 4	99.7
No. 10	99.7

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on: Total Sample

Specific Gravity 2.72

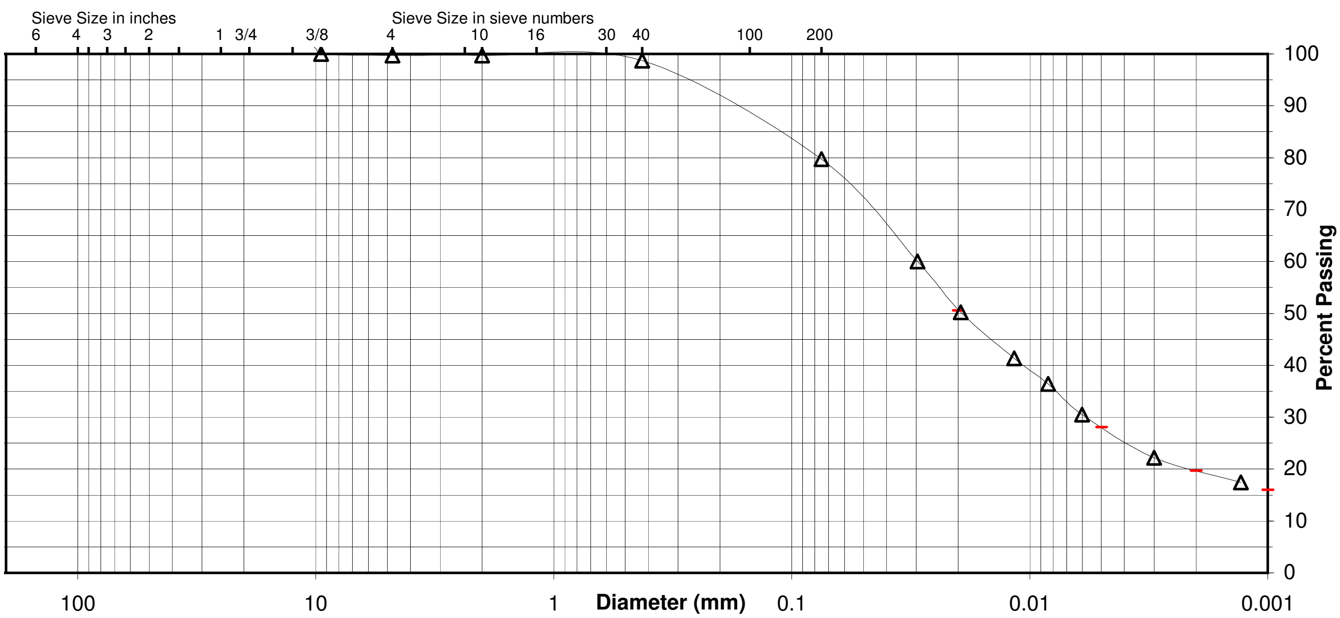
Dispersed using: Apparatus A - Mechanical, for 1 minute

No. 40	98.7
No. 200	79.7
0.02 mm	50.6
0.005 mm	28.1
0.002 mm	19.7
0.001 mm	16.0

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.3	0.0	1.0	19.0	51.6	28.1

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	0.3	1.0	19.0	60.0	19.7



Comments

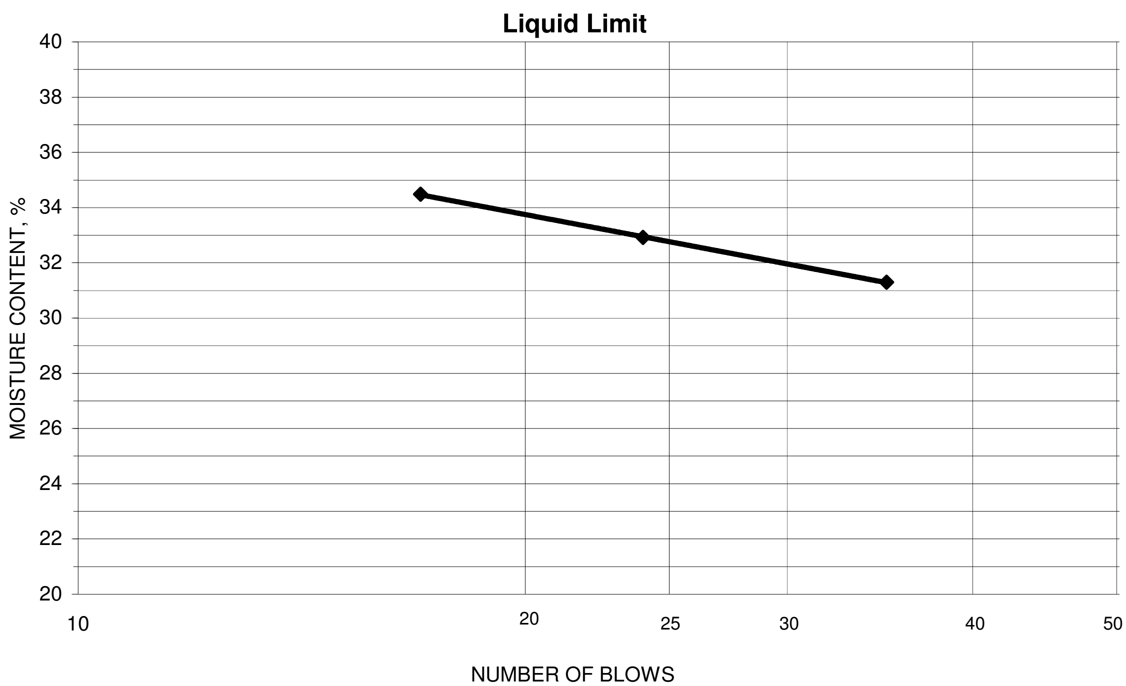
Reviewed By

ATTERBERG LIMITS

Stantec

Project	AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface e:	Project No.	175539022
Source	B-2, 32.5'-34.0', 35.0'-36.5'	Lab ID	43
		% + No. 40	1
Tested By	KR	Test Method	ASTM D 4318 Method A
Date Received	11-16-2009		
Test Date	11-23-2009	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
23.26	20.15	11.13	17	34.5	
23.44	20.29	10.72	24	32.9	
24.86	21.58	11.10	35	31.3	33



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
21.11	19.78	10.98	15.1	15	18
21.07	19.72	10.97	15.4		

Remarks:

Reviewed By

Summary of Soil Tests

Project Name: AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds Project Number: 175539022
Source: B-4, 20.0'-21.5', 22.5'-24.0' Lab ID: 87

County: Jefferson, IN Date Received: 11-16-09
Sample Type: SPT Comp Date Reported: 11-30-09

Test Results

Natural Moisture Content
Test Method: ASTM D 2216
Moisture Content (%): 26.6

Particle Size Analysis
Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size Sieve Size	Particle Size (mm)	% Passing
3"	75	
2"	50	
1 1/2"	37.5	
1"	25	
3/4"	19	
3/8"	9.5	
No. 4	4.75	100.0
No. 10	2	100.0
No. 40	0.425	99.7
No. 200	0.075	80.7
	0.02	52.0
	0.005	27.7
	0.002	19.5
estimated	0.001	15.1

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	0.0
Coarse Sand	0.0	0.3
Medium Sand	0.3	---
Fine Sand	19.0	19.0
Silt	53.0	61.2
Clay	27.7	19.5

Atterberg Limits
Test Method: ASTM D 4318 Method A
Prepared: Dry
Liquid Limit: 25
Plastic Limit: 17
Plasticity Index: 8
Activity Index: 0.40

Moisture-Density Relationship
Test Not Performed
Maximum Dry Density (lb/ft^3): N/A
Maximum Dry Density (kg/m^3): N/A
Optimum Moisture Content (%): N/A
Over Size Correction %: N/A

California Bearing Ratio
Test Not Performed
Bearing Ratio (%): N/A
Compacted Dry Density (lb/ft^3): N/A
Compacted Moisture Content (%): N/A

Specific Gravity
Test Method: ASTM D 854
Prepared: Dry
Particle Size: No. 10
Specific Gravity at 20° Celsius: 2.60

Classification
Unified Group Symbol: CL
Group Name: Lean clay with sand

AASHTO Classification: A-4 (4)

Comments:

Stantec

Particle-Size Analysis of Soils

ASTM D 422

Project Name: AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface exp
Project Number: 175539022
Source: B-4, 20.0'-21.5', 22.5'-24.0'
Lab ID: 87

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: KR
Test Date: 11-20-2009
Date Received: 11-16-2009

Maximum Particle size: No. 4 Sieve

Sieve Size	% Passing
3"	
2"	
1 1/2"	
1"	
3/4"	
3/8"	
No. 4	100.0
No. 10	100.0

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on: Total Sample

Specific Gravity: 2.6

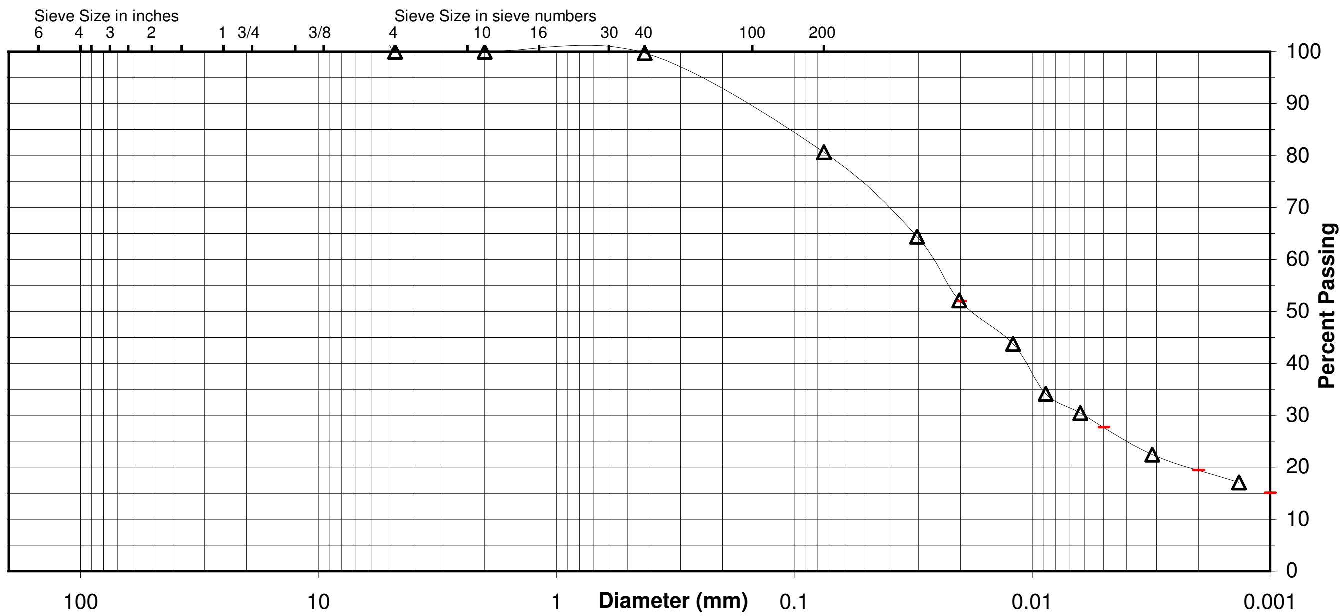
Dispersed using: Apparatus A - Mechanical, for 1 minute

No. 40	99.7
No. 200	80.7
0.02 mm	52.0
0.005 mm	27.7
0.002 mm	19.5
0.001 mm	15.1

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	0.0	0.3	19.0	53.0	27.7

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	0.0	0.3	19.0	61.2	19.5



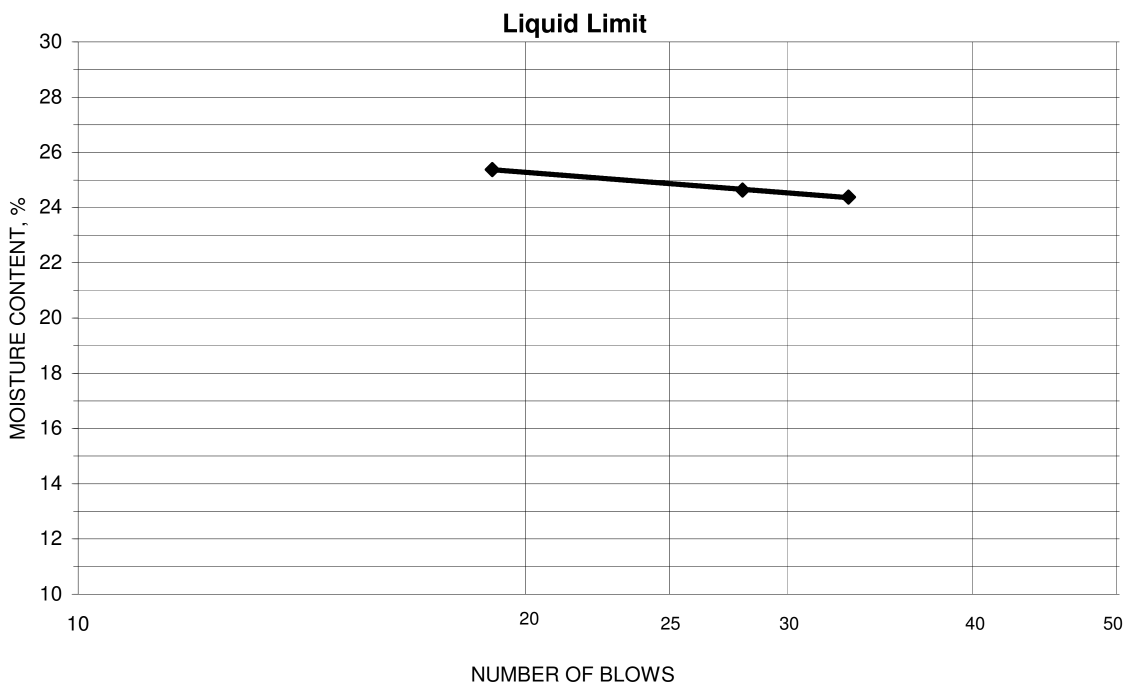
Comments

Reviewed By

ATTERBERG LIMITS

Project	AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface e:	Project No.	175539022
Source	B-4, 20.0'-21.5', 22.5'-24.0'	Lab ID	87
		% + No. 40	0
Tested By	RG	Test Method ASTM D 4318 Method A	Date Received 11-16-2009
Test Date	11-23-2009	Prepared Dry	

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
24.04	21.40	10.57	33	24.4	25
23.55	21.04	11.15	19	25.4	
23.10	20.72	11.06	28	24.6	



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
24.08	22.17	11.08	17.2	17	8
25.29	23.10	10.68	17.6		

Remarks: ______________________

Reviewed By ______________

Stantec

Summary of Soil Tests

Project Name: AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds Subs
Project Number: 175539022
Source: B-4, 57.5'-59.0', 60.0'-61.5'
Lab ID: 103

County: Jefferson, IN
Date Received: 11-16-09
Sample Type: SPT Comp
Date Reported: 11-30-09

Test Results

Natural Moisture Content
Test Method: ASTM D 2216
Moisture Content (%): 10.9

Particle Size Analysis
Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size: Sieve Size	Particle Size: (mm)	% Passing
3"	75	
2"	50	
1 1/2"	37.5	100.0
1"	25	97.1
3/4"	19	92.5
3/8"	9.5	72.7
No. 4	4.75	46.1
No. 10	2	32.6
No. 40	0.425	13.6
No. 200	0.075	5.7
	0.02	2.9
	0.005	1.5
	0.002	1.1
estimated	0.001	0.9

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	53.9	67.4
Coarse Sand	13.5	19.0
Medium Sand	19.0	---
Fine Sand	7.9	7.9
Silt	4.2	4.6
Clay	1.5	1.1

Atterberg Limits
Test Method: ASTM D 4318 Method A
Prepared: Dry
Liquid Limit: ---
Plastic Limit: Non Plastic
Plasticity Index: ---
Activity Index: N/A

Moisture-Density Relationship
Test Not Performed
Maximum Dry Density (lb/ft^3): N/A
Maximum Dry Density (kg/m^3): N/A
Optimum Moisture Content (%): N/A
Over Size Correction %: N/A

California Bearing Ratio
Test Not Performed
Bearing Ratio (%): N/A
Compacted Dry Density (lb/ft^3): N/A
Compacted Moisture Content (%): N/A

Specific Gravity
Test Method: ASTM D 854
Prepared: Dry
Particle Size: No. 10
Specific Gravity at 20° Celsius: 2.72

Classification
Unified Group Symbol: GW-GM
Group Name: Well-graded gravel with silt and sand
AASHTO Classification: A-1-a (1)

Comments:

Particle-Size Analysis of Soils
ASTM D 422

Project Name: AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface exp
Project Number: 175539022
Source: B-4, 57.5'-59.0', 60.0'-61.5'
Lab ID: 103

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: KR
Test Date: 11-20-2009
Date Received 11-16-2009

Maximum Particle size: 1 1/2" Sieve

Sieve Size	% Passing
3"	
2"	
1 1/2"	100.0
1"	97.1
3/4"	92.5
3/8"	72.7
No. 4	46.1
No. 10	32.6

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on: Total Sample

Specific Gravity 2.72

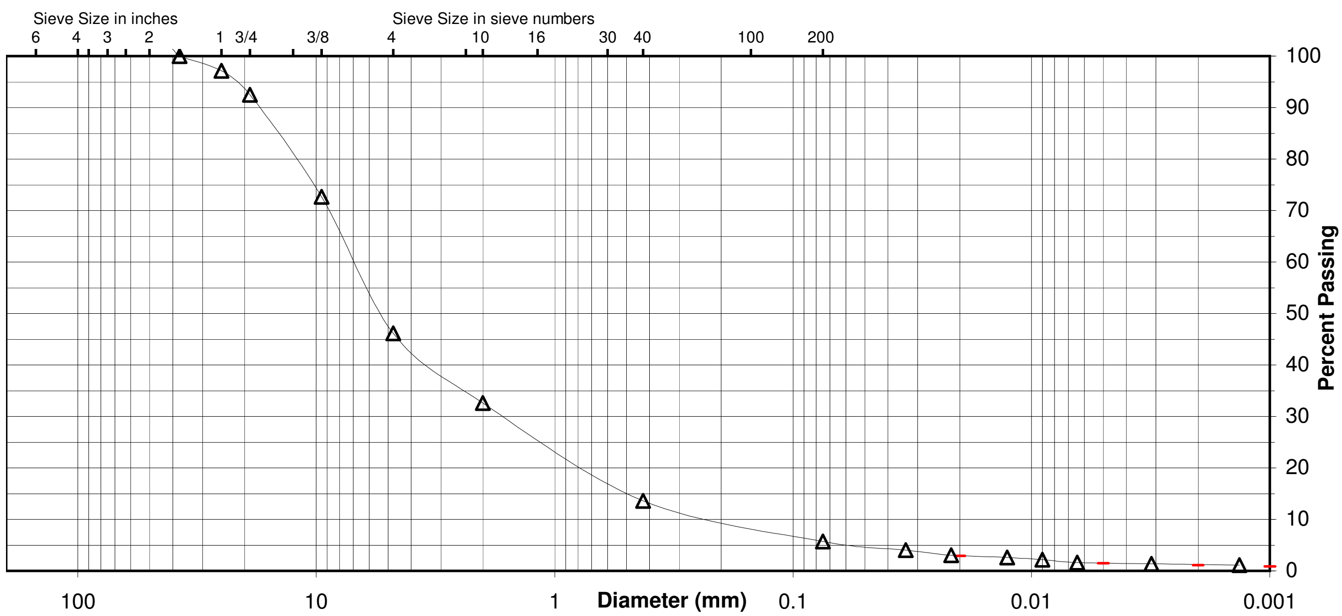
Dispersed using: Apparatus A - Mechanical, for 1 minute

No. 40	13.6
No. 200	5.7
0.02 mm	2.9
0.005 mm	1.5
0.002 mm	1.1
0.001 mm	0.9

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	7.5	46.4	13.5	19.0	7.9	4.2	1.5

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	67.4	19.0	7.9	4.6	1.1



Comments

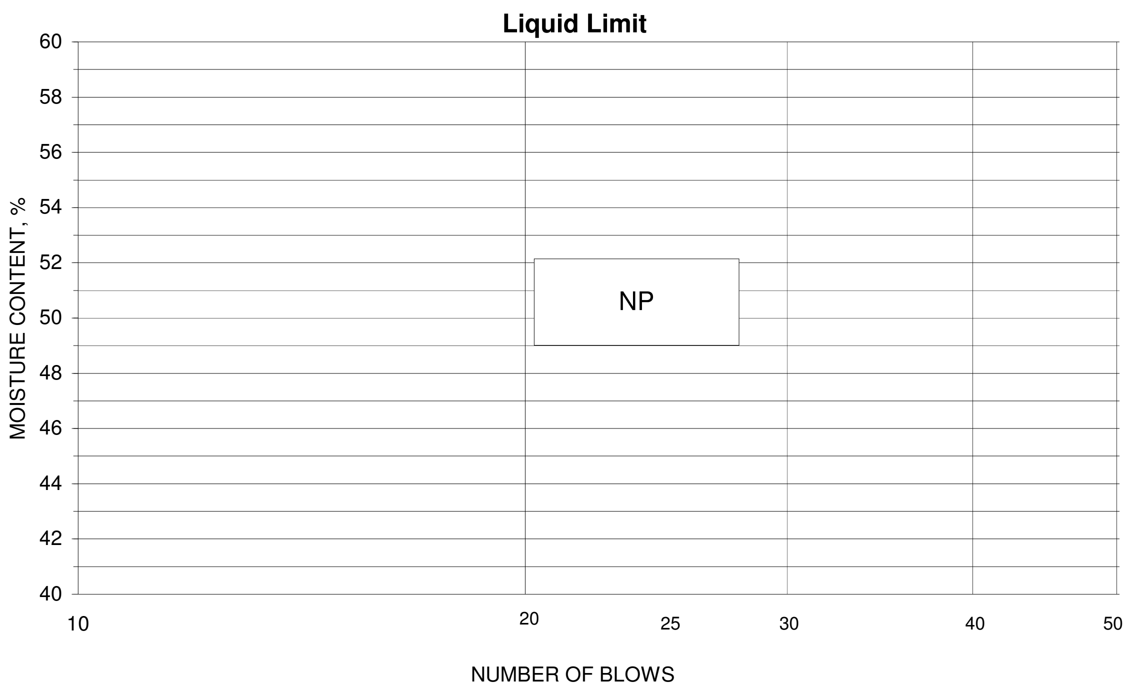
Reviewed By

Stantec

ATTERBERG LIMITS

Project	AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface e:	Project No.	175539022
Source	B-4, 57.5'-59.0', 60.0'-61.5'	Lab ID	103
		% + No. 40	86
Tested By	RG	Test Method	ASTM D 4318 Method A
Date Received	11-16-2009		
Test Date	11-23-2009	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
					#VALUE!



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
					#VALUE!

Remarks: ______________________

Reviewed By ______________

Summary of Soil Tests

Project Name: AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds Embankments
Project Number: 175539022
Source: B-5, 55.0'-56.5', 57.5'-59.0'
Lab ID: 129

County: Jefferson, IN
Date Received: 11-16-09
Sample Type: SPT Comp
Date Reported: 11-30-09

Test Results

Natural Moisture Content

Test Method: ASTM D 2216

Moisture Content (%): 24.9

Particle Size Analysis

Preparation Method: ASTM D 421

Gradation Method: ASTM D 422

Hydrometer Method: ASTM D 422

Particle Size: Sieve Size	Particle Size: (mm)	% Passing
3"	75	
2"	50	
1 1/2"	37.5	
1"	25	
3/4"	19	
3/8"	9.5	100.0
No. 4	4.75	100.0
No. 10	2	100.0
No. 40	0.425	99.9
No. 200	0.075	54.0
	0.02	26.2
	0.005	16.7
	0.002	13.0
estimated	0.001	10.5

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	0.0
Coarse Sand	0.0	0.1
Medium Sand	0.1	---
Fine Sand	45.9	45.9
Silt	37.3	41.0
Clay	16.7	13.0

Atterberg Limits

Test Method: ASTM D 4318 Method A

Prepared: Dry

Liquid Limit: ---

Plastic Limit: Non Plastic

Plasticity Index: ---

Activity Index: N/A

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3): N/A

Maximum Dry Density (kg/m^3): N/A

Optimum Moisture Content (%): N/A

Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A

Compacted Dry Density (lb/ft^3): N/A

Compacted Moisture Content (%): N/A

Specific Gravity

Test Method: ASTM D 854

Prepared: Dry

Particle Size: No. 10

Specific Gravity at 20° Celsius: 2.74

Classification

Unified Group Symbol: ML

Group Name: Sandy silt

AASHTO Classification: A-4 (0)

Comments:

Stantec

Particle-Size Analysis of Soils

ASTM D 422

Project Name: AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface exp

Project Number: 175539022

Source: B-5, 55.0'-56.5', 57.5'-59.0'

Lab ID: 129

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422

Prepared using: ASTM D 421

Particle Shape: Angular

Particle Hardness: Hard and Durable

Tested By: KR

Test Date: 11-20-2009

Date Received: 11-16-2009

Maximum Particle size: 3/8" Sieve

Sieve Size	% Passing
3"	
2"	
1 1/2"	
1"	
3/4"	
3/8"	100.0
No. 4	100.0
No. 10	100.0

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on: Total Sample

Specific Gravity: 2.74

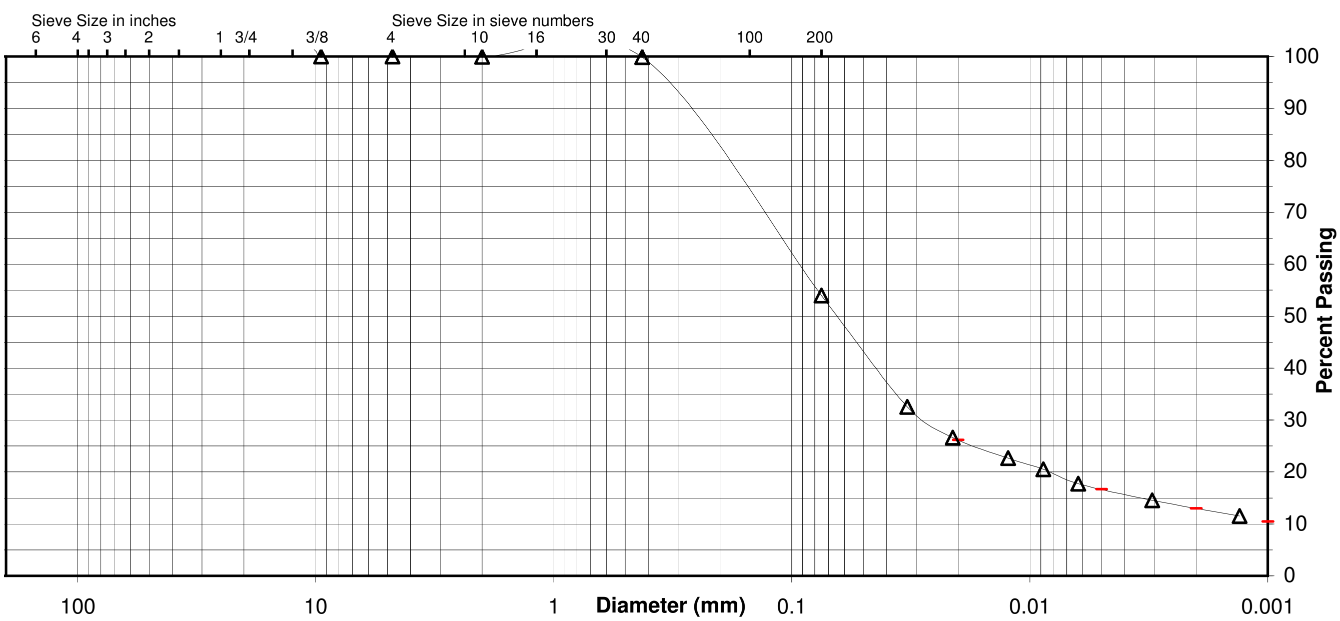
Dispersed using: Apparatus A - Mechanical, for 1 minute

No. 40	99.9
No. 200	54.0
0.02 mm	26.2
0.005 mm	16.7
0.002 mm	13.0
0.001 mm	10.5

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	0.0	0.1	45.9	37.3	16.7

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	0.0	0.1	45.9	41.0	13.0



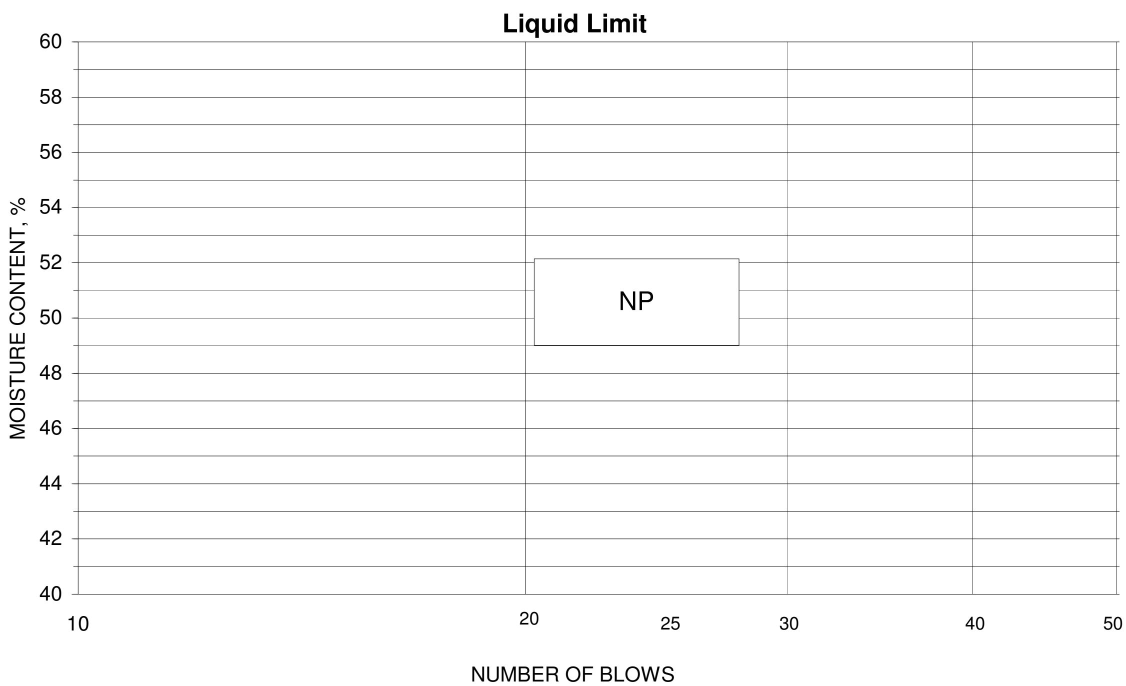
Comments

Reviewed By

ATTERBERG LIMITS

Project	AEP - Clifty Creek - West Bottom Ash and Fly Ash Ponds subsurface e:	Project No.	175539022
Source	B-5, 55.0'-56.5', 57.5'-59.0'	Lab ID	129
		% + No. 40	0
Tested By	RG	Test Method	ASTM D 4318 Method A
Date Received	11-16-2009		
Test Date	11-23-2009	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
					#VALUE!



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
					#VALUE!

Remarks:

Reviewed By

LANDFILL RUNOFF COLLECTION POND:
2009 GEOTECNICAL EXPLORATION

GeoTesting Express

SPECIFIC GRAVITY TEST

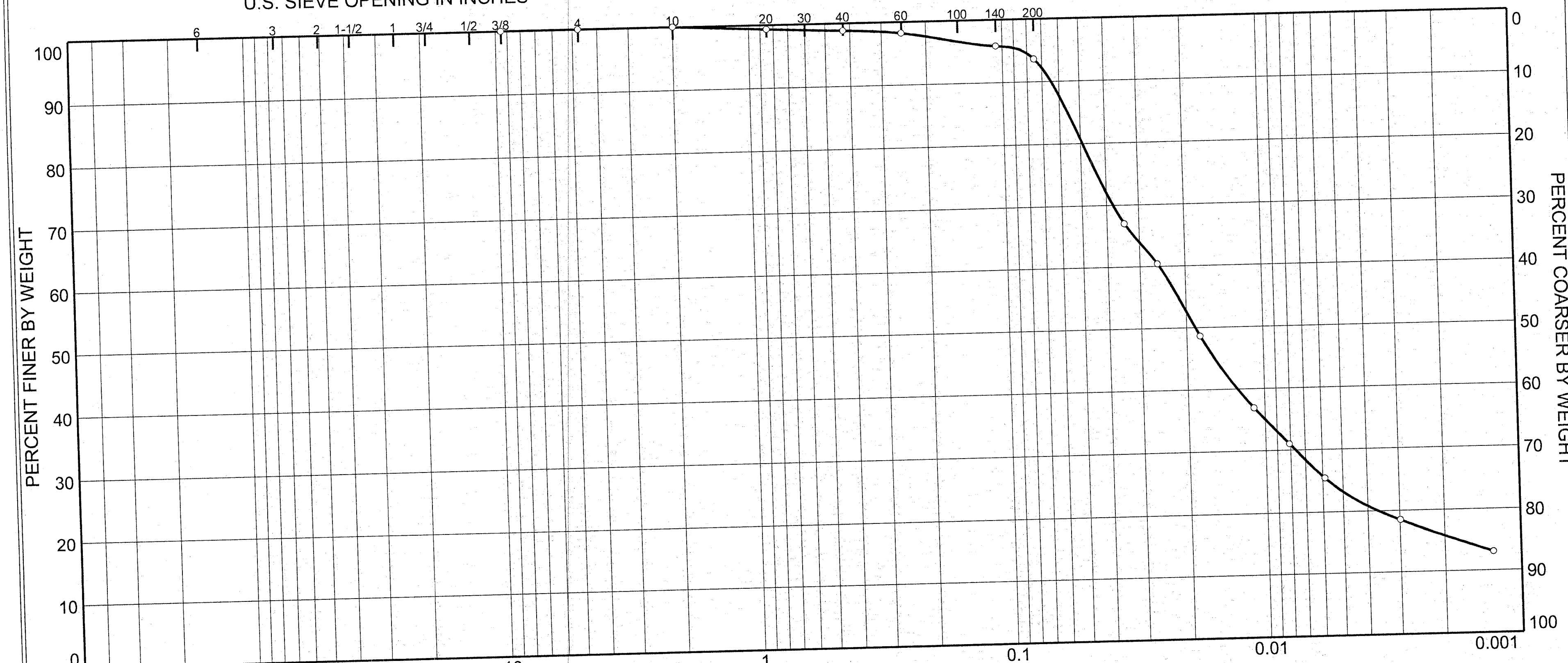
(ASTM D854)

Project No.	GTX-1516	Tested By	JM	Reviewed By	MM
Project Name	Clifty Creek	Test Date	12/8/2009	Review Date	12/13/2009

(1) Boring No.	(2) Depth (ft)	(3) Sample No.	(4) Lab No.	(5) Flask No.	(6) Temperature (^{0}C)	(7) Weight, WF (grams)	(8) Weight, WFS (grams)	(9) Weight of Soil (grams) (8)-(7)	(10) Weight, CWF (grams)	(11) Weight, DS (grams)	(12) Specific Gravity (9)/[(10)-(11)+(9)]	(13) Specific Gravity at 20^0 C
B-7	27.2-27.8	-	--	41	17	304.60	358.10	53.50	433.68	466.86	2.633	2.634
B-8	25.5-25.8	-	--	33	17	286.35	316.64	30.29	408.76	427.56	2.636	2.638
B-8	29.7-30.3	-	--	34	18	273.88	322.48	48.60	407.64	437.9	2.650	2.651
B-9	30.2-20.8	-	--	40	18	303.59	336.38	32.79	437.43	457.84	2.649	2.650
B-10	14.2-14.8	-	--	29	17	265.69	319.25	53.56	405.05	438.63	2.681	2.682
B-10	16.2-16.8	-	--	29	21	273.96	325.28	51.32	404.86	436.87	2.658	2.657

WF - Water and Flask
WFS - Water, Flask and Soil
CWF - Calibration Water and Flask
DS - Deaired Sample

Particle Size Distribution Report ASTM D422



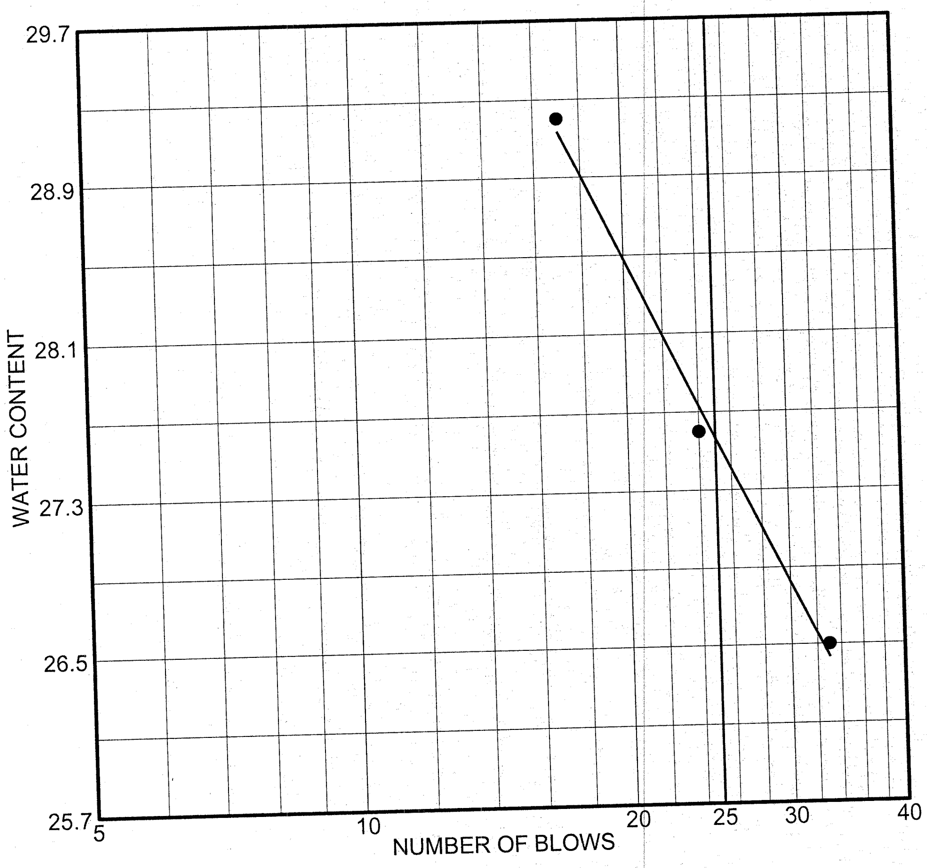
% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	6.4	70.4	23.2

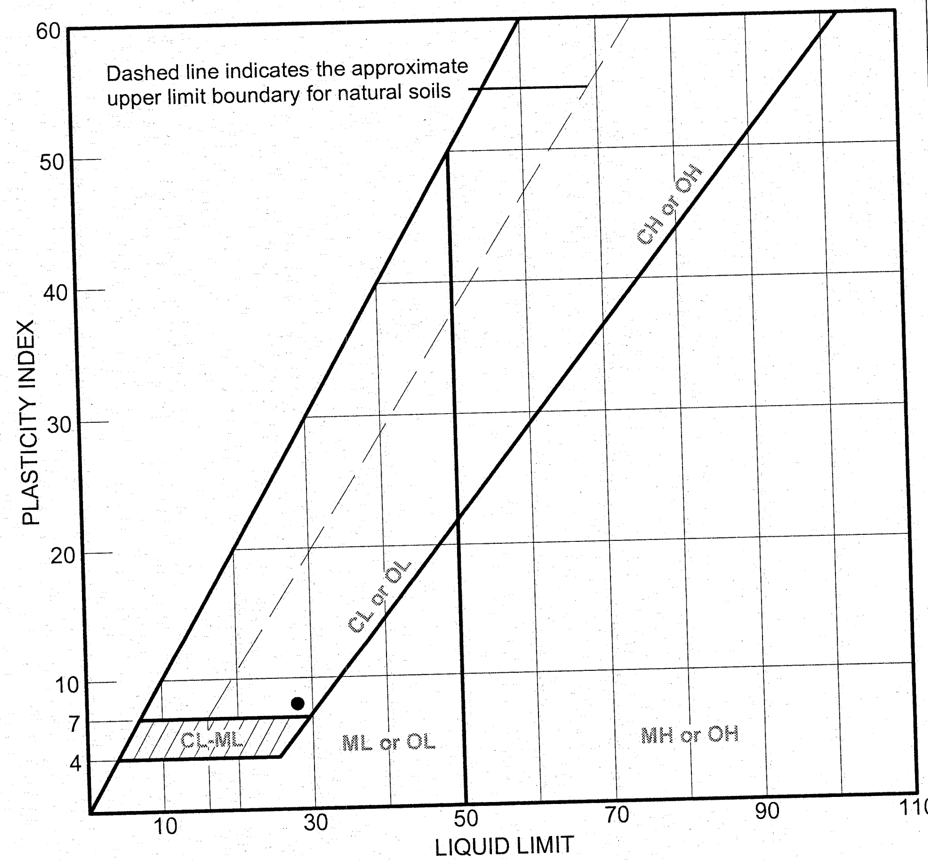
SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PL
	B-7	27.2-27.8 ft	12/10/09	CL	Lean clay		28	20

Client Stantec
Project Clifty Creek
Project No. GTX-1516
Lab no.

GeoTesting Express Inc.

LIQUID AND PLASTIC LIMITS TEST REPORT





	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
●		B-7	27.2-27.8 ft	12/10/09	CL	Lean clay		28	8

Client Stantec

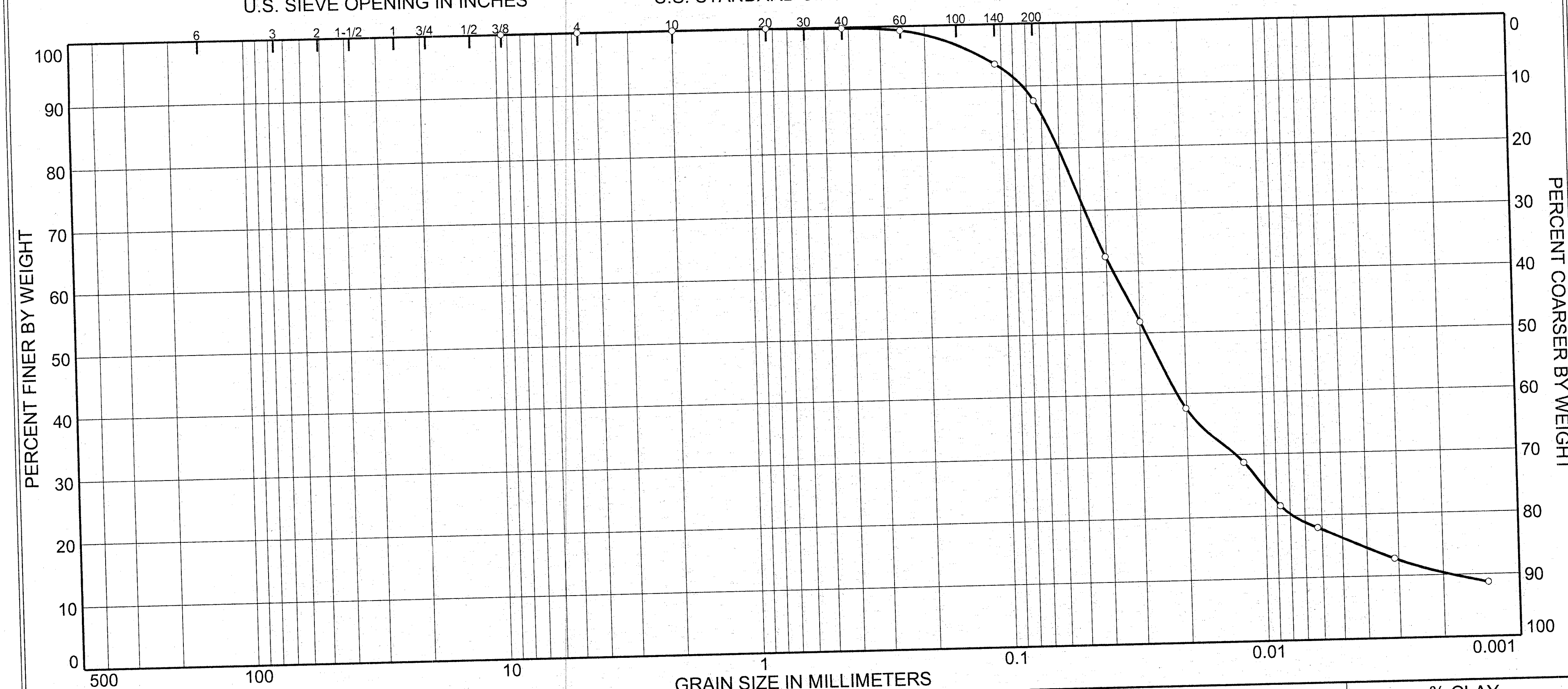
Project Clifty Creek

Project No. GTX-1516

Lab no.

GeoTesting Express Inc.

Particle Size Distribution Report ASTM D422



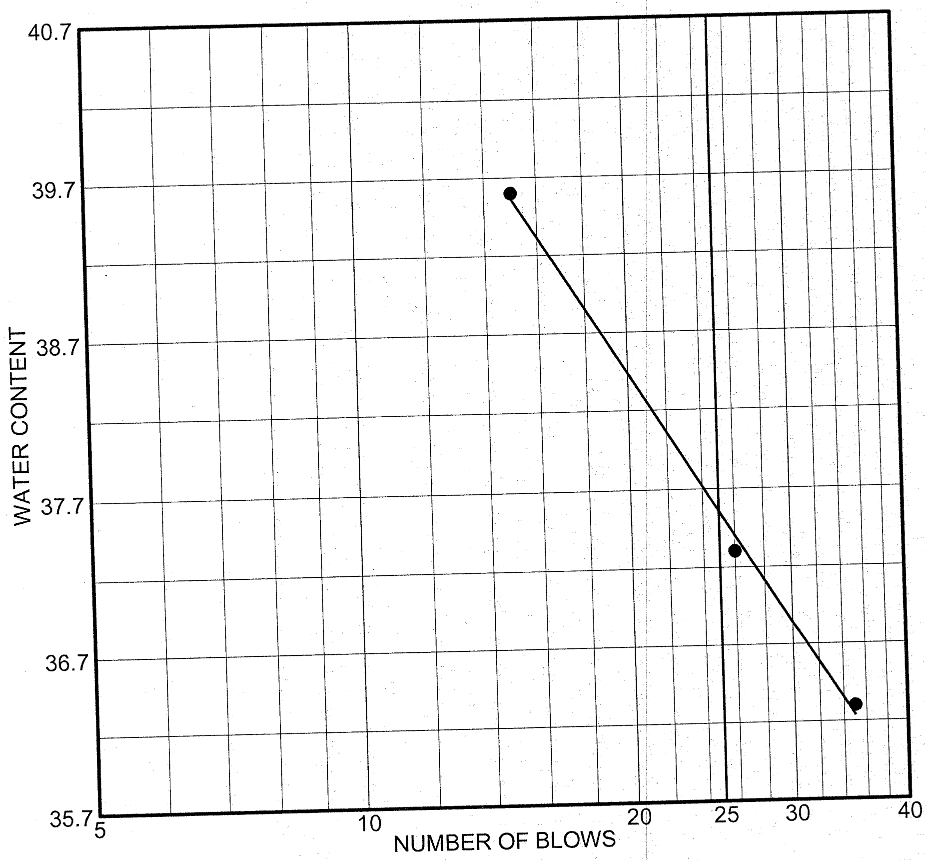
% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	0.0	12.4	71.3	16.3

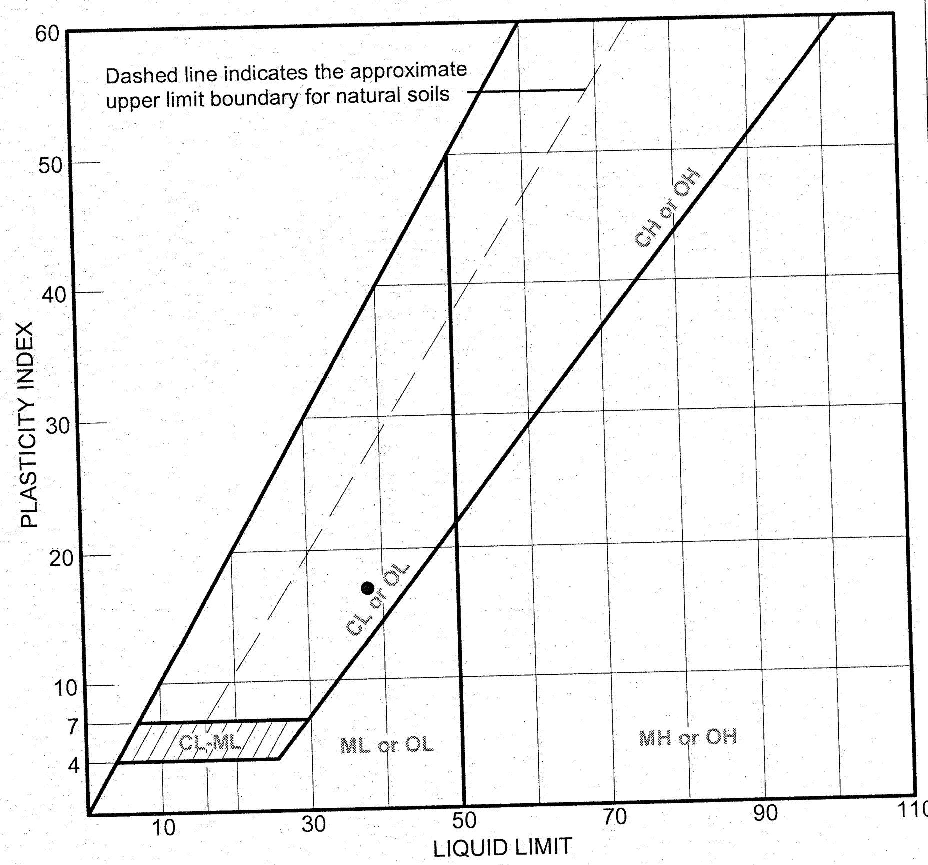
SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PL
	B-8	25.5-25.8 ft	12/10/09	CL	Lean clay		38	21

Client Stantec
Project Clifty Creek
Project No. GTX-1516
Lab no.

GeoTesting Express Inc.

LIQUID AND PLASTIC LIMITS TEST REPORT





	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
●		B-8	25.5-25.8 ft	12/10/09	CL	Lean clay		38	17

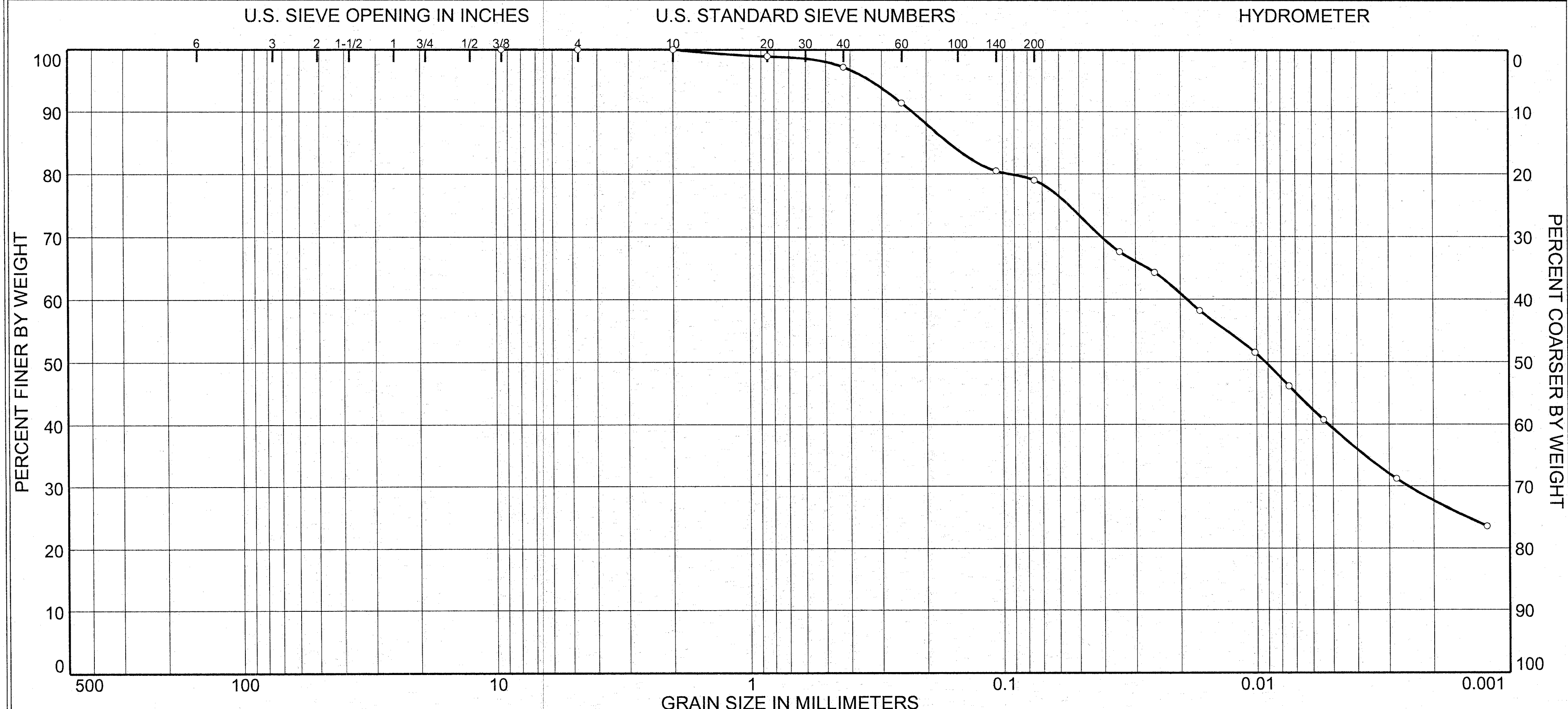
Client Stantec

Project Clifty Creek

Project No. GTX-1516 Lab no.

GeoTesting Express Inc.

Particle Size Distribution Report ASTM D422



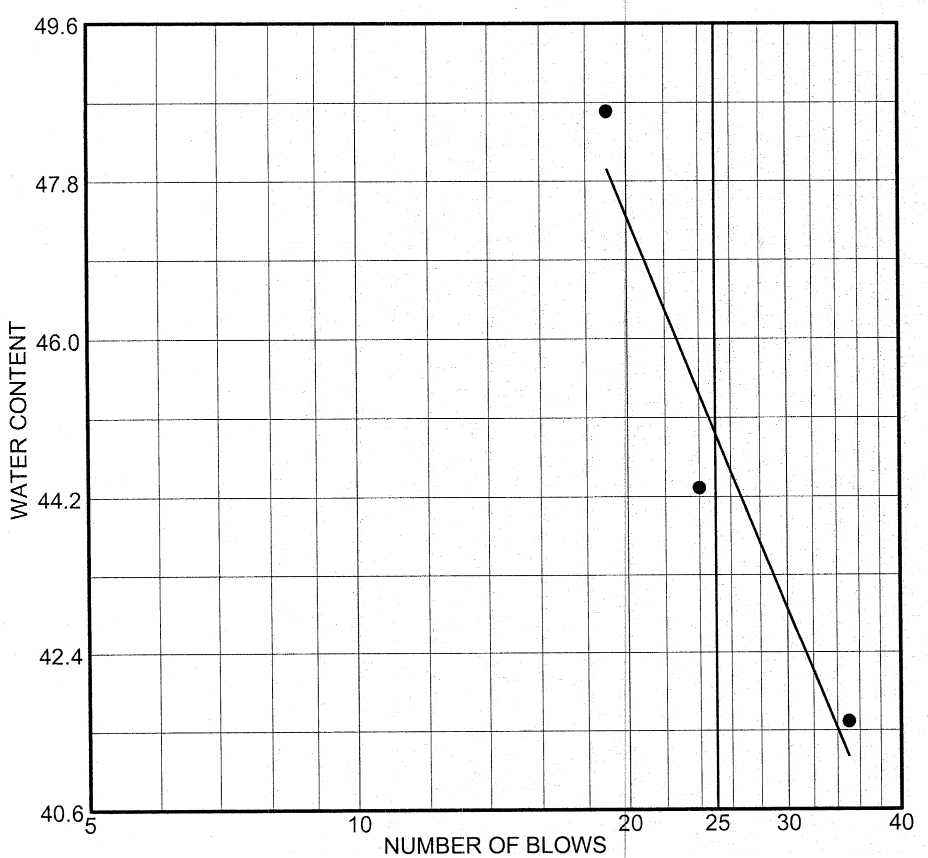
	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	0.0	21.0	39.6	39.4

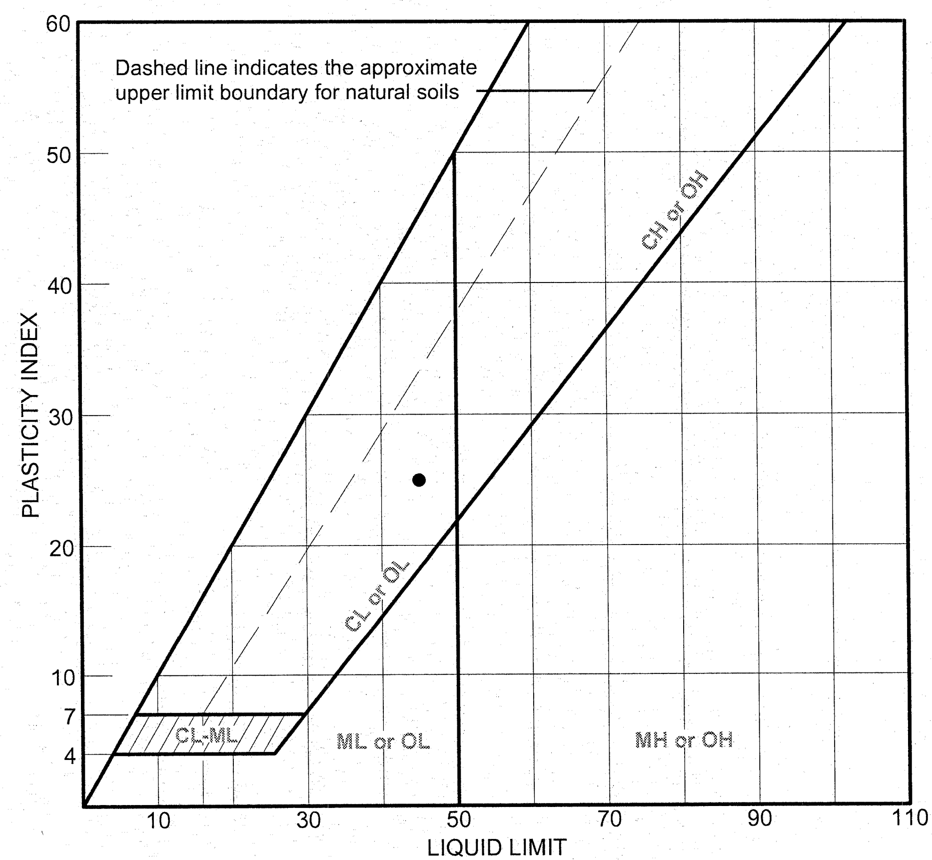
	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PL
○		B-8	29.7-30.3 ft	12/10/09	CL	Lean clay with sand		45	20

Client Stantec
Project Clifty Creek
Project No. GTX-1516
Lab no.

GeoTesting Express Inc.

LIQUID AND PLASTIC LIMITS TEST REPORT





	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
●		B-8	29.7-30.3 ft	12/10/09	CL	Lean clay with sand		45	25

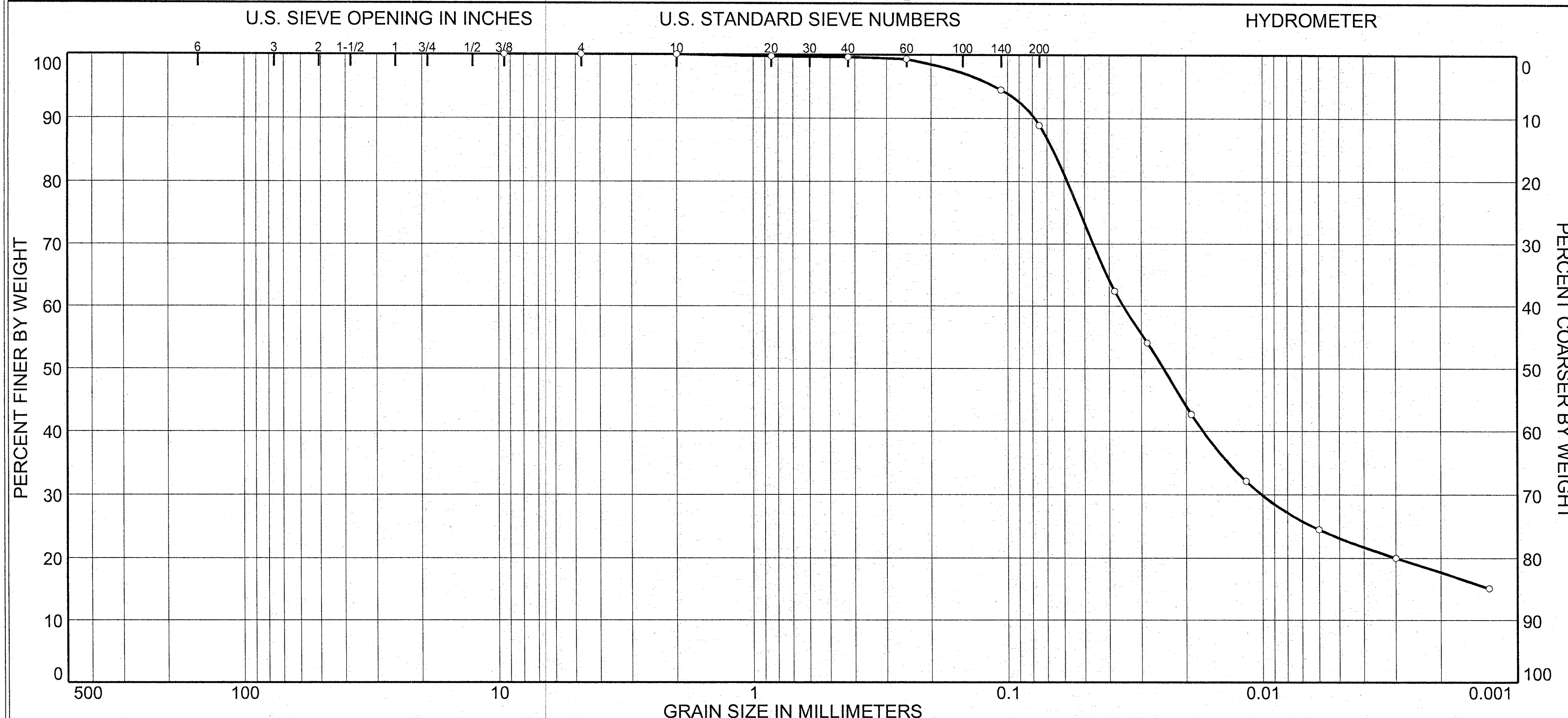
Client Stantec
Project Clifty Creek

Project No. GTX-1516 Lab no.

GeoTesting Express Inc.

●

Particle Size Distribution Report ASTM D422



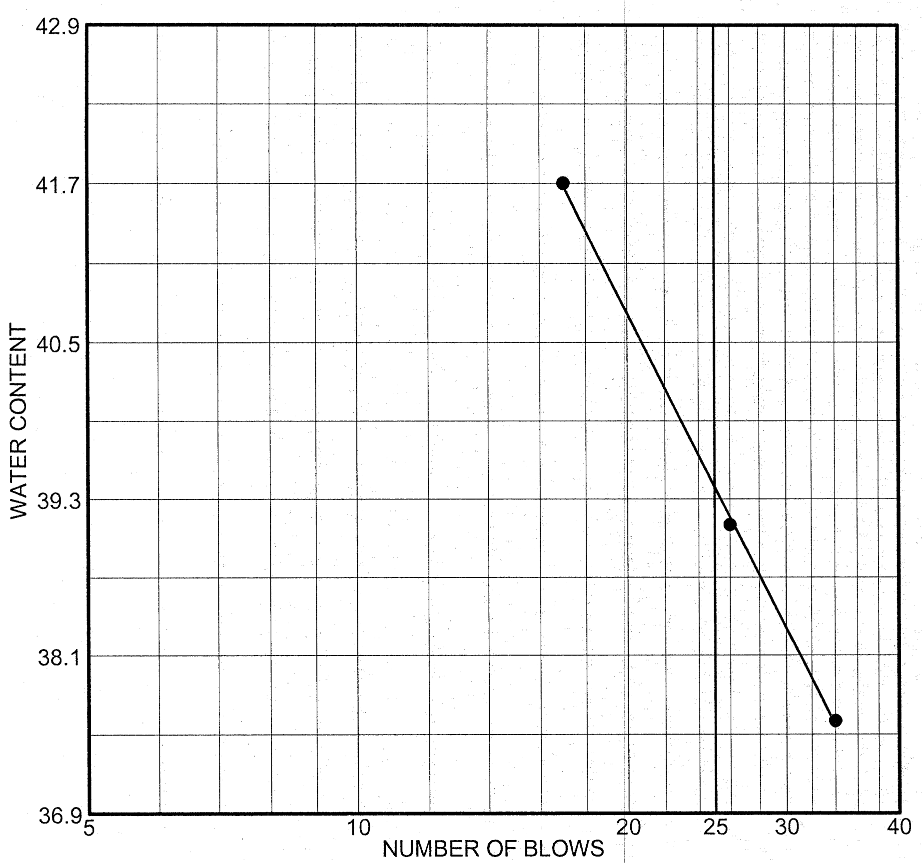
	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	0.0	11.1	65.8	23.1

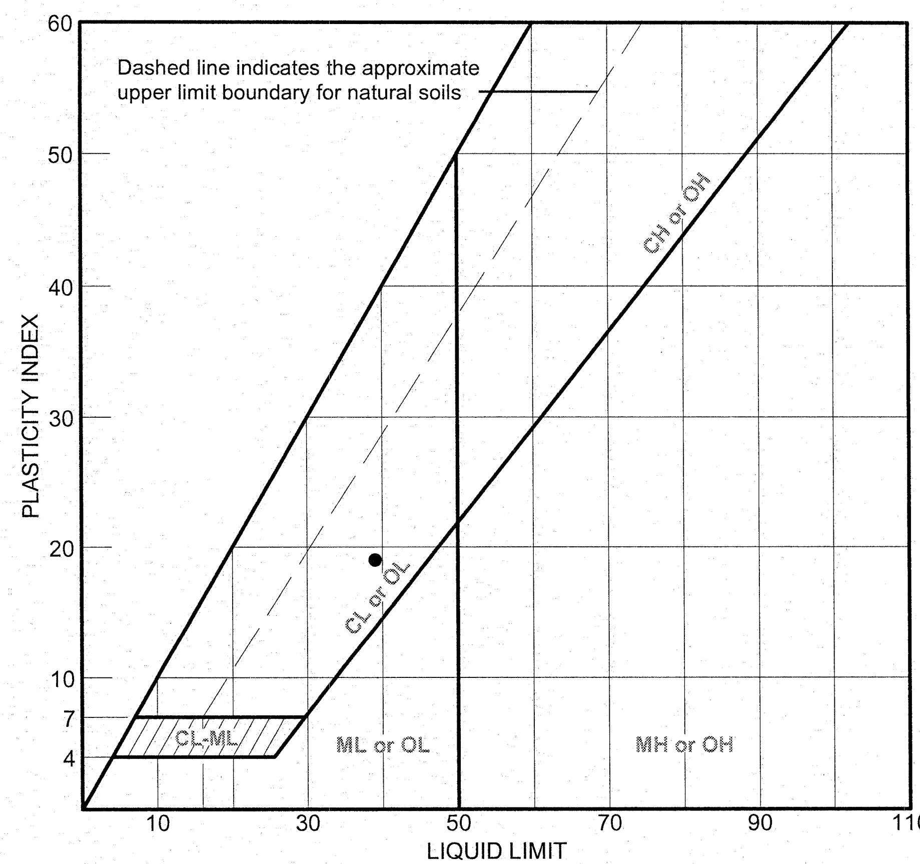
	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PL
○		B-9	20.2-20.8 ft	12/10/09	CL	Lean clay		39	20

Client Stantec
Project Clifty Creek
Project No. GTX-1516
Lab no.

GeoTesting Express Inc.

LIQUID AND PLASTIC LIMITS TEST REPORT





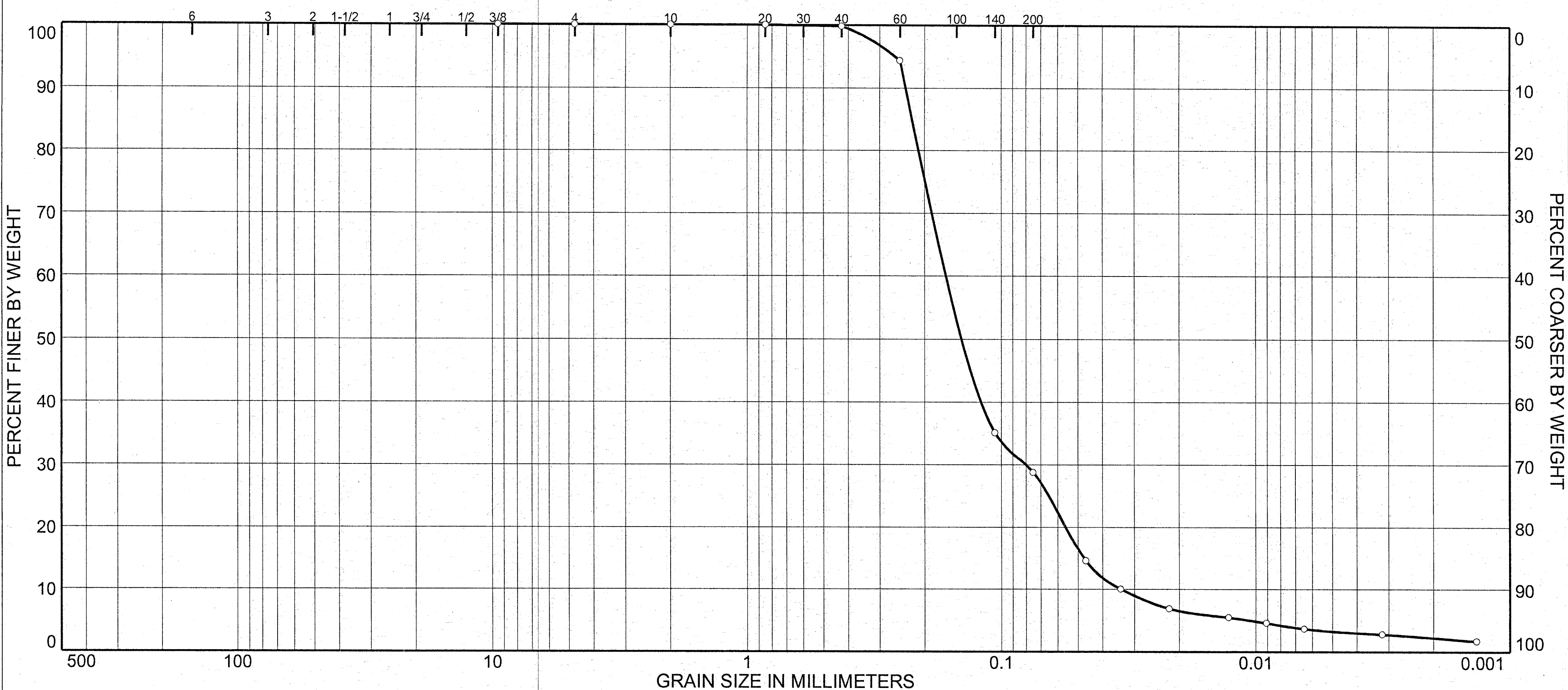
	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
●		B-9	20.2-20.8 ft	12/10/09	CL	Lean clay		39	19

Client Stantec
Project Clifty Creek

Project No. GTX-1516
Lab no.

GeoTesting Express Inc.

Particle Size Distribution Report ASTM D422



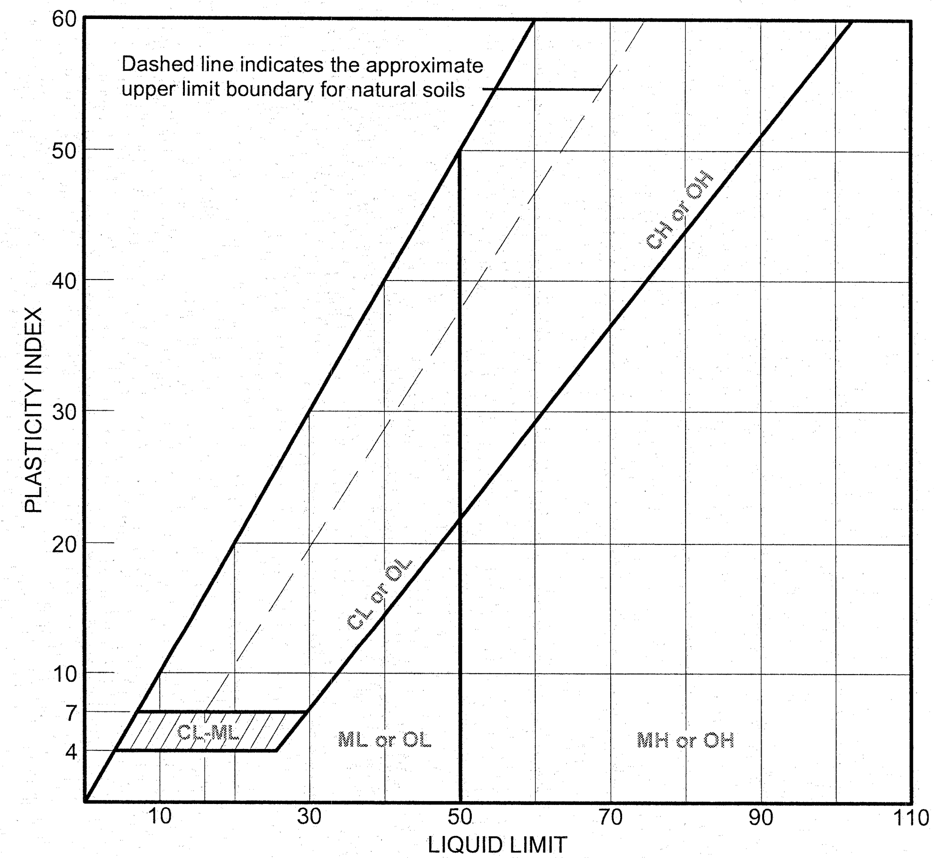
	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	0.0	71.2	25.5	3.3

	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PL
○		B-10	14.2-14.8 ft	12/10/09	SM	Silty sand		NV	NP

Client Stantec
Project Clifty Creek
Project No. GTX-1516 Lab no.

GeoTesting Express Inc.

LIQUID AND PLASTIC LIMITS TEST REPORT



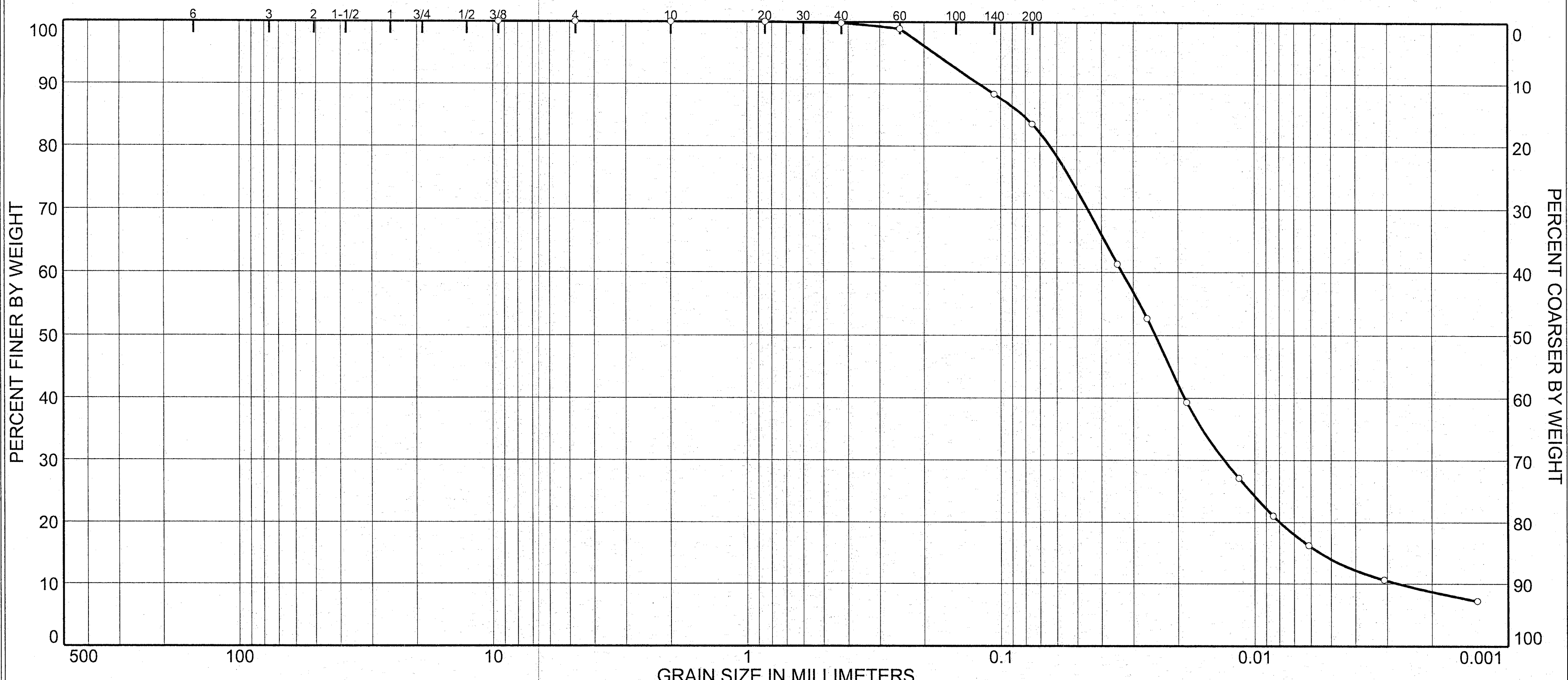
	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
●		B-10	14.2-14.8 ft	12/10/09	SM	Silty sand		NV	NP

Client Stantec
Project Clifty Creek
Project No. GTX-1516
Lab no.

GeoTesting Express Inc.

●

Particle Size Distribution Report ASTM D422



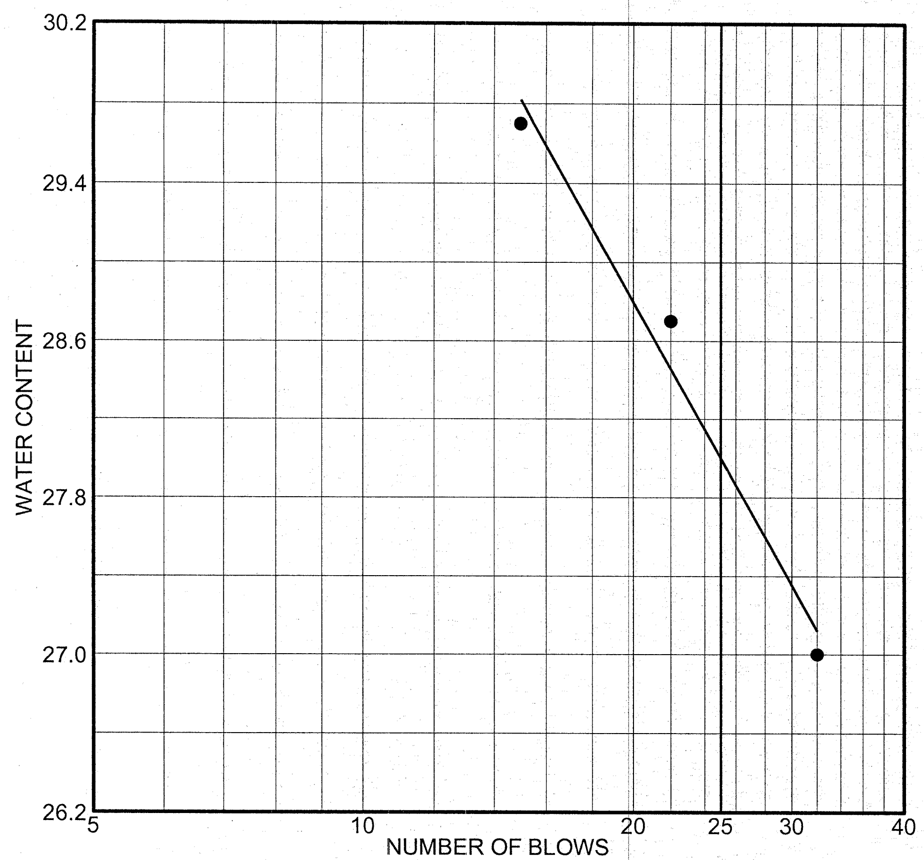
	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	0.0	16.4	69.7	13.9

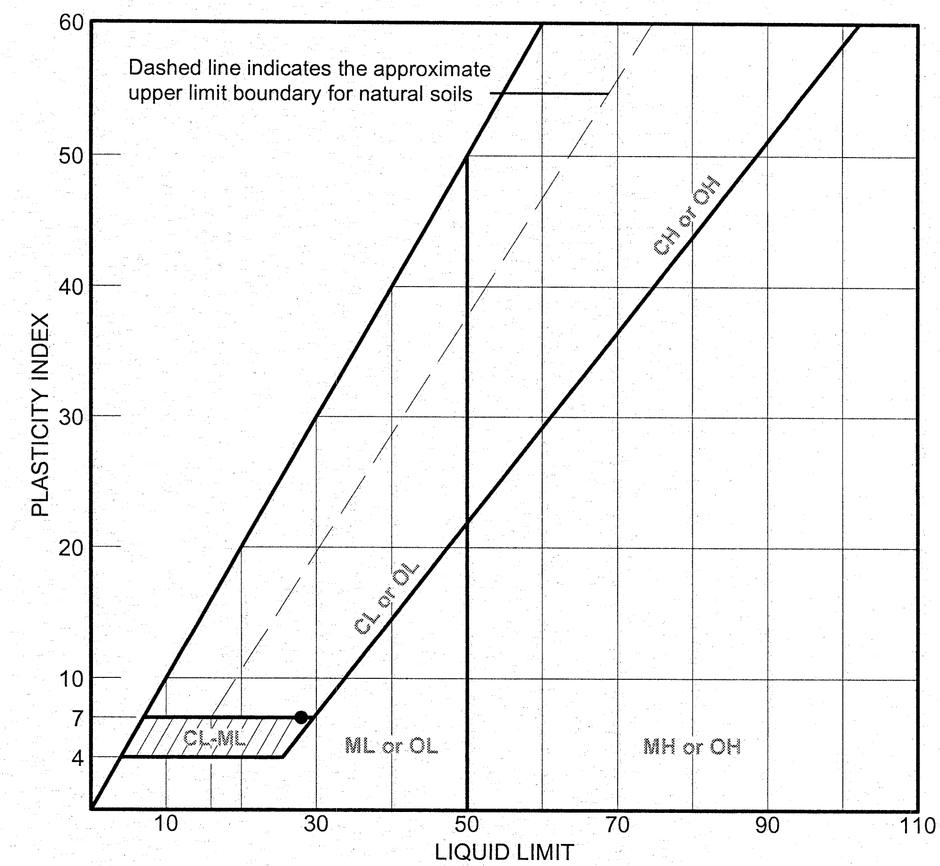
	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PL
○		B-10	16.2-16.8 ft	12/10/09	CL-ML	Silty clay with sand		28	21

Client Stantec
Project Clifty Creek
Project No. GTX-1516 Lab no.

GeoTesting Express Inc.

LIQUID AND PLASTIC LIMITS TEST REPORT





	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
●		B-10	16.2-16.8 ft	12/10/09	CL-ML	Silty clay with sand		28	7

Client Stantec

Project Clifty Creek

Project No. GTX-1516 | Lab no.

GeoTesting Express Inc.

●

LANDFILL RUNOFF COLLECTION POND:
2015 GEOTECNICAL EXPLORATION

Stantec

Summary of Soil Tests

Project Name: CCR Rule - AEP Clifty Creek
Project Number: 175553022
Source: B-12, 10.0'-11.5'
Lab ID: 3

Sample Type: SPT
Date Received: 7-21-15
Date Reported: 8-3-15

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
Moisture Content (%): 23.1

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size Sieve Size	Particle Size (mm)	% Passing
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
No. 4	4.75	100.0
No. 10	2	74.7
No. 40	0.425	74.1
No. 200	0.075	71.7
	0.02	54.4
	0.005	30.3
	0.002	21.1
estimated	0.001	17.0

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	25.3
Coarse Sand	25.3	0.6
Medium Sand	0.6	---
Fine Sand	2.4	2.4
Silt	41.4	50.6
Clay	30.3	21.1

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry
Liquid Limit: 43
Plastic Limit: 21
Plasticity Index: 22
Activity Index: 1.05

Moisture-Density Relationship

Test Not Performed
Maximum Dry Density (lb/ft^3): N/A
Maximum Dry Density (kg/m^3): N/A
Optimum Moisture Content (%): N/A
Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed
Bearing Ratio (%): N/A
Compacted Dry Density (lb/ft^3): N/A
Compacted Moisture Content (%): N/A

Specific Gravity

Test Method: ASTM D 854
Prepared: Dry
Particle Size: No. 10
Specific Gravity at 20° Celsius: 2.70

Classification

Unified Group Symbol: CL
Group Name: Lean clay with sand

AASHTO Classification: A-7-6 (15)

Comments:

Reviewed By RJ

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name	CCR Rule - AEP Clifty Creek	Project Number	175553022
Source	B-12, 10.0'-11.5'	Lab ID	3

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: JS
Test Date: 07-24-2015
Date Received: 07-21-2015

Maximum Particle size: No. 4 Sieve

Sieve Size	% Passing
No. 4	100.0
No. 10	74.7

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

Specific Gravity: 2.7

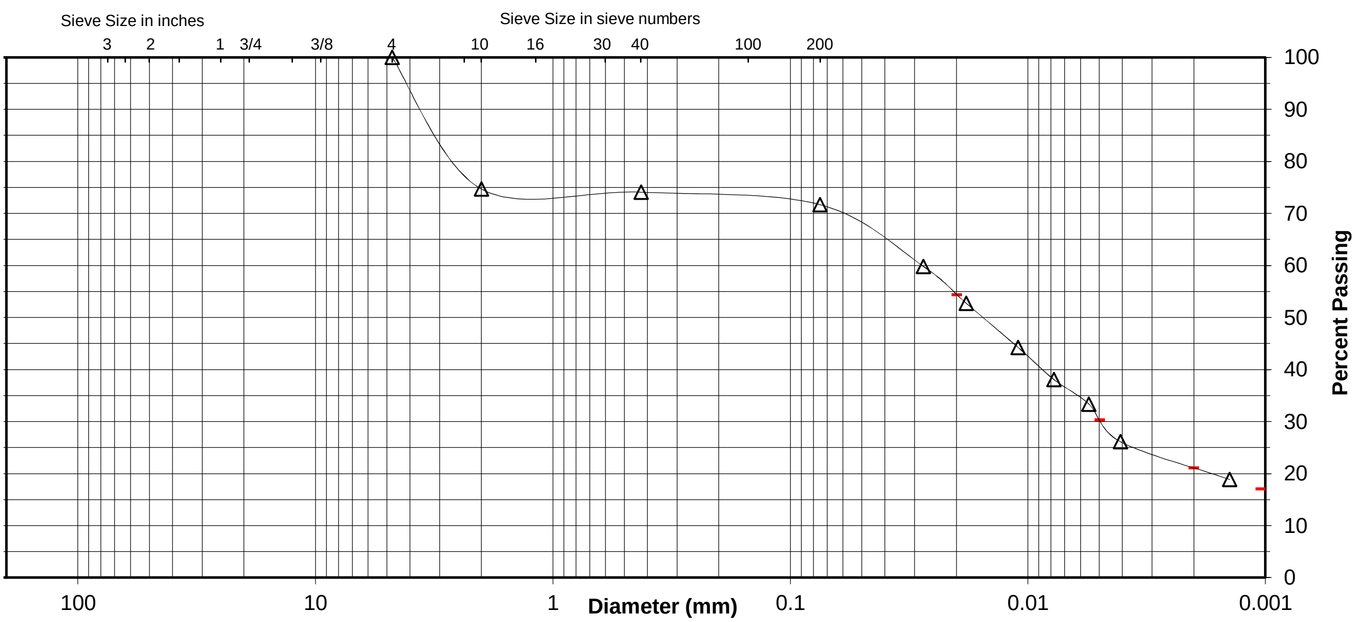
Dispersed using Apparatus A - Mechanical, for 1 minute

No. 40	74.1
No. 200	71.7
0.02 mm	54.4
0.005 mm	30.3
0.002 mm	21.1
0.001 mm	17.0

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	25.3	0.6	2.4	41.4	30.3

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	25.3	0.6	2.4	50.6	21.1



Comments ______

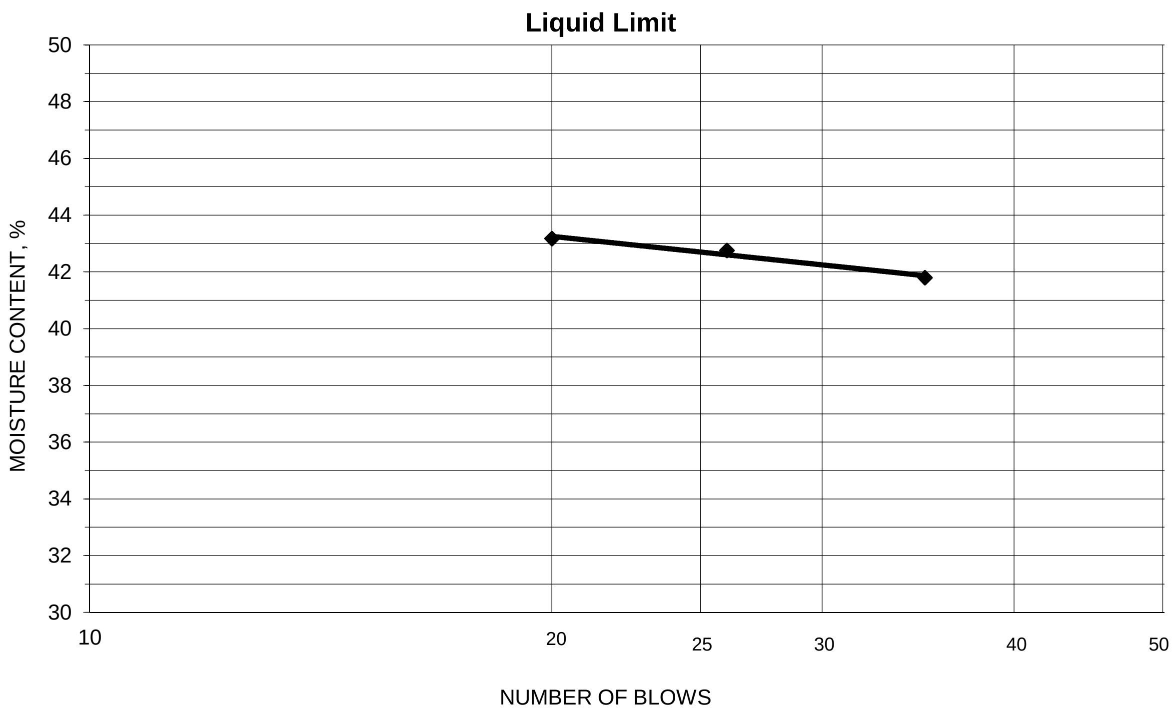
Reviewed By RJ

Stantec

ATTERBERG LIMITS

Project	CCR Rule - AEP Clifty Creek	Project No.	175553022
Source	B-12, 10.0'-11.5'	Lab ID	3
		% + No. 40	26
Tested By	kws	Test Method	ASTM D 4318 Method A
Date Received	07-21-2015		
Test Date	07-27-2015	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
19.52	17.10	11.31	35	41.8	
18.33	16.09	10.85	26	42.7	
19.57	17.04	11.18	20	43.2	43



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
18.01	16.88	11.47	20.9	21	22
17.57	16.44	11.11	21.2		

Remarks: ______

Reviewed By RJ

Stantec

Summary of Soil Tests

Project Name: CCR Rule - AEP Clifty Creek
Project Number: 175553022
Source: B-12, 30.0'-31.5'
Lab ID: 7

Sample Type: SPT
Date Received: 7-21-15
Date Reported: 8-3-15

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
Moisture Content (%): 19.0

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
	N/A	
3/4"	19	100.0
3/8"	9.5	99.8
No. 4	4.75	89.2
No. 10	2	77.8
No. 40	0.425	77.3
No. 200	0.075	71.4
	0.02	42.9
	0.005	21.6
	0.002	15.2
estimated	0.001	12.0

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	10.8	22.2
Coarse Sand	11.4	0.5
Medium Sand	0.5	---
Fine Sand	5.9	5.9
Silt	49.8	56.2
Clay	21.6	15.2

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry

Liquid Limit: 31
Plastic Limit: 18
Plasticity Index: 13
Activity Index: 0.87

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3): N/A
Maximum Dry Density (kg/m^3): N/A
Optimum Moisture Content (%): N/A
Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A
Compacted Dry Density (lb/ft^3): N/A
Compacted Moisture Content (%): N/A

Specific Gravity

Test Method: ASTM D 854
Prepared: Dry

Particle Size: No. 10
Specific Gravity at 20° Celsius: 2.68

Classification

Unified Group Symbol: CL
Group Name: Lean clay with sand

AASHTO Classification: A-6 (7)

Comments:

Reviewed By RJ

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name: CCR Rule - AEP Clifty Creek
Source: B-12, 30.0'-31.5'

Project Number: 175553022
Lab ID: 7

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: JS
Test Date: 07-24-2015
Date Received: 07-21-2015

Maximum Particle size: 3/4" Sieve

Sieve Size	% Passing
3/4"	100.0
3/8"	99.8
No. 4	89.2
No. 10	77.8

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

Specific Gravity: 2.68

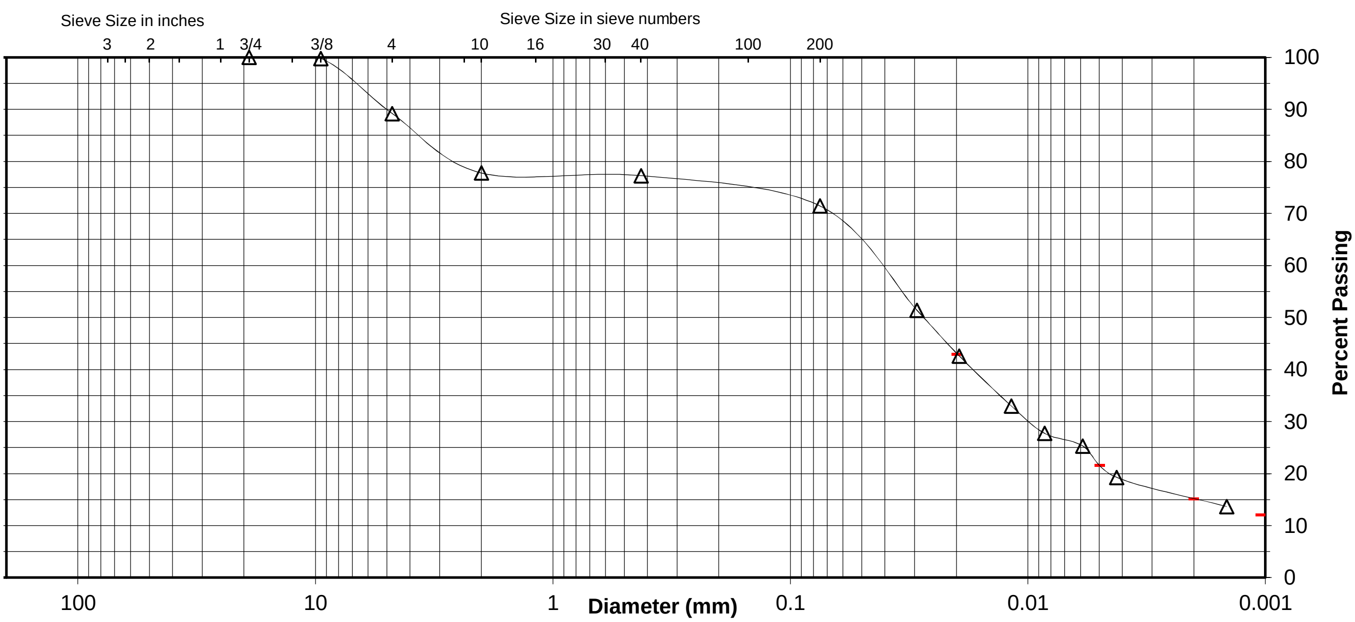
Dispersed using Apparatus A - Mechanical, for 1 minute

No. 40	77.3
No. 200	71.4
0.02 mm	42.9
0.005 mm	21.6
0.002 mm	15.2
0.001 mm	12.0

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	10.8	11.4	0.5	5.9	49.8	21.6

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	22.2	0.5	5.9	56.2	15.2



Comments ______

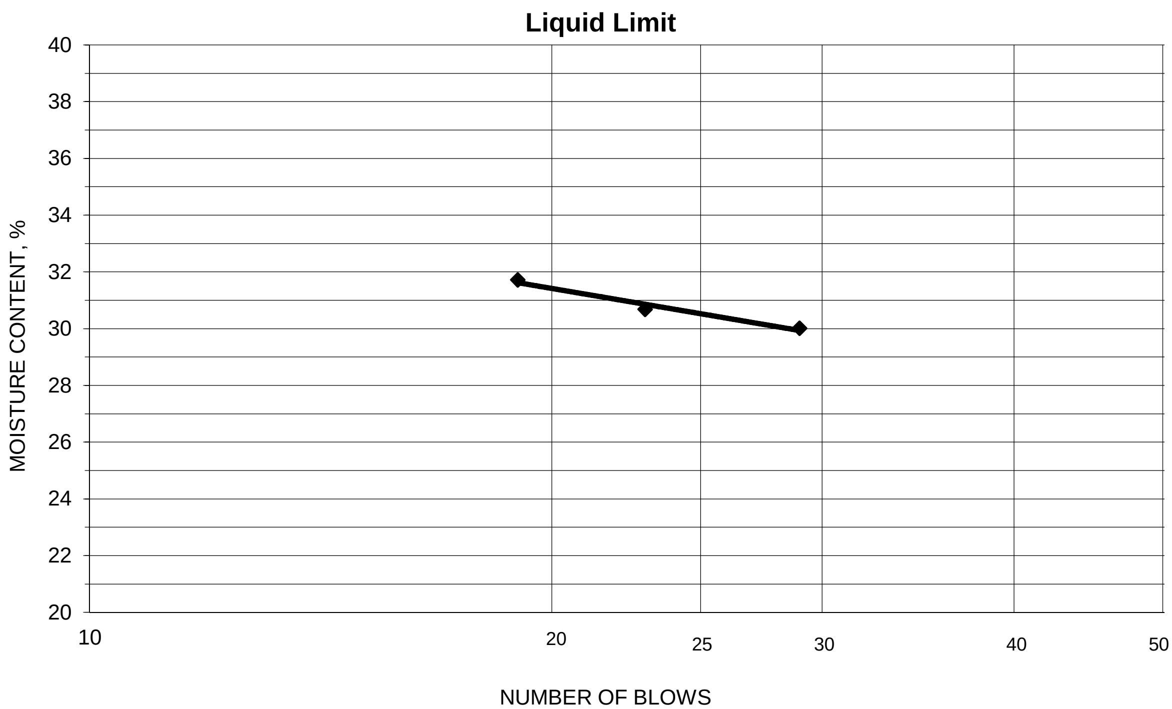
Reviewed By: RJ

Stantec

ATTERBERG LIMITS

Project	CCR Rule - AEP Clifty Creek	Project No.	175553022
Source	B-12, 30.0'-31.5'	Lab ID	7
		% + No. 40	23
Tested By	KG	Test Method	ASTM D 4318 Method A
Date Received	07-21-2015		
Test Date	07-31-2015	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
19.80	17.75	10.92	29	30.0	31
19.72	17.68	11.03	23	30.7	
20.84	18.48	11.04	19	31.7	



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
19.95	18.61	11.11	17.9	18	13
20.10	18.75	11.18	17.8		

Remarks:

Reviewed By RJ

Stantec

Summary of Soil Tests

Project Name: CCR Rule - AEP Clifty Creek
Project Number: 175553022
Source: B-12, 45.0'-46.5'
Lab ID: 10

Sample Type: SPT
Date Received: 7-21-15
Date Reported: 8-3-15

Test Results

Natural Moisture Content
Test Method: ASTM D 2216
Moisture Content (%): 18.7

Particle Size Analysis
Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size: Sieve Size	Particle Size: (mm)	% Passing
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
No. 4	4.75	100.0
No. 10	2	99.3
No. 40	0.425	99.2
No. 200	0.075	82.2
	0.02	34.0
	0.005	14.0
	0.002	10.7
estimated	0.001	10.0

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	0.7
Coarse Sand	0.7	0.1
Medium Sand	0.1	---
Fine Sand	17.0	17.0
Silt	68.2	71.5
Clay	14.0	10.7

Atterberg Limits
Test Method: ASTM D 4318 Method A
Prepared: Dry
Liquid Limit: 26
Plastic Limit: 19
Plasticity Index: 7
Activity Index: 0.64

Moisture-Density Relationship
Test Not Performed
Maximum Dry Density (lb/ft^3): N/A
Maximum Dry Density (kg/m^3): N/A
Optimum Moisture Content (%): N/A
Over Size Correction %: N/A

California Bearing Ratio
Test Not Performed
Bearing Ratio (%): N/A
Compacted Dry Density (lb/ft^3): N/A
Compacted Moisture Content (%): N/A

Specific Gravity
Test Method: ASTM D 854
Prepared: Dry
Particle Size: No. 10
Specific Gravity at 20° Celsius: 2.72

Classification
Unified Group Symbol: CL-ML
Group Name: Silty clay with sand

AASHTO Classification: A-4 (4)

Comments:

Reviewed By: RJ

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name	CCR Rule - AEP Clifty Creek	Project Number	175553022
Source	B-12, 45.0'-46.5'	Lab ID	10

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: JS
Test Date: 07-24-2015
Date Received: 07-21-2015

Maximum Particle size: No. 4 Sieve

Sieve Size	% Passing
No. 4	100.0
No. 10	99.3

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

Specific Gravity: 2.72

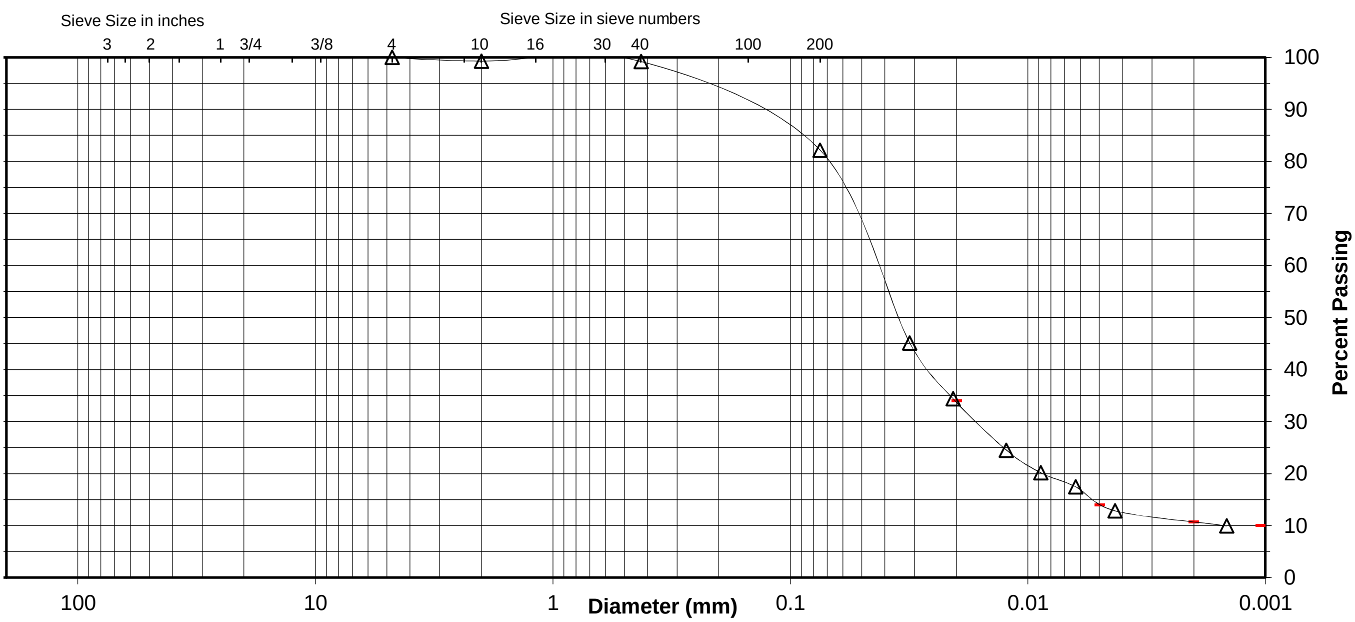
Dispersed using Apparatus A - Mechanical, for 1 minute

No. 40	99.2
No. 200	82.2
0.02 mm	34.0
0.005 mm	14.0
0.002 mm	10.7
0.001 mm	10.0

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	0.7	0.1	17.0	68.2	14.0

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	0.7	0.1	17.0	71.5	10.7



Comments ____________________

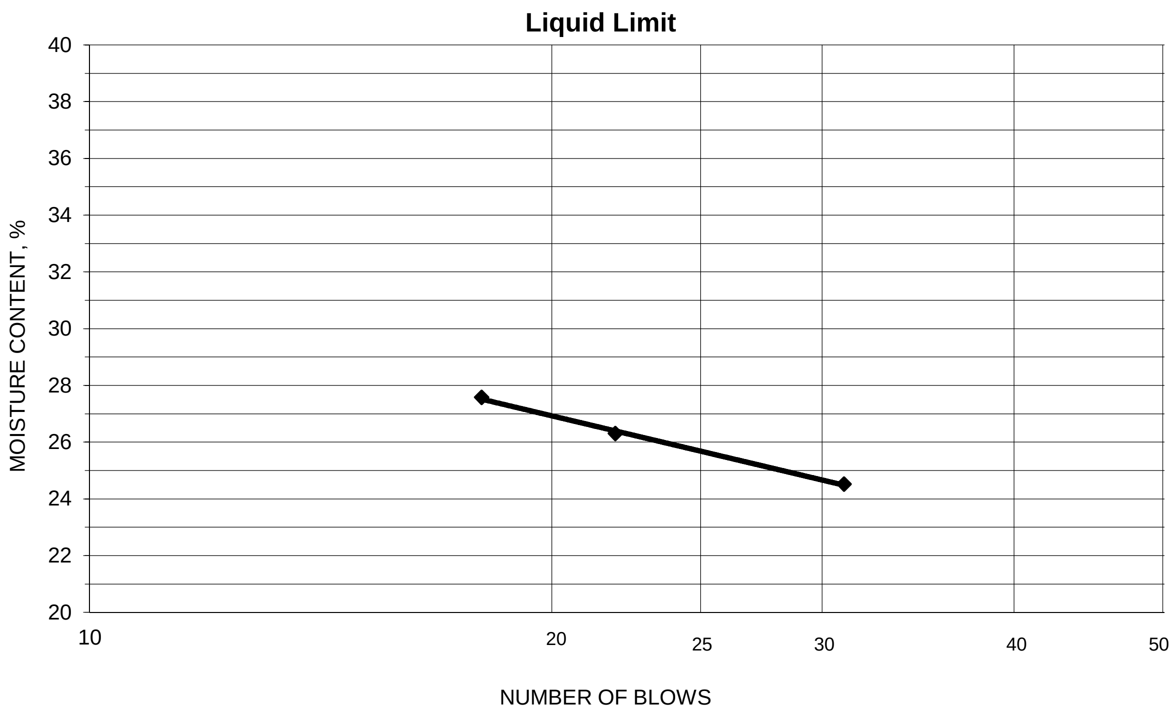
Reviewed By RJ

Stantec

ATTERBERG LIMITS

Project	CCR Rule - AEP Clifty Creek			Project No.	175553022
Source	B-12, 45.0'-46.5'			Lab ID	10
				% + No. 40	1
Tested By	TA	Test Method	ASTM D 4318 Method A	Date Received	07-21-2015
Test Date	07-30-2015	Prepared	Dry		

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
19.13	17.46	11.11	22	26.3	26
21.65	19.32	10.87	18	27.6	
22.47	20.32	11.55	31	24.5	



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
17.45	16.47	11.42	19.4	19	7
17.70	16.74	11.60	18.7		

Remarks:

Reviewed By RJ

Stantec

Summary of Soil Tests

Project Name: CCR Rule - AEP Clifty Creek
Project Number: 175553022
Source: B-12, 50.0'-51.5'
Lab ID: 11

Sample Type: SPT
Date Received: 7-21-15
Date Reported: 8-3-15

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
Moisture Content (%): 21.9

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
No. 10	2	100.0
No. 40	0.425	99.8
No. 200	0.075	81.3
	0.02	29.1
	0.005	6.3
	0.002	3.2
estimated	0.001	1.0

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	0.0
Coarse Sand	0.0	0.2
Medium Sand	0.2	---
Fine Sand	18.5	18.5
Silt	75.0	78.1
Clay	6.3	3.2

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry

Liquid Limit: NP
Plastic Limit: NP
Plasticity Index: NP
Activity Index: N/A

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3): N/A
Maximum Dry Density (kg/m^3): N/A
Optimum Moisture Content (%): N/A
Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A
Compacted Dry Density (lb/ft^3): N/A
Compacted Moisture Content (%): N/A

Specific Gravity

Test Method: ASTM D 854
Prepared: Dry

Particle Size: No. 10
Specific Gravity at 20° Celsius: 2.68

Classification

Unified Group Symbol: ML
Group Name: Silt with sand

AASHTO Classification: A-4 (0)

Comments:

Reviewed By RJ

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name: CCR Rule - AEP Clifty Creek
Source: B-12, 50.0'-51.5'
Project Number: 175553022
Lab ID: 11

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared using: ASTM D 421

Particle Shape: N/A
Particle Hardness: N/A

Tested By: JS
Test Date: 07-24-2015
Date Received: 07-21-2015

Maximum Particle size: No. 10 Sieve

Sieve Size	% Passing
No. 10	100.0

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

Specific Gravity: 2.68

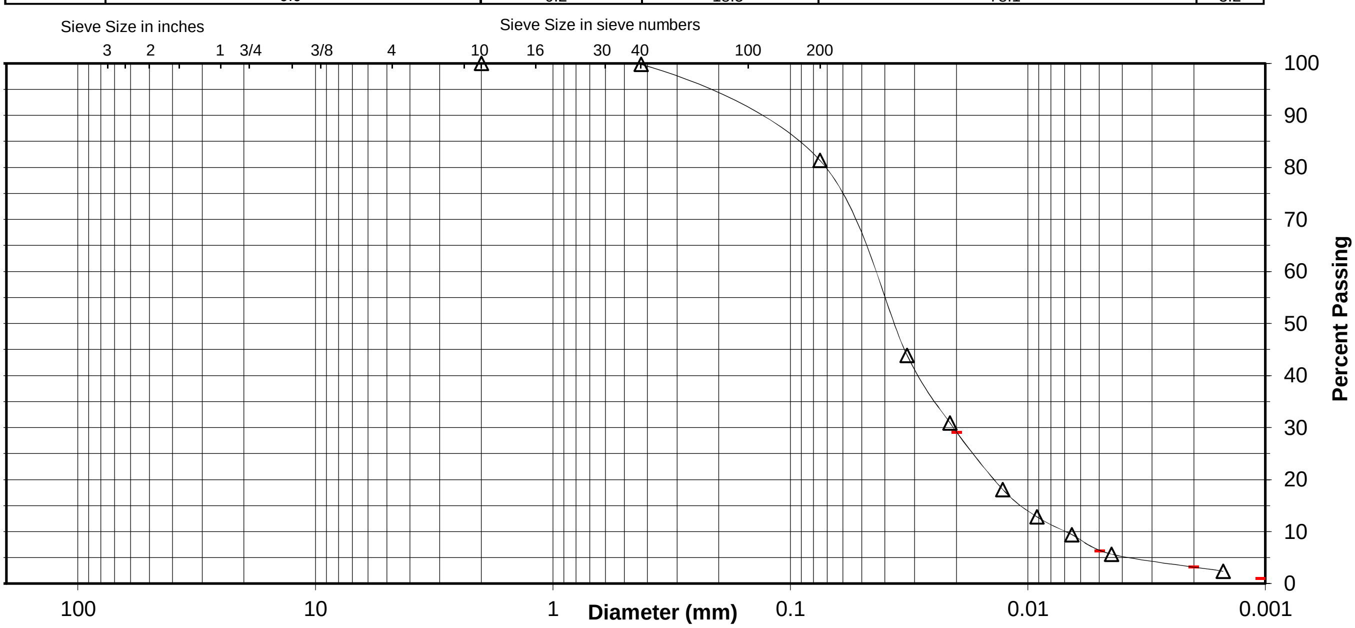
Dispersed using Apparatus A - Mechanical, for 1 minute

No. 40	99.8
No. 200	81.3
0.02 mm	29.1
0.005 mm	6.3
0.002 mm	3.2
0.001 mm	1.0

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	0.0	0.2	18.5	75.0	6.3

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	0.0	0.2	18.5	78.1	3.2



Comments ______

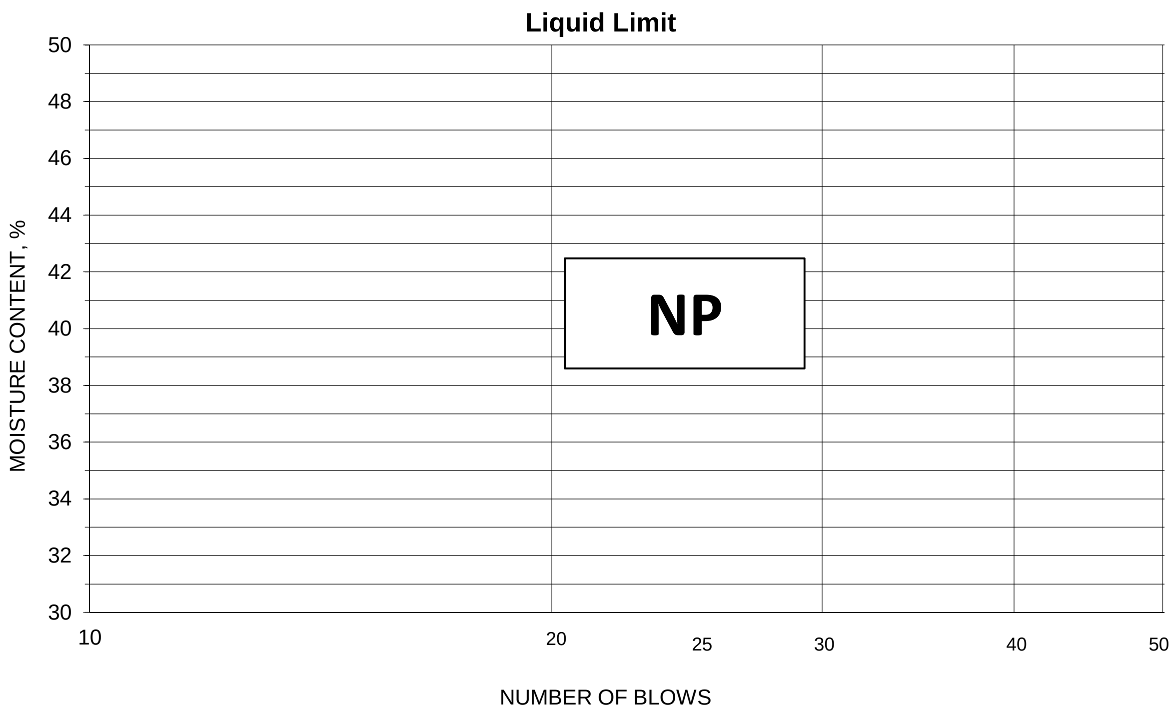
Reviewed By RJ

Stantec

ATTERBERG LIMITS

Project	CCR Rule - AEP Clifty Creek	Project No.	175553022
Source	B-12, 50.0'-51.5'	Lab ID	11
		% + No. 40	0
Tested By	TA	Test Method	ASTM D 4318 Method A
Date Received	07-21-2015		
Test Date	07-30-2015	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index

Remarks:

Reviewed By RJ

Stantec

Summary of Soil Tests

Project Name	CCR Rule - AEP Clifty Creek	Project Number	175553022
Source	B-12, 60.0'-61.5'	Lab ID	13
Sample Type	SPT	Date Received	7-21-15
		Date Reported	8-3-15

Test Results

Natural Moisture Content

Test Method: ASTM D 2216

Moisture Content (%): 14.8

Particle Size Analysis

Preparation Method: ASTM D 421

Gradation Method: ASTM D 422

Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
No. 4	4.75	100.0
No. 10	2	98.5
No. 40	0.425	95.7
No. 200	0.075	36.1
	0.02	12.4
	0.005	5.1
	0.002	2.8
estimated	0.001	1.0

Plus 3 in. material, not included: 0 (%)

	ASTM	AASHTO
Range	(%)	(%)
Gravel	0.0	1.5
Coarse Sand	1.5	2.8
Medium Sand	2.8	---
Fine Sand	59.6	59.6
Silt	31.0	33.3
Clay	5.1	2.8

Atterberg Limits

Test Method: ASTM D 4318 Method A

Prepared: Dry

Liquid Limit: NP

Plastic Limit: NP

Plasticity Index: NP

Activity Index: N/A

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3): N/A

Maximum Dry Density (kg/m^3): N/A

Optimum Moisture Content (%): N/A

Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A

Compacted Dry Density (lb/ft^3): N/A

Compacted Moisture Content (%): N/A

Specific Gravity

Test Method: ASTM D 854

Prepared: Dry

Particle Size: No. 10

Specific Gravity at 20° Celsius: 2.75

Classification

Unified Group Symbol: SM

Group Name: Silty sand

AASHTO Classification: A-4 (0)

Comments:

Reviewed By RJ

Stantec

Particle-Size Analysis of Soils

ASTM D 422

Project Name: CCR Rule - AEP Clifty Creek
Project Number: 175553022
Source: B-12, 60.0'-61.5'
Lab ID: 13

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: JS
Test Date: 07-24-2015
Date Received: 07-21-2015

Maximum Particle size: No. 4 Sieve

Sieve Size	% Passing
No. 4	100.0
No. 10	98.5

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

Specific Gravity: 2.75

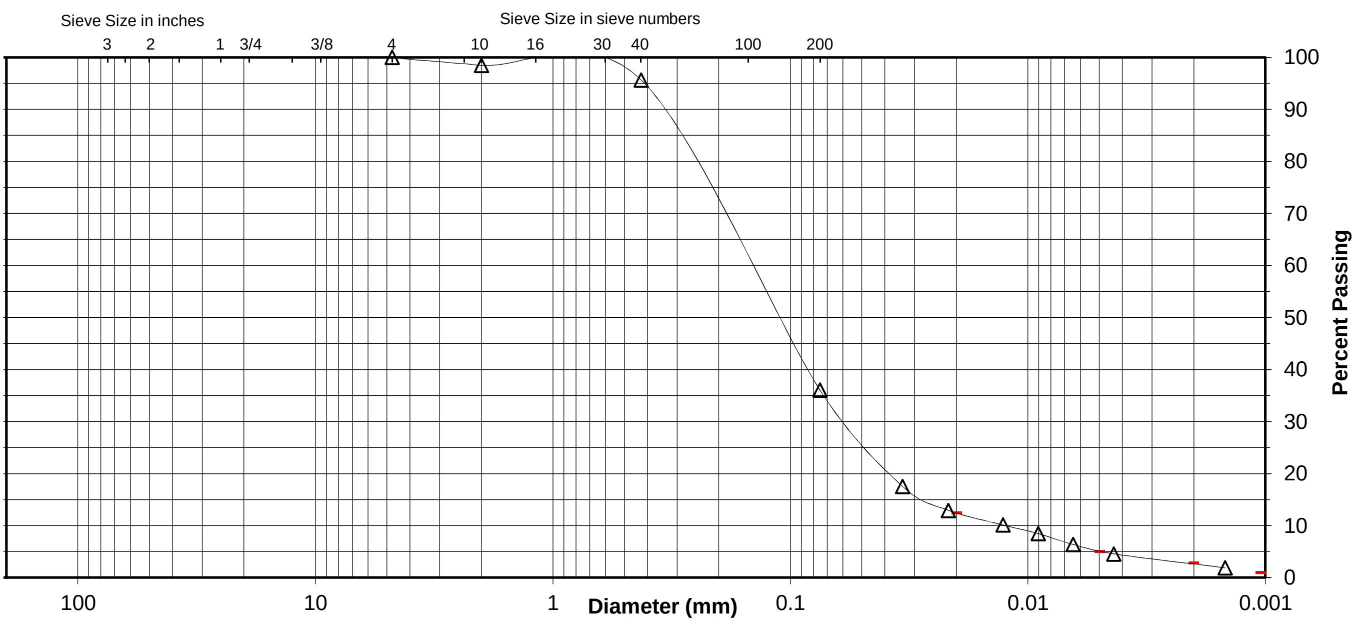
Dispersed using Apparatus A - Mechanical, for 1 minute

No. 40	95.7
No. 200	36.1
0.02 mm	12.4
0.005 mm	5.1
0.002 mm	2.8
0.001 mm	1.0

Particle Size Distribution

	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
ASTM	0.0	0.0	1.5	2.8	59.6	31.0	5.1

	Gravel	Coarse Sand	Fine Sand	Silt	Clay
AASHTO	1.5	2.8	59.6	33.3	2.8



Comments ______

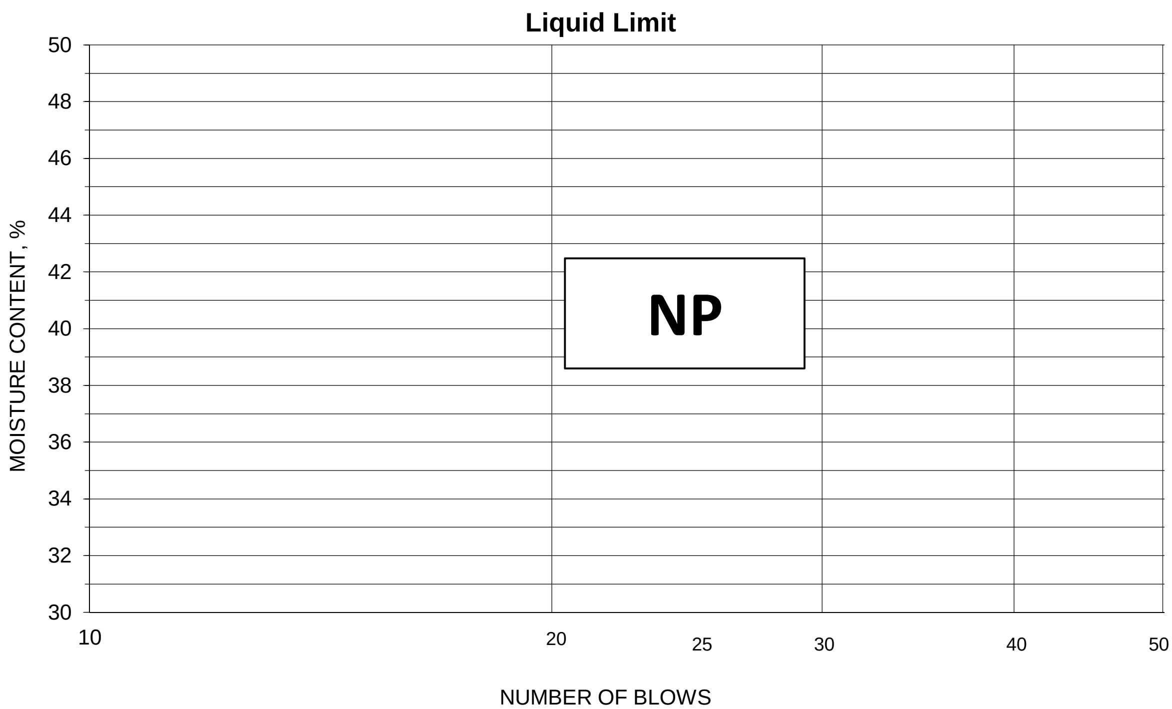
Reviewed By RJ

Stantec

ATTERBERG LIMITS

Project	CCR Rule - AEP Clifty Creek	Project No.	175553022
Source	B-12, 60.0'-61.5'	Lab ID	13
		% + No. 40	4
Tested By	DB	Test Method	ASTM D 4318 Method A
Date Received	07-21-2015		
Test Date	07-24-2015	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index

Remarks:

Reviewed By RJ

Stantec

Summary of Soil Tests

Project Name	CCR Rule - AEP Clifty Creek	Project Number	175553022
Source	B-12, 70.0'-71.5'	Lab ID	15
Sample Type	SPT	Date Received	7-21-15
		Date Reported	8-3-15

Test Results

Natural Moisture Content

Test Method: ASTM D 2216

Moisture Content (%): 21.6

Particle Size Analysis

Preparation Method: ASTM D 421

Gradation Method: ASTM D 422

Hydrometer Method: ASTM D 422

Particle Size		%
Sieve Size	(mm)	Passing
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
No. 10	2	100.0
No. 40	0.425	98.6
No. 200	0.075	56.5
	0.02	21.7
	0.005	3.7
	0.002	1.5
estimated	0.001	1.0

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	0.0
Coarse Sand	0.0	1.4
Medium Sand	1.4	---
Fine Sand	42.1	42.1
Silt	52.8	55.0
Clay	3.7	1.5

Atterberg Limits

Test Method: ASTM D 4318 Method A

Prepared: Dry

Liquid Limit: NP

Plastic Limit: NP

Plasticity Index: NP

Activity Index: N/A

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3): N/A

Maximum Dry Density (kg/m^3): N/A

Optimum Moisture Content (%): N/A

Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A

Compacted Dry Density (lb/ft^3): N/A

Compacted Moisture Content (%): N/A

Specific Gravity

Test Method: ASTM D 854

Prepared: Dry

Particle Size: No. 10

Specific Gravity at 20° Celsius: 2.71

Classification

Unified Group Symbol: ML

Group Name: Sandy silt

AASHTO Classification: A-4 (0)

Comments:

Reviewed By RJ

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name	CCR Rule - AEP Clifty Creek	Project Number	175553022
Source	B-12, 70.0'-71.5'	Lab ID	15

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method ASTM D 422
Prepared using ASTM D 421

Particle Shape N/A
Particle Hardness: N/A

Tested By JS
Test Date 07-24-2015
Date Received 07-21-2015

Maximum Particle size: No. 10 Sieve

Sieve Size	% Passing
No. 10	100.0

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

Specific Gravity 2.71

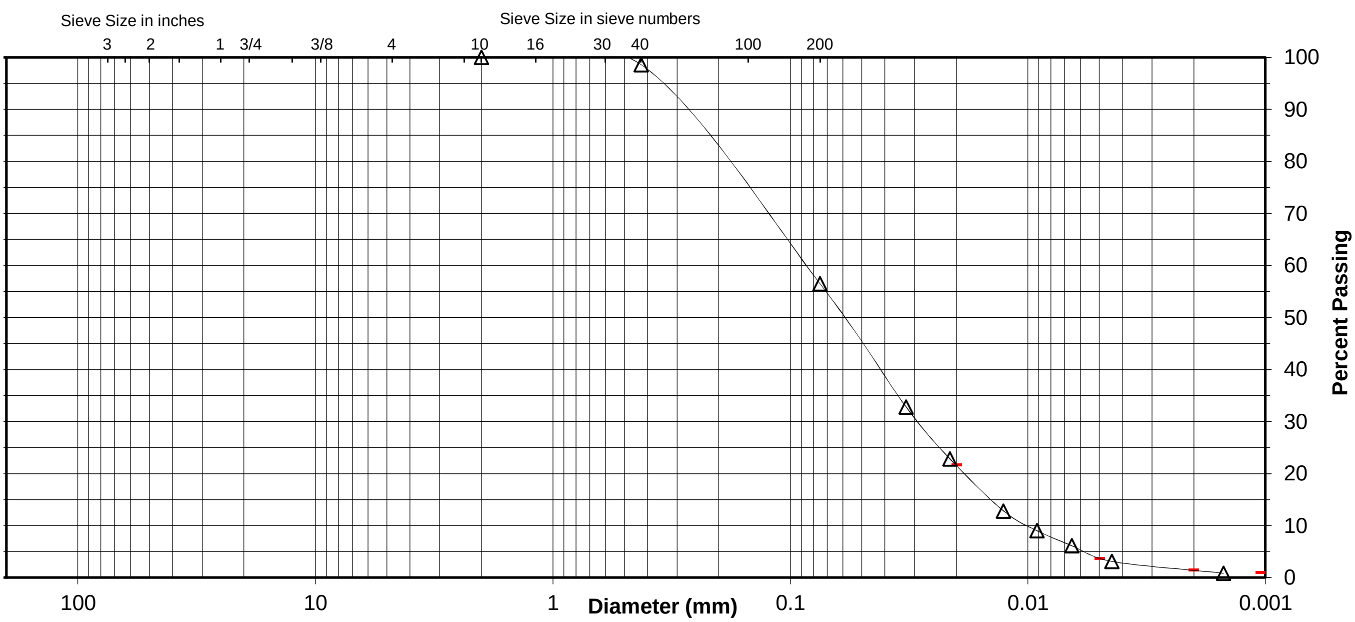
Dispersed using Apparatus A - Mechanical, for 1 minute

No. 40	98.6
No. 200	56.5
0.02 mm	21.7
0.005 mm	3.7
0.002 mm	1.5
0.001 mm	1.0

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	0.0	1.4	42.1	52.8	3.7

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	0.0	1.4	42.1	55.0	1.5



Comments ______

Reviewed By RJ

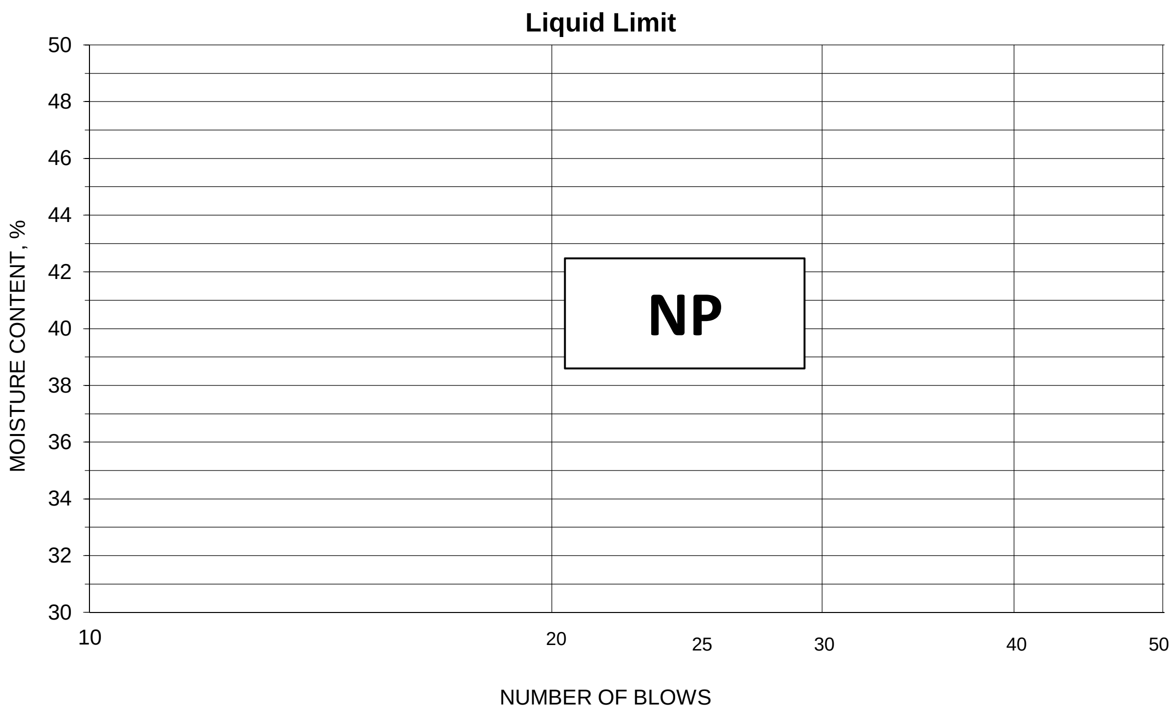
Stantec

ATTERBERG LIMITS

Project	CCR Rule - AEP Clifty Creek	Project No.	175553022
Source	B-12, 70.0'-71.5'	Lab ID	15
		% + No. 40	1

Tested By	KDG	Test Method	ASTM D 4318 Method A	Date Received	07-21-2015
Test Date	07-31-2015	Prepared	Dry		

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index

Remarks:

Reviewed By RJ

Stantec

Summary of Soil Tests

Project Name: CCR Rule - AEP Clifty Creek
Project Number: 175553022
Source: B-12, 80.0'-81.5'
Lab ID: 17

Sample Type: SPT
Date Received: 7-21-15
Date Reported: 8-3-15

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
Moisture Content (%): 25.7

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size Sieve Size	(mm)	% Passing
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
No. 4	4.75	100.0
No. 10	2	98.9
No. 40	0.425	98.9
No. 200	0.075	90.2
	0.02	28.8
	0.005	5.6
	0.002	1.4
estimated	0.001	0.0

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	1.1
Coarse Sand	1.1	0.0
Medium Sand	0.0	---
Fine Sand	8.7	8.7
Silt	84.6	88.8
Clay	5.6	1.4

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry

Liquid Limit: NP
Plastic Limit: NP
Plasticity Index: NP
Activity Index: N/A

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3): N/A
Maximum Dry Density (kg/m^3): N/A
Optimum Moisture Content (%): N/A
Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A
Compacted Dry Density (lb/ft^3): N/A
Compacted Moisture Content (%): N/A

Specific Gravity

Test Method: ASTM D 854
Prepared: Dry

Particle Size: No. 10
Specific Gravity at 20° Celsius: 2.73

Classification

Unified Group Symbol: ML
Group Name: Silt

AASHTO Classification: A-4 (0)

Comments:

Reviewed By RJ

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name	CCR Rule - AEP Clifty Creek	Project Number	175553022
Source	B-12, 80.0'-81.5'	Lab ID	17

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: JS
Test Date: 07-24-2015
Date Received: 07-21-2015

Maximum Particle size: No. 4 Sieve

Sieve Size	% Passing
No. 4	100.0
No. 10	98.9

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

Specific Gravity 2.73

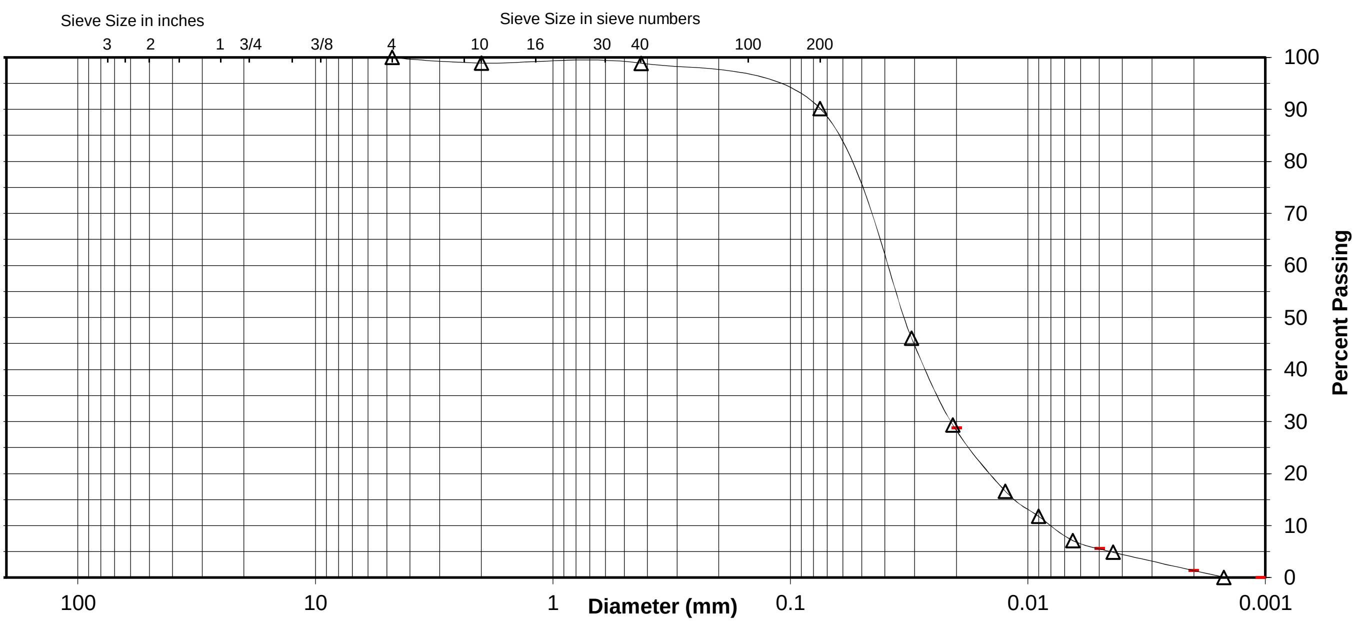
Dispersed using Apparatus A - Mechanical, for 1 minute

No. 40	98.9
No. 200	90.2
0.02 mm	28.8
0.005 mm	5.6
0.002 mm	1.4
0.001 mm	0.0

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	1.1	0.0	8.7	84.6	5.6

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	1.1	0.0	8.7	88.8	1.4



Comments ______

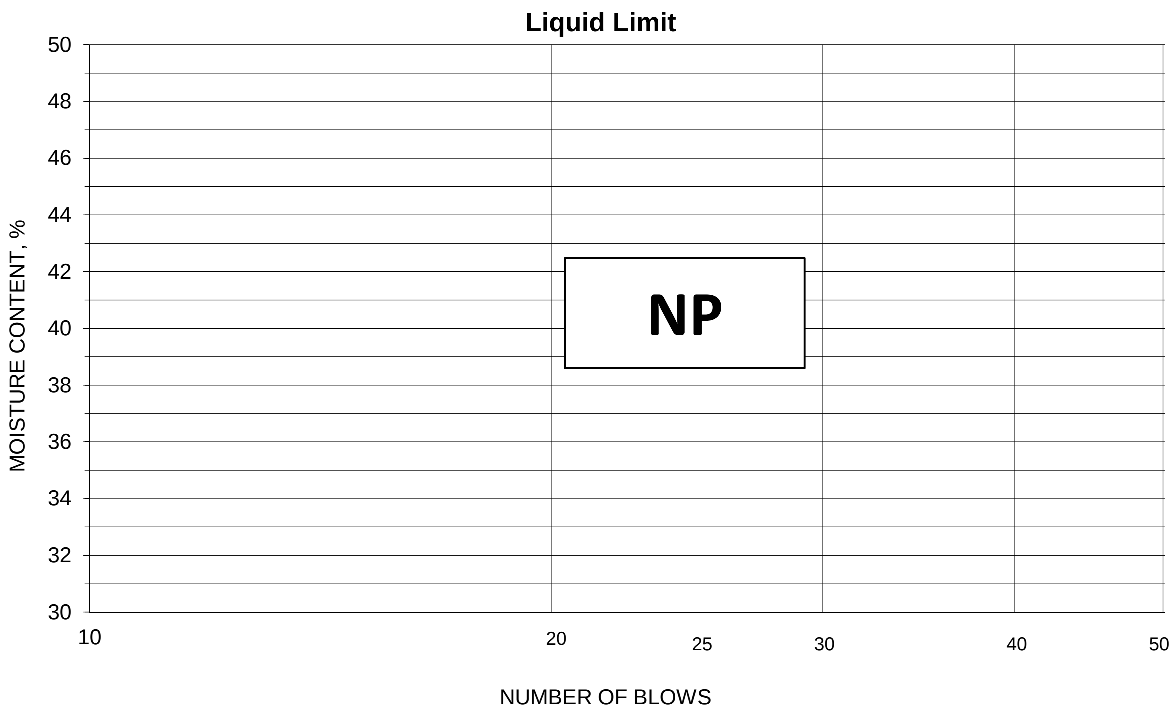
Reviewed By RJ

Stantec

ATTERBERG LIMITS

Project	CCR Rule - AEP Clifty Creek	Project No.	175553022
Source	B-12, 80.0'-81.5'	Lab ID	17
		% + No. 40	1
Tested By	KG	Test Method	ASTM D 4318 Method A
Date Received	07-21-2015		
Test Date	07-24-2015	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index

Remarks:

Reviewed By RJ

Stantec

Summary of Soil Tests

Project Name: CCR Rule - AEP Clifty Creek
Project Number: 175553022
Source: B-12, 95.0'-96.5'
Lab ID: 20

Sample Type: SPT
Date Received: 7-21-15
Date Reported: 8-3-15

Test Results

Natural Moisture Content

Test Method: ASTM D 2216
Moisture Content (%): 23.4

Particle Size Analysis

Preparation Method: ASTM D 421
Gradation Method: ASTM D 422
Hydrometer Method: ASTM D 422

Particle Size Sieve Size	(mm)	% Passing
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
	N/A	
No. 4	4.75	100.0
No. 10	2	92.9
No. 40	0.425	92.4
No. 200	0.075	86.2
	0.02	71.6
	0.005	43.0
	0.002	30.6
estimated	0.001	26.0

Plus 3 in. material, not included: 0 (%)

Range	ASTM (%)	AASHTO (%)
Gravel	0.0	7.1
Coarse Sand	7.1	0.5
Medium Sand	0.5	---
Fine Sand	6.2	6.2
Silt	43.2	55.6
Clay	43.0	30.6

Atterberg Limits

Test Method: ASTM D 4318 Method A
Prepared: Dry

Liquid Limit: 42
Plastic Limit: 19
Plasticity Index: 23
Activity Index: 0.74

Moisture-Density Relationship

Test Not Performed

Maximum Dry Density (lb/ft^3): N/A
Maximum Dry Density (kg/m^3): N/A
Optimum Moisture Content (%): N/A
Over Size Correction %: N/A

California Bearing Ratio

Test Not Performed

Bearing Ratio (%): N/A
Compacted Dry Density (lb/ft^3): N/A
Compacted Moisture Content (%): N/A

Specific Gravity

Test Method: ASTM D 854
Prepared: Dry

Particle Size: No. 10
Specific Gravity at 20° Celsius: 2.68

Classification

Unified Group Symbol: CL
Group Name: Lean clay

AASHTO Classification: A-7-6 (20)

Comments:

Reviewed By RJ

Stantec

Particle-Size Analysis of Soils
ASTM D 422

Project Name	CCR Rule - AEP Clifty Creek	Project Number	175553022
Source	B-12, 95.0'-96.5'	Lab ID	20

Sieve analysis for the Portion Coarser than the No. 10 Sieve

Test Method: ASTM D 422
Prepared using: ASTM D 421

Particle Shape: Angular
Particle Hardness: Hard and Durable

Tested By: JS
Test Date: 07-24-2015
Date Received: 07-21-2015

Maximum Particle size: No. 4 Sieve

Sieve Size	% Passing
No. 4	100.0
No. 10	92.9

Analysis for the portion Finer than the No. 10 Sieve

Analysis Based on -3 inch fraction only

Specific Gravity: 2.68

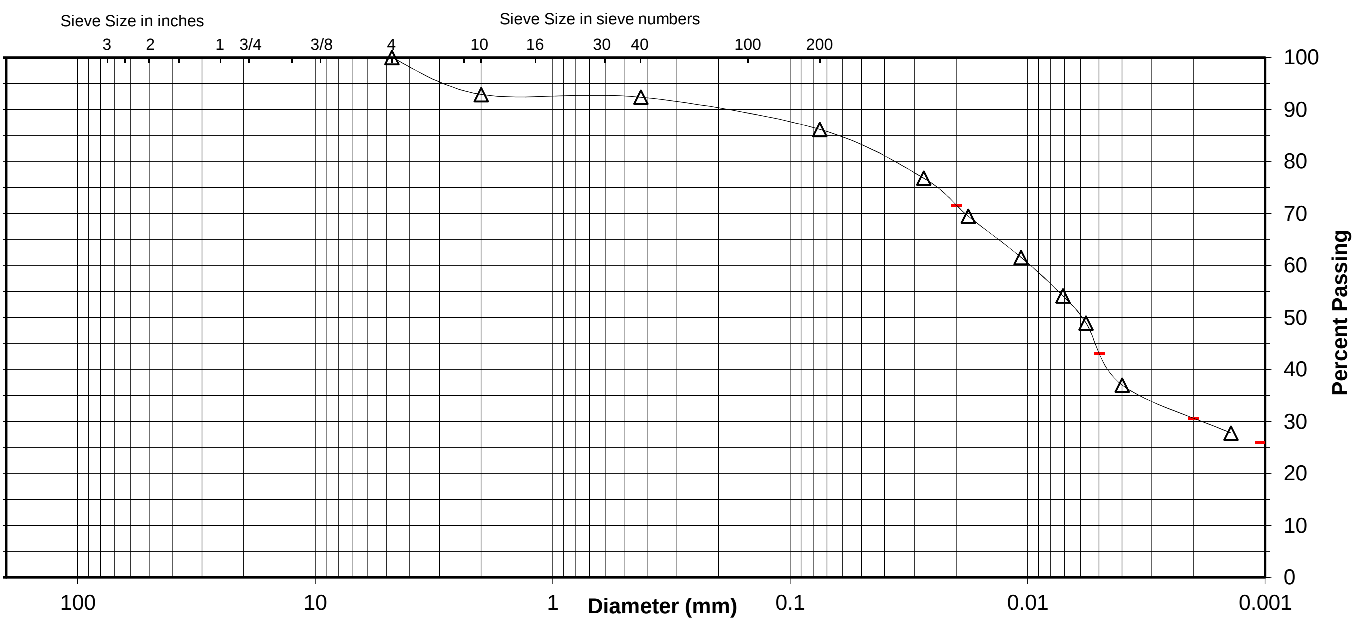
Dispersed using Apparatus A - Mechanical, for 1 minute

No. 40	92.4
No. 200	86.2
0.02 mm	71.6
0.005 mm	43.0
0.002 mm	30.6
0.001 mm	26.0

Particle Size Distribution

ASTM	Coarse Gravel	Fine Gravel	C. Sand	Medium Sand	Fine Sand	Silt	Clay
	0.0	0.0	7.1	0.5	6.2	43.2	43.0

AASHTO	Gravel	Coarse Sand	Fine Sand	Silt	Clay
	7.1	0.5	6.2	55.6	30.6



Comments ______

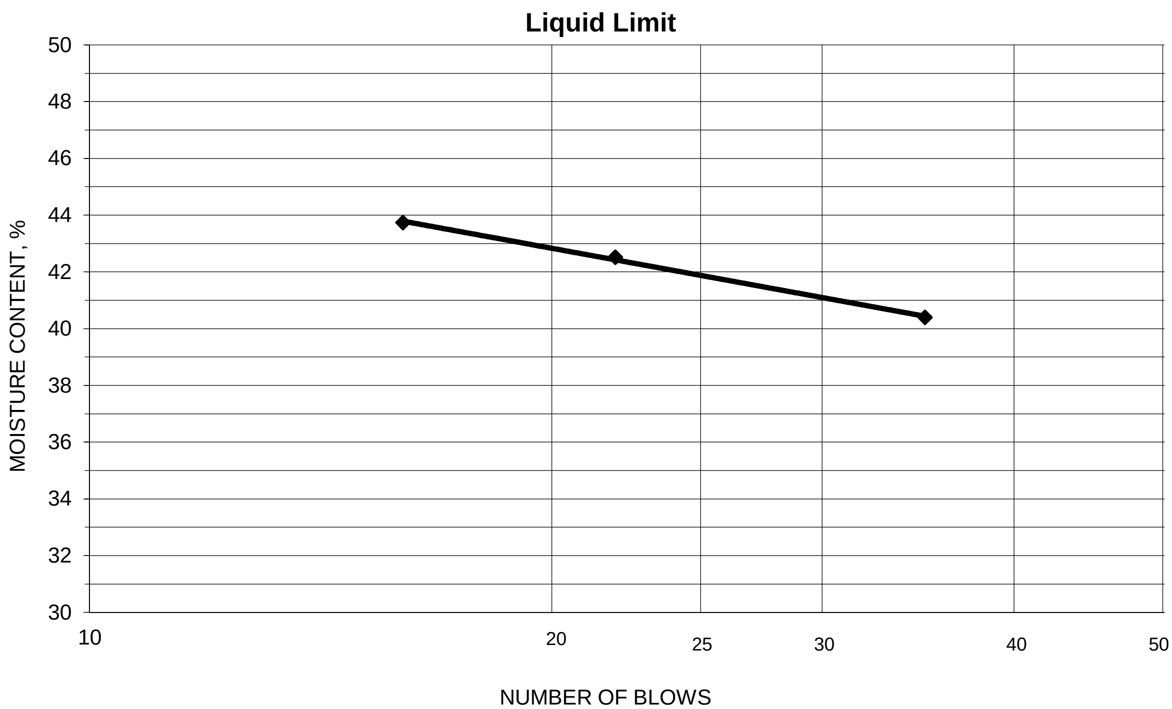
Reviewed By RJ

Stantec

ATTERBERG LIMITS

Project	CCR Rule - AEP Clifty Creek	Project No.	175553022
Source	B-12, 95.0'-96.5'	Lab ID	20
		% + No. 40	8
Tested By	KDG	Test Method	ASTM D 4318 Method A
Date Received	07-21-2015		
Test Date	07-31-2015	Prepared	Dry

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Number of Blows	Water Content (%)	Liquid Limit
23.24	19.63	11.14	22	42.5	42
20.15	17.36	10.98	16	43.7	
21.03	18.17	11.09	35	40.4	



PLASTIC LIMIT AND PLASTICITY INDEX

Wet Soil and Tare Mass (g)	Dry Soil and Tare Mass (g)	Tare Mass (g)	Water Content (%)	Plastic Limit	Plasticity Index
17.59	16.51	10.80	18.9	19	23
17.15	16.14	10.89	19.2		

Remarks:

Reviewed By RJ

APPENDIX E

CONSOLIDATED-UNDRAINED TRIAXIAL TESTS

BOILER SLAG POND DAM

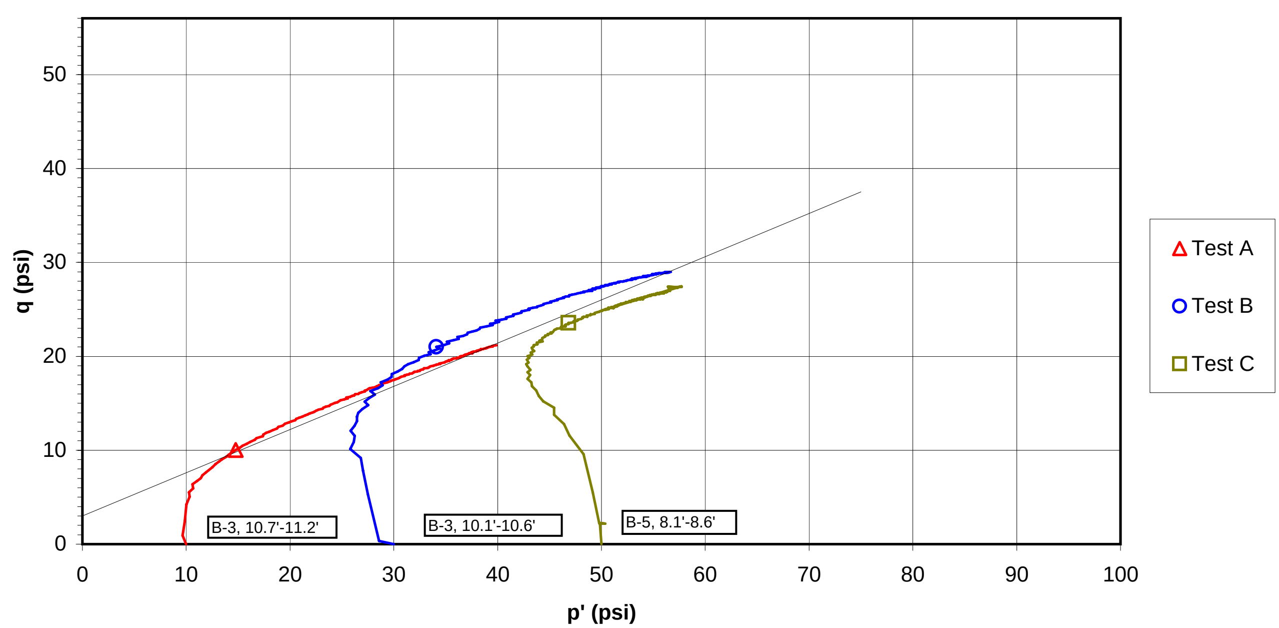
Consolidated Undrained Triaxial Test
ASTM D4767-04

Project	AEP-Clifty Creek-West Bottom and Fly Ash Ponds subsurface exploration	Project No.	175539022
Sample ID	B-3, 10.7'-11.2' & B-3, 10.1'-10.6' & B-5, 8.1'-8.6'	Test Number	1

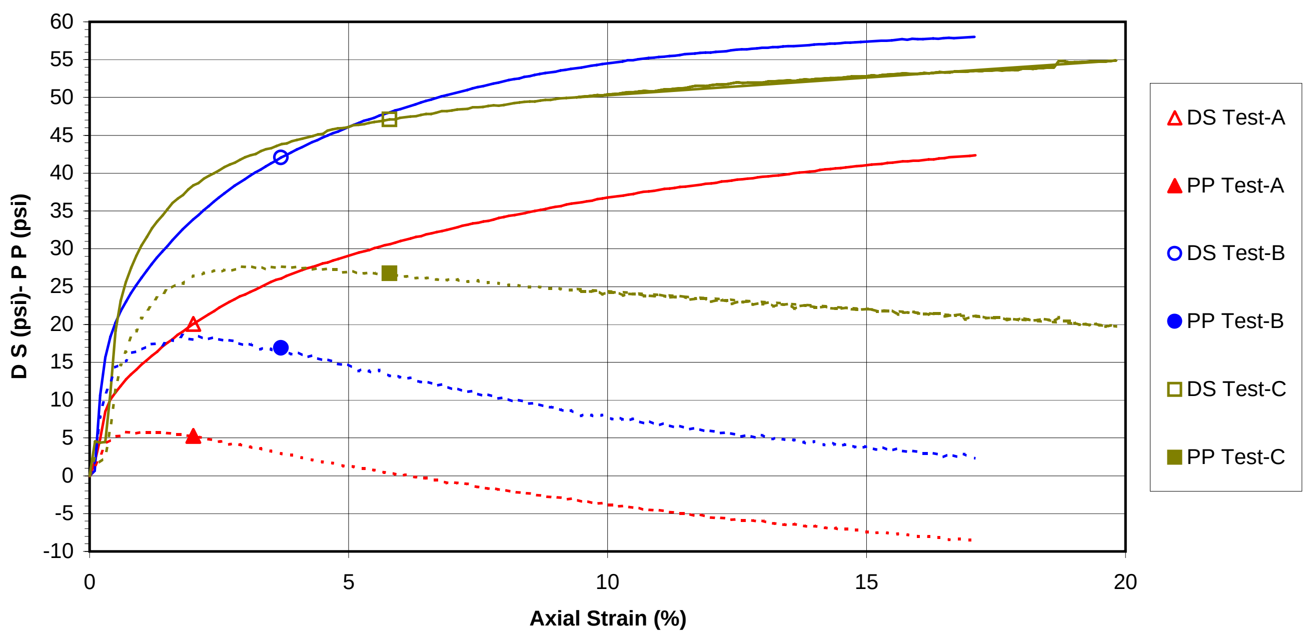
ϕ' = 27.4 deg. c' = 490 psf

Failure Criterion: Maximum Effective Principal Stress Ratio

p' vs. q Plot



Deviator Stress and Induced Pore Pressure vs. Axial Strain

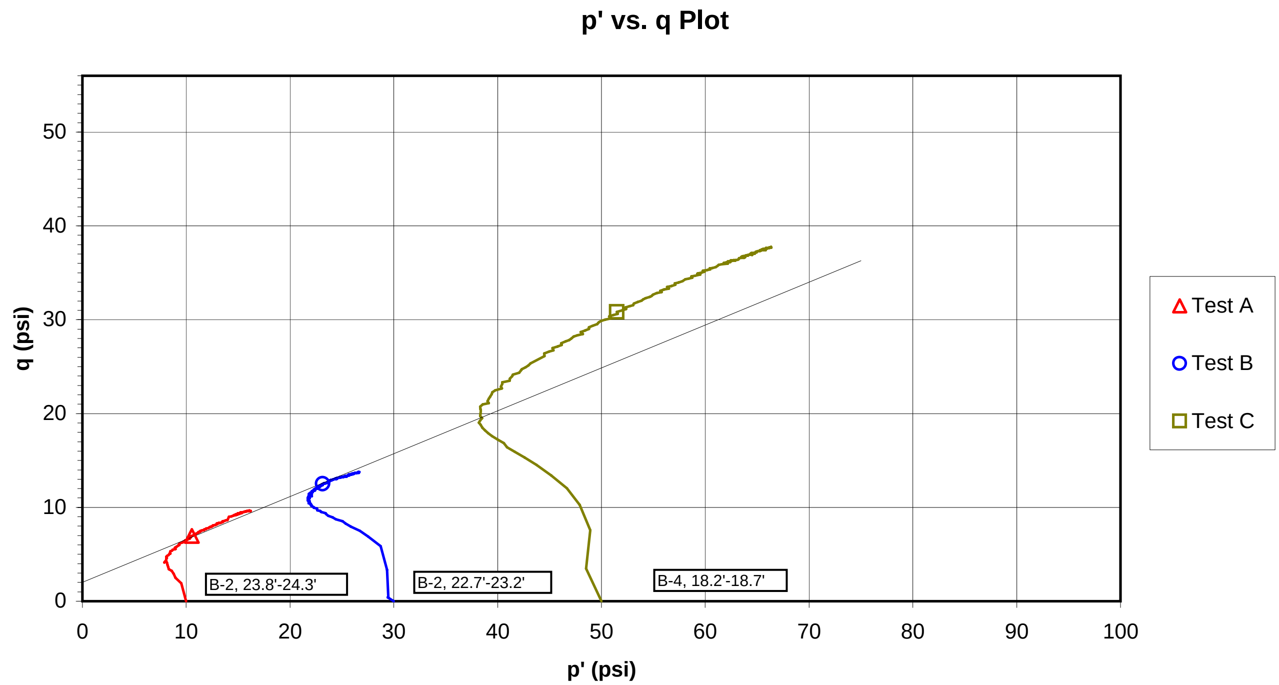


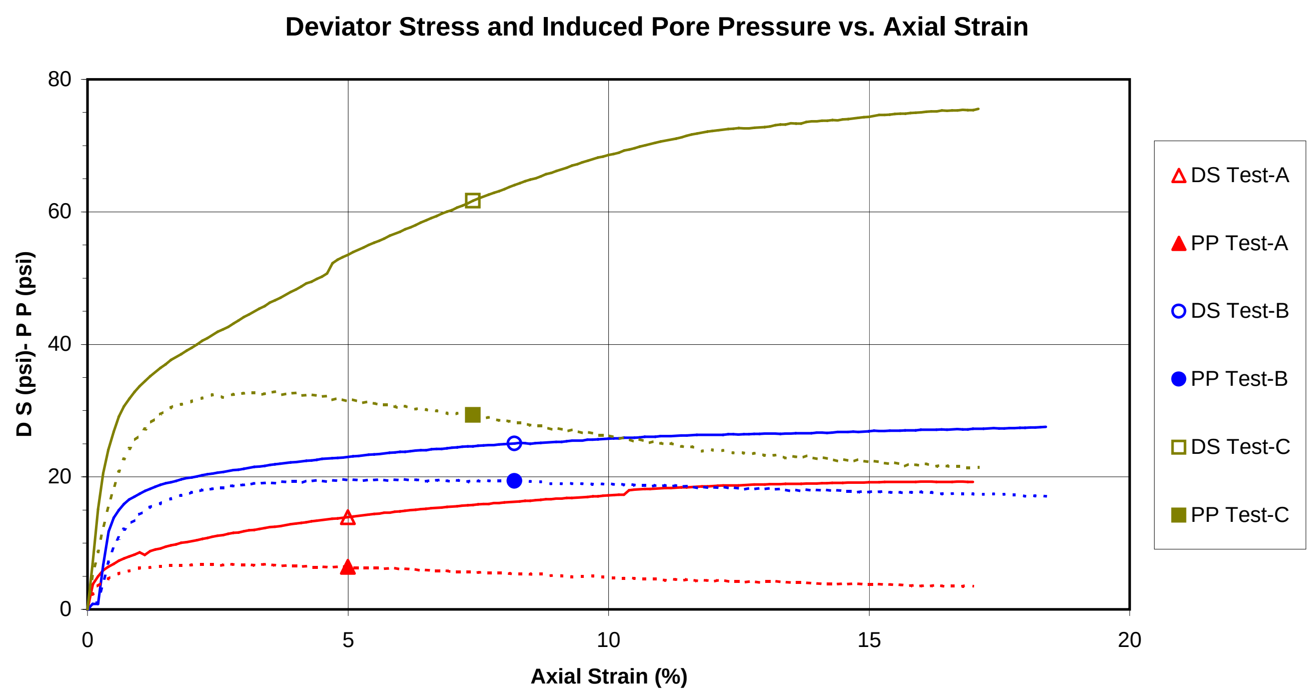
Consolidated Undrained Triaxial Test
ASTM D4767-04

Project	AEP-Clifty Creek-West Bottom Ash and Fly Ash Ponds subsurface exploration	Project No.	175539022
Sample ID	B-2, 23.8'-24.3' & B-2, 22.7'-23.2' & B-4, 18.2'-18.7'	Test Number	2

ϕ' = 27.2 deg. c' = 320 psf

Failure Criterion: Maximum Effective Principal Stress Ratio





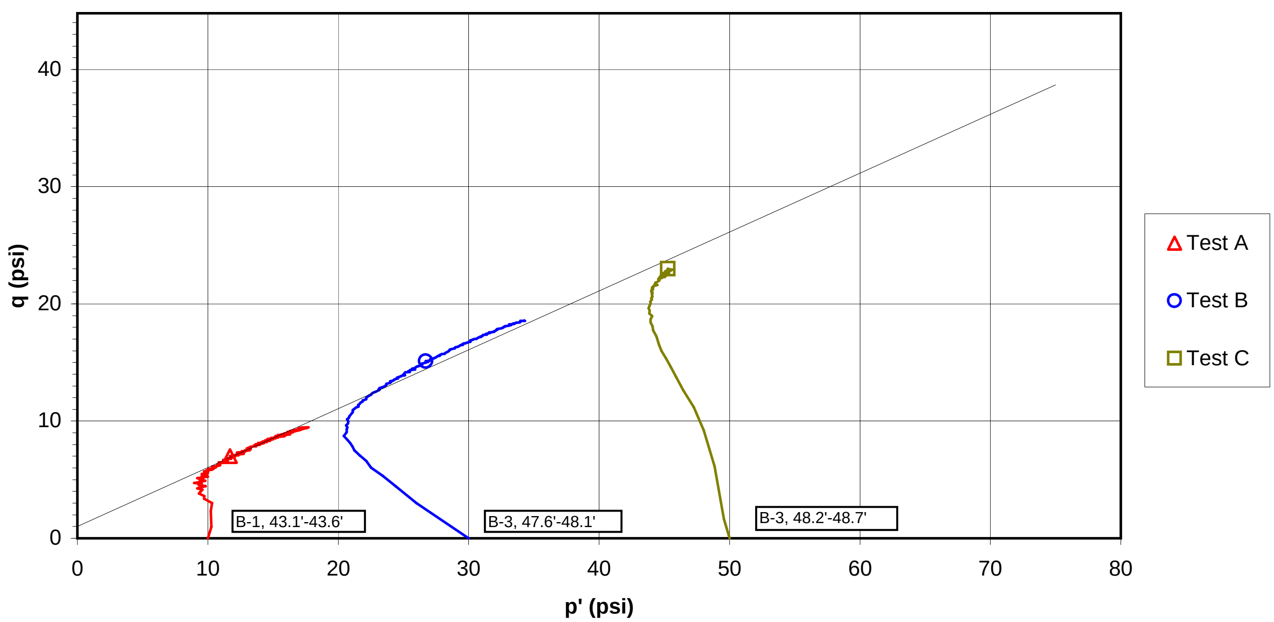
Consolidated Undrained Triaxial Test
ASTM D4767-04

Project	AEP-Clifty Creek-West Bottom Ash and Fly Ash Ponds subsurface exploration	Project No.	175539022
Sample ID	B-1, 43.1'-43.6' & B-3, 47.6'-48.1' & B-3, 48.2'-48.7'	Test Number	3

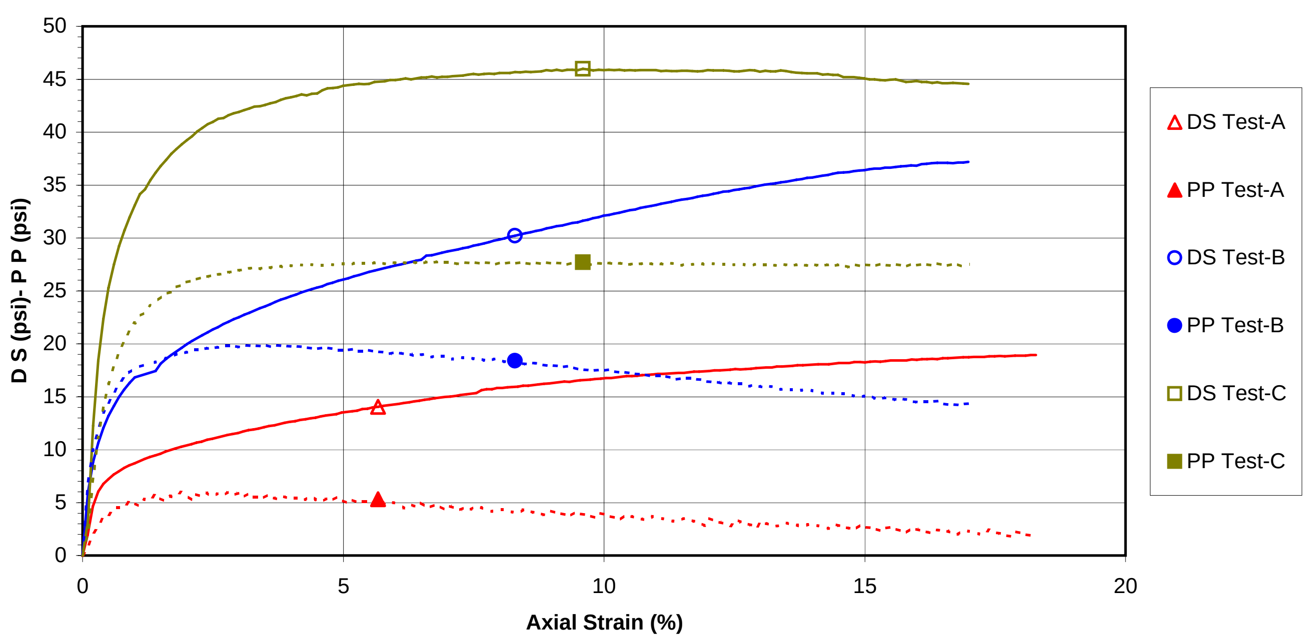
ϕ' = 30.2 deg. c' = 170 psf

Failure Criterion: Maximum Effective Principal Stress Ratio

p' vs. q Plot



Deviator Stress and Induced Pore Pressure vs. Axial Strain

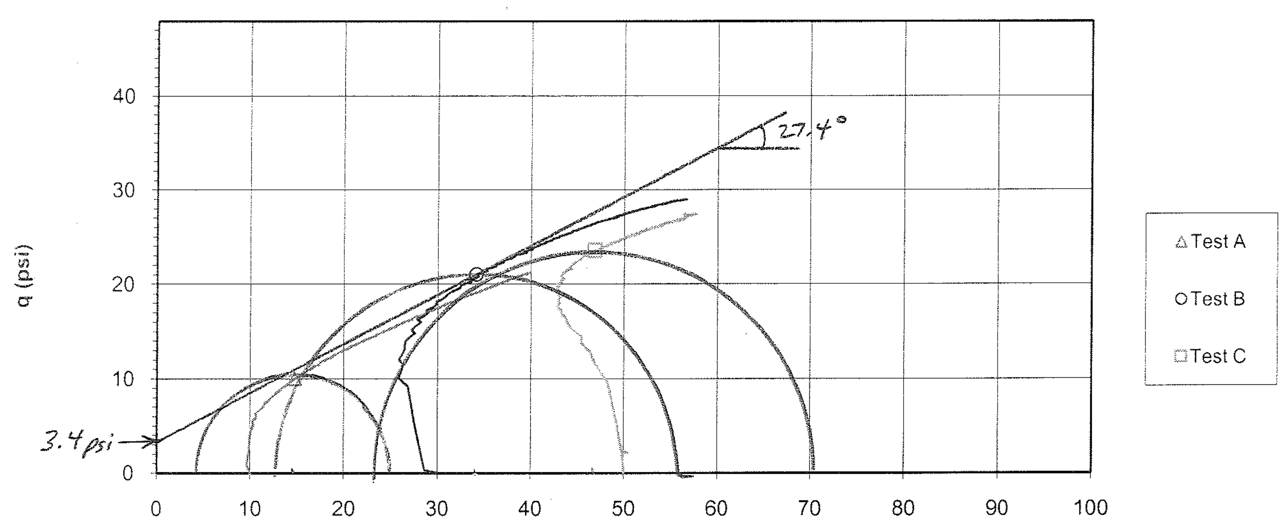


Consolidated Undrained Triaxial Test
ASTM D4767-04

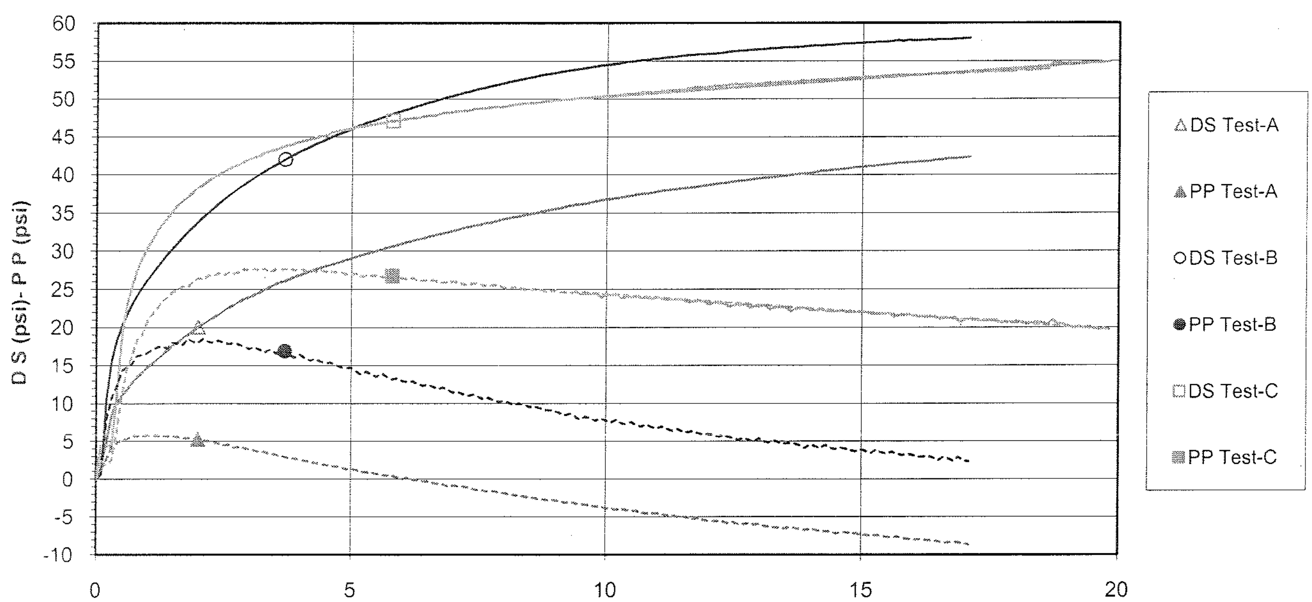
Project	AEP-Clifty Creek-West Bottom and Fly Ash Ponds subsurface exploration	Project No.	175539022
Sample ID	B-3, 10.7'-11.2' & B-3, 10.1'-10.6' & B-5, 8.1'-8.6'	Test Number	1
	ϕ' = 27.4 deg.	c' =	490 psf

Failure Criterion: Maximum Effective Principal Stress Ratio

p' vs. q Plot



Deviator Stress and Induced Pore Pressure vs. Axial Strain

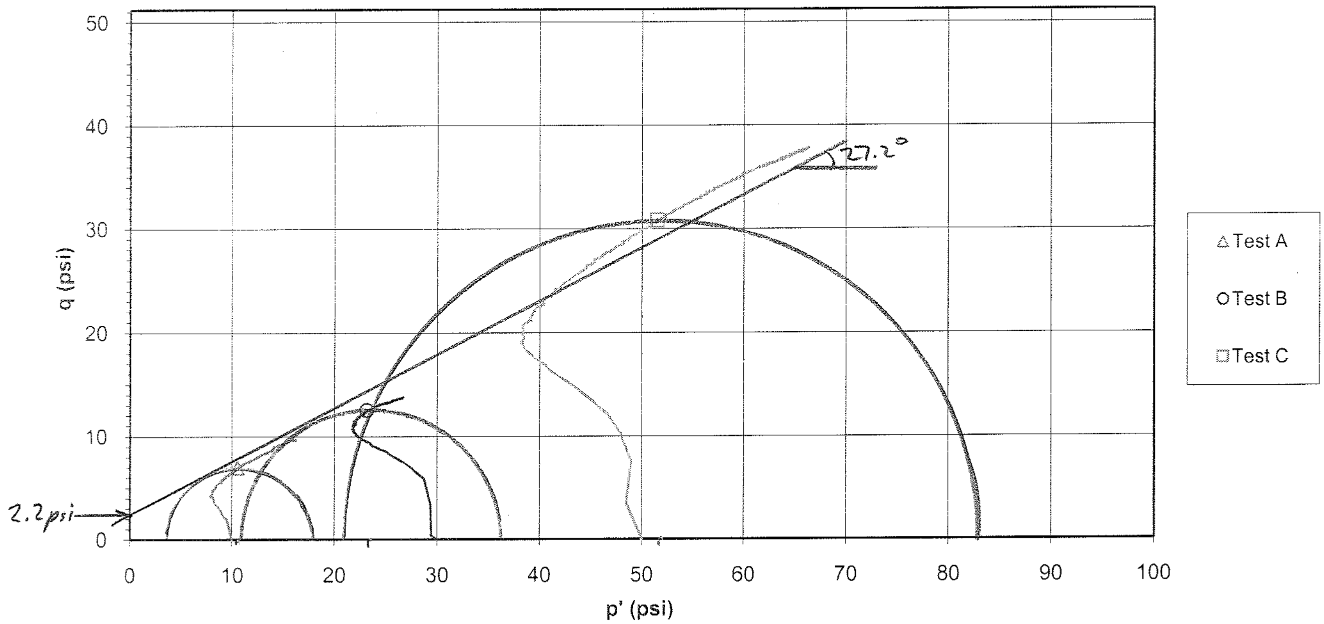


Stantec

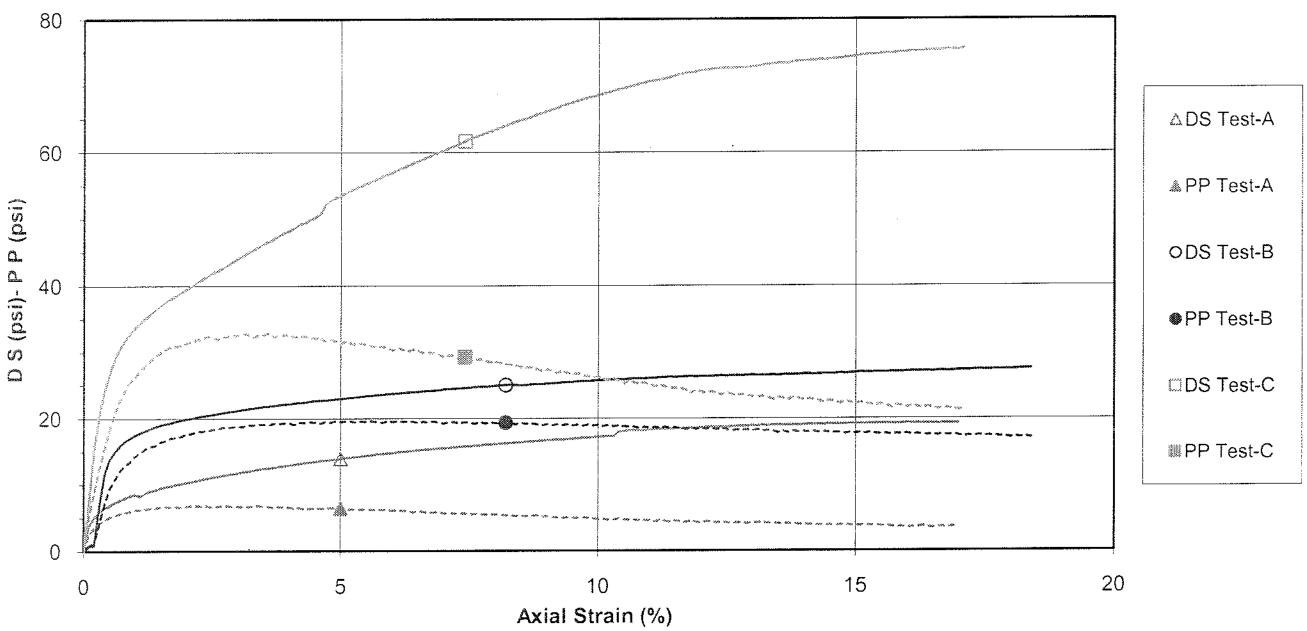
Consolidated Undrained Triaxial Test
ASTM D4767-04

Project	AEP-Clifty Creek-West Bottom Ash and Fly Ash Ponds subsurface exploration	Project No.	175539022
Sample ID	B-2, 23.8'-24.3' & B-2, 22.7'-23.2' & B-4, 18.2'-18.7'	Test Number	2
	ϕ' = 27.2 deg.	c' =	320 psf
	Failure Criterion: Maximum Effective Principal Stress Ratio		

p' vs. q Plot



Deviator Stress and Induced Pore Pressure vs. Axial Strain



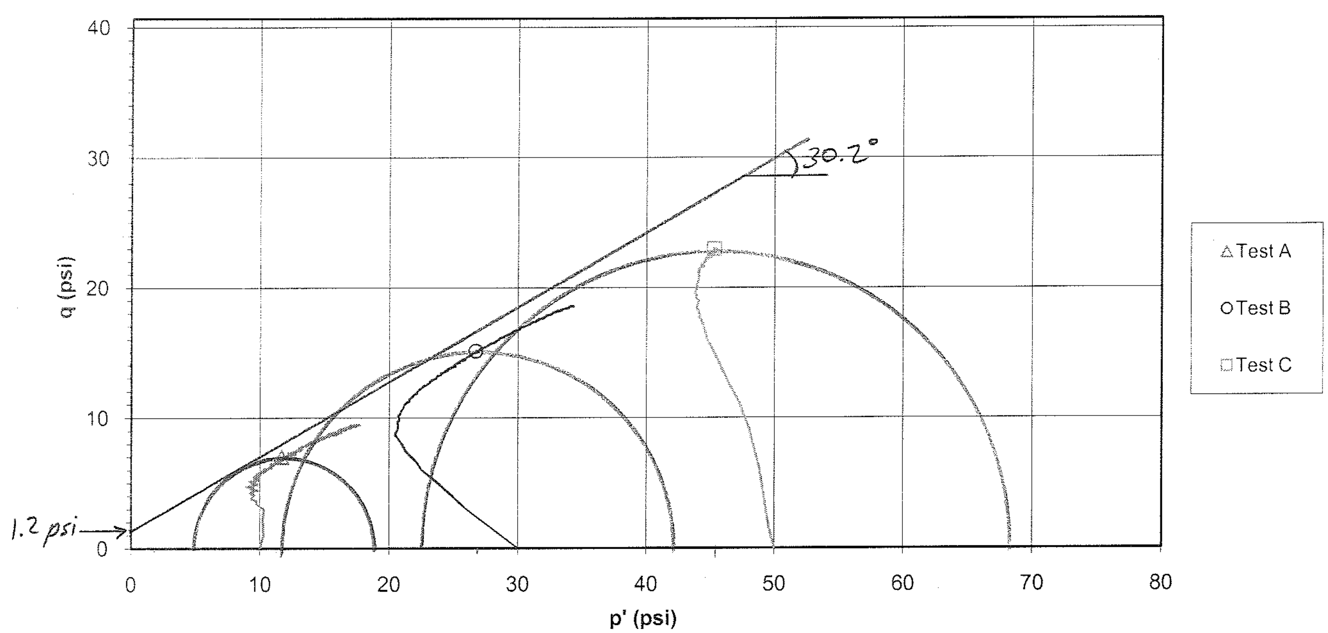
Stantec

Consolidated Undrained Triaxial Test
ASTM D4767-04

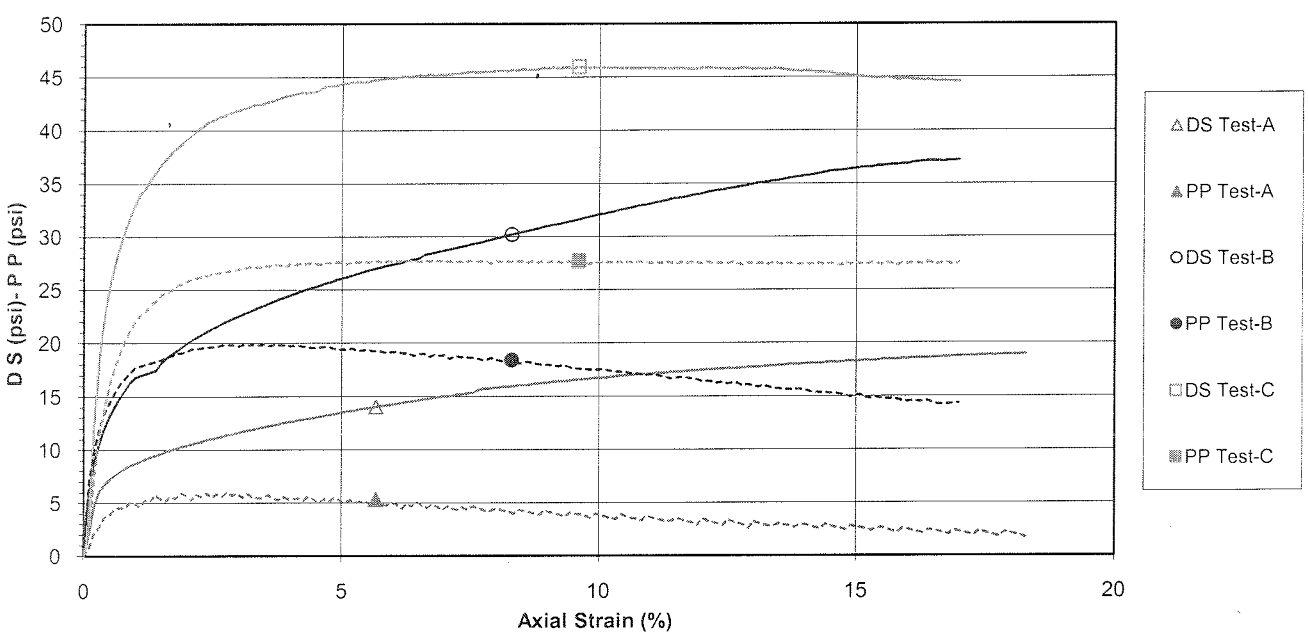
Project	AEP-Clifty Creek-West Bottom Ash and Fly Ash Ponds subsurface exploration	Project No.	175539022
Sample ID	B-1, 43.1'-43.6' & B-3, 47.6'-48.1' & B-3, 48.2'-48.7'	Test Number	3
	ϕ' = 30.2 deg.	c' =	170 psf

Failure Criterion: Maximum Effective Principal Stress Ratio

p' vs. q Plot

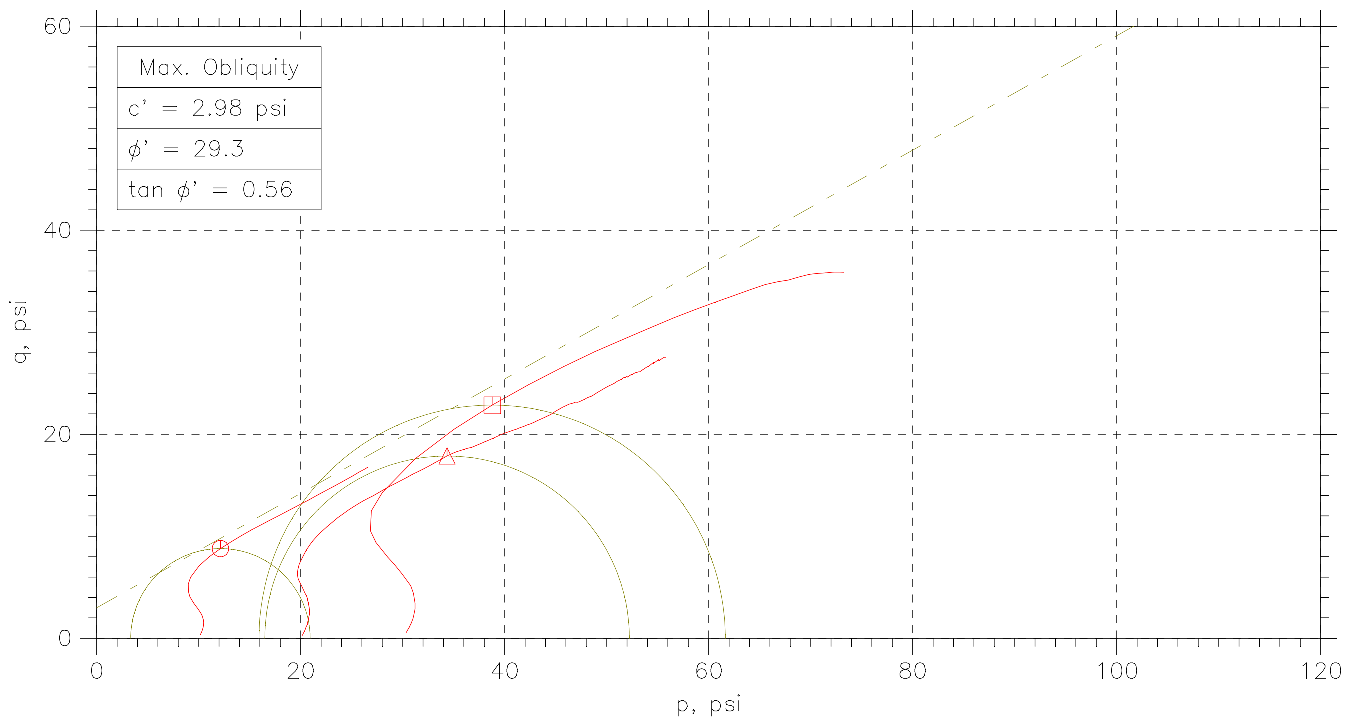


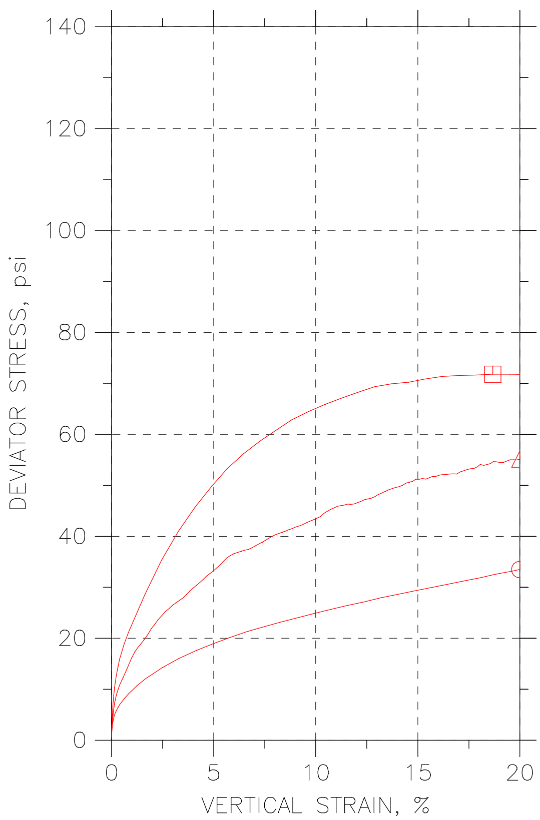
Deviator Stress and Induced Pore Pressure vs. Axial Strain



LANDFILL RUNOFF COLLECTION POND

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





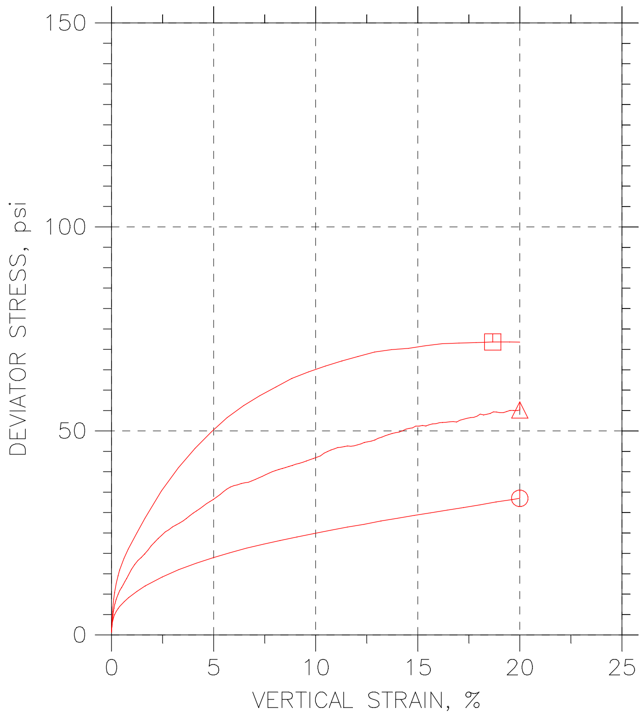
	Symbol	○	△	□	
	Sample No.	---	---	---	
	Test No.	1.1	1.2	1.3	
	Depth	25.8-26.0	26.4-27.0	28.4-29.0	
Initial	Diameter, in	2.835	2.834	2.832	
	Height, in	6.314	5.928	5.929	
	Water Content, %	20.2	21.0	19.0	
	Dry Density, pcf	109.	107.5	111.3	
	Saturation, %	99.8	99.6	99.7	
	Void Ratio	0.546	0.568	0.515	
Before Shear	Water Content, %	21.0	21.6	19.1	
	Dry Density, pcf	107.7	106.5	111.2	
	Saturation*, %	100.0	100.0	100.0	
	Void Ratio	0.566	0.583	0.515	
	Back Press., psi	137.2	125.1	116.2	
	Ver. Eff. Cons. Stress, psi	9.834	19.88	29.8	
	Shear Strength, psi	16.74	27.57	35.9	
	Strain at Failure, %	20	20	18.7	
	Strain Rate, %/min	0.08	0.08	0.08	
	B-Value	0.96	0.95	0.95	
	Estimated Specific Gravity	2.7	2.7	2.7	
	Liquid Limit	---	---	---	
	Plastic Limit	---	---	---	

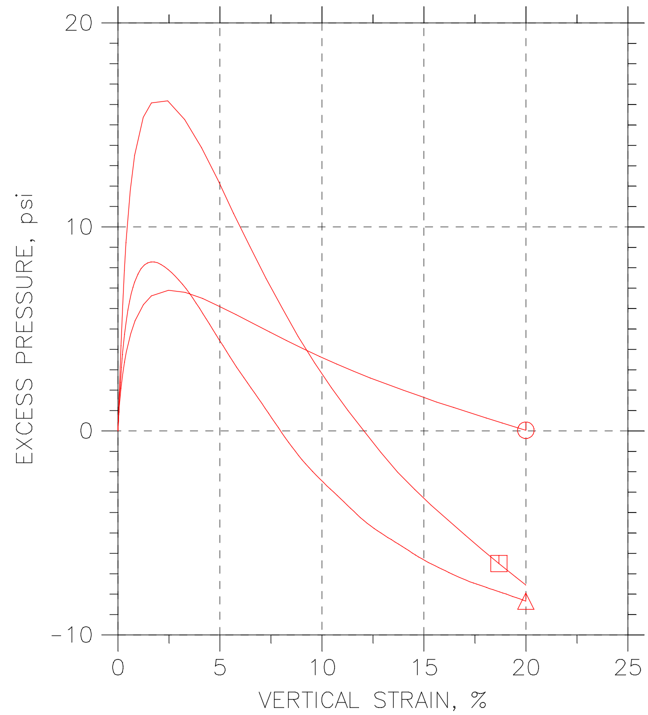
GeoTesting express
a subsidiary of Geocomp Corporation

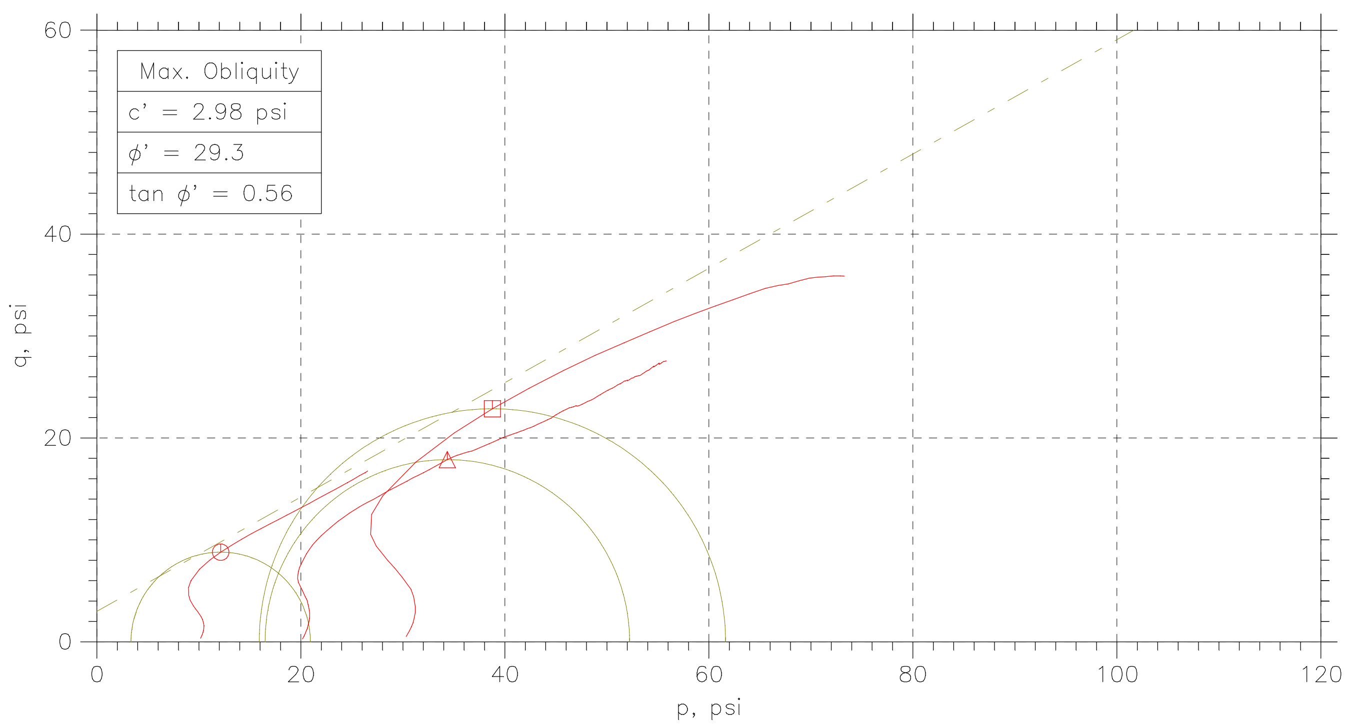
Project: Clifty Creek
Location: Jefferson, IN
Project No.: GTX-1516
Boring No.: B-7
Sample Type: UD
Description: Light Brown
Remarks: System 1062

Mon, 18-JAN-2010 16:57:15

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767







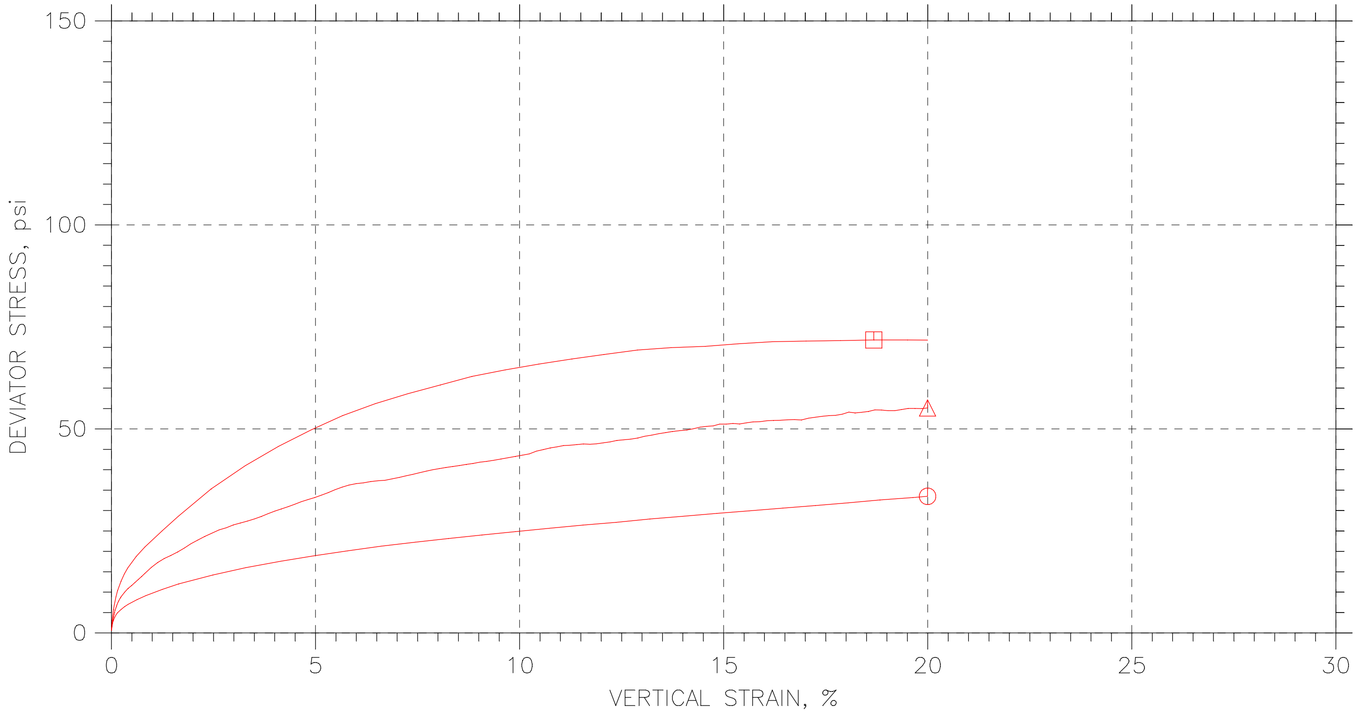
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	1.1	25.8-26.0	jm	12/10/09	mm		1516-1.1.dat
△	---	1.2	26.4-27.0	jm	12/10/09	mm		1516-1.2.dat
□	---	1.3	28.4-29.0	jm	12/9/09	mm		1516-1.3.dat

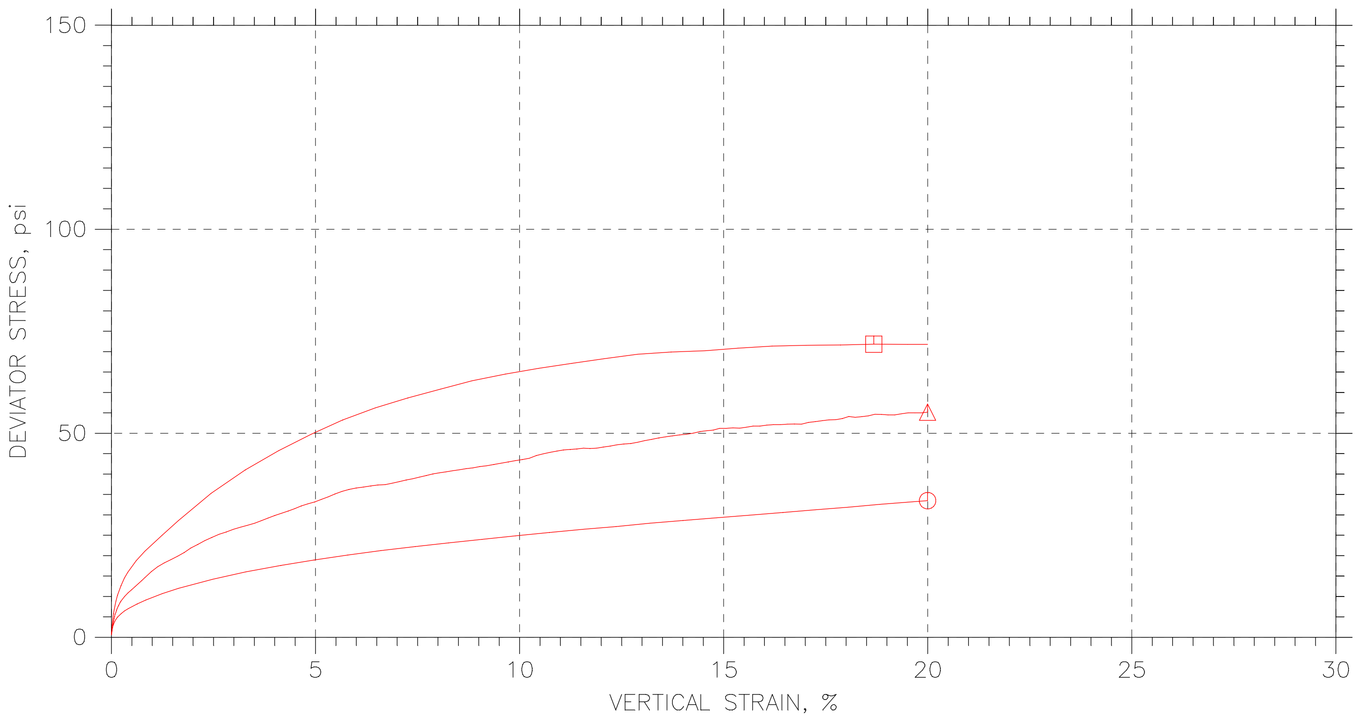
GeoTesting express
a subsidiary of Geocomp Corporation

Project: Clifty Creek	Location: Jefferson, IN	Project No.: GTX-1516
Boring No.: B-7	Sample Type: UD	
Description: Light Brown		
Remarks: System 1062		

Mon, 18-JAN-2010 16:57:17

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





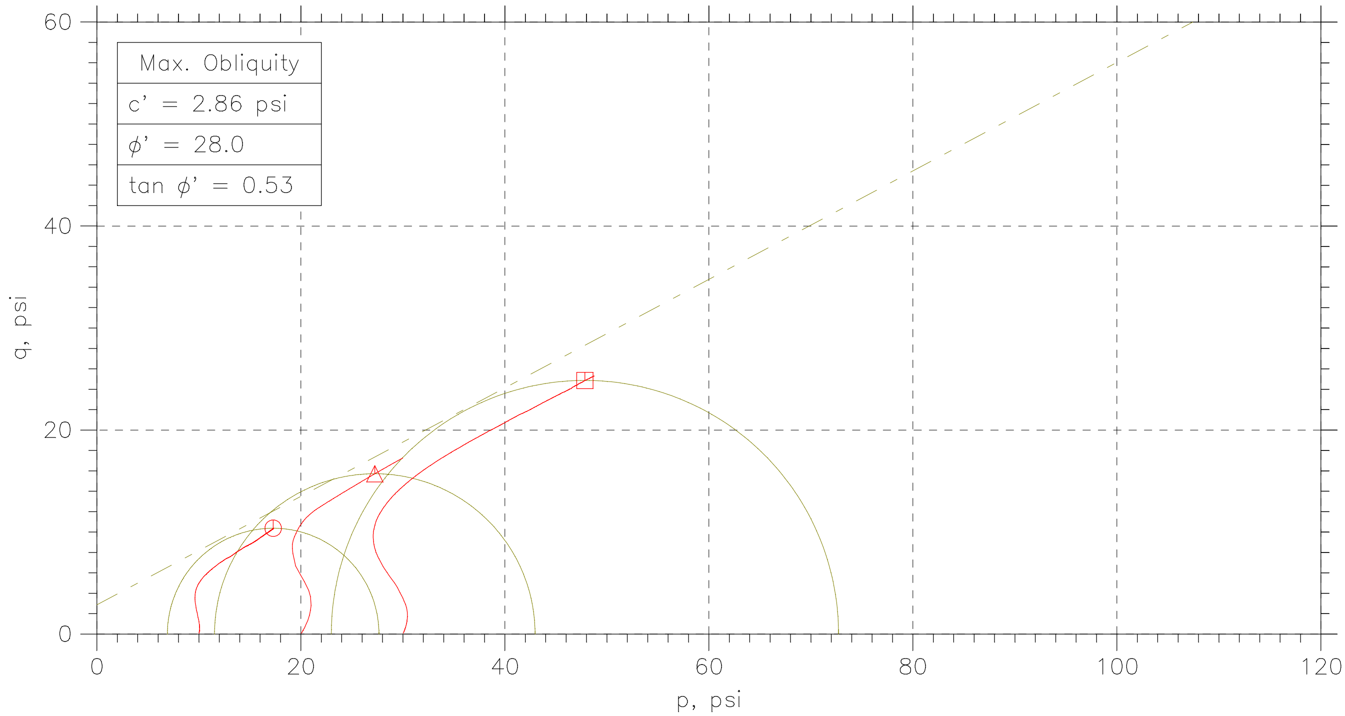
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	1.1	25.8-26.0	jm	12/10/09	mm		1516-1.1.dat
△	---	1.2	26.4-27.0	jm	12/10/09	mm		1516-1.2.dat
□	---	1.3	28.4-29.0	jm	12/9/09	mm		1516-1.3.dat

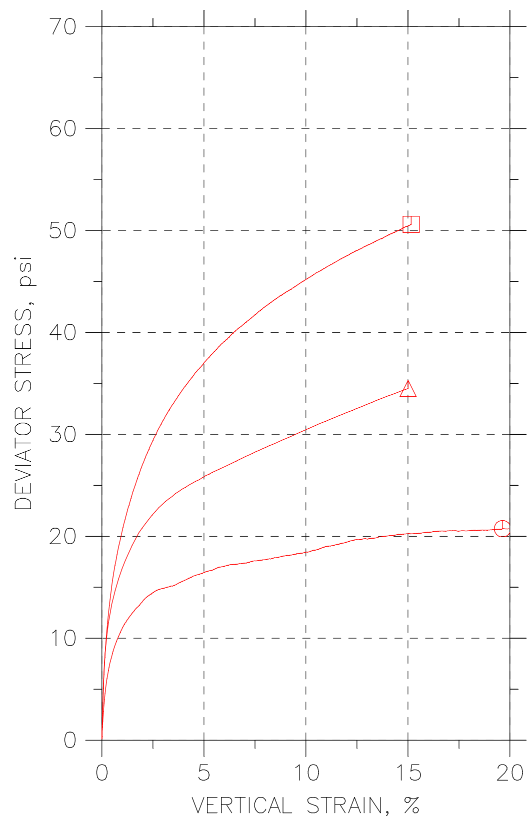
GeoTesting express
a subsidiary of Geocomp Corporation

Project: Clifty Creek	Location: Jefferson, IN	Project No.: GTX-1516
Boring No.: B-7	Sample Type: UD	
Description: Light Brown		
Remarks: System 1062		

Mon, 18-JAN-2010 16:57:18

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





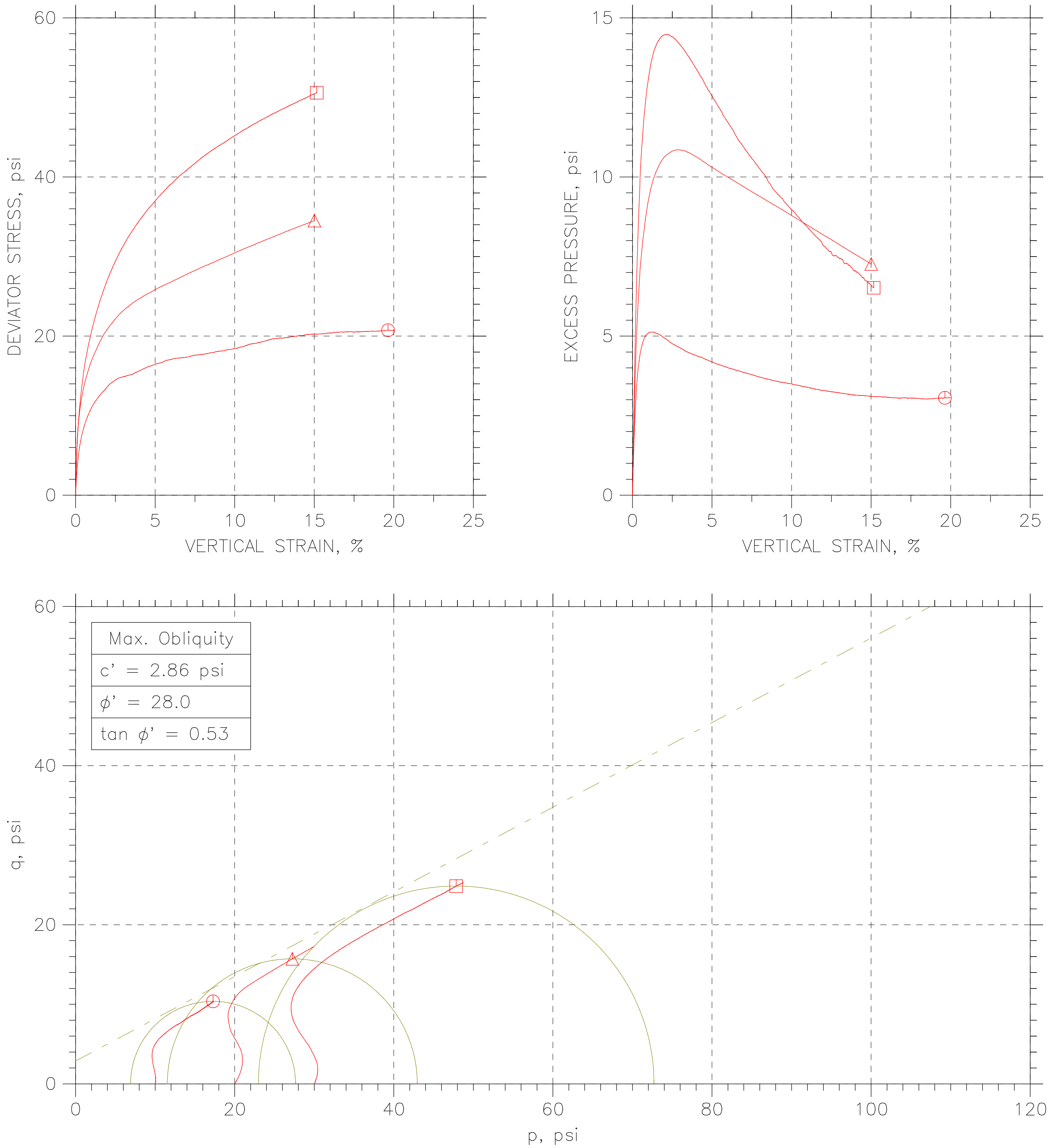
	Symbol	○	△	□	
	Sample No.	---	---	---	
	Test No.	2.1	2.2	2.3	
	Depth	25.8-26.4	28.4-29.0	30.3-30.9'	
Initial	Diameter, in	2.82	2.824	2.838	
	Height, in	5.82	6.027	6.001	
	Water Content, %	21.0	20.7	20.9	
	Dry Density, pcf	107.2	107.6	107.6	
	Saturation, %	99.2	98.7	99.6	
	Void Ratio	0.572	0.567	0.567	
Before Shear	Water Content, %	20.5	19.8	19.0	
	Dry Density, pcf	108.5	109.8	111.4	
	Saturation*, %	100.0	100.0	100.0	
	Void Ratio	0.554	0.535	0.513	
	Back Press., psi	59.25	124.8	56.31	
	Ver. Eff. Cons. Stress, psi	9.968	19.98	29.96	
	Shear Strength, psi	10.37	17.25	25.3	
	Strain at Failure, %	19.6	15	15.2	
	Strain Rate, %/min	0.016	0.016	0.016	
	B-Value	0.95	0.96	0.95	
	Estimated Specific Gravity	2.7	2.7	2.7	
	Liquid Limit	---	---	---	
	Plastic Limit	---	---	---	

GeoTesting express
a subsidiary of Geocomp Corporation

Project: Clifty Creek	
Location: Jefferson, IN.	
Project No.: GTX-1516	
Boring No.: B-8	
Sample Type: UD	
Description: Greenish brown lean clay with sand	
Remarks: 2054	

Tue, 19-JAN-2010 09:45:51

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



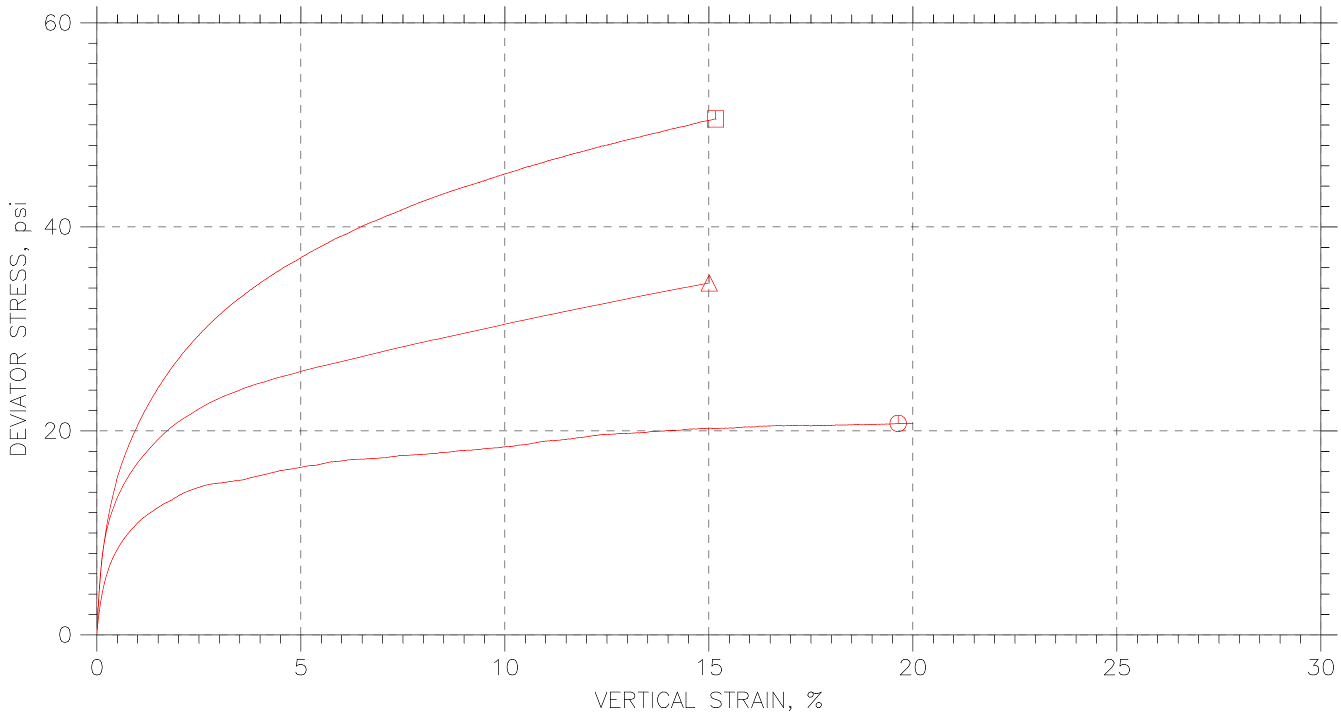
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	2.1	25.8-26.4	jm	12/11/09	mm		1516-2.1.dat
△	---	2.2	28.4-29.0	jm	12/11/09	mm		1516-2.2A.dat
□	---	2.3	30.3-30.9'	jm	12/09/09	mm		1516-2.3.dat

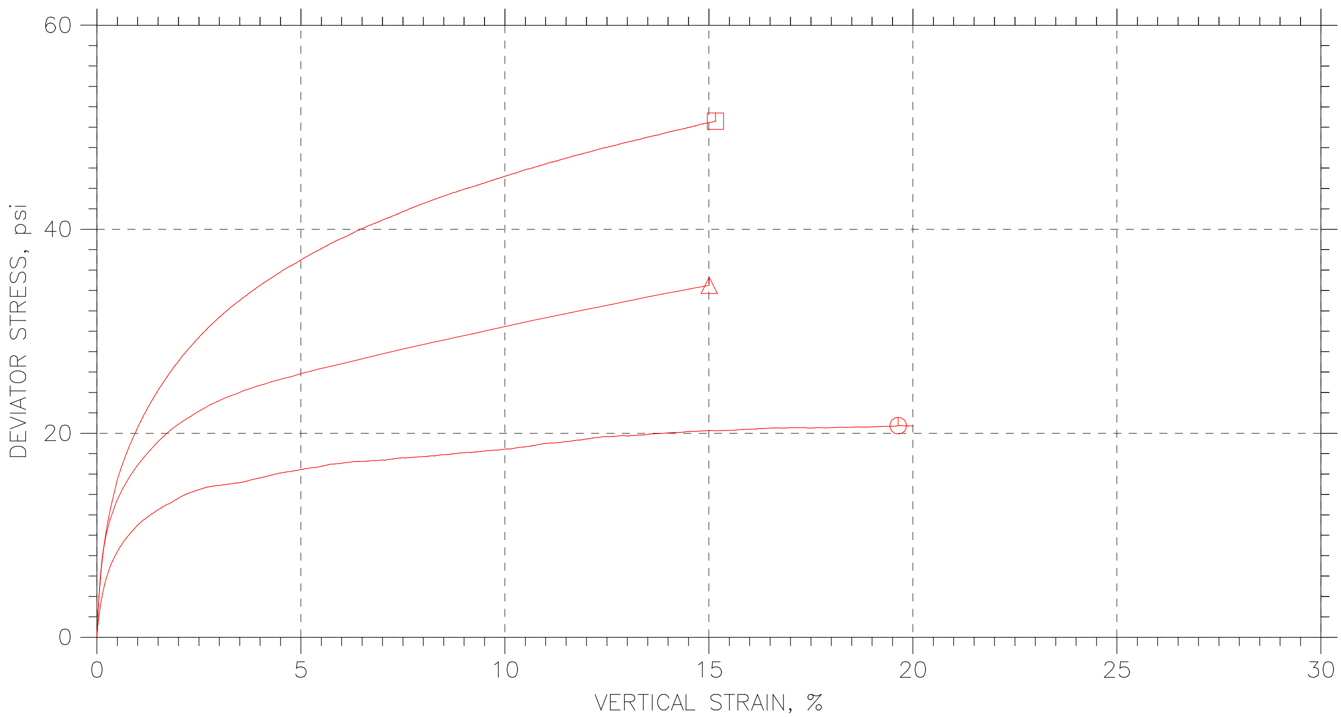
GeoTesting express
a subsidiary of Geocomp Corporation

Project: Clifty Creek	Location: Jefferson, IN.	Project No.: GTX-1516
Boring No.: B-8	Sample Type: UD	
Description: Greenish brown lean clay with sand		
Remarks: 2054		

Tue, 19-JAN-2010 09:45:53

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





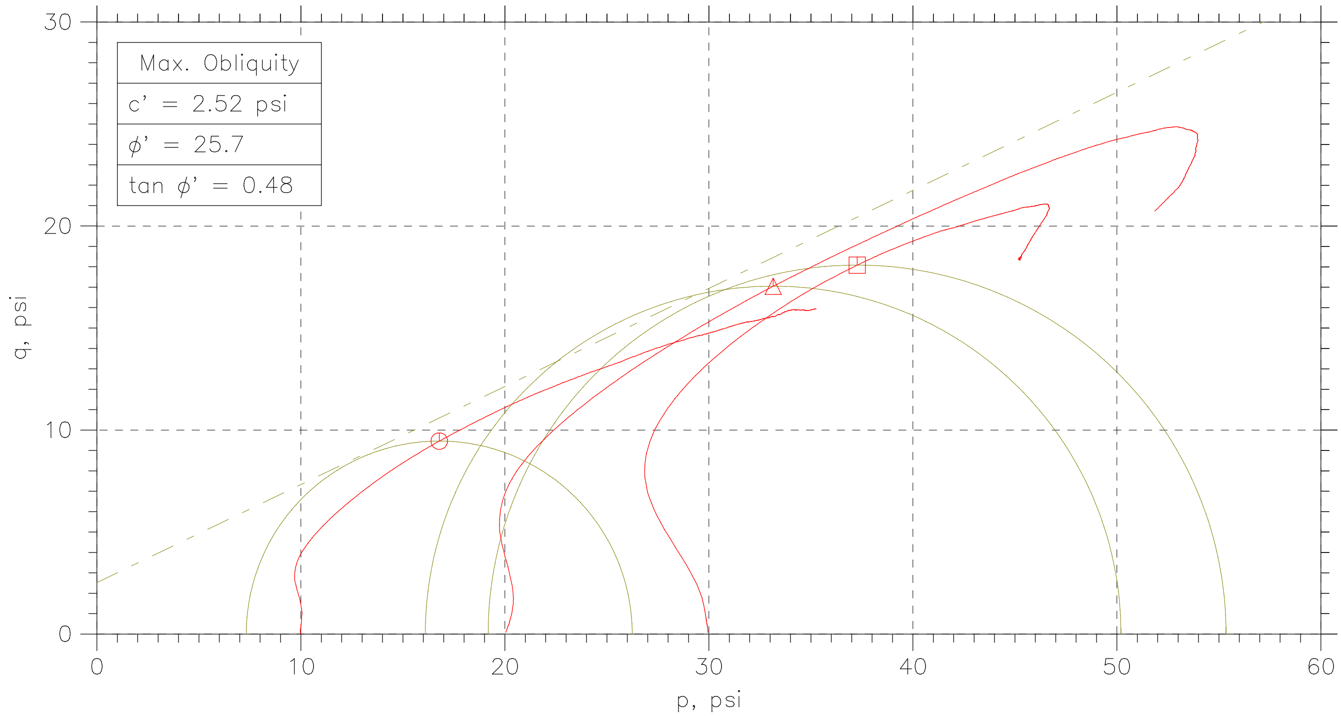
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	2.1	25.8-26.4	jm	12/11/09	mm		1516-2.1.dat
△	---	2.2	28.4-29.0	jm	12/11/09	mm		1516-2.2A.dat
□	---	2.3	30.3-30.9'	jm	12/09/09	mm		1516-2.3.dat

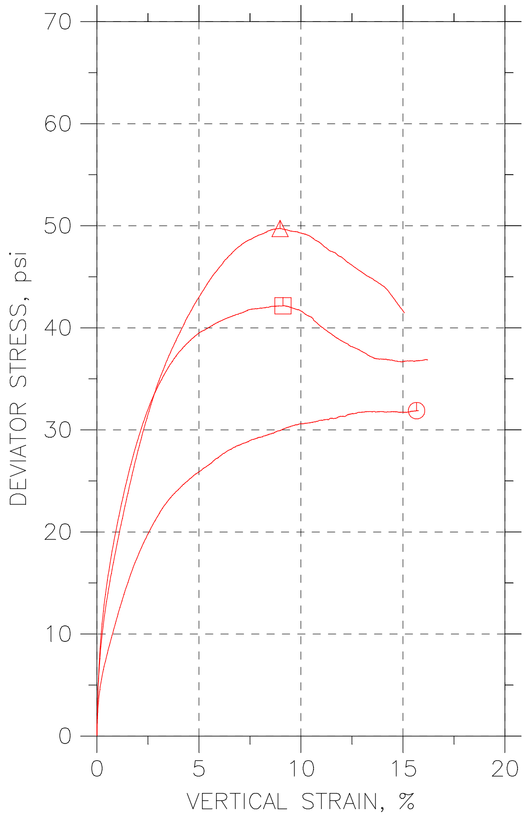
GeoTesting express
a subsidiary of Geocomp Corporation

Project: Clifty Creek	Location: Jefferson, IN.	Project No.: GTX-1516
Boring No.: B-8	Sample Type: UD	
Description: Greenish brown lean clay with sand		
Remarks: 2054		

Tue, 19-JAN-2010 09:45:54

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





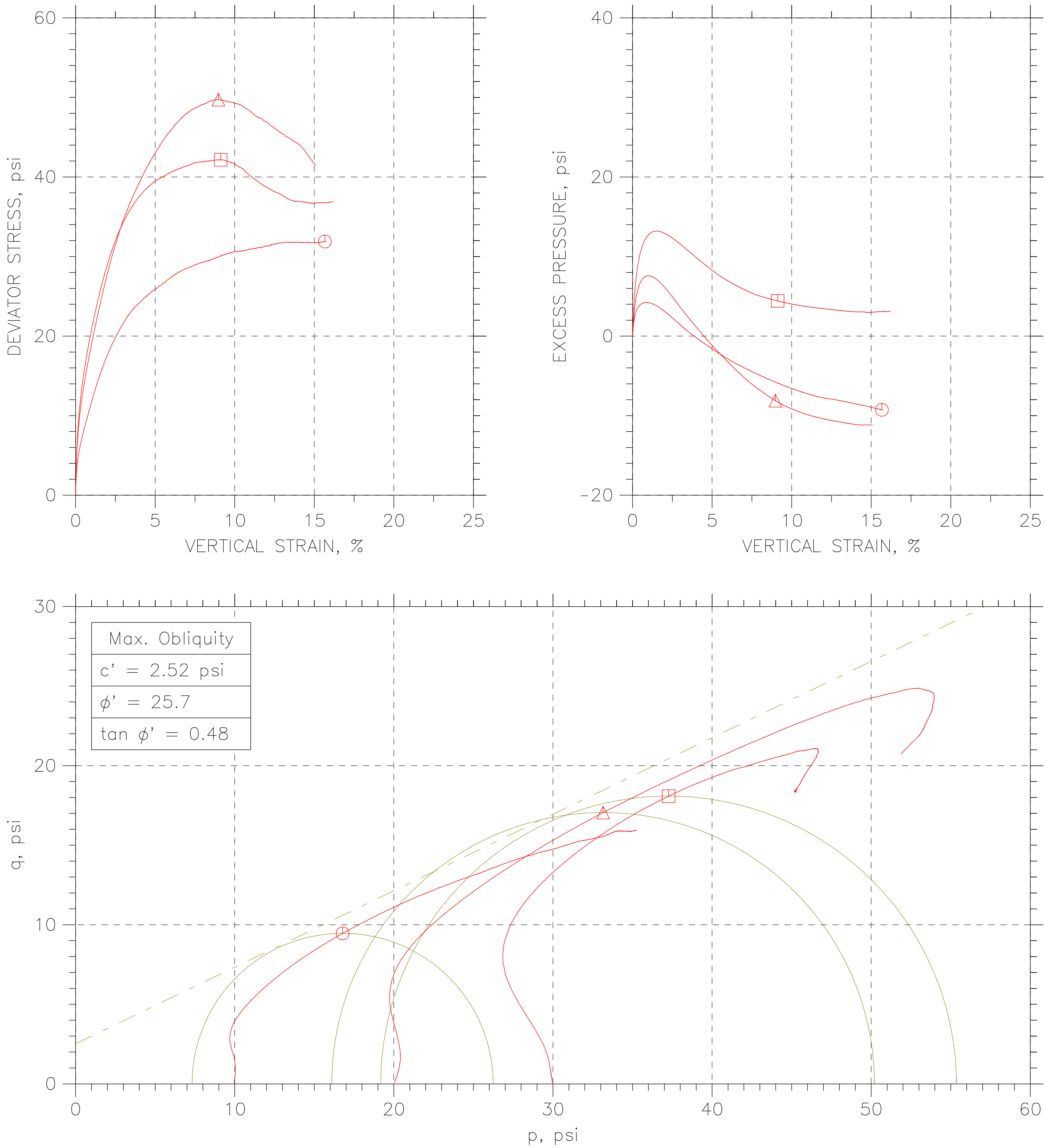
	Symbol	○	△	□	
	Sample No.	---	---	---	
	Test No.	3.1	3.2	3.3	
	Depth	17.4-18.0	19.4-20.0	20.8--21.4	
Initial	Diameter, in	2.835	2.835	2.837	
	Height, in	6.319	6.281	6.177	
	Water Content, %	19.4	18.4	20.8	
	Dry Density, pcf	109.7	111.4	107.3	
	Saturation, %	97.8	96.9	98.6	
	Void Ratio	0.536	0.514	0.571	
Before Shear	Water Content, %	19.2	18.9	22.7	
	Dry Density, pcf	111.	111.7	104.5	
	Saturation*, %	100.0	100.0	100.0	
	Void Ratio	0.518	0.509	0.613	
	Back Press., psi	136.8	122	116.2	
	Ver. Eff. Cons. Stress, psi	9.997	19.96	29.88	
	Shear Strength, psi	15.94	24.86	21.08	
	Strain at Failure, %	15.7	8.98	9.12	
	Strain Rate, %/min	0.016	0.016	0.016	
	B-Value	0.95	0.96	0.95	
	Estimated Specific Gravity	2.7	2.7	2.7	
	Liquid Limit	---	---	---	
	Plastic Limit	---	---	---	

GeoTesting express
a subsidiary of Geocomp Corporation

Project: Clifty Creek
Location: Jefferson, IN
Project No.: GTX-1516
Boring No.: B-9
Sample Type: UD
Description: Brown lean clay with sand
Remarks: System 1057

Tue, 19-JAN-2010 10:34:11

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



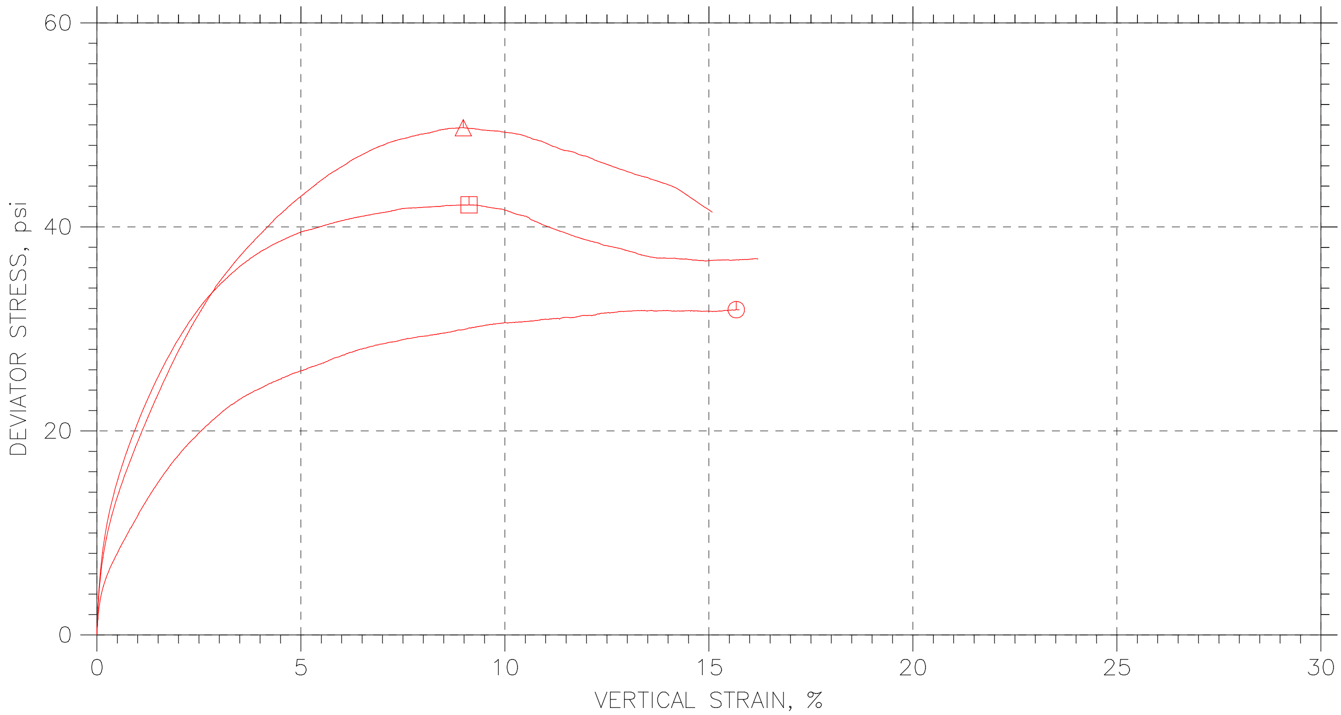
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	3.1	17.4-18.0	jm	12/15/09	mm		1516-3.1.dat
△	---	3.2	19.4-20.0	jm	12/16/09	mm		1516-3.2Adat.dat
□	---	3.3	20.8--21.4	jm	12/10/09	mm		1516-3.3.dat

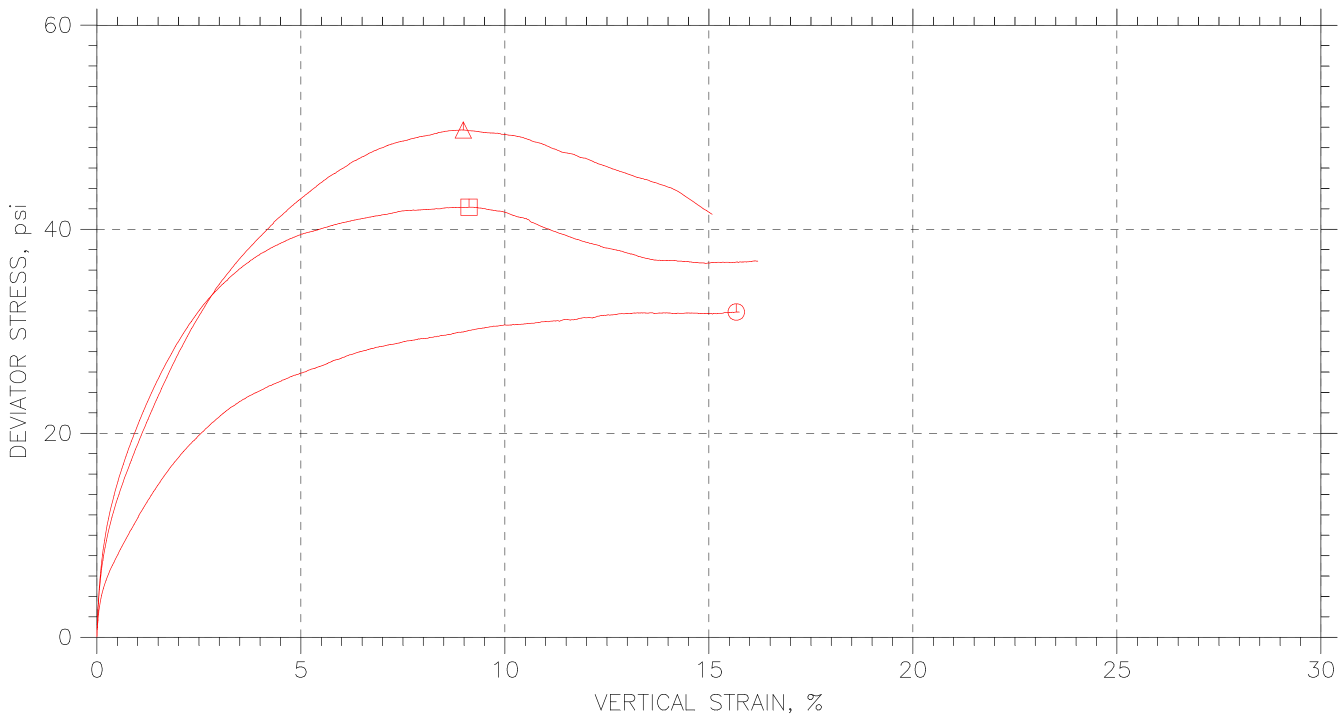
GeoTesting express
a subsidiary of Geocomp Corporation

Project: Clifty Creek	Location: Jefferson, IN	Project No.: GTX-1516
Boring No.: B-9	Sample Type: UD	
Description: Brown lean clay with sand		
Remarks: System 1057		

Tue, 19-JAN-2010 10:34:12

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





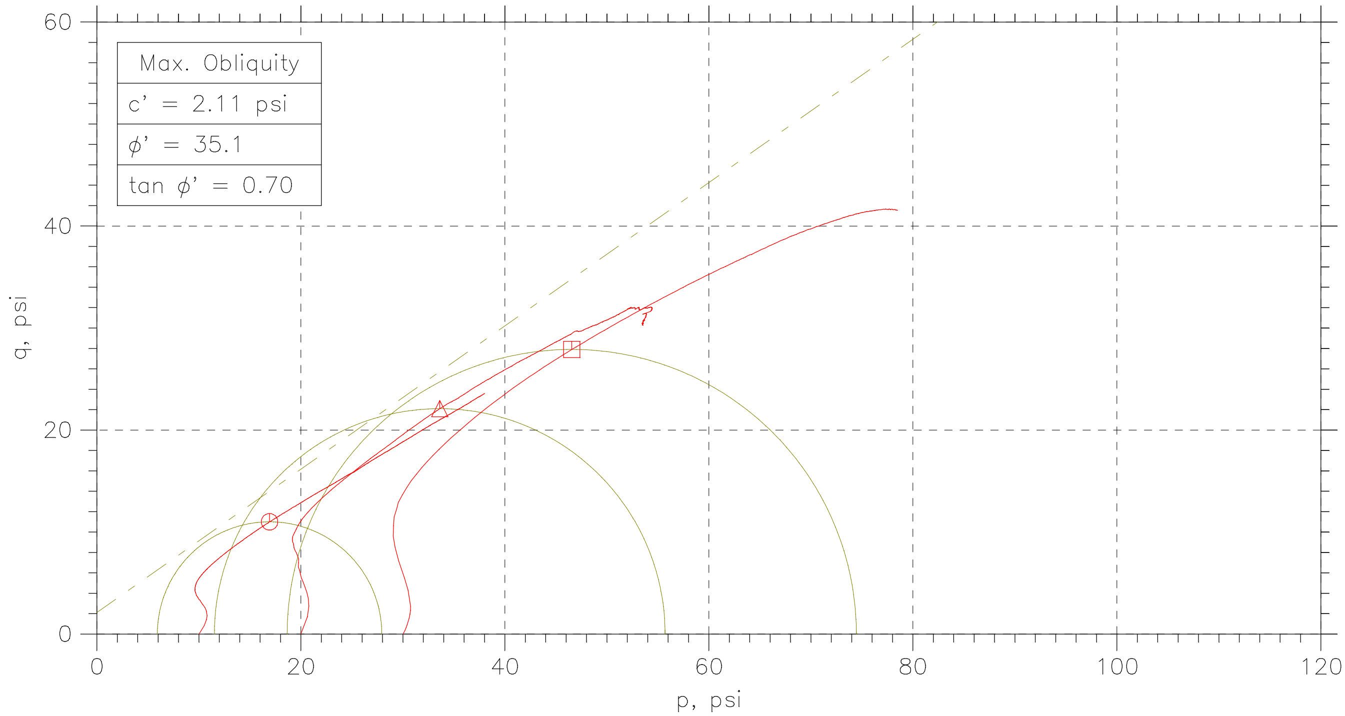
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	3.1	17.4-18.0	jm	12/15/09	mm		1516-3.1.dat
△	---	3.2	19.4-20.0	jm	12/16/09	mm		1516-3.2Adat.dat
□	---	3.3	20.8--21.4	jm	12/10/09	mm		1516-3.3.dat

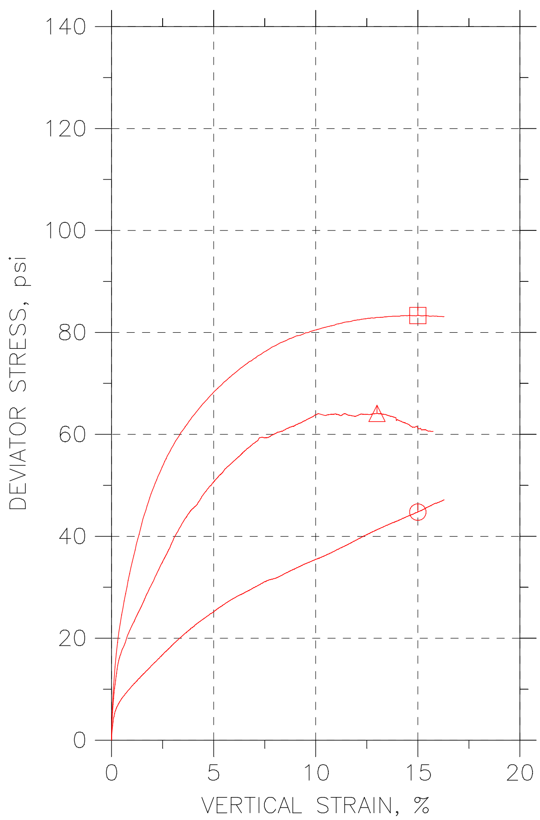
GeoTesting express
a subsidiary of Geocomp Corporation

Project: Clifty Creek	Location: Jefferson, IN	Project No.: GTX-1516
Boring No.: B-9	Sample Type: UD	
Description: Brown lean clay with sand		
Remarks: System 1057		

Tue, 19-JAN-2010 10:34:14

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





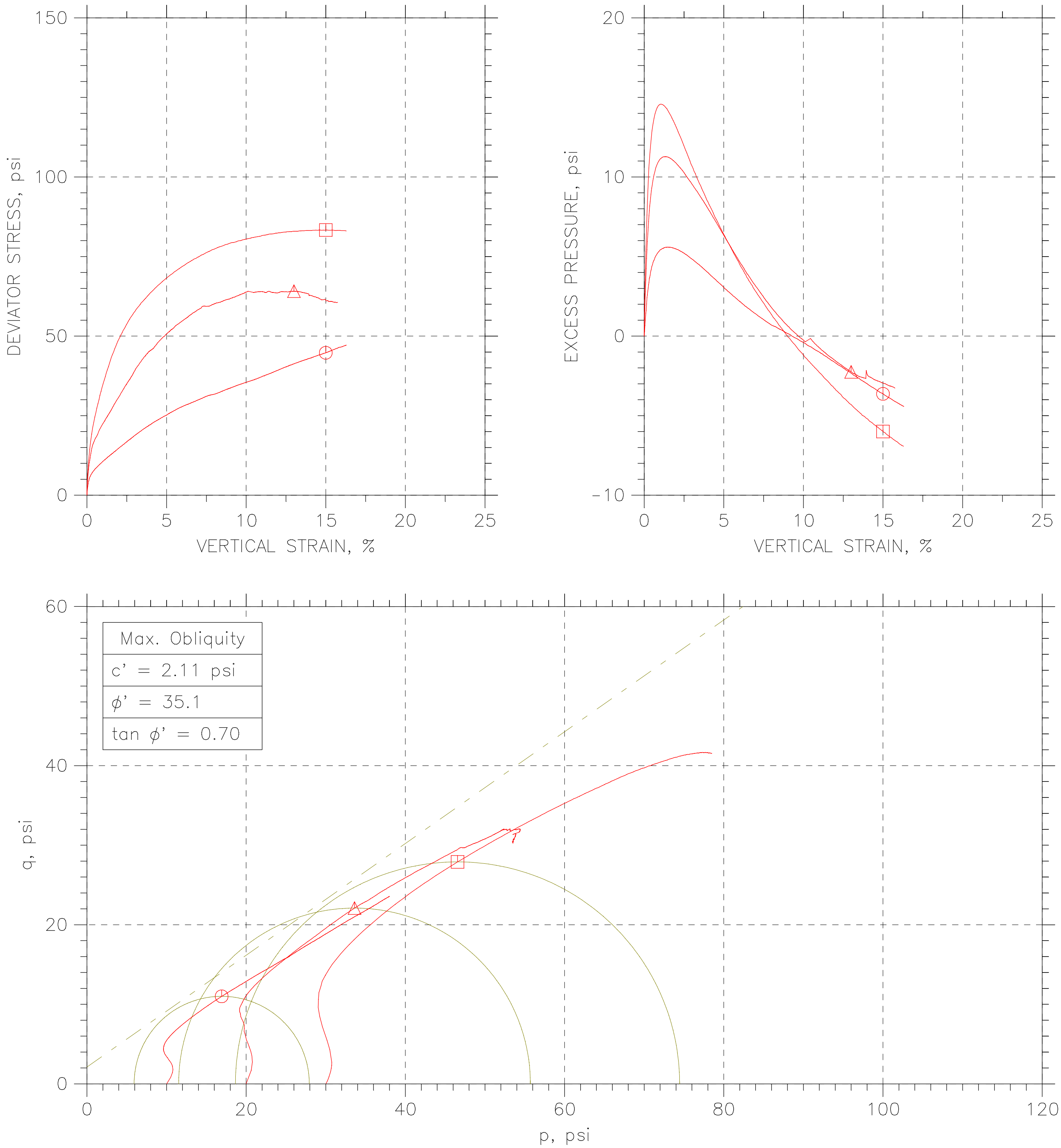
Symbol		○	△	□	
Sample No.		---	----	----	
Test No.		CU-4.1	CU-4.2	CU-4.3	
Depth		13.4-14.0'	16.8-17.4'	17.4-18.'	
Initial	Diameter, in	2.83	2.71	2.72	
	Height, in	5.78	5.52	5.51	
	Water Content, %	14.2	27.4	26.6	
	Dry Density, pcf	102.9	93.8	93.72	
	Saturation, %	59.9	93.0	89.9	
	Void Ratio	0.638	0.797	0.798	
Before Shear	Water Content, %	23.2	18.5	19.2	
	Dry Density, pcf	103.7	112.4	111.	
	Saturation*, %	100.0	100.0	100.0	
	Void Ratio	0.625	0.5	0.519	
	Back Press., psi	27.99	73	84.99	
Ver. Eff. Cons. Stress, psi		10	19.99	30	
Shear Strength, psi		22.37	32.06	41.66	
Strain at Failure, %		15	13	15	
Strain Rate, %/min		0.032	0.032	0.032	
B-Value		0.95	0.95	0.96	
Estimated Specific Gravity		2.7	2.7	2.7	
Liquid Limit		---	---	---	
Plastic Limit		---	---	---	

GeoTesting express
a subsidiary of Geocomp Corporation

Project: Clifty Creek	
Location: ----	
Project No.: GTX-1516	
Boring No.: B-10	
Sample Type: UD	
Description:	
Remarks: 2054	

Tue, 19-JAN-2010 11:56:28

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



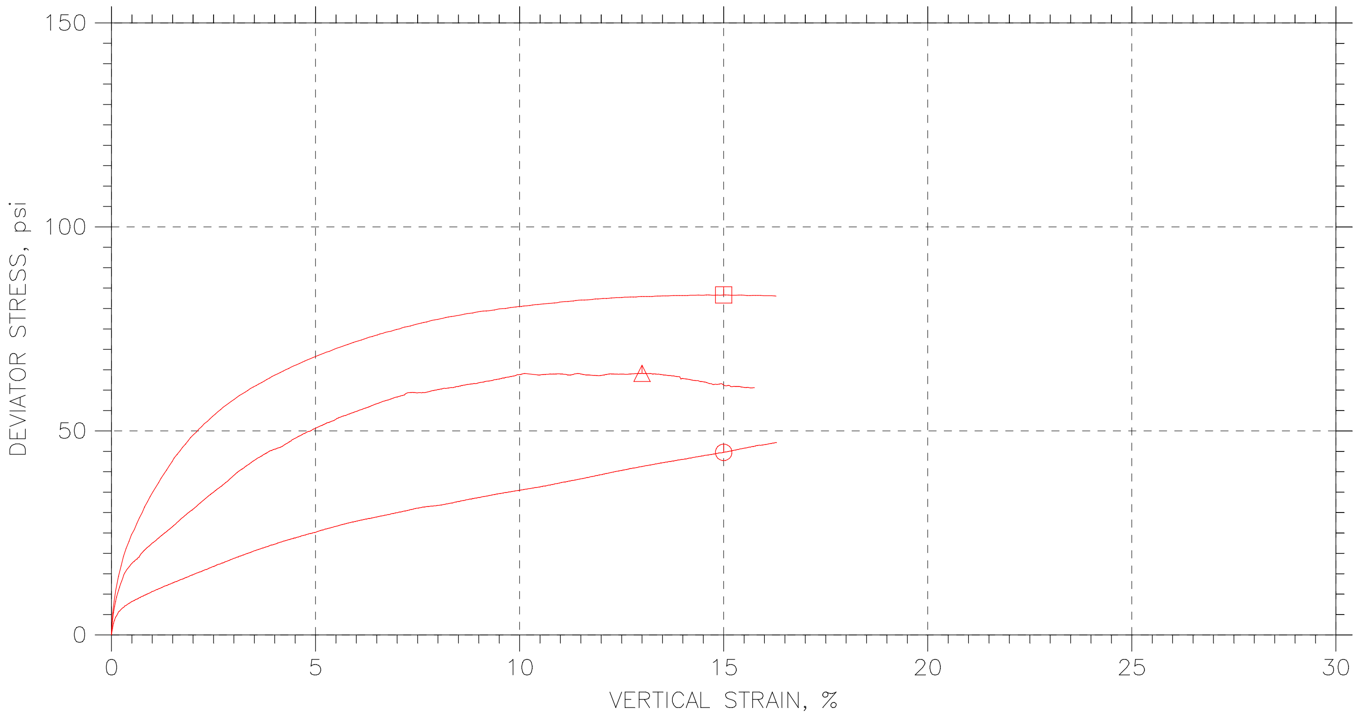
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	CU-4.1	13.4-14.0'	JM	12/12/09	MM		1516-4.1.dat
△	----	CU-4.2	16.8-17.4'	JM	12/13/09	MM		1516-4.2.dat
□	----	CU-4.3	17.4-18.'	JM	12/12/09	MM		1516-4.3.dat

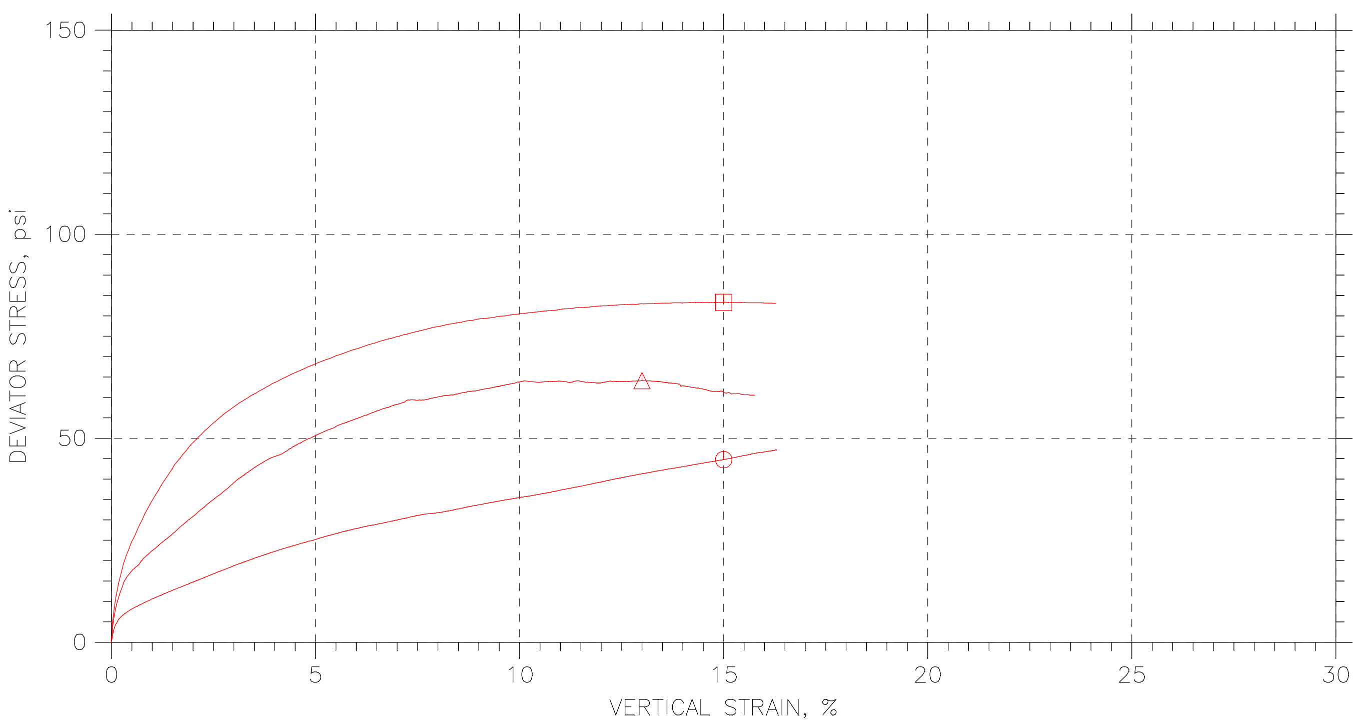
GeoTesting express
a subsidiary of Geocomp Corporation

Project: Clifty Creek	Location: ----	Project No.: GTX-1516
Boring No.: B-10	Sample Type: UD	
Description:		
Remarks: 2054		

Tue, 19-JAN-2010 11:56:29

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	CU-4.1	13.4-14.0'	JM	12/12/09	MM		1516-4.1.dat
△	----	CU-4.2	16.8-17.4'	JM	12/13/09	MM		1516-4.2.dat
□	----	CU-4.3	17.4-18.'	JM	12/12/09	MM		1516-4.3.dat

GeoTesting express
a subsidiary of Geocomp Corporation

Project: Clifty Creek	Location: ----	Project No.: GTX-1516
Boring No.: B-10	Sample Type: UD	
Description:		
Remarks: 2054		

Tue, 19-JAN-2010 11:56:31

APPENDIX F

PERMEABILITY TESTS

BOILER SLAB POND DAM

Stantec

Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter ASTM D 5084-03

Project Name AEP-Clifty Creek-West Bottom Ash and Fly Ash Ponds subsurface exploration
Project No. 175539022
Source B-1, 15.0'-17.0', TI 16.1'-16.6'
Test ID 7A
Visual Classification Lean Clay (CL), brown, moist, firm
Prepared By CSM
Undisturbed XX
Specific Gravity 2.72 ASTM D854-A
Date 12-9-09
Maximum Dry Density (pcf)
Percent of Maximum
Permeant: De-aired tap water
Selection and Preparation Comments:

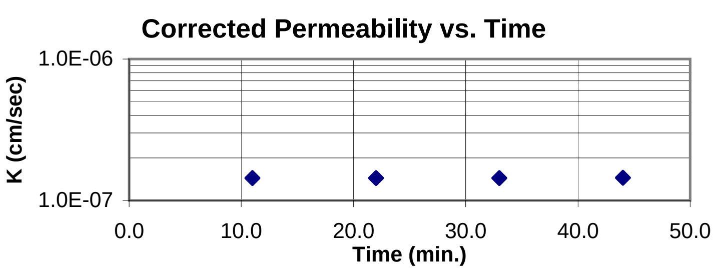
Specimens (if compacted) were compacted in a Proctor Mold as follows: The Maximum Dry Density was converted to Wet Density, this mass was divided by 4 (layers) and 3 of the 4 layers were compacted into the mold using a Proctor Hammer using 19 blows per layer. The density was varied by reducing the height of the drop by the amount listed beside "Compacted". The specimen was trimmed from the bottom two layers.

	Initial Specimen Data	After Consolidation Data	After Test Data
Height (in.)	1.4783	1.4675	1.4676
Diameter (in.)	2.8043		2.8179
Moisture Content (%)	19.7		20.8
Dry Unit Weight (pcf)	109.5		109.2
Void Ratio	0.551		0.555
Degree of Saturation (%)	97.3		101.9
Trimmings MC (%)	19.6		

Final Pressures (psi)	
Chamber	75
Influent	70
Effluent	65

Applied Head Difference (psi)	5
Back Pressure Saturated to (psi)	65
Maximum Effective Consolidation Stress (psi)	10
Minimum Effective Consolidation Stress (psi)	5

						Hydraulic Conductivity			
Date	Clock (24H:M)	Temp. °F	Bottom Head	Top Head	Test Time (sec)	k (m/s)	k (cm/s)	k @ 20° C (m/s)	k @ 20° C (cm/s)
12-21-09	10:24	73.0	15.02	8.57	0	---	---	---	---
12-21-09	10:35	73.0	14.90	8.69	6.60E+02	1.5E-09	1.5E-07	1.4E-09	1.4E-07
12-21-09	10:46	73.0	14.78	8.81	6.60E+02	1.5E-09	1.5E-07	1.4E-09	1.4E-07
12-21-09	10:57	73.0	14.66	8.93	6.60E+02	1.5E-09	1.5E-07	1.4E-09	1.4E-07
12-21-09	11:08	73.0	14.54	9.05	6.60E+02	1.5E-09	1.5E-07	1.4E-09	1.4E-07



A gradient of approximately 93.4 was used for this test. This gradient exceeds ASTM guidelines for maximum gradient, but was used to achieve the requestors desired test duration. Examination of the sample shows no signs of material loss or clogging that may affect test results.

Average Hydraulic Conductivity @ 20° C (last 4 determinations) m/s 1.44E-09 cm/s 1.44E-07
Average Hydraulic Conductivity @ 20° C (last run) m/s 1.44E-09 cm/s 1.44E-07

Reviewed by:

Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter ASTM D 5084-03

Stantec

Project Name	AEP-Clifty Creek-West Bottom Ash and Fly Ash Ponds subsurface exploration	Project No.	175539022
Source	B-2, 42.5'-44.5', TI 42.6'-43.1'	Test ID	48A
Visual Classification	Lean Clay (CL), gray, wet, soft	Prepared By	CSM
Undisturbed	XX	Date	11-30-09

Specific Gravity 2.69 ASTM D854-A

Maximum Dry Density (pcf) ______ Percent of Maximum ______

Permeant: De-aired tap water

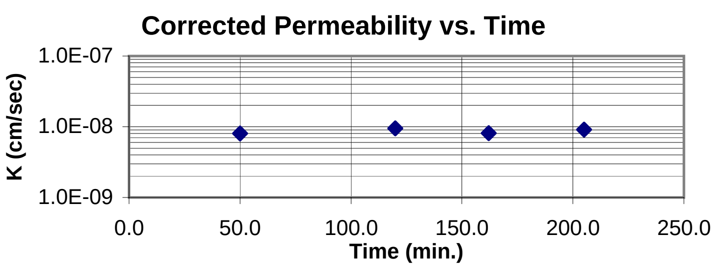
Selection and Preparation Comments: ______

Specimens (if compacted) were compacted in a Proctor Mold as follows: The Maximum Dry Density was converted to Wet Density, this mass was divided by 4 (layers) and 3 of the 4 layers were compacted into the mold using a Proctor Hammer using 19 blows per layer. The density was varied by reducing the height of the drop by the amount listed beside "Compacted". The specimen was trimmed from the bottom two layers.

	Initial Specimen Data	After Consolidation Data	After Test Data	Final Pressures (psi)	
Height (in.)	1.4906	1.3473	1.3472	Chamber	75
Diameter (in.)	2.8023		2.8480	Influent	70
Moisture Content (%)	31.6		26.0	Effluent	65
Dry Unit Weight (pcf)	91.6		98.1		
Void Ratio	0.834		0.712		
Degree of Saturation (%)	101.8		98.1		
Trimmings MC (%)	30.9				

Applied Head Difference (psi)	5
Back Pressure Saturated to (psi)	65
Maximum Effective Consolidation Stress (psi)	10
Minimum Effective Consolidation Stress (psi)	5

						Hydraulic Conductivity			
Date	Clock (24H:M)	Temp. °F	Bottom Head	Top Head	Test Time (sec)	k (m/s)	k (cm/s)	k @ 20° C (m/s)	k @ 20° C (cm/s)
12-22-09	8:20	70.0	22.26	3.46	0	---	---	---	---
12-22-09	9:10	70.0	22.13	3.59	3.00E+03	8.3E-11	8.3E-09	8.1E-11	8.1E-09
12-22-09	10:20	70.0	21.92	3.81	4.20E+03	9.8E-11	9.8E-09	9.5E-11	9.5E-09
12-22-09	11:02	70.0	21.81	3.92	2.52E+03	8.4E-11	8.4E-09	8.1E-11	8.1E-09
12-22-09	11:45	70.0	21.68	4.04	2.58E+03	9.3E-11	9.3E-09	9.1E-11	9.1E-09



A gradient of approximately 92.6 was used for this test. This gradient exceeds ASTM guidelines for maximum gradient, but was used to achieve the requestors desired test duration. Examination of the sample shows no signs of material loss or clogging that may affect test results.

Average Hydraulic Conductivity @ 20° C (last 4 determinations)	m/s	8.70E-11	cm/s	8.70E-09
Average Hydraulic Conductivity @ 20° C (last run)	m/s	8.70E-11	cm/s	8.70E-09

Reviewed by: ______

Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
ASTM D 5084-03

Project Name	AEP-Clifty Creek- West Bottom Ash and Fly Ash Ponds subsurface exploration	Project No.	175539022
Source	B-4, 7.5'-9.5', TI 7.6'-8.1'	Test ID	82A
Visual Classification	Lean Clay (CL), brown, moist, firm, organic odor	Prepared By	CSM
Undisturbed	XX	Date	12-9-09

Specific Gravity 2.7 ASTM D854-A

Maximum Dry Density (pcf) ______ Percent of Maximum ______

Permeant: De-aired tap water

Selection and Preparation Comments: ______

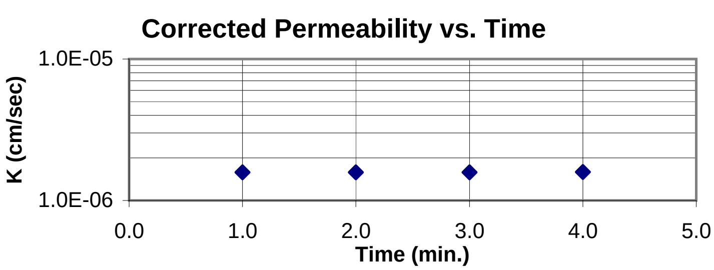
Specimens (if compacted) were compacted in a Proctor Mold as follows: The Maximum Dry Density was converted to Wet Density, this mass was divided by 4 (layers) and 3 of the 4 layers were compacted into the mold using a Proctor Hammer using 19 blows per layer. The density was varied by reducing the height of the drop by the amount listed beside "Compacted". The specimen was trimmed from the bottom two layers.

	Initial Specimen Data	After Consolidation Data	After Test Data
Height (in.)	1.4754	1.4631	1.4654
Diameter (in.)	2.8057		2.8200
Moisture Content (%)	18.8		20.1
Dry Unit Weight (pcf)	110.0		109.6
Void Ratio	0.532		0.537
Degree of Saturation (%)	95.6		100.8
Trimmings MC (%)	19.1		

Final Pressures (psi)	
Chamber	75
Influent	70
Effluent	65

Applied Head Difference (psi)	5
Back Pressure Saturated to (psi)	65
Maximum Effective Consolidation Stress (psi)	10
Minimum Effective Consolidation Stress (psi)	5

						Hydraulic Conductivity			
Date	Clock (24H:M)	Temp. °F	Bottom Head	Top Head	Test Time (sec)	k (m/s)	k (cm/s)	k @ 20° C (m/s)	k @ 20° C (cm/s)
12-21-09	11:25	73.0	15.06	10.34	0	---	---	---	---
12-21-09	11:26	73.0	14.94	10.46	6.00E+01	1.7E-08	1.7E-06	1.6E-08	1.6E-06
12-21-09	11:27	73.0	14.82	10.58	6.00E+01	1.7E-08	1.7E-06	1.6E-08	1.6E-06
12-21-09	11:28	73.0	14.70	10.70	6.00E+01	1.7E-08	1.7E-06	1.6E-08	1.6E-06
12-21-09	11:29	73.0	14.58	10.82	6.00E+01	1.7E-08	1.7E-06	1.6E-08	1.6E-06



A gradient of approximately 93.5 was used for this test. This gradient exceeds ASTM guidelines for maximum gradient, but was used to achieve the requestors desired test duration. Examination of the sample shows no signs of material loss or clogging that may affect test results.

Average Hydraulic Conductivity @ 20° C (last 4 determinations)	m/s	1.58E-08	cm/s	1.58E-06
Average Hydraulic Conductivity @ 20° C (last run)	m/s	1.58E-08	cm/s	1.58E-06

Reviewed by: ______

Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter ASTM D 5084-03

Stantec

Project Name AEP-Clifty Creek-West Bottom Ash and Fly Ash Ponds subsurface exploration
Project No. 175539022
Source B-6, 17.5'-19.0', TI 17.6'-18.1'
Test ID 291
Visual Classification Lean Clay (CL), brown, moist, firm
Prepared By CSM
Undisturbed XX
Specific Gravity 2.68 ASTM D854-A
Date 12-9-09
Maximum Dry Density (pcf)
Percent of Maximum
Permeant: De-aired tap water
Selection and Preparation Comments:

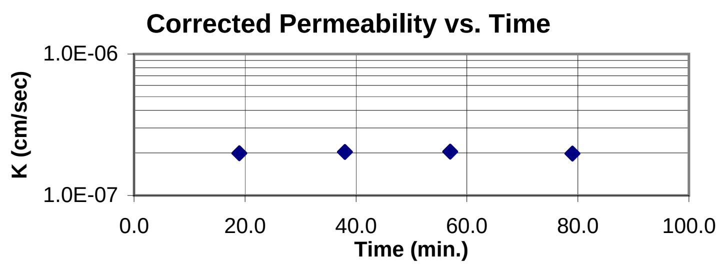
Specimens (if compacted) were compacted in a Proctor Mold as follows: The Maximum Dry Density was converted to Wet Density, this mass was divided by 4 (layers) and 3 of the 4 layers were compacted into the mold using a Proctor Hammer using 19 blows per layer. The density was varied by reducing the height of the drop by the amount listed beside "Compacted". The specimen was trimmed from the bottom two layers.

	Initial Specimen Data	After Consolidation Data	After Test Data
Height (in.)	1.4778	1.4443	1.4478
Diameter (in.)	2.8030		2.7955
Moisture Content (%)	32.0		33.2
Dry Unit Weight (pcf)	87.1		89.4
Void Ratio	0.921		0.872
Degree of Saturation (%)	93.1		102.1
Trimmings MC (%)	33.1		

Final Pressures (psi)	
Chamber	75
Influent	70
Effluent	65

Applied Head Difference (psi)	5
Back Pressure Saturated to (psi)	65
Maximum Effective Consolidation Stress (psi)	10
Minimum Effective Consolidation Stress (psi)	5

						Hydraulic Conductivity			
Date	Clock (24H:M)	Temp. °F	Bottom Head	Top Head	Test Time (sec)	k (m/s)	k (cm/s)	k @ 20° C (m/s)	k @ 20° C (cm/s)
12-21-09	13:10	73.0	19.94	4.28	0	---	---	---	---
12-21-09	13:29	73.0	19.65	4.56	1.14E+03	2.1E-09	2.1E-07	2.0E-09	2.0E-07
12-21-09	13:48	73.0	19.36	4.85	1.14E+03	2.2E-09	2.2E-07	2.0E-09	2.0E-07
12-21-09	14:07	73.0	19.07	5.14	1.14E+03	2.2E-09	2.2E-07	2.0E-09	2.0E-07
12-21-09	14:29	73.0	18.71	5.43	1.32E+03	2.1E-09	2.1E-07	2.0E-09	2.0E-07



A gradient of approximately 93.4 was used for this test. This gradient exceeds ASTM guidelines for maximum gradient, but was used to achieve the requestors desired test duration. Examination of the sample shows no signs of material loss or clogging that may affect test results.

Average Hydraulic Conductivity @ 20° C (last 4 determinations) m/s 2.01E-09 cm/s 2.01E-07
Average Hydraulic Conductivity @ 20° C (last run) m/s 2.01E-09 cm/s 2.01E-07

Reviewed by:

LANDFILL RUNOFF COLLECTION POND

PERMEABILITY TEST
(ASTM D5084 - 90) (Method C, Increasing Tailwater Level)

Project Number	GTX-1516	Tested By	JM
Project Name	Clifty Creek	Test Date	12/12/10
Boring No.	B-7	Reviewed By	MM
Sample No.	---	Review Date	12/15/10
Sample Depth	27.4-27.7 ft	Lab No.	5
Sample Description	Lean clay		

GeoTesting express

Sample Data

Length, in		Diameter, in		Pan No.	CS-1
Location 1	2.831	Location 1	2.825	Dry Soil+Pan, grams	484.22
Location 2	2.830	Location 2	2.825	Pan Weight, grams	8.17
Location3	2.829	Location 3	2.825		
Average	2.830	Average	2.825	Moisture Content, %	24.6
		Wet Soil + Tare, grams	593.33	Wet Unit Weight, pcf	127.4
		Tare Weight, grams	0.00	Dry Unit Weight, pcf	102.2

Remarks:

Chamber Pressure, psi	65
Back Pressure, psi	60
Confining Pressure, psi	5

Date Start	Date Finish	Time Start	Time Finish	Time (sec)	H_a (cm)	H_1 (cm)	H_b (cm)	H_2 (cm)	k cm/sec	Temp (°C)	k cm/sec at 20 °C
				2820	9.9	100.3	10.60	99.5	8.4E-08	22	8.1E-08
				6300	9.9	100.3	11.80	98.4	9.7E-08	24	8.8E-08
				9000	9.9	100.3	12.50	97.7	9.4E-08	24	8.5E-08
				14400	9.9	100.3	14.00	96.1	9.5E-08	24	8.6E-08
				27000	9.9	100.3	17.00	93	9.1E-08	24	8.3E-08

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
5	UD	102.2	N/A	Vertical

Avg. k at 20 °C 8.4E-08 cm/sec

a = area of burette in cm^2
L = length of sample in cm
A = area of sample in cm^2

Ha = initial inlet head in cm
H_1 = initial outlet head in cm
t = time in seconds

H_b = final inlet head in cm
H_2 = final outlet head in cm

a = 0.16 cm^2
A = 40.44 cm^2
L = 7.19 cm

GeoTesting express

HYDRAULIC CONDUCTIVITY

Project No.	*GTX-1516*	Tested By	*JM*
Project Name	*Clifty Creek*	Test Date	*12/12/2010*
Boring No.	*B-7*	Reviewed By	*MM*
Sample No.	---	Review Date	*12/15/2010*
Sample Depth	*27.4-27.7 ft*	Lab No.	*5*
Sample Description	*Lean clay*		

ASTM D5084 - Falling Head (Method C RisingTail)

Sample Type:	*UD*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*24.6*
Wet Unit Weight, pcf:	*127.4*
Dry Unit Weight, pcf:	*102.2*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***8.4E-08***

Remarks:

PERMEABILITY TEST
(ASTM D5084 - 90) (Method C, Increasing Tailwater Level)

Project Number	GTX-1516	Tested By	JM
Project Name	Clifty Creek	Test Date	12/12/10
Boring No.	B-8	Reviewed By	MM
Sample No.	---	Review Date	12/15/10
Sample Depth	29.7-30.3 ft	Lab No.	7

Sample Description: Lean clay with sand

Sample Data

Length, in		Diameter, in		Pan No.	A44
Location 1	2.841	Location 1	2.775	Dry Soil+Pan, grams	487.70
Location 2	2.843	Location 2	2.784	Pan Weight, grams	8.99
Location3	2.844	Location 3	2.788		
Average	2.843	Average	2.782	Moisture Content, %	23.5
		Wet Soil + Tare, grams	591.11	Wet Unit Weight, pcf	130.3
		Tare Weight, grams	0.00	Dry Unit Weight, pcf	105.5

Remarks:

Chamber Pressure, psi	65
Back Pressure, psi	60
Confining Pressure, psi	5

Date Start	Date Finish	Time Start	Time Finish	Time (sec)	H_a (cm)	H_1 (cm)	H_b (cm)	H_2 (cm)	k cm/sec	Temp (°C)	k cm/sec at 20 °C
				3200	6.5	107.2	6.90	106.9	3.2E-08	22	3.1E-08
				6600	6.5	107.2	7.40	106.4	3.8E-08	24	3.4E-08
				11400	6.5	107.2	8.10	105.7	4.0E-08	24	3.7E-08
				18000	6.5	107.2	9.00	104.8	4.1E-08	24	3.7E-08
				30000	6.5	107.2	10.20	103.6	3.7E-08	24	3.3E-08

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
5	UD	105.5	N/A	Vertical

Avg. k at 20 °C 3.4E-08 cm/sec

a = area of burette in cm²
L = length of sample in cm
A = area of sample in cm²

Ha = initial inlet head in cm
H_1 = initial outlet head in cm
t = time in seconds

H_b = final inlet head in cm
H_2 = final outlet head in cm

a = 0.16 cm²
A = 39.23 cm²
L = 7.22 cm

GeoTesting express

HYDRAULIC CONDUCTIVITY

Project No.	***GTX-1516***	Tested By	***JM***
Project Name	***Clifty Creek***	Test Date	***12/12/2010***
Boring No.	***B-8***	Reviewed By	***MM***
Sample No.	***---***	Review Date	***12/15/2010***
Sample Depth	***29.7-30.3 ft***	Lab No.	***7***
Sample Description	***Lean clay with sand***		

ASTM D5084 - Falling Head (Method C RisingTail)

Sample Type:	*UD*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*23.5*
Wet Unit Weight, pcf:	*130.3*
Dry Unit Weight, pcf:	*105.5*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***3.4E-08***

Remarks:

PERMEABILITY TEST
(ASTM D5084 - 90) (Method C, Increasing Tailwater Level)

Project Number	GTX-1516	Tested By	JM
Project Name	Clifty Creek	Test Date	12/12/10
Boring No.	B-9	Reviewed By	MM
Sample No.	---	Review Date	12/15/10
Sample Depth	18.3-18.6	Lab No.	8
Sample Description	Lean clay		

GeoTesting express

Sample Data

Length, in		Diameter, in		Pan No.	a-18
Location 1	2.899	Location 1	2.872	Dry Soil+Pan, grams	541.33
Location 2	2.901	Location 2	2.877	Pan Weight, grams	9.11
Location3	2.905	Location 3	2.877		
Average	2.902	Average	2.875	Moisture Content, %	21.0
		Wet Soil + Tare, grams	644.22	Wet Unit Weight, pcf	130.3
		Tare Weight, grams	0.00	Dry Unit Weight, pcf	107.6

Remarks:

Chamber Pressure, psi	65
Back Pressure, psi	60
Confining Pressure, psi	5

Date Start	Date Finish	Time Start	Time Finish	Time (sec)	H_a (cm)	H_1 (cm)	H_b (cm)	H_2 (cm)	k cm/sec	Temp (°C)	k cm/sec at 20 °C
				1800	5.3	100.4	5.70	100	6.6E-08	22	6.3E-08
				4800	5.3	100.4	6.40	99.3	6.9E-08	24	6.2E-08
				8400	5.3	100.4	7.20	98.5	6.8E-08	24	6.2E-08
				16200	5.3	100.4	8.80	96.9	6.6E-08	24	6.0E-08
				27000	5.3	100.4	11.00	94.7	6.7E-08	24	6.0E-08

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
5	UD	107.6	N/A	Vertical

Avg. k at 20 °C 6.2E-08 cm/sec

a = area of burette in cm²
L = length of sample in cm
A = area of sample in cm²

Ha = initial inlet head in cm
H_1 = initial outlet head in cm
t = time in seconds

H_b = final inlet head in cm
H_2 = final outlet head in cm

a = 0.16 cm²
A = 41.89 cm²
L = 7.37 cm

GeoTesting express

HYDRAULIC CONDUCTIVITY

Project No.	*GTX-1516*	Tested By	*JM*
Project Name	*Clifty Creek*	Test Date	*12/12/2010*
Boring No.	*B-9*	Reviewed By	*MM*
Sample No.	---	Review Date	*12/15/2010*
Sample Depth	*18.3-18.6*	Lab No.	*8*
Sample Description	*Lean clay*		

ASTM D5084 - Falling Head (Method C RisingTail)

Sample Type:	*UD*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*21.0*
Wet Unit Weight, pcf:	*130.3*
Dry Unit Weight, pcf:	*107.6*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***6.2E-08***

Remarks: ______________________________

PERMEABILITY TEST
(ASTM D5084 - 90) (Method C, Increasing Tailwater Level)

Project Number GTX-1516 — Tested By JM
Project Name Clifty Creek — Test Date 12/12/10
Boring No. B-10 — Reviewed By MM
Sample No. --- — Review Date 12/15/10
Sample Depth 16.4-16.7 ft — Lab No. 11
Sample Description Lean clay

GeoTesting express

Sample Data

Length, in		Diameter, in		Pan No.	a-22
Location 1	3.121	Location 1	2.876	Dry Soil+Pan, grams	539.99
Location 2	3.203	Location 2	2.877	Pan Weight, grams	9.13
Location3	3.126	Location 3	2.877		
Average	3.150	Average	2.877	Moisture Content, %	21.1
		Wet Soil + Tare, grams	642.99	Wet Unit Weight, pcf	119.6
		Tare Weight, grams	0.00	Dry Unit Weight, pcf	98.8

Remarks:

Chamber Pressure, psi 65
Back Pressure, psi 60
Confining Pressure, psi 5

Date Start	Date Finish	Time Start	Time Finish	Time (sec)	H_a (cm)	H_1 (cm)	H_b (cm)	H_2 (cm)	k cm/sec	Temp (°C)	k cm/sec at 20 °C
				1800	7.7	99.3	8.50	98.5	1.5E-07	22	1.4E-07
				4800	7.7	99.3	9.90	97.1	1.6E-07	22	1.5E-07
				8400	7.7	99.3	11.20	94.7	1.7E-07	22	1.6E-07
				16200	7.7	99.3	13.00	92.9	1.3E-07	22	1.2E-07
				24000	7.7	99.3	15.00	90.9	1.2E-07	22	1.1E-07

No. of Trials	Sample Type	Max. Density (pcf)	Compaction %	Sample Orientation
5	UD	107.6	N/A	Vertical

Avg. k at 20 °C 1.4E-07 cm/sec

a = area of burette in cm² — Ha = initial inlet head in cm — H_b = final inlet head in cm

L = length of sample in cm — H_1 = initial outlet head in cm — H_2 = final outlet head in cm

A = area of sample in cm² — t = time in seconds

a = 0.16 cm²
A = 41.93 cm²
L = 8.00 cm

GeoTesting express

HYDRAULIC CONDUCTIVITY

Project No.	*GTX-1516*	Tested By	*JM*
Project Name	*Clifty Creek*	Test Date	*12/12/2010*
Boring No.	*B-10*	Reviewed By	*MM*
Sample No.	---	Review Date	*12/15/2010*
Sample Depth	*16.4-16.7 ft*	Lab No.	*11*
Sample Description	*Lean clay*		

ASTM D5084 - Falling Head (Method C RisingTail)

Sample Type:	*UD*
Sample Orientation:	*Vertical*
Initial Water Content, %:	*21.1*
Wet Unit Weight, pcf:	*119.6*
Dry Unit Weight, pcf:	*98.8*
Compaction, %:	*N/A*
Hydraulic Conductivity, cm/sec. @20 °C	***1.4E-07***

Remarks:

APPENDIX G

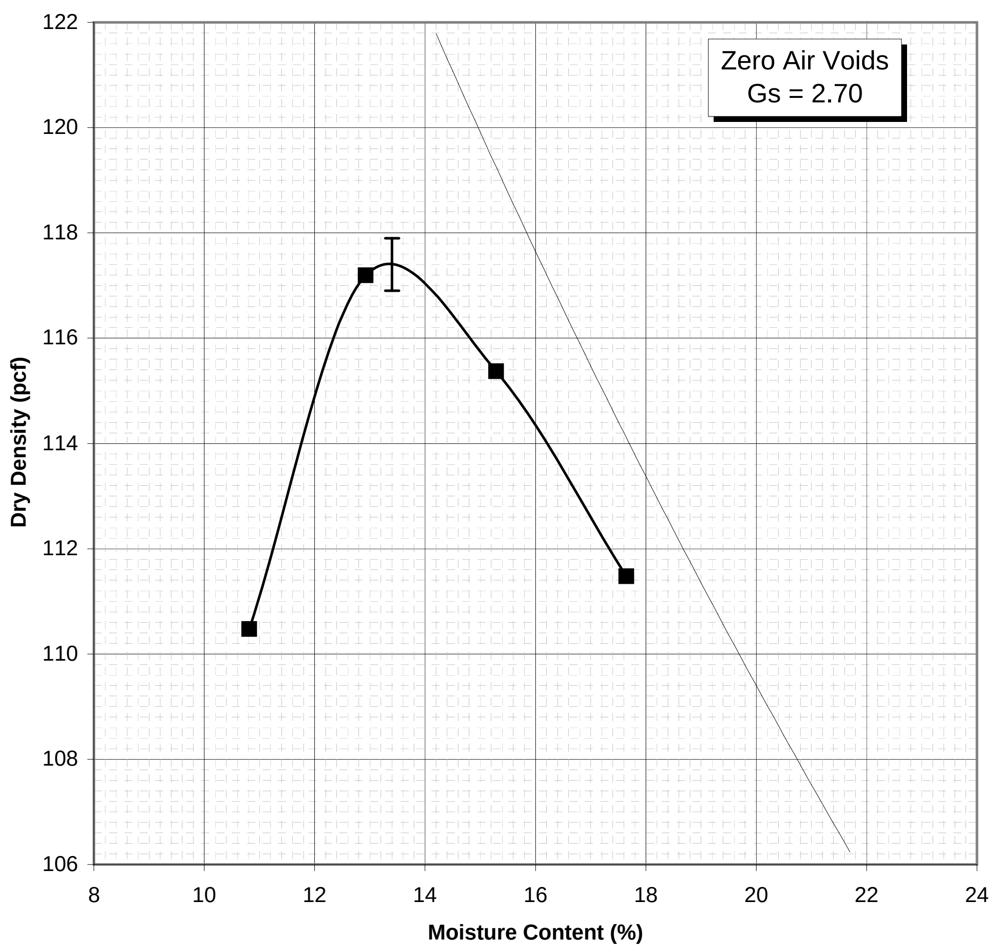
STANDARD PROCTOR MOISTURE-DENSITY TESTS

BOILER SLAG POND DAM

Moisture-Density Data Sheet

Project: AEP - Clifty Creek - West Bottom Ash Pond
Project No.: 175539022
Source: B-1, 5.0'
Sample No.: 319
Sample Description: Brown lean clay with gravel, moist
Nmc: 15.6 %
Visual Notes: N/A
Test Method: ASTM D 698 - Method A
Prepared: Dry
Oversized Fraction: < 5 %
Rammer: Mechanical
Gs - Fines: Assumed

Mold Weight 2041 grams		Moisture Determination				
Wet Weight plus Mold (grams)	Wet Weight minus Mold (grams)	Wet Soil and Can Weight (grams)	Dry Soil and Can Weight (grams)	Can Weight (grams)	Water Content (%)	Dry Density (pcf)
3879	1838	432.75	397.39	70.52	10.8	110.5
4028	1987	462.87	418.39	74.30	12.9	117.2
4038	1997	405.73	362.08	76.62	15.3	115.4
4010	1969	368.39	324.37	74.94	17.6	111.5



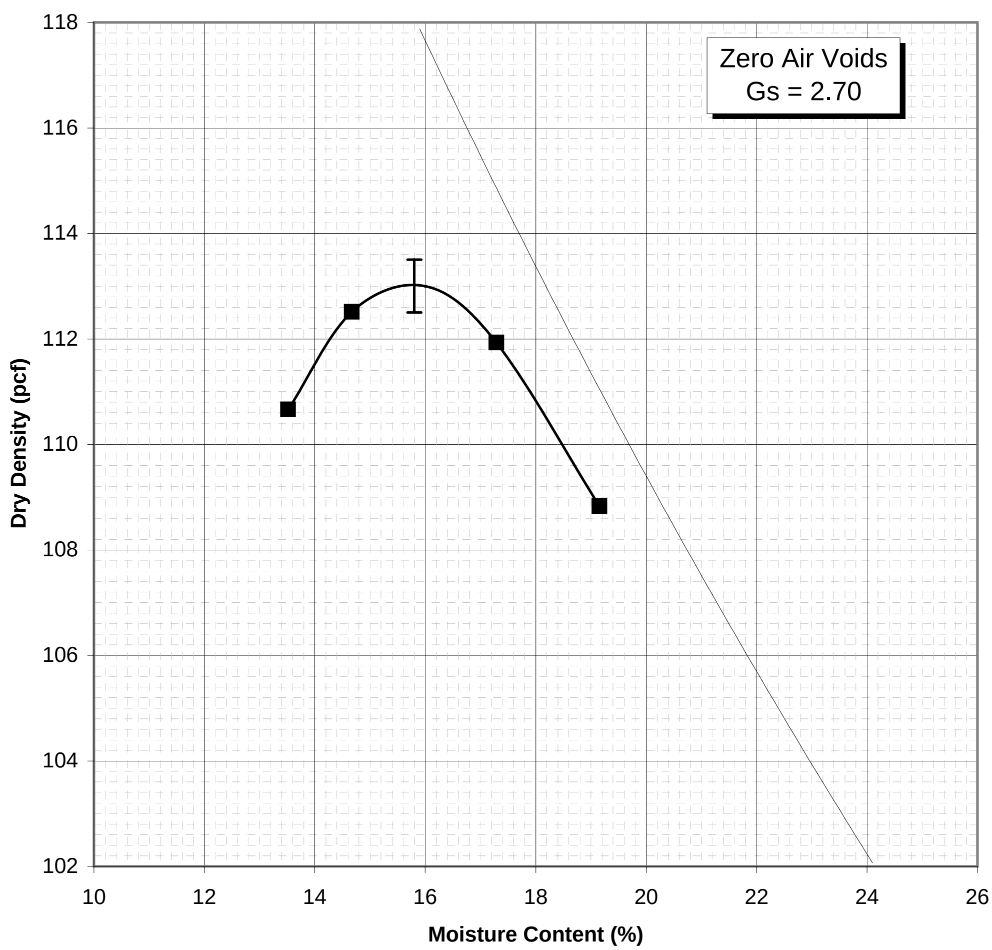
Maximum Dry Density 117.4 PCF
Optimum Moisture Content 13.4 %

Stantec

Moisture-Density Data Sheet

Project: AEP - Clifty Creek - West Bottom Ash Pond
Project No.: 175539022
Source: B-5, 7.5'
Sample No.: 320
Sample Description: brown lean clay, moist
Nmc: 18.2 %
Visual Notes: N/A
Test Method: ASTM D 698 - Method A
Prepared: Dry
Oversized Fraction: < 5 %
Rammer: Mechanical
Gs - Fines: Assumed

Mold Weight 2041 grams		Moisture Determination				
Wet Weight plus Mold (grams)	Wet Weight minus Mold (grams)	Wet Soil and Can Weight (grams)	Dry Soil and Can Weight (grams)	Can Weight (grams)	Water Content (%)	Dry Density (pcf)
3927	1886	422.84	381.18	72.94	13.5	110.7
3978	1937	388.97	348.78	74.79	14.7	112.5
4012	1971	392.34	345.43	74.11	17.3	111.9
3988	1947	409.73	355.79	74.24	19.2	108.8



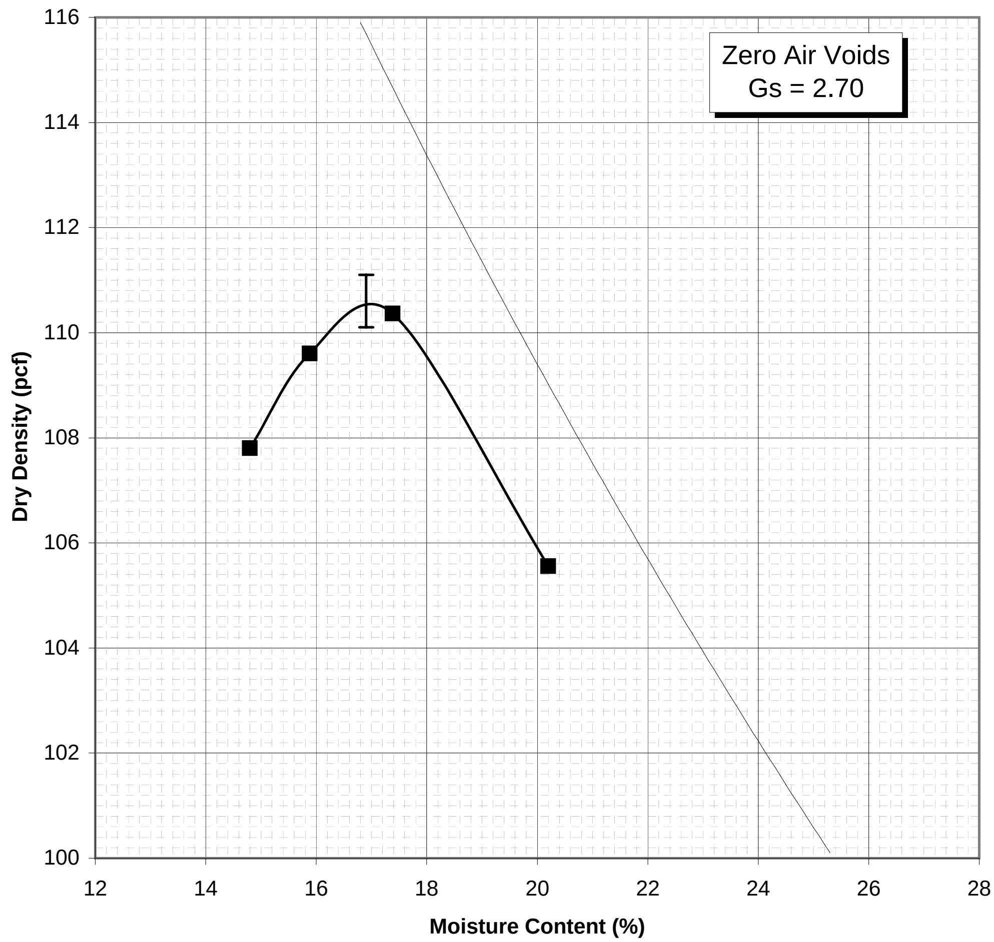
Maximum Dry Density 113.0 PCF
Optimum Moisture Content 15.8 %

LANDFILL RUNOFF COLLECTION POND

Moisture-Density Data Sheet

Project: AEP - Clifty Creek - South Fly Ash Pond
Project No.: 175539022
Source: B-7, 7.0'
Sample No.: 321
Sample Description: brown lean clay, moist
Nmc: 20.5 %
Visual Notes: N/A
Test Method: ASTM D 698 - Method A
Prepared: Dry
Oversized Fraction: < 5 %
Rammer: Mechanical
Gs - Fines: Assumed

Mold Weight 2041 grams		Moisture Determination				
Wet Weight plus Mold (grams)	Wet Weight minus Mold (grams)	Wet Soil and Can Weight (grams)	Dry Soil and Can Weight (grams)	Can Weight (grams)	Water Content (%)	Dry Density (pcf)
3899	1858	421.72	374.30	53.84	14.8	107.8
3948	1907	420.48	370.25	54.04	15.9	109.6
3986	1945	425.03	373.25	75.37	17.4	110.4
3946	1905	465.82	400.33	76.15	20.2	105.6



Maximum Dry Density 110.6 PCF
Optimum Moisture Content 16.9 %

APPENDIX H

LIQUEFACTION ANALYSIS

BOILER SLAG POND DAM: 2015 CCR MANDATE

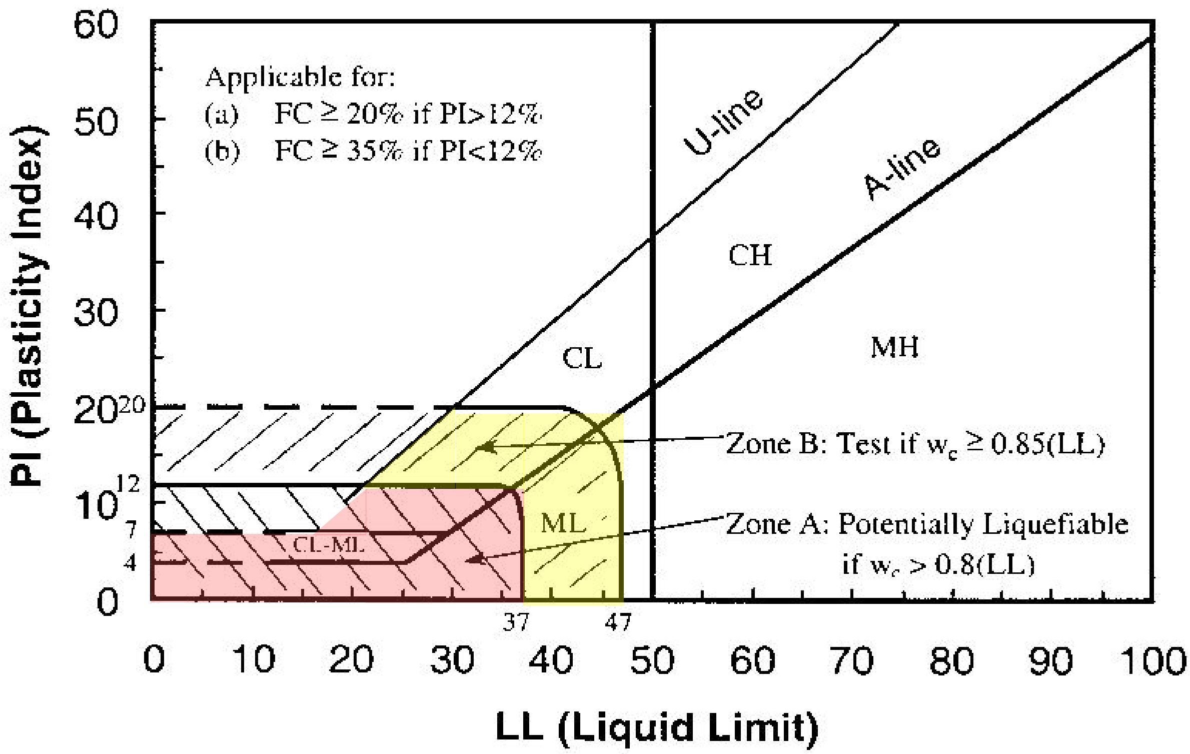
FINE-GRAINED ANALYSIS

Liquefaction Susceptibility of Fine-Grained Soils

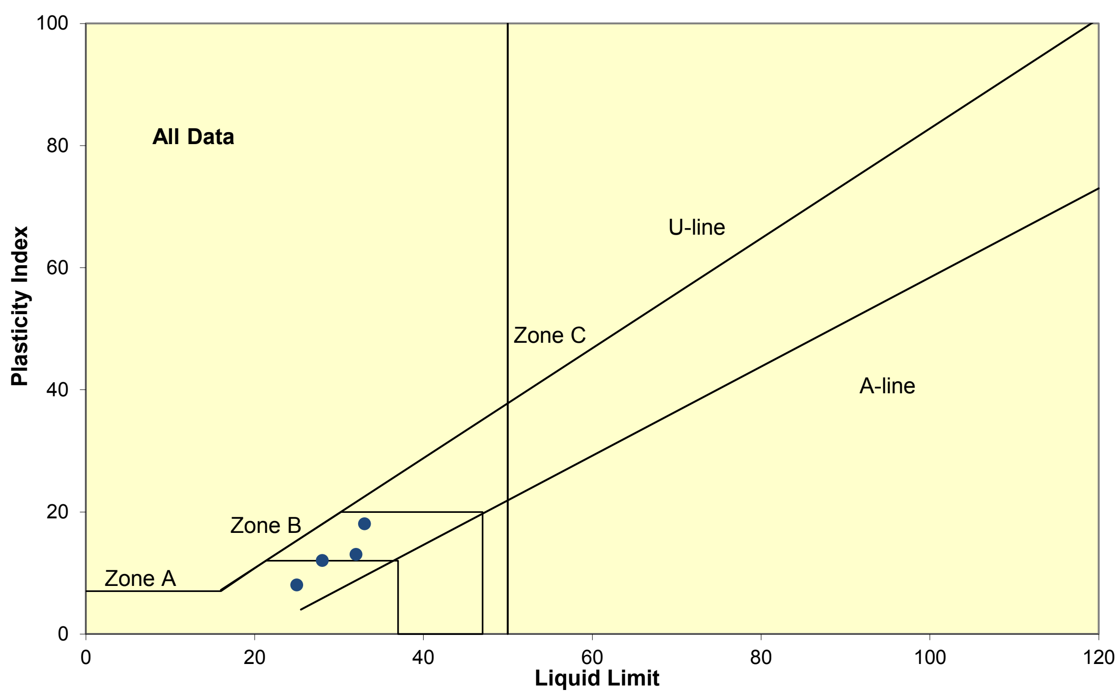
Stantec Project Number:	175553022
Project Name:	AEP Clifty Creek
Site/Structure Name:	West Bottom Ash Dam

Note: NP = Non-Plastic

									Sand-like versus Clay-like Behavior (-1 indicates result does not meet criteria, green shading indicates result does meet criteria, no results shown for non-plastic material)											
									Using Criteria published by Seed et al (2003)						Using Criteria published by Idriss and Boulanger (2008)		Using criteria published by MSHA (2010)			Overall Judgement based on 3 methods (sand-like or clay-like)
									Meets criteria for sand-like behavior		Meets criteria for clay-like behavior				Meets criteria for sand-like behavior	Meets criteria for clay-like behavior	Meets criteria for sand-like behavior	Meets criteria for clay-like behavior	Borderline soils (treat as sand-like)	
Lab ID	Boring	Depth(s)	Soil Classification	NMC (w_c) (%)	% Passing #200	% Passing #40	LL	PI	LL in Zone A (see plot)	PI in Zone A (see plot)	LL in Zone B (see plot)	PI in Zone B (see plot)	LL in Zone C (see plot)	PI in Zone C (see plot)	PI < 7	PI >= 7	PI <= 7	P40>=35%, P200>=20%, and PI>=10	7 < PI < 10, or does not meet P40 or P200	
4	B-1	10.0-11.5, 12.5-14.0	CL	19.1	84	98.4	32	13	-1	-1	32	13	-1	-1	-1	13	-1	13	-1	Clay-like
20	B-1	47.5-49.0, 50.0-51.5	CL	25.3	84.1	99.7	28	12	28	12	-1	-1	-1	-1	-1	12	-1	12	-1	Clay-like
43	B-2	32.5-34.0, 35.0-36.5	CL	32.1	79.7	98.7	33	18	-1	-1	33	18	-1	-1	-1	18	-1	18	-1	Clay-like
87	B-4	20.0-21.5, 22.5-24.0	CL	26.6	80.7	99.7	25	8	25	8	-1	-1	-1	-1	-1	8	-1	-1	8	Sand-like
103	B-4	57.5-59.0, 60.0-61.5	GW-GM	10.9	5.7	13.6	NP	NP												Sand-like
129	B-5	55.0-56.5, 57.5-59.0	ML	24.9	54	99.9	NP	NP												Sand-like

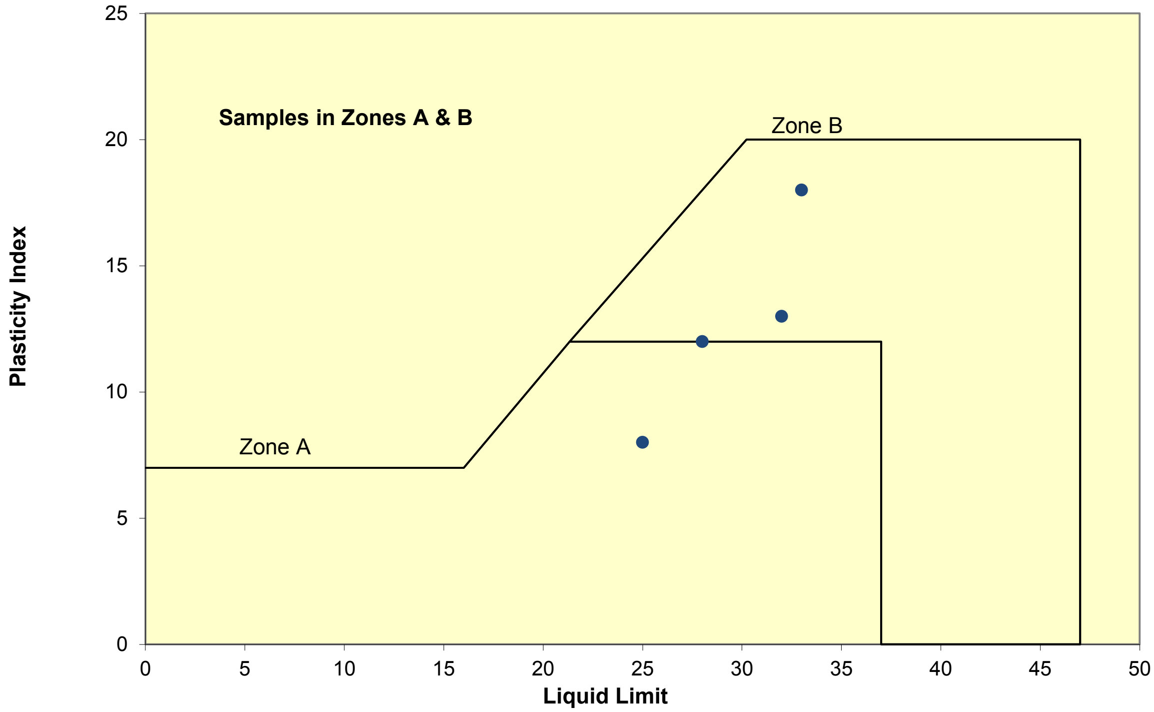


(a)

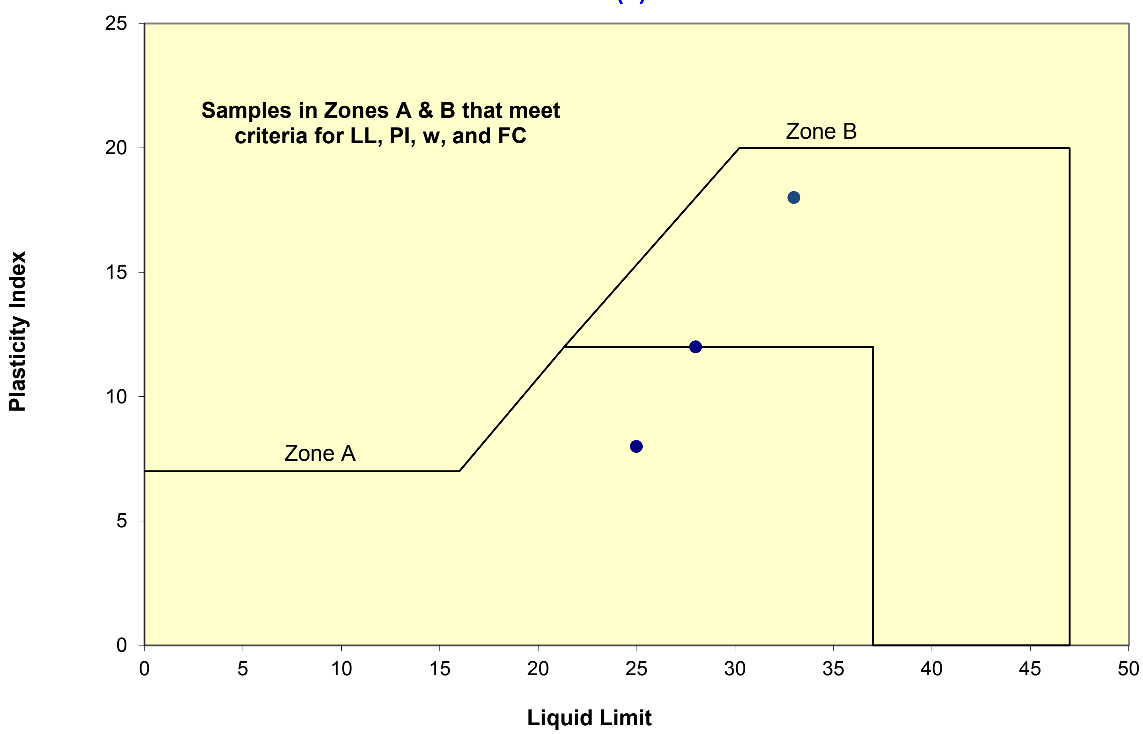


(b)

Screening Criteria for Liquefiable Fine-Grained Soils (Seed et al. 2003)

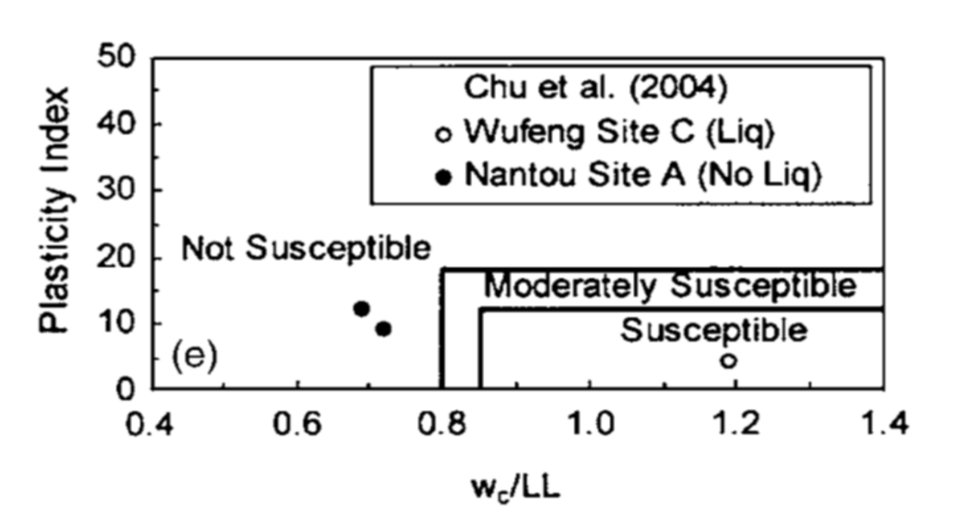


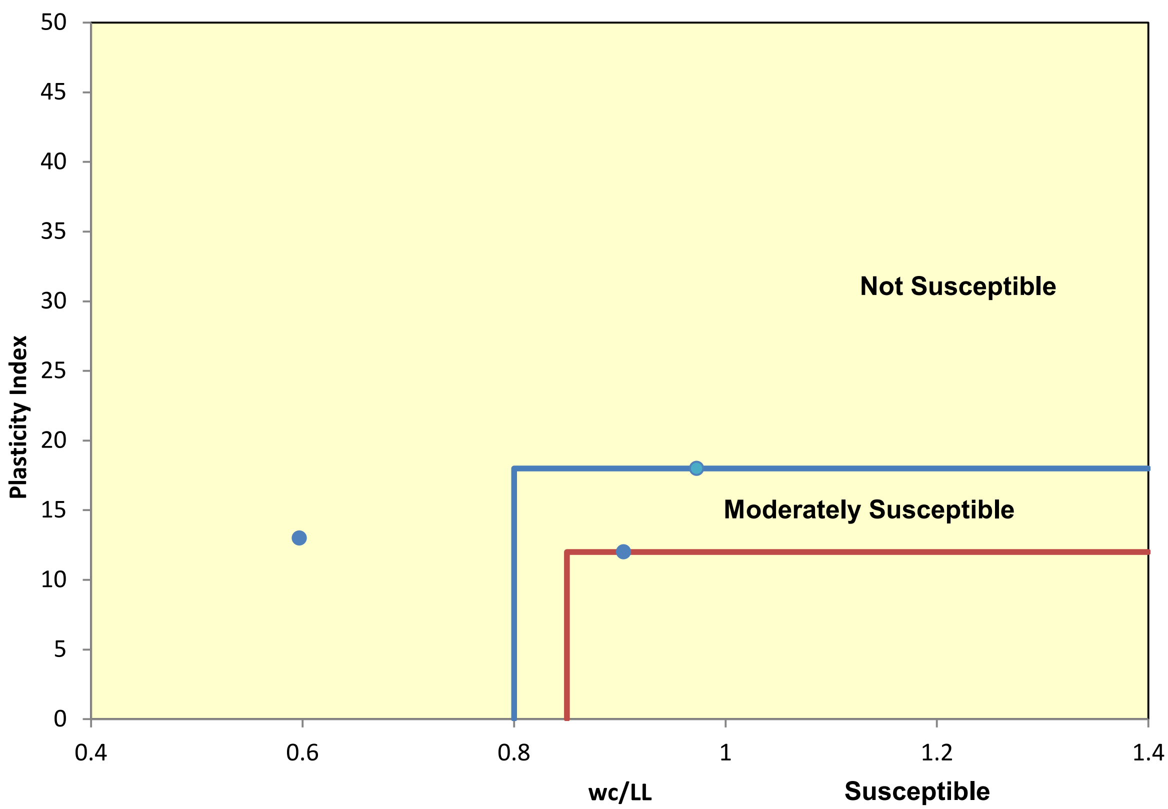
(c)



(d)

Screening Criteria for Liquefiable Fine-Grained Soils (Seed et al. 2003)





Screening Criteria for Assessing Liquefaction in Fine Grained Soils (Bray and Sancio 2006)

COARSE-GRAINED ANALYSIS

EQ Source: 0
a max (g): 0.085
EQ Mag (Mw): 7.7

Event (MCE, OBE, etc.): 0
EQ Motion File: 0

Shake Stress Curve Fit Parameters
m4: 0
m3: 0
m2: 0
m1: 0

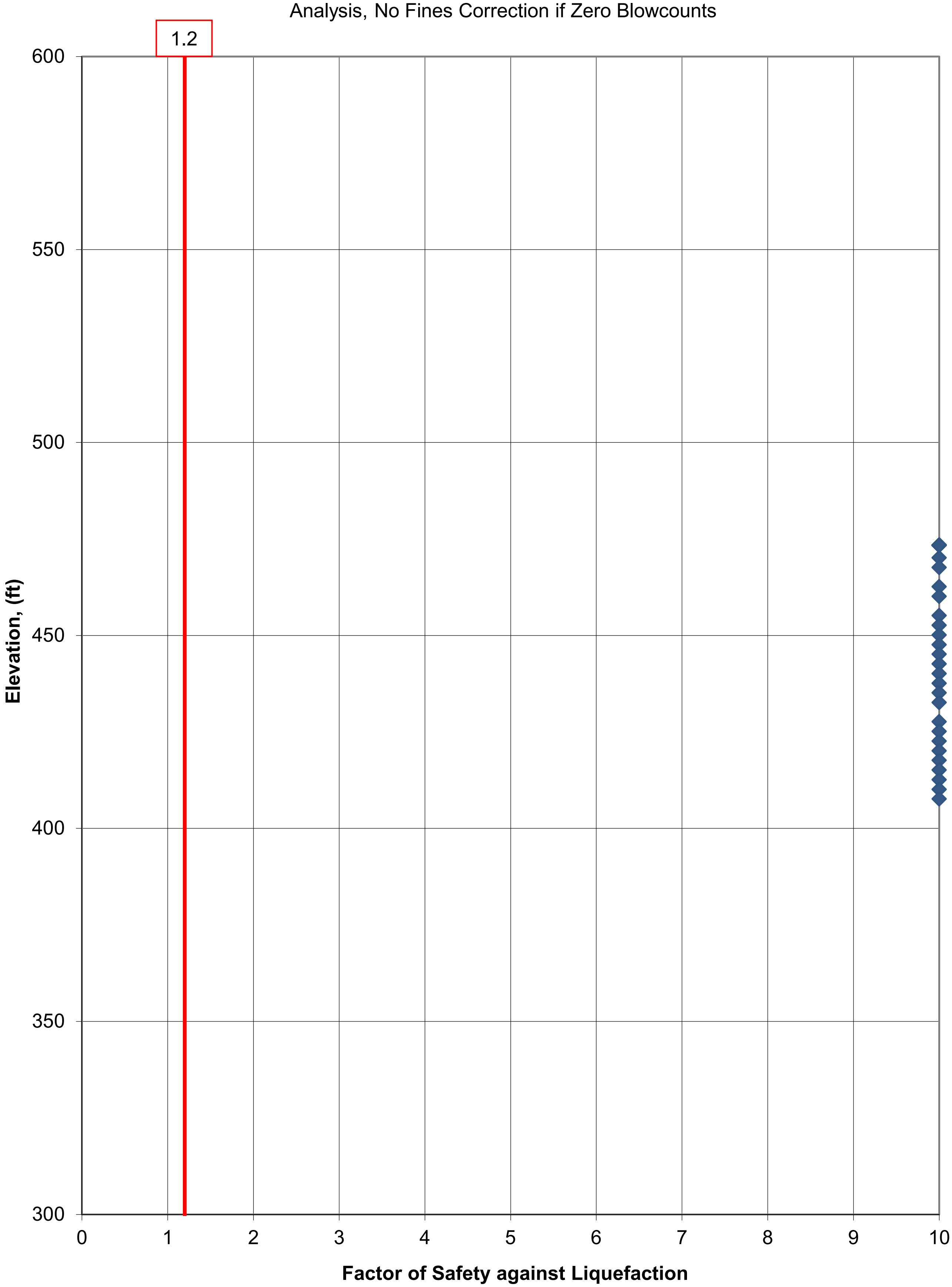
Boring ID: **B-1**
Top of Fill Elevation: 473.4
Fill Height: 0.0
Fill Total Unit Weight: 125
Fill Total Stress: 0.00

Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.

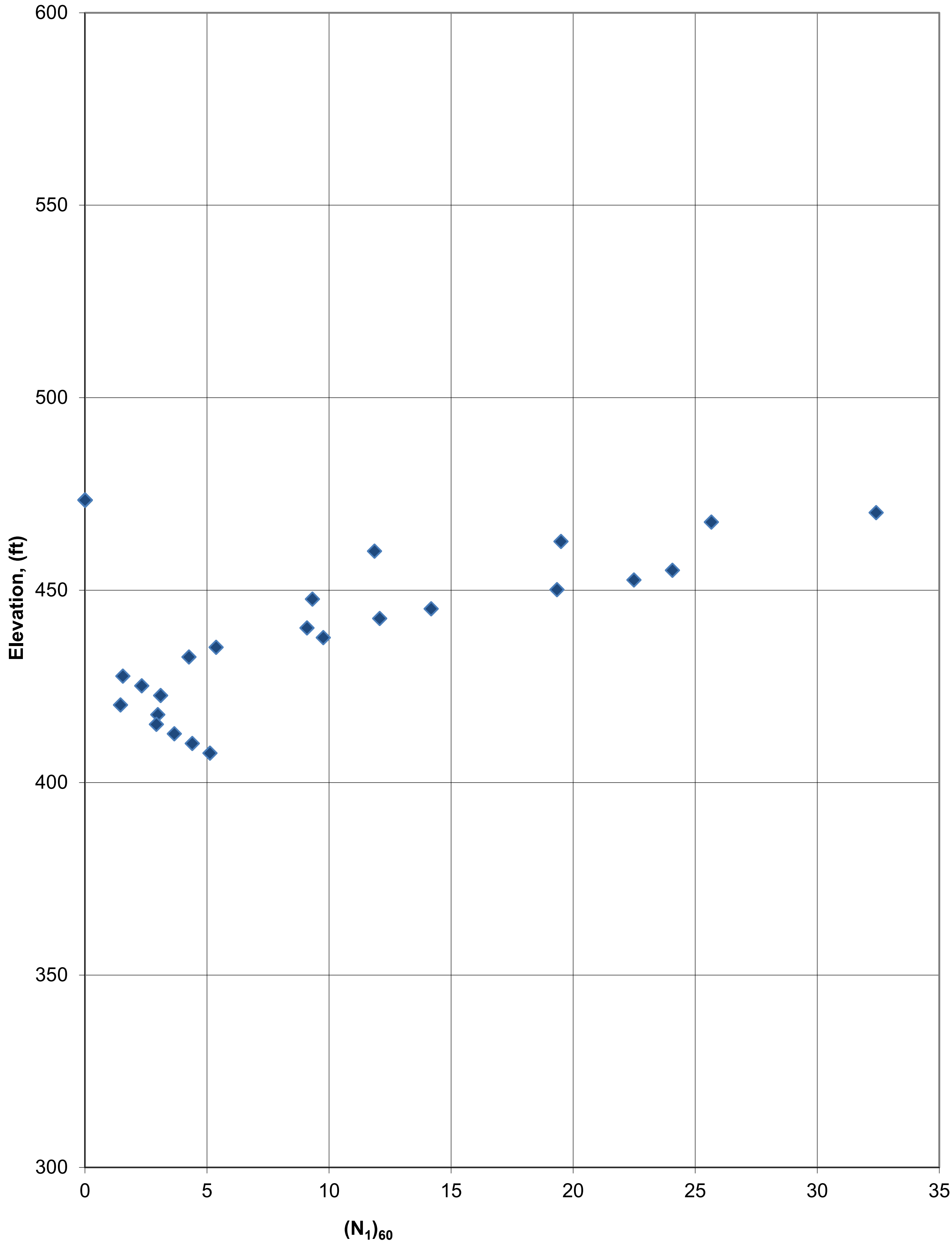
totstr-top: 0.16
u-top: 0.00
effstr-top: 0.16

Depth of Mid. Pt. of Sample (ft.) z	Vert. Total Stress during EQ (tsf) σ_v	Vert. Total Stress during EQ w/ Fill (tsf) $\sigma_{v\ with\ fill}$	Static Pore Pressure during EQ (tsf) u	Vert. Eff. Stress during EQ (tsf) σ'_v	Vert. Eff. Stress during EQ w/ Fill (tsf) $\sigma'_{v\ with\ fill}$	Alpha I	Beta I	Equivalent Clean Sand N-Value $(N_1)_{60cs}$	CRR7.5	Ksigma	Kalpha	Mag. Scaling Factor (Cm)	CRR Design EQ	Simplified Stress Reduction Coeff., r_d	Simplified CSR eq Design EQ	Max. Shake Stress (psf) Design EQ	Avg. Shake Stress (psf) Design EQ	Using SHAKE Data: CSR eq Design EQ	Using SHAKE Data: FS liq Design EQ	Using SHAKE Data: FS liq for plot	Simplified: FS liq Design EQ	Simplified: FS liq for plot
3.3	0.20	0.20	0.00	0.20	0.20	NA	NA	NA	NA	NA	NA	0.95	NA	0.994	0.055	0	0	0.000	NA	10.0	NA	10.00
5.8	0.36	0.36	0.00	0.36	0.36	NA	NA	NA	NA	NA	NA	0.95	NA	0.989	0.055	0	0	0.000	NA	10.0	NA	10.00
10.8	0.67	0.67	0.00	0.67	0.67	NA	NA	NA	NA	NA	NA	0.95	NA	0.978	0.054	0	0	0.000	NA	10.0	NA	10.00
13.3	0.83	0.83	0.00	0.83	0.83	NA	NA	NA	NA	NA	NA	0.95	NA	0.972	0.054	0	0	0.000	NA	10.0	NA	10.00
18.3	1.14	1.14	0.00	1.14	1.14	NA	NA	NA	NA	NA	NA	0.95	NA	0.961	0.053	0	0	0.000	NA	10.0	NA	10.00
20.8	1.30	1.30	0.00	1.30	1.30	NA	NA	NA	NA	NA	NA	0.95	NA	0.955	0.053	0	0	0.000	NA	10.0	NA	10.00
23.3	1.45	1.45	0.00	1.45	1.45	NA	NA	NA	NA	NA	NA	0.95	NA	0.948	0.052	0	0	0.000	NA	10.0	NA	10.00
25.8	1.61	1.61	0.00	1.61	1.61	NA	NA	NA	NA	NA	NA	0.95	NA	0.939	0.052	0	0	0.000	NA	10.0	NA	10.00
28.3	1.77	1.77	0.00	1.77	1.77	NA	NA	NA	NA	NA	NA	0.95	NA	0.929	0.051	0	0	0.000	NA	10.0	NA	10.00
30.8	1.92	1.92	0.00	1.92	1.92	NA	NA	NA	NA	NA	NA	0.95	NA	0.917	0.051	0	0	0.000	NA	10.0	NA	10.00
33.3	2.08	2.08	0.00	2.08	2.08	NA	NA	NA	NA	NA	NA	0.95	NA	0.902	0.050	0	0	0.000	NA	10.0	NA	10.00
35.8	2.23	2.23	0.00	2.23	2.23	NA	NA	NA	NA	NA	NA	0.95	NA	0.885	0.049	0	0	0.000	NA	10.0	NA	10.00
38.3	2.39	2.39	0.04	2.35	2.35	NA	NA	NA	NA	NA	NA	0.95	NA	0.866	0.049	0	0	0.000	NA	10.0	NA	10.00
40.8	2.55	2.55	0.12	2.43	2.43	NA	NA	NA	NA	NA	NA	0.95	NA	0.844	0.049	0	0	0.000	NA	10.0	NA	10.00
45.8	2.86	2.86	0.27	2.59	2.59	NA	NA	NA	NA	NA	NA	0.95	NA	0.796	0.049	0	0	0.000	NA	10.0	NA	10.00
48.3	3.02	3.02	0.35	2.66	2.66	NA	NA	NA	NA	NA	NA	0.95	NA	0.771	0.048	0	0	0.000	NA	10.0	NA	10.00
50.8	3.17	3.17	0.43	2.74	2.74	NA	NA	NA	NA	NA	NA	0.95	NA	0.745	0.048	0	0	0.000	NA	10.0	NA	10.00
53.3	3.33	3.33	0.51	2.82	2.82	NA	NA	NA	NA	NA	NA	0.95	NA	0.720	0.047	0	0	0.000	NA	10.0	NA	10.00
55.8	3.48	3.48	0.59	2.90	2.90	NA	NA	NA	NA	NA	NA	0.95	NA	0.696	0.046	0	0	0.000	NA	10.0	NA	10.00
58.3	3.64	3.64	0.66	2.98	2.98	NA	NA	NA	NA	NA	NA	0.95	NA	0.674	0.046	0	0	0.000	NA	10.0	NA	10.00
60.8	3.80	3.80	0.74	3.06	3.06	NA	NA	NA	NA	NA	NA	0.95	NA	0.653	0.045	0	0	0.000	NA	10.0	NA	10.00
63.3	3.95	3.95	0.82	3.13	3.13	NA	NA	NA	NA	NA	NA	0.95	NA	0.634	0.044	0	0	0.000	NA	10.0	NA	10.00
65.8	4.11	4.11	0.90	3.21	3.21	NA	NA	NA	NA	NA	NA	0.95	NA	0.617	0.044	0	0	0.000	NA	10.0	NA	10.00

Clifty Creek AEP, Boring = B-1, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts



Clifty Creek AEP, Boring = B-1, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts



EQ Source	
0	
a max (g)	0.085
EQ Mag (Mw)	7.7

Event (MCE, OBE, etc.): 0

EQ Motion File: 0

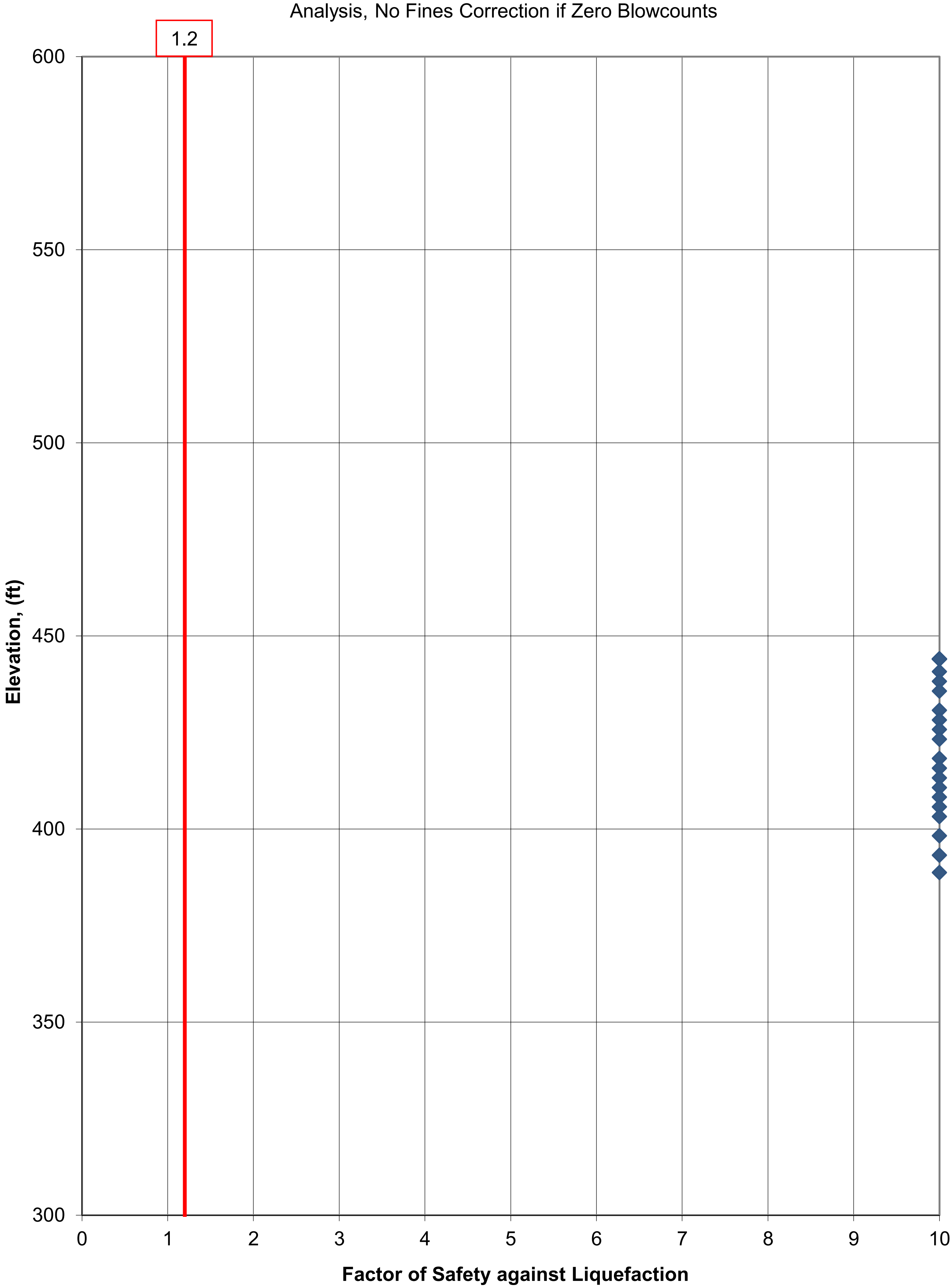
Shake Stress Curve Fit Parameters	
m4:	0
m3:	0
m2:	0
m1:	0

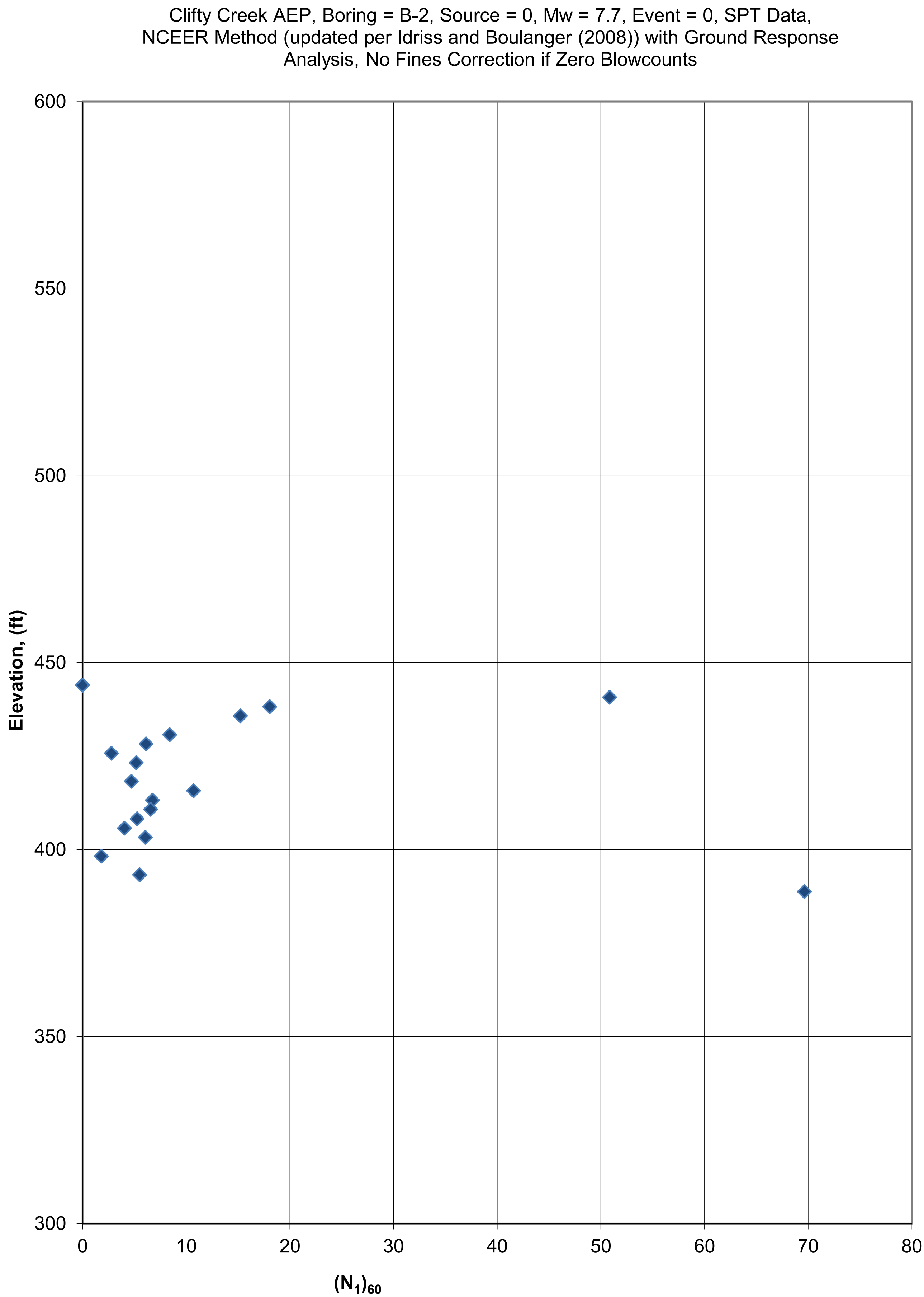
Boring ID:	B-2
Top of Fill Elevation:	444.0
Fill Height:	0.0
Fill Total Unit Weight:	125
Fill Total Stress:	0.00

Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.

Depth of Mid. Pt. of Sample (ft.) z	Vert. Total Stress during EQ (tsf) σ_v	Vert. Total Stress during EQ w/ Fill (tsf) $\sigma_{v\ with\ fill}$	Static Pore Pressure during EQ (tsf) u	Vert. Eff. Stress during EQ (tsf) σ'_v	Vert. Eff. Stress during EQ w/ Fill (tsf) $\sigma'_{v\ with\ fill}$	Alpha I	Beta I	Equivalent Clean Sand N-Value $(N_1)_{60cs}$	CRR7.5	Ksigma	Kalpha	Mag. Scaling Factor (Cm)	CRR Design EQ	Simplified Stress Reduction Coeff., r_d	Simplified CSR eq Design EQ	Max. Shake Stress (psf) Design EQ	Avg. Shake Stress (psf) Design EQ	Using SHAKE Data: CSR eq Design EQ	Using SHAKE Data: FS liq Design EQ	Using SHAKE Data: FS liq for plot	Simplified: FS liq Design EQ	Simplified: FS liq for plot
	totstr-top 0.16		u-top 0.00	effstr-top 0.16																		
3.3	0.20	0.20	0.00	0.20	0.20	NA	NA	NA	NA	NA	NA	0.95	NA	0.994	0.055	0	0	0.000	NA	10.0	NA	10.0
5.8	0.36	0.36	0.00	0.36	0.36	NA	NA	NA	NA	NA	NA	0.95	NA	0.989	0.055	0	0	0.000	NA	10.0	NA	10.0
8.3	0.52	0.52	0.00	0.52	0.52	NA	NA	NA	NA	NA	NA	0.95	NA	0.983	0.054	0	0	0.000	NA	10.0	NA	10.0
13.3	0.83	0.83	0.00	0.83	0.83	NA	NA	NA	NA	NA	NA	0.95	NA	0.972	0.054	0	0	0.000	NA	10.0	NA	10.0
15.8	0.98	0.98	0.02	0.96	0.96	NA	NA	NA	NA	NA	NA	0.95	NA	0.967	0.055	0	0	0.000	NA	10.0	NA	10.0
18.3	1.14	1.14	0.10	1.04	1.04	NA	NA	NA	NA	NA	NA	0.95	NA	0.961	0.058	0	0	0.000	NA	10.0	NA	10.0
20.8	1.30	1.30	0.18	1.12	1.12	NA	NA	NA	NA	NA	NA	0.95	NA	0.955	0.061	0	0	0.000	NA	10.0	NA	10.0
25.8	1.61	1.61	0.34	1.27	1.27	NA	NA	NA	NA	NA	NA	0.95	NA	0.939	0.066	0	0	0.000	NA	10.0	NA	10.0
28.3	1.77	1.77	0.41	1.35	1.35	NA	NA	NA	NA	NA	NA	0.95	NA	0.929	0.067	0	0	0.000	NA	10.0	NA	10.0
30.8	1.92	1.92	0.49	1.43	1.43	NA	NA	NA	NA	NA	NA	0.95	NA	0.917	0.068	0	0	0.000	NA	10.0	NA	10.0
33.3	2.08	2.08	0.57	1.51	1.51	NA	NA	NA	NA	NA	NA	0.95	NA	0.902	0.069	0	0	0.000	NA	10.0	NA	10.0
35.8	2.23	2.23	0.65	1.59	1.59	NA	NA	NA	NA	NA	NA	0.95	NA	0.885	0.069	0	0	0.000	NA	10.0	NA	10.0
38.3	2.39	2.39	0.73	1.67	1.67	NA	NA	NA	NA	NA	NA	0.95	NA	0.866	0.069	0	0	0.000	NA	10.0	NA	10.0
40.8	2.55	2.55	0.80	1.74	1.74	NA	NA	NA	NA	NA	NA	0.95	NA	0.844	0.068	0	0	0.000	NA	10.0	NA	10.0
45.8	2.86	2.86	0.96	1.90	1.90	NA	NA	NA	NA	NA	NA	0.95	NA	0.796	0.066	0	0	0.000	NA	10.0	NA	10.0
50.8	3.17	3.17	1.12	2.06	2.06	NA	NA	NA	NA	NA	NA	0.95	NA	0.745	0.063	0	0	0.000	NA	10.0	NA	10.0
55.3	3.45	3.45	1.26	2.20	2.20	0.02	1.00	70	NA	0.781	1.000	0.95	NA	0.701	0.061	0	0	0.000	NA	10.0	NA	10.0

Clifty Creek AEP, Boring = B-2, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts





Clifty Creek AEP, Boring = B-2, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts
Elevation, (ft)
600
550
500
450
400
350
300
0
10
20
30
40
50
60
70
80
(N1)60

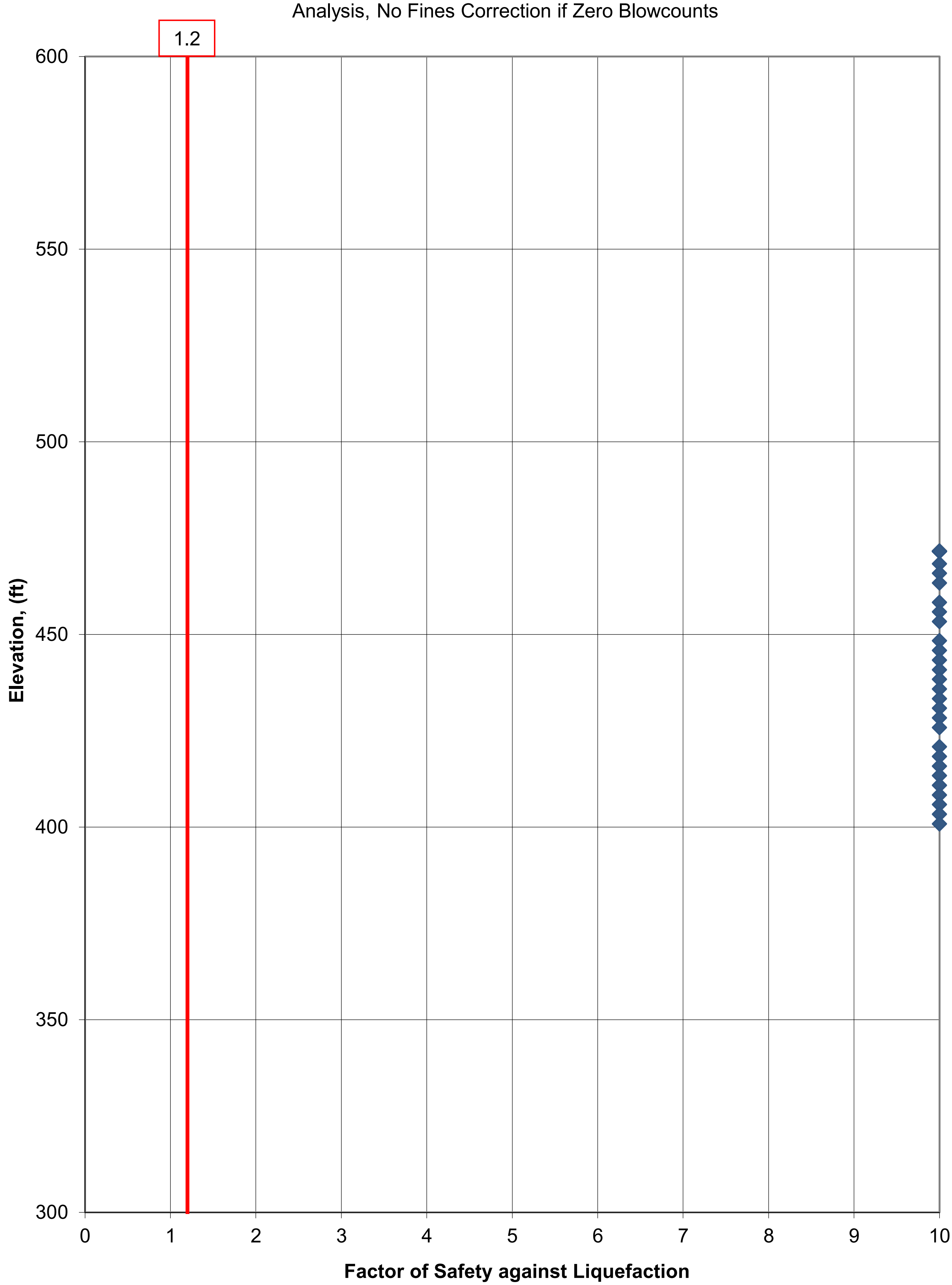
EQ Source	Event (MCE, OBE, etc.)	Shake Stress Curve Fit Parameters	
0	0	m4:	0
a max (g)		m3:	0
0.085	EQ Motion File	m2:	0
EQ Mag (Mw)	0	m1:	0
7.7			

Boring ID:	B-3
Top of Fill Elevation:	471.6
Fill Height:	0.0
Fill Total Unit Weight:	125
Fill Total Stress:	0.00

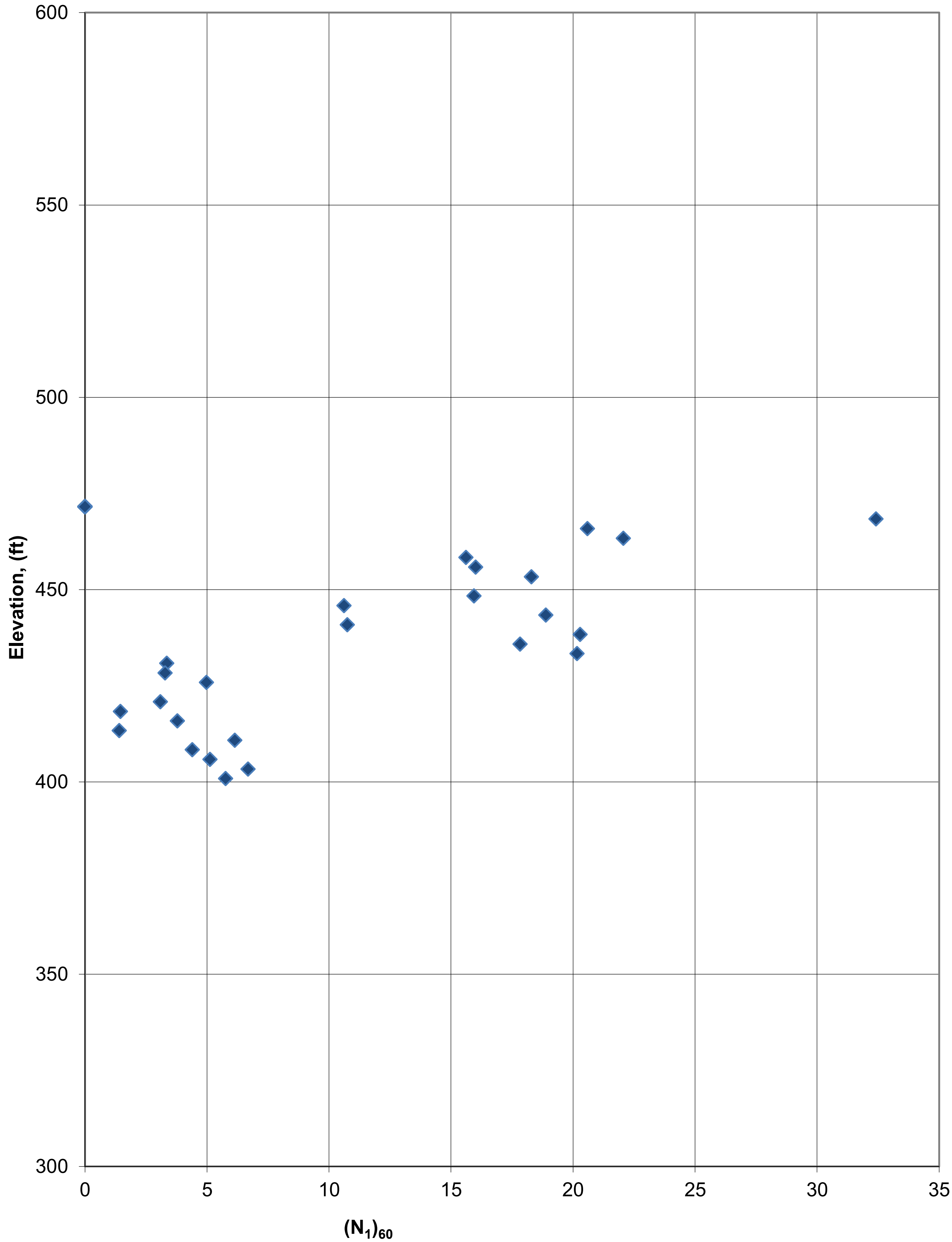
Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.

Depth of Mid. Pt. of Sample (ft.)	Vert. Total Stress during EQ (tsf)	Vert. Total Stress during EQ w/ Fill (tsf)	Static Pore Pressure during EQ (tsf)	Vert. Eff. Stress during EQ (tsf)	Vert. Eff. Stress during EQ w/ Fill (tsf)			Equivalent Clean Sand N-Value				Mag. Scaling Factor (Cm)	CRR Design EQ	Simplified Stress Reduction Coeff., r_d	Simplified CSR eq Design EQ	Max. Shake Stress (psf) Design EQ	Avg. Shake Stress (psf) Design EQ	Using SHAKE Data CSR eq Design EQ	Using SHAKE Data FS liq Design EQ	Using SHAKE Data FS liq for plot	Simplified FS liq Design EQ	Simplified FS liq for plot
z	σ_v	$\sigma_{v\ with\ fill}$	u	σ'_v	$\sigma'_{v\ with\ fill}$	Alpha I	Beta I	$(N_1)_{60cs}$	CRR7.5	Ksigma	Kalpha											
	totstr-top		u-top	effstr-top																		
	0.16		0.00	0.16																		
3.3	0.20	0.20	0.00	0.20	0.20	NA	NA	NA	NA	NA	NA	0.95	NA	0.994	0.055	0	0	0.000	NA	10.0	NA	10.00
5.8	0.36	0.36	0.00	0.36	0.36	NA	NA	NA	NA	NA	NA	0.95	NA	0.989	0.055	0	0	0.000	NA	10.0	NA	10.00
8.3	0.52	0.52	0.00	0.52	0.52	NA	NA	NA	NA	NA	NA	0.95	NA	0.983	0.054	0	0	0.000	NA	10.0	NA	10.00
13.3	0.83	0.83	0.00	0.83	0.83	NA	NA	NA	NA	NA	NA	0.95	NA	0.972	0.054	0	0	0.000	NA	10.0	NA	10.00
15.8	0.98	0.98	0.00	0.98	0.98	NA	NA	NA	NA	NA	NA	0.95	NA	0.967	0.053	0	0	0.000	NA	10.0	NA	10.00
18.3	1.14	1.14	0.00	1.14	1.14	NA	NA	NA	NA	NA	NA	0.95	NA	0.961	0.053	0	0	0.000	NA	10.0	NA	10.00
23.3	1.45	1.45	0.00	1.45	1.45	NA	NA	NA	NA	NA	NA	0.95	NA	0.948	0.052	0	0	0.000	NA	10.0	NA	10.00
25.8	1.61	1.61	0.00	1.61	1.61	NA	NA	NA	NA	NA	NA	0.95	NA	0.939	0.052	0	0	0.000	NA	10.0	NA	10.00
28.3	1.77	1.77	0.00	1.77	1.77	NA	NA	NA	NA	NA	NA	0.95	NA	0.929	0.051	0	0	0.000	NA	10.0	NA	10.00
30.8	1.92	1.92	0.00	1.92	1.92	NA	NA	NA	NA	NA	NA	0.95	NA	0.917	0.051	0	0	0.000	NA	10.0	NA	10.00
33.3	2.08	2.08	0.00	2.08	2.08	NA	NA	NA	NA	NA	NA	0.95	NA	0.902	0.050	0	0	0.000	NA	10.0	NA	10.00
35.8	2.23	2.23	0.00	2.23	2.23	NA	NA	NA	NA	NA	NA	0.95	NA	0.885	0.049	0	0	0.000	NA	10.0	NA	10.00
38.3	2.39	2.39	0.07	2.32	2.32	NA	NA	NA	NA	NA	NA	0.95	NA	0.866	0.049	0	0	0.000	NA	10.0	NA	10.00
40.8	2.55	2.55	0.15	2.40	2.40	NA	NA	NA	NA	NA	NA	0.95	NA	0.844	0.050	0	0	0.000	NA	10.0	NA	10.00
43.3	2.70	2.70	0.23	2.48	2.48	NA	NA	NA	NA	NA	NA	0.95	NA	0.821	0.049	0	0	0.000	NA	10.0	NA	10.00
45.8	2.86	2.86	0.30	2.56	2.56	NA	NA	NA	NA	NA	NA	0.95	NA	0.796	0.049	0	0	0.000	NA	10.0	NA	10.00
50.8	3.17	3.17	0.46	2.71	2.71	NA	NA	NA	NA	NA	NA	0.95	NA	0.745	0.048	0	0	0.000	NA	10.0	NA	10.00
53.3	3.33	3.33	0.54	2.79	2.79	NA	NA	NA	NA	NA	NA	0.95	NA	0.720	0.047	0	0	0.000	NA	10.0	NA	10.00
55.8	3.48	3.48	0.62	2.87	2.87	NA	NA	NA	NA	NA	NA	0.95	NA	0.696	0.047	0	0	0.000	NA	10.0	NA	10.00
58.3	3.64	3.64	0.69	2.95	2.95	NA	NA	NA	NA	NA	NA	0.95	NA	0.674	0.046	0	0	0.000	NA	10.0	NA	10.00
60.8	3.80	3.80	0.77	3.02	3.02	NA	NA	NA	NA	NA	NA	0.95	NA	0.653	0.045	0	0	0.000	NA	10.0	NA	10.00
63.3	3.95	3.95	0.85	3.10	3.10	NA	NA	NA	NA	NA	NA	0.95	NA	0.634	0.045	0	0	0.000	NA	10.0	NA	10.00
65.8	4.11	4.11	0.93	3.18	3.18	NA	NA	NA	NA	NA	NA	0.95	NA	0.617	0.044	0	0	0.000	NA	10.0	NA	10.00
68.3	4.27	4.27	1.01	3.26	3.26	NA	NA	NA	NA	NA	NA	0.95	NA	0.602	0.044	0	0	0.000	NA	10.0	NA	10.00
70.8	4.42	4.42	1.08	3.34	3.34	NA	NA	NA	NA	NA	NA	0.95	NA	0.588	0.043	0	0	0.000	NA	10.0	NA	10.00

Clifty Creek AEP, Boring = B-3, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts



Clifty Creek AEP, Boring = B-3, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts



EQ Source	
0	
a max (g)	0.085
EQ Mag (Mw)	7.7

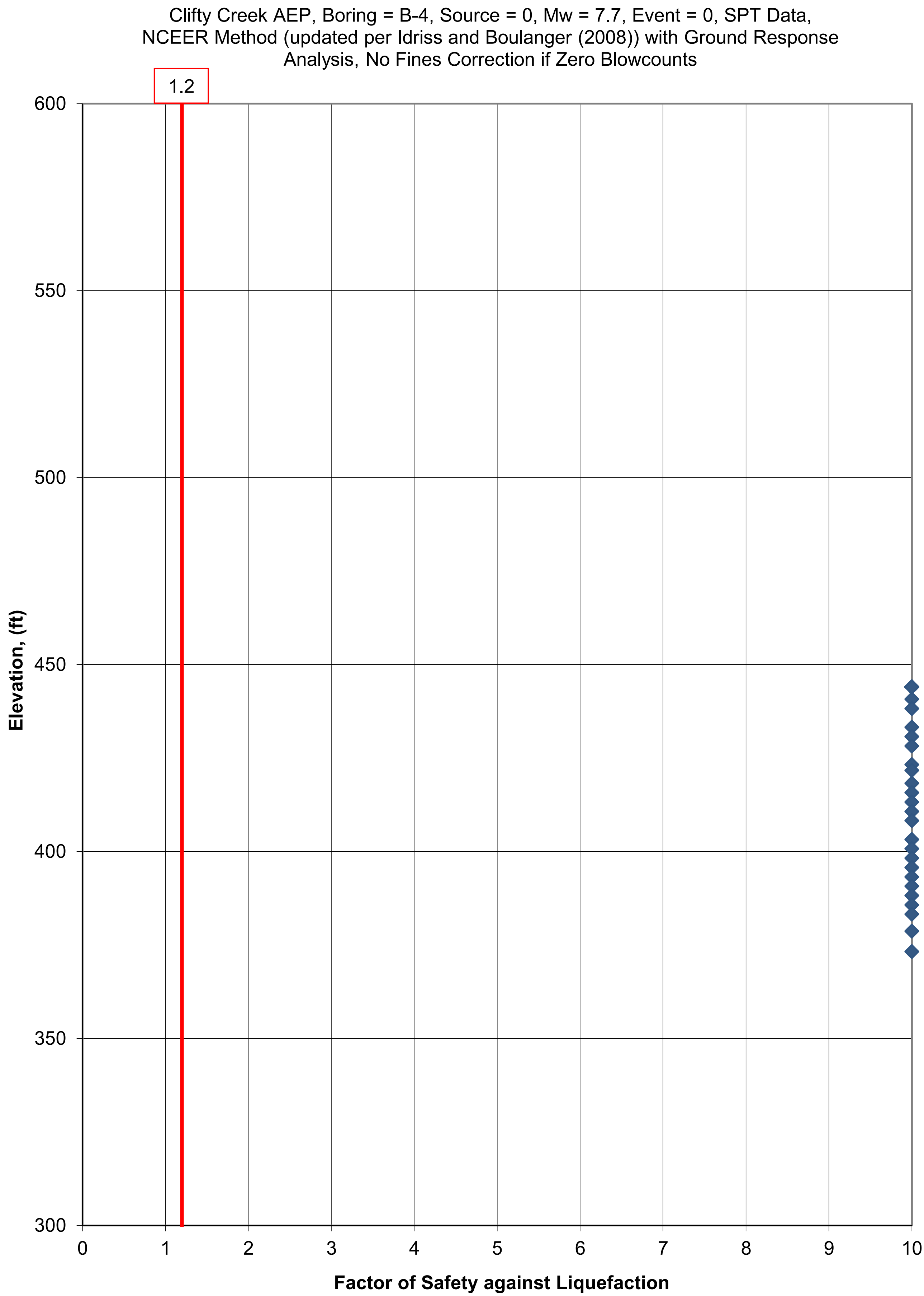
Event (MCE, OBE, etc.)	EQ Motion File
0	0

Shake Stress Curve Fit Parameters	
m4:	0
m3:	0
m2:	0
m1:	0

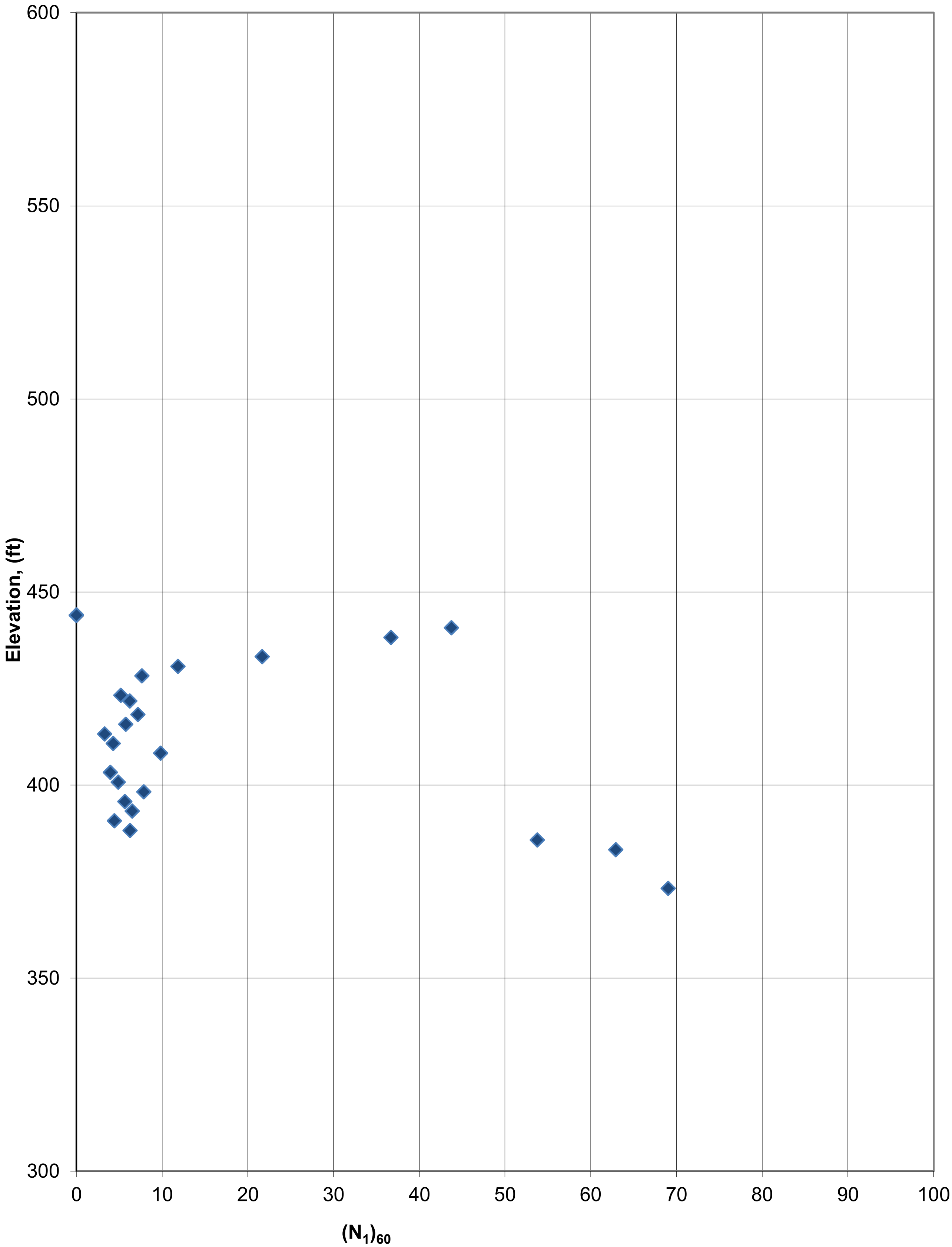
Boring ID:	**B-4**
Top of Fill Elevation:	444.0
Fill Height:	0.0
Fill Total Unit Weight:	125
Fill Total Stress:	0.00

Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.

Depth of Mid. Pt. of Sample (ft.)	Vert. Total Stress during EQ (tsf)	Vert. Total Stress during EQ w/ Fill (tsf)	Static Pore Pressure during EQ (tsf)	Vert. Eff. Stress during EQ (tsf)	Vert. Eff. Stress during EQ w/ Fill (tsf)			Equivalent Clean Sand N-Value				Mag. Scaling	CRR	Simplified Stress Reduction	Simplified CSR eq	Max. Shake Stress (psf)	Avg. Shake Stress (psf)	Using SHAKE Data CSR eq	FS liq	FS liq	Simplified FS liq	FS liq
z	σ_v	$\sigma_{v\ with\ fill}$	u	σ'_v	$\sigma'_{v\ with\ fill}$	Alpha I	Beta I	$(N_1)_{60cs}$	CRR7.5	Ksigma	Kalpha	Factor (Cm)	Design EQ	Coeff., r_d	Design EQ	Design EQ	Design EQ	Design EQ	Design EQ	for plot	Design EQ	for plot
	totstr-top 0.16		u-top 0.00	effstr-top 0.16																		
3.3	0.20	0.20	0.00	0.20	0.20	NA	NA	NA	NA	NA	NA	0.95	NA	0.994	0.055	0	0	0.000	NA	10.0	NA	10.00
5.8	0.36	0.36	0.00	0.36	0.36	NA	NA	NA	NA	NA	NA	0.95	NA	0.989	0.055	0	0	0.000	NA	10.0	NA	10.00
10.8	0.67	0.67	0.00	0.67	0.67	NA	NA	NA	NA	NA	NA	0.95	NA	0.978	0.054	0	0	0.000	NA	10.0	NA	10.00
13.3	0.83	0.83	0.00	0.83	0.83	NA	NA	NA	NA	NA	NA	0.95	NA	0.972	0.054	0	0	0.000	NA	10.0	NA	10.00
15.8	0.98	0.98	0.00	0.98	0.98	NA	NA	NA	NA	NA	NA	0.95	NA	0.967	0.053	0	0	0.000	NA	10.0	NA	10.00
20.8	1.30	1.30	0.15	1.15	1.15	NA	NA	NA	NA	NA	NA	0.95	NA	0.955	0.060	0	0	0.000	NA	10.0	NA	10.00
22.3	1.39	1.39	0.20	1.20	1.20	NA	NA	NA	NA	NA	NA	0.95	NA	0.951	0.061	0	0	0.000	NA	10.0	NA	10.00
25.8	1.61	1.61	0.30	1.31	1.31	NA	NA	NA	NA	NA	NA	0.95	NA	0.939	0.064	0	0	0.000	NA	10.0	NA	10.00
28.3	1.77	1.77	0.38	1.38	1.38	NA	NA	NA	NA	NA	NA	0.95	NA	0.929	0.066	0	0	0.000	NA	10.0	NA	10.00
30.8	1.92	1.92	0.46	1.46	1.46	NA	NA	NA	NA	NA	NA	0.95	NA	0.917	0.067	0	0	0.000	NA	10.0	NA	10.00
33.3	2.08	2.08	0.54	1.54	1.54	NA	NA	NA	NA	NA	NA	0.95	NA	0.902	0.067	0	0	0.000	NA	10.0	NA	10.00
35.8	2.23	2.23	0.62	1.62	1.62	NA	NA	NA	NA	NA	NA	0.95	NA	0.885	0.068	0	0	0.000	NA	10.0	NA	10.00
40.8	2.55	2.55	0.77	1.77	1.77	NA	NA	NA	NA	NA	NA	0.95	NA	0.844	0.067	0	0	0.000	NA	10.0	NA	10.00
43.3	2.70	2.70	0.85	1.85	1.85	NA	NA	NA	NA	NA	NA	0.95	NA	0.821	0.066	0	0	0.000	NA	10.0	NA	10.00
45.8	2.86	2.86	0.93	1.93	1.93	NA	NA	NA	NA	NA	NA	0.95	NA	0.796	0.065	0	0	0.000	NA	10.0	NA	10.00
48.3	3.02	3.02	1.01	2.01	2.01	NA	NA	NA	NA	NA	NA	0.95	NA	0.771	0.064	0	0	0.000	NA	10.0	NA	10.00
50.8	3.17	3.17	1.08	2.09	2.09	NA	NA	NA	NA	NA	NA	0.95	NA	0.745	0.063	0	0	0.000	NA	10.0	NA	10.00
53.3	3.33	3.33	1.16	2.17	2.17	NA	NA	NA	NA	NA	NA	0.95	NA	0.720	0.061	0	0	0.000	NA	10.0	NA	10.00
55.8	3.48	3.48	1.24	2.24	2.24	NA	NA	NA	NA	NA	NA	0.95	NA	0.696	0.060	0	0	0.000	NA	10.0	NA	10.00
58.3	3.64	3.64	1.32	2.32	2.32	0.02	1.00	54	NA	0.764	1.000147	0.95	NA	0.674	0.058	0	0	0.000	NA	10.0	NA	10.00
60.8	3.80	3.80	1.40	2.40	2.40	0.02	1.00	63	NA	0.754	1.000147	0.95	NA	0.653	0.057	0	0	0.000	NA	10.0	NA	10.00
65.3	4.08	4.08	1.54	2.54	2.54	0.02	1.00	1354	NA	0.737	1.000147	0.95	NA	0.620	0.055	0	0	0.000	NA	10.0	NA	10.00
70.8	4.42	4.42	1.71	2.71	2.71	0.02	1.00	69	NA	0.717	1.000147	0.95	NA	0.588	0.053	0	0	0.000	NA	10.0	NA	10.00


Clifty Creek AEP, Boring = B-4, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts
1.2
Elevation, (ft)
600
550
500
450
400
350
300
0
1
2
3
4
5
6
7
8
9
10
Factor of Safety against Liquefaction

Clifty Creek AEP, Boring = B-4, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts



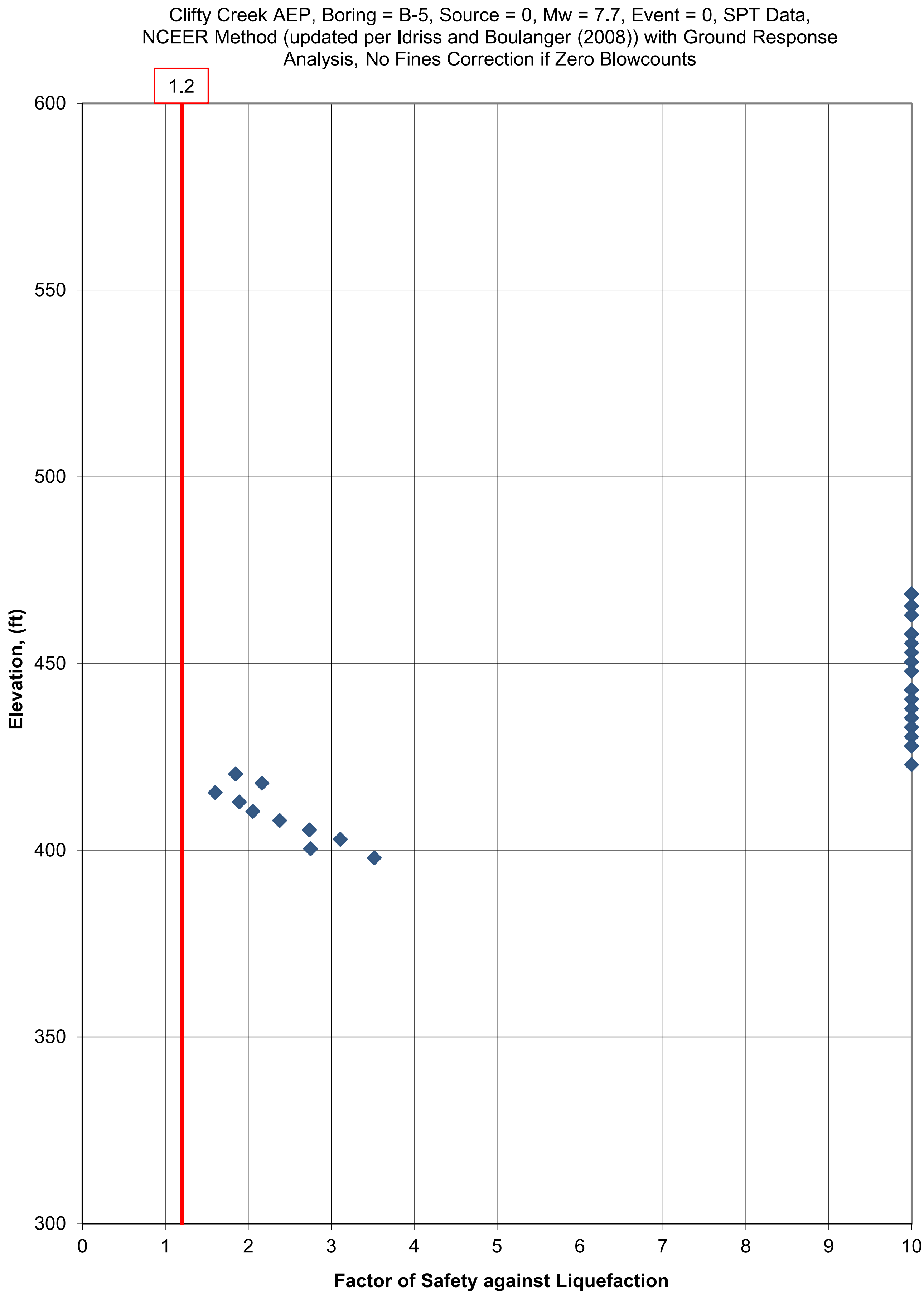
EQ Source	a max (g)	EQ Mag (Mw)	Event (MCE, OBE, etc.)	EQ Motion File
0	0.085	7.7	0	0

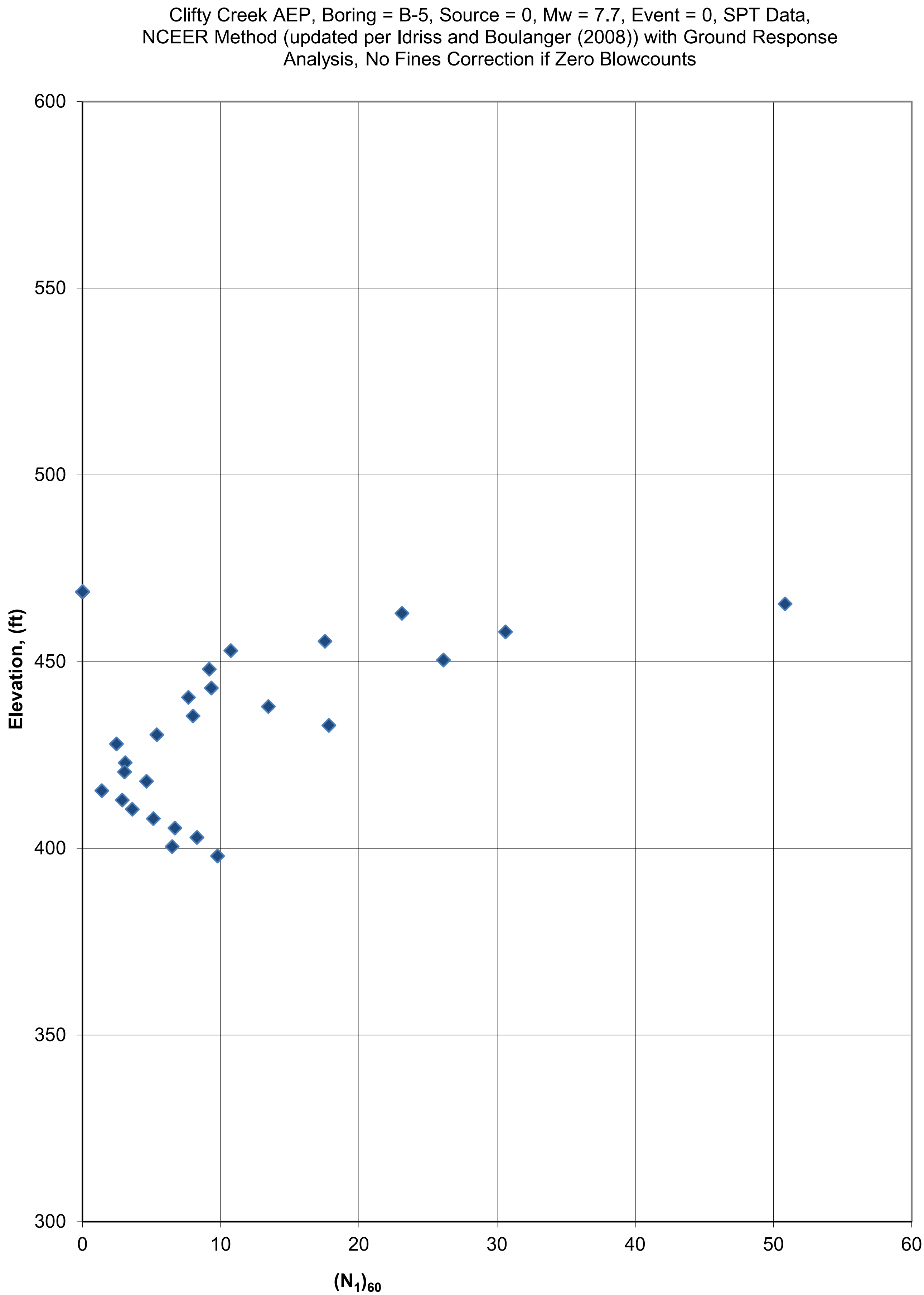
Shake Stress Curve Fit Parameters	
m4:	0
m3:	0
m2:	0
m1:	0

Boring ID:	B-5
Top of Fill Elevation:	468.7
Fill Height:	0.0
Fill Total Unit Weight:	125
Fill Total Stress:	0.00

Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.

Depth of Mid. Pt. of Sample (ft.) z	Vert. Total Stress during EQ (tsf) σ_v	Vert. Total Stress during EQ w/ Fill (tsf) $\sigma_{v\ with\ fill}$	Static Pore Pressure during EQ (tsf) u	Vert. Eff. Stress during EQ (tsf) σ'_v	Vert. Eff. Stress during EQ w/ Fill (tsf) $\sigma'_{v\ with\ fill}$	Alpha I	Beta I	Equivalent Clean Sand N-Value $(N_1)_{60cs}$	CRR7.5	Ksigma	Kalpha	Mag. Scaling Factor (Cm)	CRR Design EQ	Simplified Stress Reduction Coeff., r_d	Simplified CSR eq Design EQ	Max. Shake Stress (psf) Design EQ	Avg. Shake Stress (psf) Design EQ	Using SHAKE Data CSR eq Design EQ	Using SHAKE Data FS liq Design EQ	Using SHAKE Data FS liq for plot	Simplified FS liq Design EQ	Simplified FS liq for plot
	totstr-top 0.16		u-top 0.00	effstr-top 0.16																		
3.3	0.20	0.20	0.00	0.20	0.20	NA	NA	NA	NA	NA	NA	0.95	NA	0.994	0.055	0	0	0.000	NA	10.0	NA	10.0
5.8	0.36	0.36	0.00	0.36	0.36	NA	NA	NA	NA	NA	NA	0.95	NA	0.989	0.055	0	0	0.000	NA	10.0	NA	10.0
10.8	0.67	0.67	0.00	0.67	0.67	NA	NA	NA	NA	NA	NA	0.95	NA	0.978	0.054	0	0	0.000	NA	10.0	NA	10.0
13.3	0.83	0.83	0.00	0.83	0.83	NA	NA	NA	NA	NA	NA	0.95	NA	0.972	0.054	0	0	0.000	NA	10.0	NA	10.0
15.8	0.98	0.98	0.00	0.98	0.98	NA	NA	NA	NA	NA	NA	0.95	NA	0.967	0.053	0	0	0.000	NA	10.0	NA	10.0
18.3	1.14	1.14	0.00	1.14	1.14	NA	NA	NA	NA	NA	NA	0.95	NA	0.961	0.053	0	0	0.000	NA	10.0	NA	10.0
20.8	1.30	1.30	0.00	1.30	1.30	NA	NA	NA	NA	NA	NA	0.95	NA	0.955	0.053	0	0	0.000	NA	10.0	NA	10.0
25.8	1.61	1.61	0.00	1.61	1.61	NA	NA	NA	NA	NA	NA	0.95	NA	0.939	0.052	0	0	0.000	NA	10.0	NA	10.0
28.3	1.77	1.77	0.00	1.77	1.77	NA	NA	NA	NA	NA	NA	0.95	NA	0.929	0.051	0	0	0.000	NA	10.0	NA	10.0
30.8	1.92	1.92	0.00	1.92	1.92	NA	NA	NA	NA	NA	NA	0.95	NA	0.917	0.051	0	0	0.000	NA	10.0	NA	10.0
33.3	2.08	2.08	0.00	2.08	2.08	NA	NA	NA	NA	NA	NA	0.95	NA	0.902	0.050	0	0	0.000	NA	10.0	NA	10.0
35.8	2.23	2.23	0.00	2.23	2.23	NA	NA	NA	NA	NA	NA	0.95	NA	0.885	0.049	0	0	0.000	NA	10.0	NA	10.0
38.3	2.39	2.39	0.07	2.32	2.32	NA	NA	NA	NA	NA	NA	0.95	NA	0.866	0.049	0	0	0.000	NA	10.0	NA	10.0
40.8	2.55	2.55	0.15	2.40	2.40	NA	NA	NA	NA	NA	NA	0.95	NA	0.844	0.050	0	0	0.000	NA	10.0	NA	10.0
45.8	2.86	2.86	0.30	2.56	2.56	NA	NA	NA	NA	NA	NA	0.95	NA	0.796	0.049	0	0	0.000	NA	10.0	NA	10.0
48.3	3.02	3.02	0.38	2.63	2.63	5.00	1.20	9	0.101	0.937	1.000	0.95	0.090	0.771	0.049	0	0	0.000	#DIV/0!	#DIV/0!	1.8	1.85
50.8	3.17	3.17	0.46	2.71	2.71	5.00	1.20	11	0.118	0.932	1.000	0.95	0.104	0.745	0.048	0	0	0.000	#DIV/0!	#DIV/0!	2.2	2.17
53.3	3.33	3.33	0.54	2.79	2.79	5.00	1.20	7	0.085	0.941	1.000	0.95	0.076	0.720	0.047	0	0	0.000	#DIV/0!	#DIV/0!	1.6	1.60
55.8	3.48	3.48	0.62	2.87	2.87	5.00	1.20	8	0.100	0.935	1.000	0.95	0.088	0.696	0.047	0	0	0.000	#DIV/0!	#DIV/0!	1.9	1.89
58.3	3.64	3.64	0.69	2.95	2.95	5.00	1.20	9	0.107	0.929	1.000003	0.95	0.094	0.674	0.046	0	0	0.000	#DIV/0!	#DIV/0!	2.1	2.05
60.8	3.80	3.80	0.77	3.02	3.02	5.00	1.20	11	0.123	0.920	1.000004	0.95	0.108	0.653	0.045	0	0	0.000	#DIV/0!	#DIV/0!	2.4	2.38
63.3	3.95	3.95	0.85	3.10	3.10	5.00	1.20	13	0.141	0.915	1.000006	0.95	0.122	0.634	0.045	0	0	0.000	#DIV/0!	#DIV/0!	2.7	2.74
65.8	4.11	4.11	0.93	3.18	3.18	5.00	1.20	15	0.159	0.906	1.000008	0.95	0.137	0.617	0.044	0	0	0.000	#DIV/0!	#DIV/0!	3.1	3.11
68.3	4.27	4.27	1.01	3.26	3.26	5.00	1.20	13	0.138	0.911	1.000006	0.95	0.120	0.602	0.044	0	0	0.000	#DIV/0!	#DIV/0!	2.8	2.75
70.8	4.42	4.42	1.08	3.34	3.34	5.00	1.20	17	0.178	0.898	1.00001	0.95	0.151	0.588	0.043	0	0	0.000	#DIV/0!	#DIV/0!	3.5	3.52


Clifty Creek AEP, Boring = B-5, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts
1.2
Elevation, (ft)
600
550
500
450
400
350
300
0
1
2
3
4
5
6
7
8
9
10
Factor of Safety against Liquefaction

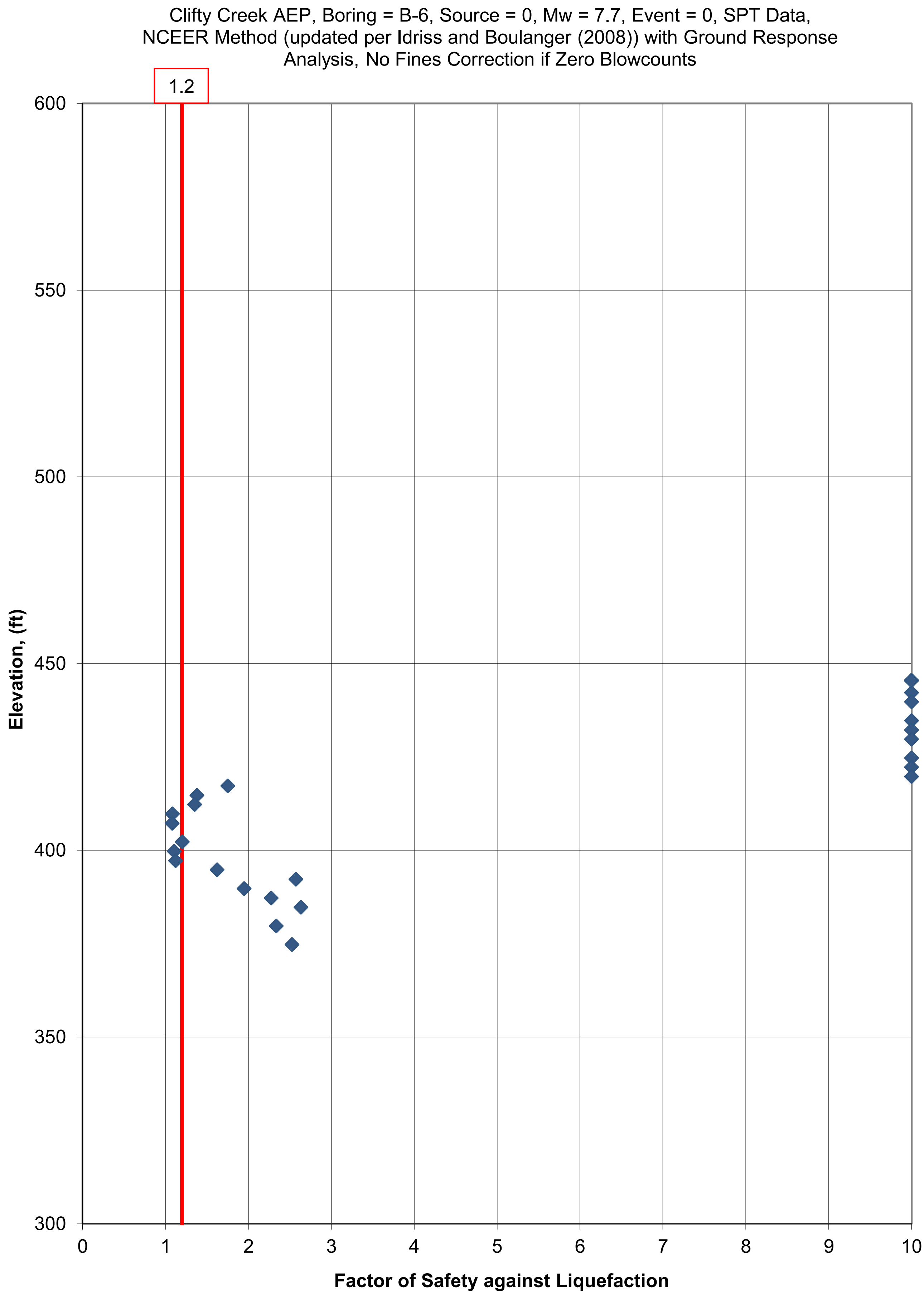

Clifty Creek AEP, Boring = B-5, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts
600
550
500
450
400
350
300
Elevation, (ft)
0
10
20
30
40
50
60
$(N_1)_{60}$

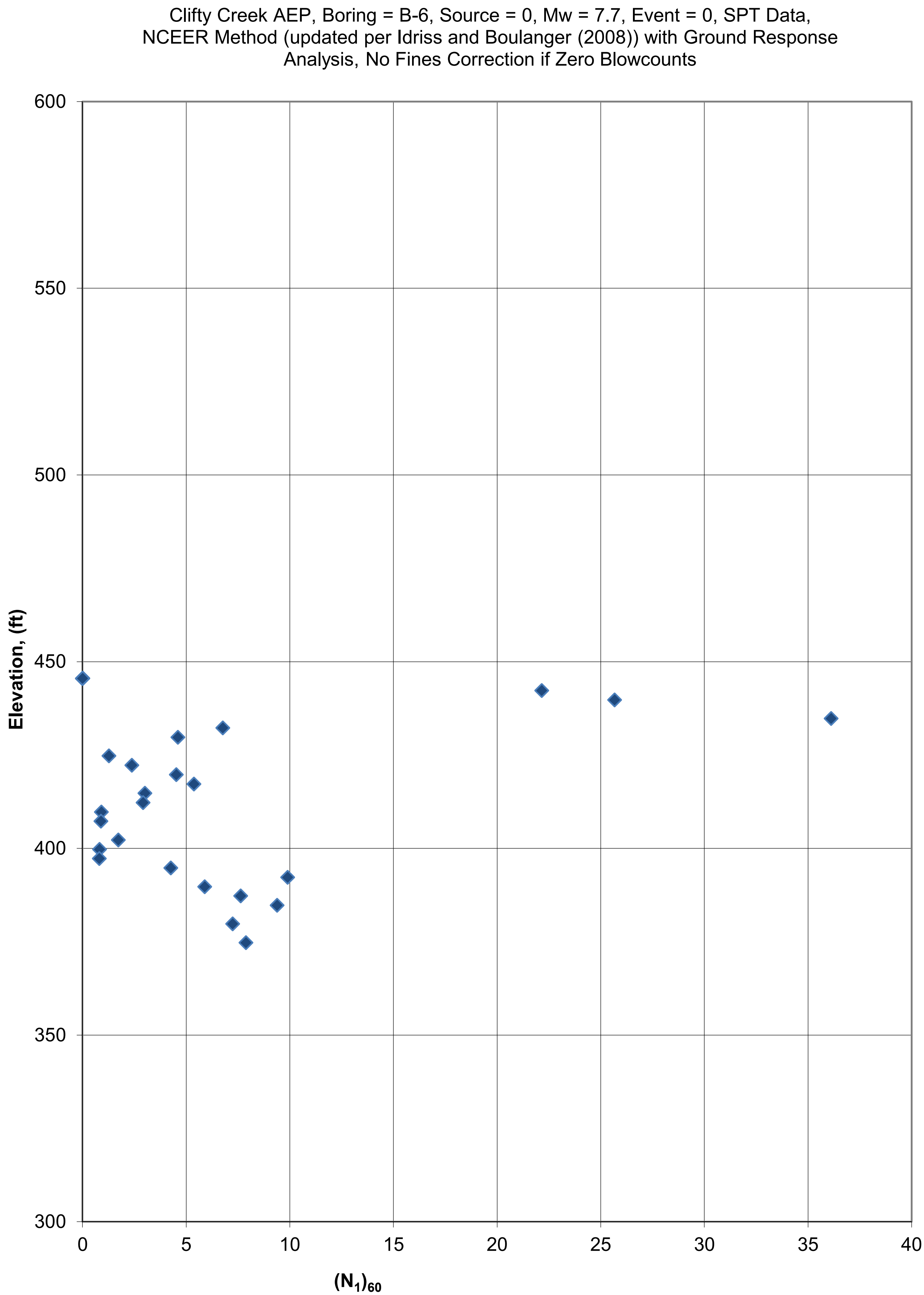
EQ Source	Event (MCE, OBE, etc.)	Shake Stress Curve Fit Parameters	
0	0	m4:	0
a max (g)		m3:	0
0.085	EQ Motion File	m2:	0
EQ Mag (Mw)	0	m1:	0
7.7			

Boring ID:	**B-6**
Top of Fill Elevation:	445.5
Fill Height:	0.0
Fill Total Unit Weight:	125
Fill Total Stress:	0.00

Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.

Depth of Mid. Pt. of Sample (ft.) z	Vert. Total Stress during EQ (tsf) σ_v	Vert. Total Stress during EQ w/ Fill (tsf) $\sigma_{v\ with\ fill}$	Static Pore Pressure during EQ (tsf) u	Vert. Eff. Stress during EQ (tsf) σ'_v	Vert. Eff. Stress during EQ w/ Fill (tsf) $\sigma'_{v\ with\ fill}$	Alpha I	Beta I	Equivalent Clean Sand N-Value $(N_1)_{60cs}$	CRR7.5	Ksigma	Kalpha	Mag. Scaling Factor (Cm)	CRR Design EQ	Simplified Stress Reduction Coeff., r_d	Simplified CSR eq Design EQ	Max. Shake Stress (psf) Design EQ	Avg. Shake Stress (psf) Design EQ	Using SHAKE Data CSR eq Design EQ	Using SHAKE Data FS liq Design EQ	Using SHAKE Data FS liq for plot	Simplified FS liq Design EQ	Simplified FS liq for plot
	totstr-top 0.16		u-top 0.00	effstr-top 0.16																		
3.3	0.20	0.20	0.00	0.20	0.20	NA	NA	NA	NA	NA	NA	0.95	NA	0.994	0.055	0	0	0.000	NA	10.0	NA	10.0
5.8	0.36	0.36	0.00	0.36	0.36	NA	NA	NA	NA	NA	NA	0.95	NA	0.989	0.055	0	0	0.000	NA	10.0	NA	10.0
10.8	0.67	0.67	0.00	0.67	0.67	NA	NA	NA	NA	NA	NA	0.95	NA	0.978	0.054	0	0	0.000	NA	10.0	NA	10.0
13.3	0.83	0.83	0.00	0.83	0.83	NA	NA	NA	NA	NA	NA	0.95	NA	0.972	0.054	0	0	0.000	NA	10.0	NA	10.0
15.8	0.98	0.98	0.02	0.96	0.96	NA	NA	NA	NA	NA	NA	0.95	NA	0.967	0.055	0	0	0.000	NA	10.0	NA	10.0
20.8	1.30	1.30	0.18	1.12	1.12	NA	NA	NA	NA	NA	NA	0.95	NA	0.955	0.061	0	0	0.000	NA	10.0	NA	10.0
23.3	1.45	1.45	0.26	1.20	1.20	NA	NA	NA	NA	NA	NA	0.95	NA	0.948	0.064	0	0	0.000	NA	10.0	NA	10.0
25.8	1.61	1.61	0.34	1.27	1.27	NA	NA	NA	NA	NA	NA	0.95	NA	0.939	0.066	0	0	0.000	NA	10.0	NA	10.0
28.3	1.77	1.77	0.41	1.35	1.35	5.00	1.20	11	0.126	0.981	1.000	0.95	0.117	0.929	0.067	0	0	0.000	#DIV/0!	#DIV/0!	1.8	1.75
30.8	1.92	1.92	0.49	1.43	1.43	5.00	1.20	9	0.101	0.979	1.000	0.95	0.094	0.917	0.068	0	0	0.000	#DIV/0!	#DIV/0!	1.4	1.38
33.3	2.08	2.08	0.57	1.51	1.51	5.00	1.20	9	0.100	0.977	1.000	0.95	0.093	0.902	0.069	0	0	0.000	#DIV/0!	#DIV/0!	1.4	1.35
35.8	2.23	2.23	0.65	1.59	1.59	5.00	1.20	6	0.080	0.978	1.000	0.95	0.075	0.885	0.069	0	0	0.000	#DIV/0!	#DIV/0!	1.1	1.08
38.3	2.39	2.39	0.73	1.67	1.67	5.00	1.20	6	0.080	0.976	1.000	0.95	0.074	0.866	0.069	0	0	0.000	#DIV/0!	#DIV/0!	1.1	1.08
43.3	2.70	2.70	0.88	1.82	1.82	5.00	1.20	7	0.088	0.967	1.000	0.95	0.081	0.821	0.067	0	0	0.000	#DIV/0!	#DIV/0!	1.2	1.20
45.8	2.86	2.86	0.96	1.90	1.90	5.00	1.20	6	0.080	0.969	1.000	0.95	0.073	0.796	0.066	0	0	0.000	#DIV/0!	#DIV/0!	1.1	1.11
48.3	3.02	3.02	1.04	1.98	1.98	5.00	1.20	6	0.079	0.967	1.000	0.95	0.073	0.771	0.065	0	0	0.000	#DIV/0!	#DIV/0!	1.1	1.12
50.8	3.17	3.17	1.12	2.06	2.06	5.00	1.20	10	0.114	0.952	1.000	0.95	0.103	0.745	0.063	0	0	0.000	#DIV/0!	#DIV/0!	1.6	1.62
53.3	3.33	3.33	1.19	2.13	2.13	5.00	1.20	17	0.180	0.938	1.000	0.95	0.160	0.720	0.062	0	0	0.000	#DIV/0!	#DIV/0!	2.6	2.57
55.8	3.48	3.48	1.27	2.21	2.21	5.00	1.20	12	0.132	0.944	1.000	0.95	0.118	0.696	0.061	0	0	0.000	#DIV/0!	#DIV/0!	1.9	1.95
58.3	3.64	3.64	1.35	2.29	2.29	5.00	1.20	14	0.152	0.935	1.000008	0.95	0.135	0.674	0.059	0	0	0.000	#DIV/0!	#DIV/0!	2.3	2.27
60.8	3.80	3.80	1.43	2.37	2.37	5.00	1.20	16	0.173	0.928	1.000011	0.95	0.152	0.653	0.058	0	0	0.000	#DIV/0!	#DIV/0!	2.6	2.64
65.8	4.11	4.11	1.58	2.53	2.53	5.00	1.20	14	0.147	0.928	1.000007	0.95	0.130	0.617	0.055	0	0	0.000	#DIV/0!	#DIV/0!	2.3	2.34
70.8	4.42	4.42	1.74	2.68	2.68	5.00	1.20	14	0.155	0.922	1.000008	0.95	0.135	0.588	0.054	0	0	0.000	#DIV/0!	#DIV/0!	2.5	2.53


Clifty Creek AEP, Boring = B-6, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts
1.2
600
550
500
450
400
350
300
Elevation, (ft)
0
1
2
3
4
5
6
7
8
9
10
Factor of Safety against Liquefaction


Clifty Creek AEP, Boring = B-6, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts
Elevation, (ft)
600
550
500
450
400
350
300
0
5
10
15
20
25
30
35
40
(N1)60

LANDFILL RUNOFF COLLECTION POND: 2015 CCR MANDATE

FINE-GRAINED ANALYSIS

Liquefaction Susceptibility of Fine-Grained Soils

Stantec Project Number:	175553022
Project Name:	AEP Clifty Creek
Site/Structure Name:	Landfill Runoff Collection Pond Dam

Note: NP = Non-Plastic

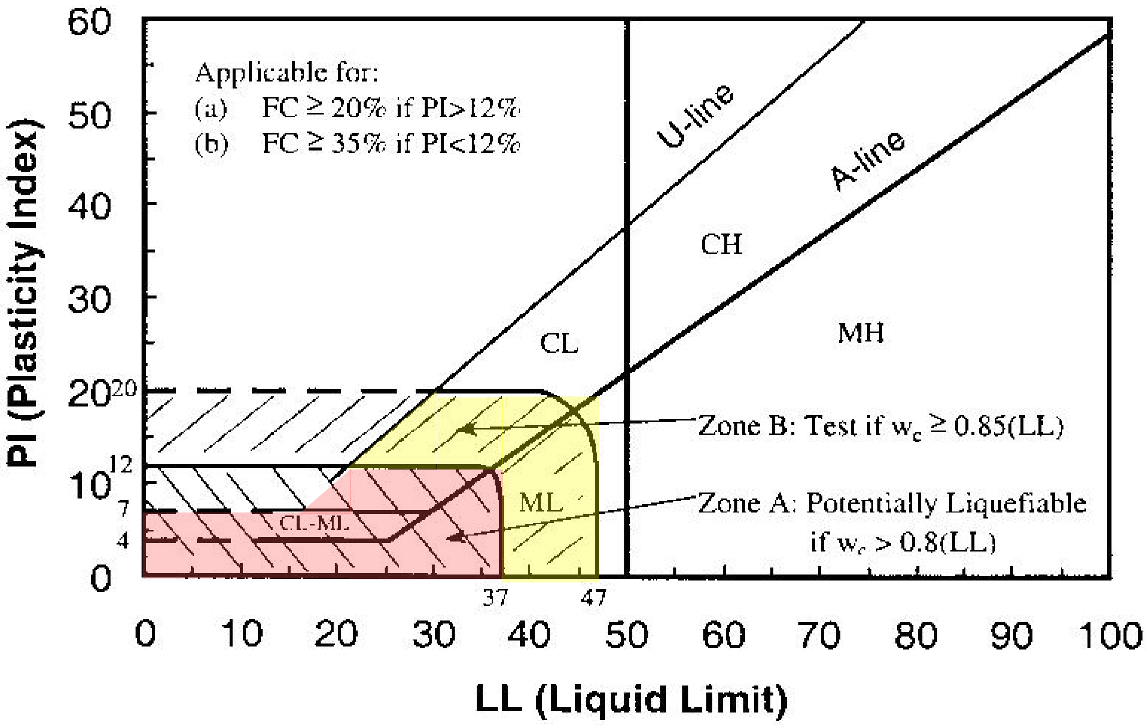
Lab ID	Boring	Depth(s)	Soil Classification	NMC (w_c) (%)	% Passing #200	% Passing #40	LL	PI
	B-7	27.2-27.8	CL	23.6	93.5	98	28	8
	B-8	25.5-25.8	CL	26.8	93.5	99.5	38	17
	B-8	29.7-30.3	CL	23.5	79	99	45	25
	B-9	20.2-20.8	CL	20.2	89	99.9	39	19
	B-10	14.2-14.8	SM	20.0	100	29	NP	NP
	B-10	16.2-16.8	CL-ML	20.6	100	84	28	7
3	B-12	10.0-11.5	CL	23.1	71.7	74.1	43	22
7	B-12	30.0-31.5	CL	19.0	71.4	77.3	31	13
10	B-12	45.0-46.5	CL-ML	18.7	82.2	99.2	26	7
11	B-12	50.0-51.5	ML	21.9	81.3	99.8	NP	NP
13	B-12	60.0-61.5	SM	14.8	36.1	95.7	NP	NP
15	B-12	70.0-71.5	ML	21.6	56.5	98.6	NP	NP
17	B-12	80.0-81.5	ML	25.7	90.2	98.9	NP	NP
20	B-12	95.0-96.5	CL	23.4	86.2	92.4	42	23

Sand-like versus Clay-like Behavior (-1 indicates result does not meet criteria, green shading indicates result does meet criteria, no results shown for non-plastic material)

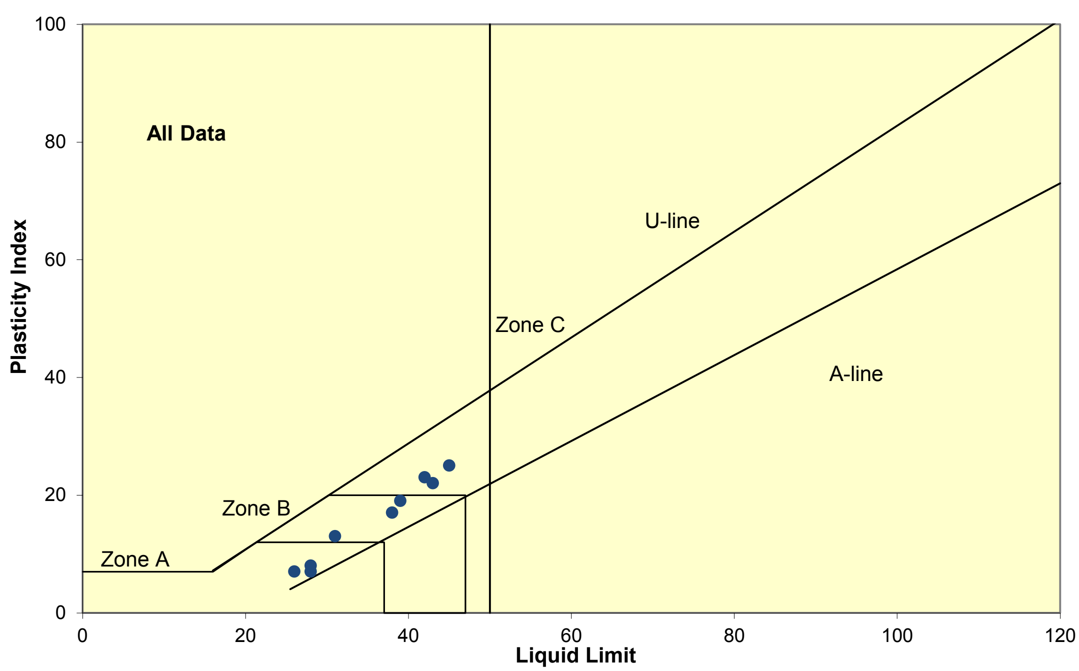
		Using Criteria published by Seed et al (2003)						Using Criteria published by Idriss and Boulanger (2008)		Using criteria published by MSHA (2010)			Overall Judgement based on 3 methods (sand-like or clay-like)
		Meets criteria for sand-like behavior		Meets criteria for clay-like behavior				Meets criteria for sand-like behavior	Meets criteria for clay-like behavior	Meets criteria for sand-like behavior	Meets criteria for clay-like behavior	Borderline soils (treat as sand-like)	
Boring	Depth(s)	LL in Zone A (see plot)	PI in Zone A (see plot)	LL in Zone B (see plot)	PI in Zone B (see plot)	LL in Zone C (see plot)	PI in Zone C (see plot)	PI < 7	PI >= 7	PI <= 7	P40>=35%, P200>=20%, and PI>=10	7 < PI < 10, or does not meet P40 or P200	
B-7	27.2-27.8	28	8	-1	-1	-1	-1	-1	8	-1	-1	8	Sand-like
B-8	25.5-25.8	-1	-1	38	17	-1	-1	-1	17	-1	17	-1	Clay-like
B-8	29.7-30.3	-1	-1	-1	-1	45	25	-1	25	-1	25	-1	Clay-like
B-9	20.2-20.8	-1	-1	39	19	-1	-1	-1	19	-1	19	-1	Clay-like
B-10	14.2-14.8												Sand-like
B-10	16.2-16.8	28	7	-1	-1	-1	-1	-1	7	7	-1	-1	Sand-like
B-12	10.0-11.5	-1	-1	-1	-1	43	22	-1	22	-1	22	-1	Clay-like
B-12	30.0-31.5	-1	-1	31	13	-1	-1	-1	13	-1	13	-1	Clay-like
B-12	45.0-46.5	26	7	-1	-1	-1	-1	-1	7	7	-1	-1	Sand-like
B-12	50.0-51.5												Sand-like
B-12	60.0-61.5												Sand-like
B-12	70.0-71.5												Sand-like
B-12	80.0-81.5												Sand-like
B-12	95.0-96.5	-1	-1	-1	-1	42	23	-1	23	-1	23	-1	Clay-like

Susceptibility of Clay-like Soils to Cyclic Softening (-1 indicates result does not meet criteria, green shading indicates result does meet criteria, no results shown for Sand-like materials)

		Using Criteria published by Seed et al (2003)		Using Criteria published by Bray and Sancio (2006)						Overall Judgement based on 2 methods (susceptibility)
		Meets all criteria for B (clay-like and potentially liquefiable, -2 indicates zone A but susceptible, -3 indicates not applicable due to fines content		Clay-like soil is susceptible (must meet both)		Clay-like soil is not susceptible (must meet one or both)		Clay-like soil is moderately susceptible		
Boring	Depth(s)	LL	PI	w_c/LL >= 0.85	PI <= 12	w_c/LL < 0.80	PI > 18	Intermediate w_c/LL (see plot)	Intermediate PI (see plot)	
B-7	27.2-27.8									
B-8	25.5-25.8	-1	-1	-1.00	-1	0.71	17	-1.00	-1	Not Susceptible
B-8	29.7-30.3	-1	-1	-1.00	-1	0.52	25	-1.00	-1	Not Susceptible
B-9	20.2-20.8	-1	-1	-1.00	-1	0.52	19	-1.00	-1	Not Susceptible
B-10	14.2-14.8									
B-10	16.2-16.8									
B-12	10.0-11.5	-1	-1	-1.00	-1	0.54	22	-1.00	-1	Not Susceptible
B-12	30.0-31.5	-1	-1	-1.00	-1	0.61	13	-1.00	-1	Not Susceptible
B-12	45.0-46.5									
B-12	50.0-51.5									
B-12	60.0-61.5									
B-12	70.0-71.5									
B-12	80.0-81.5									
B-12	95.0-96.5	-1	-1	-1.00	-1	0.56	23	-1.00	-1	Not Susceptible

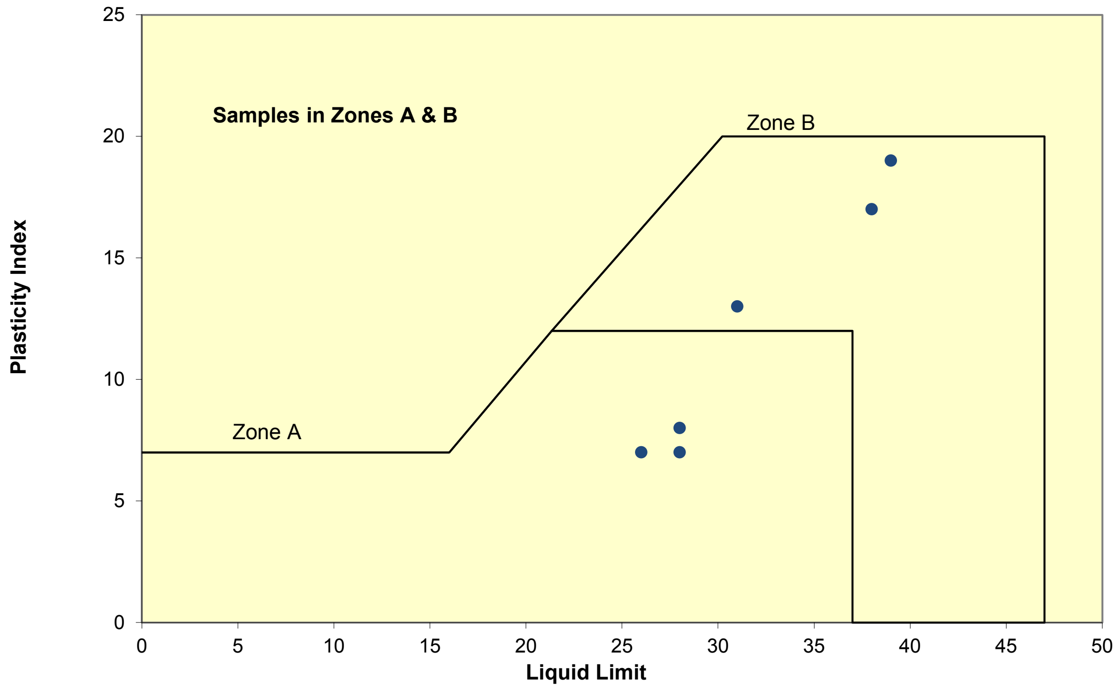


(a)

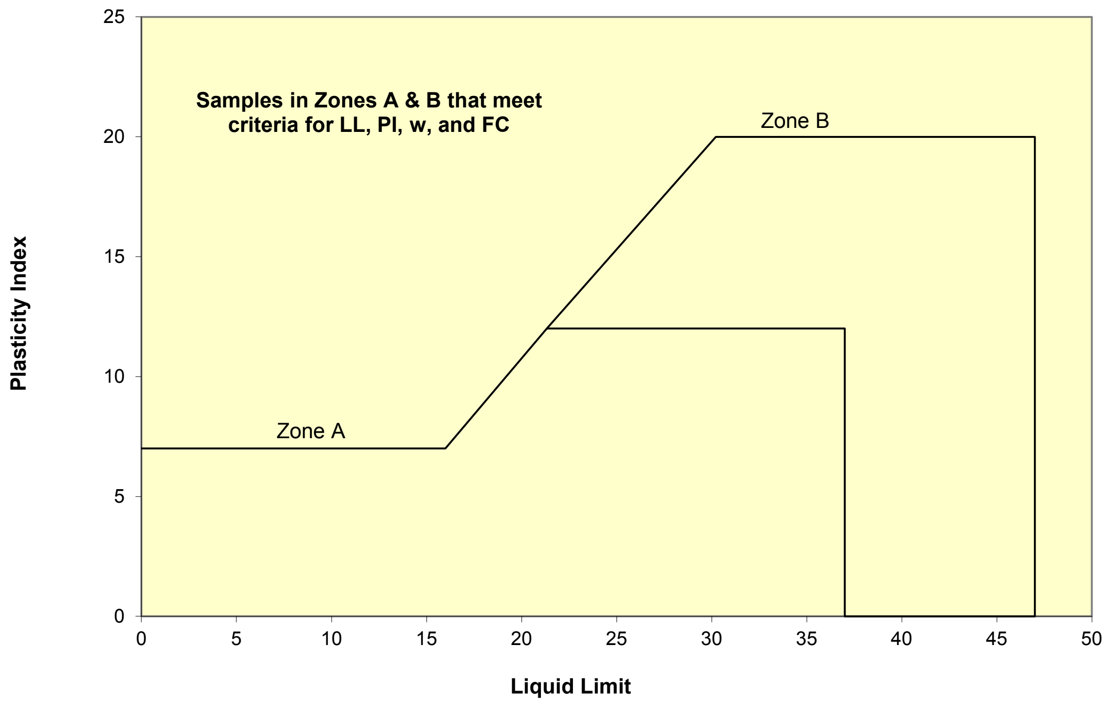


(b)

Screening Criteria for Liquefiable Fine-Grained Soils (Seed et al. 2003)

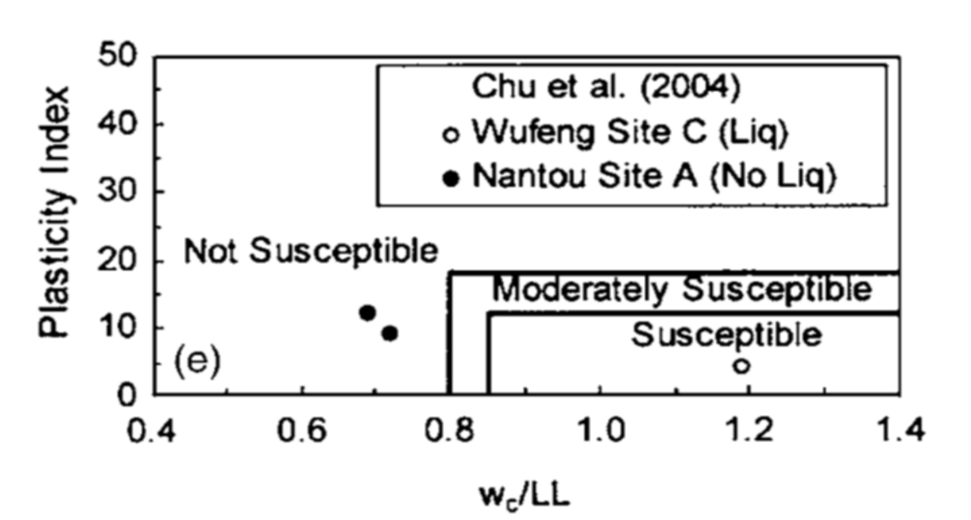


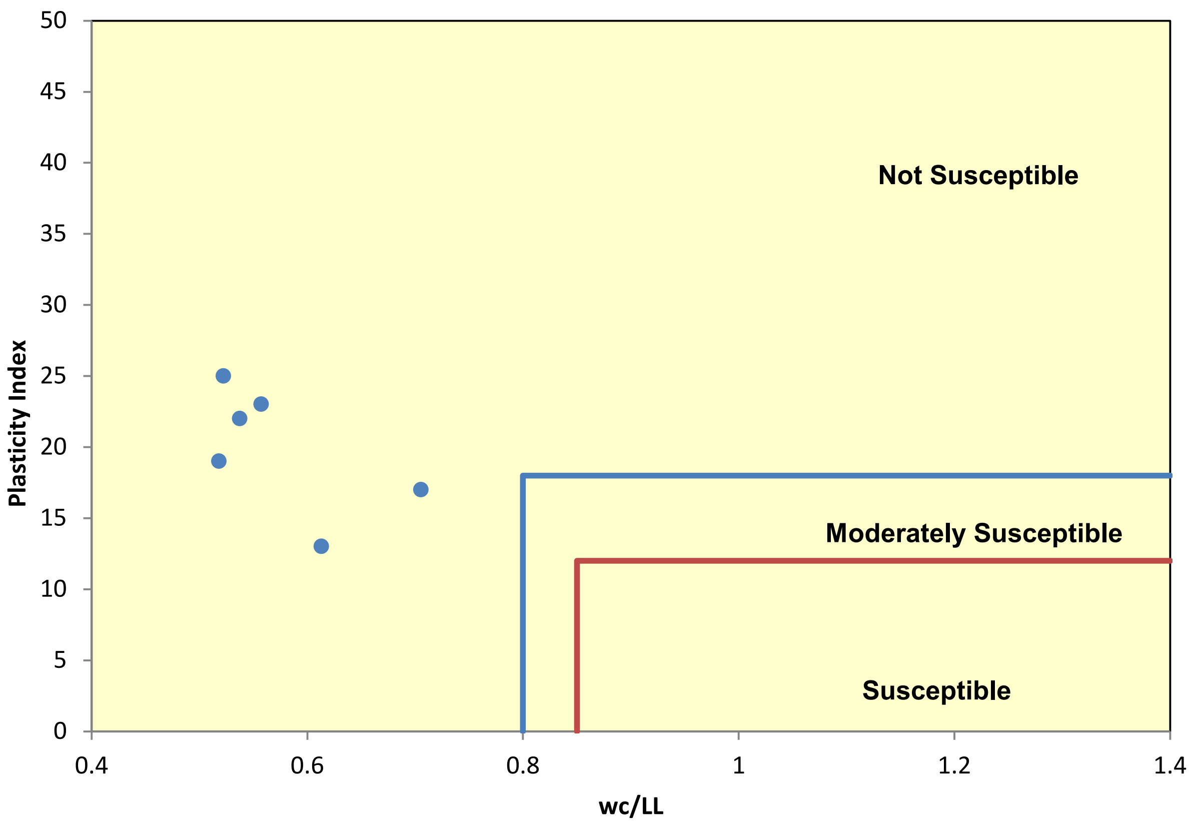
(c)



(d)

Screening Criteria for Liquefiable Fine-Grained Soils (Seed et al. 2003)





Screening Criteria for Assessing Liquefaction in Fine Grained Soils (Bray and Sancio 2006)

COARSE-GRAINED ANALYSIS

EQ Source	a max (g)	EQ Mag (Mw)	Event (MCE, OBE, etc.)	EQ Motion File
0	0.085	7.7	0	0

Shake Stress Curve Fit Parameters

m4:	0
m3:	0
m2:	0
m1:	0

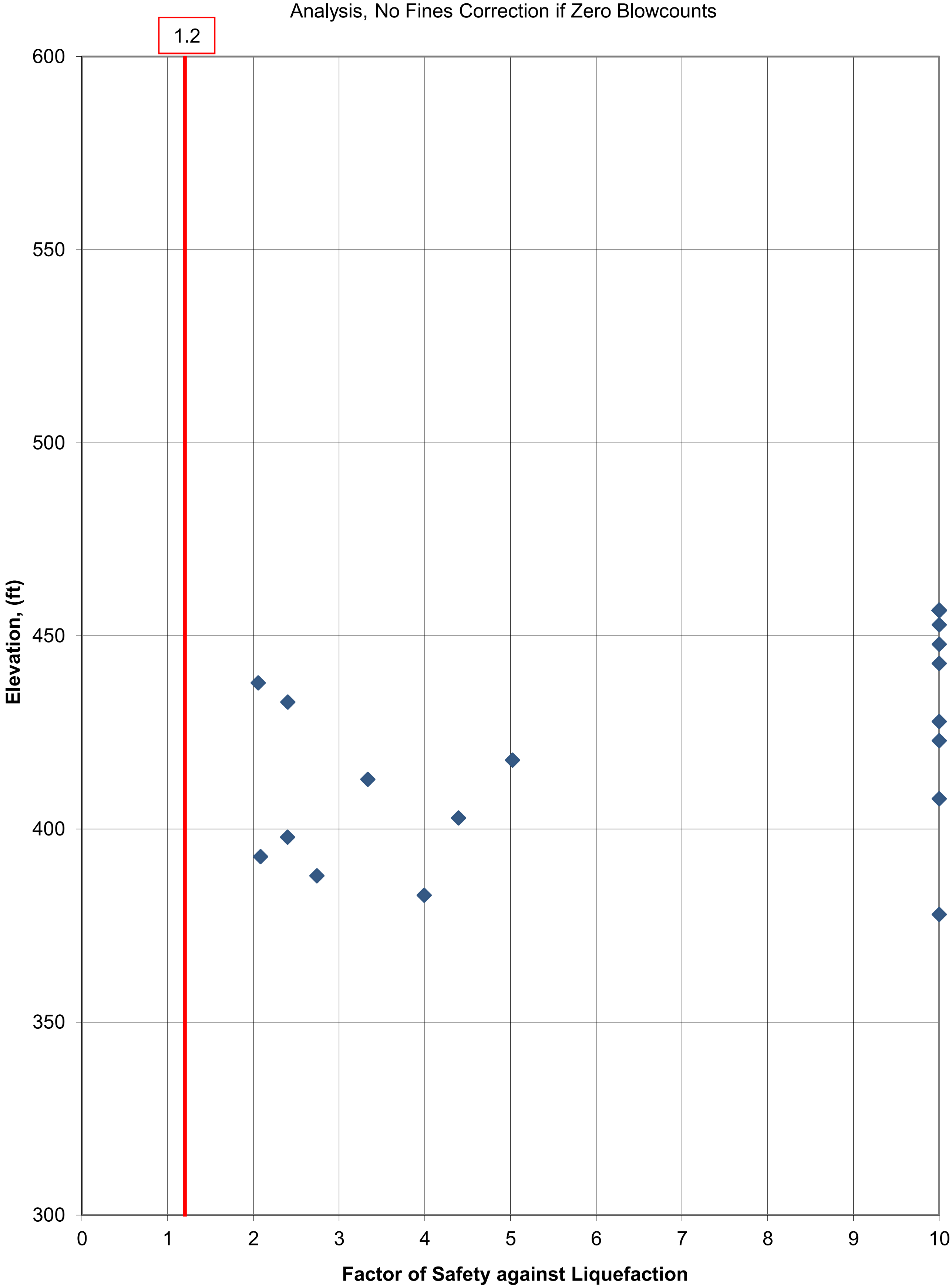
Boring ID:	SI-1
Top of Fill Elevation:	456.6
Fill Height:	0.0
Fill Total Unit Weight:	125
Fill Total Stress:	0.00

Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.

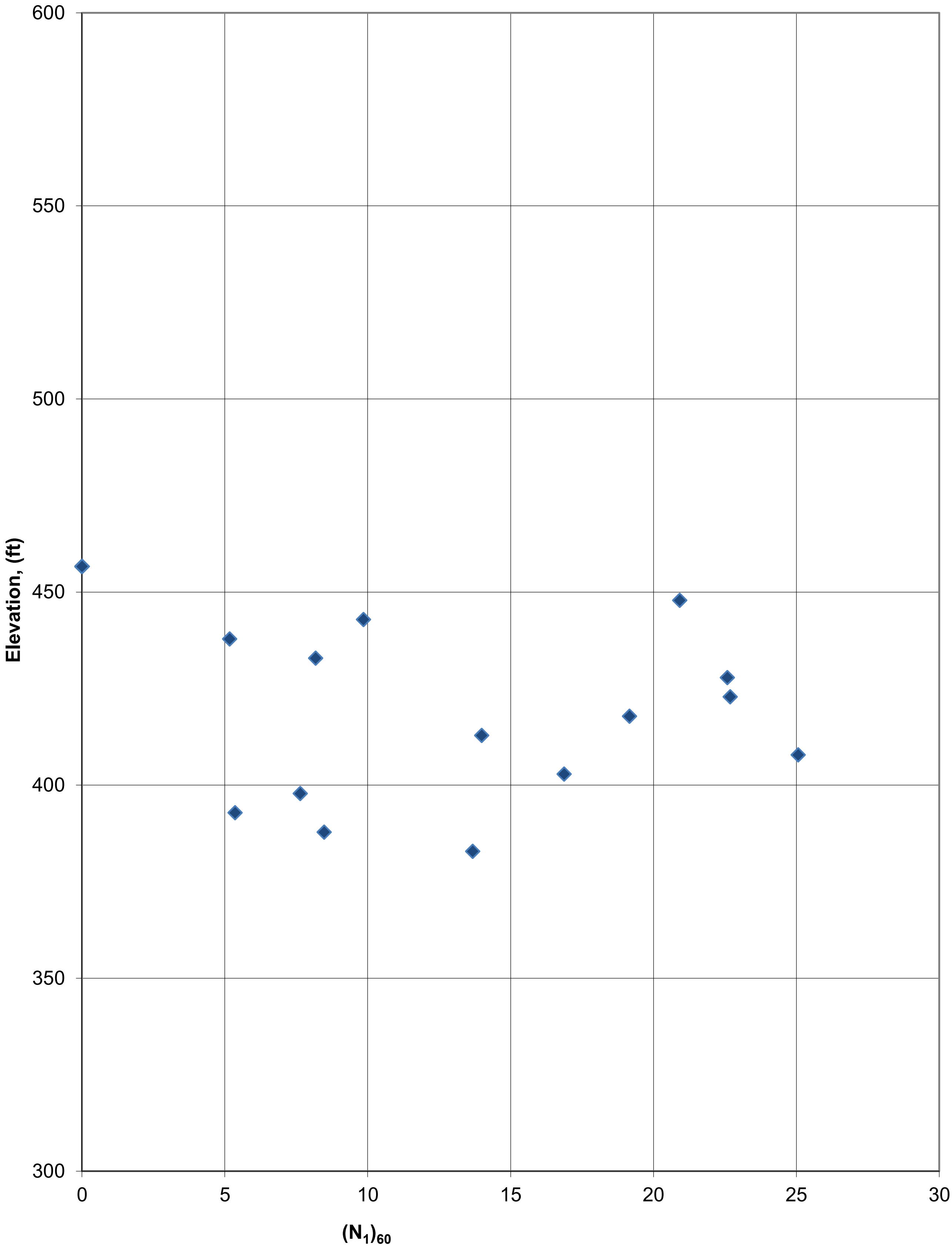
totstr-top	u-top	effstr-top
0.19	0.00	0.19

Depth of Mid. Pt. of Sample (ft.)	Vert. Total Stress during EQ (tsf)	Vert. Total Stress during EQ w/ Fill (tsf)	Static Pore Pressure during EQ (tsf)	Vert. Eff. Stress during EQ (tsf)	Vert. Eff. Stress during EQ w/ Fill (tsf)			Equivalent Clean Sand N-Value				Mag. Scaling Factor (Cm)	CRR	Simplified Stress Reduction Coeff., r_d	Simplified CSR eq	Max. Shake Stress (psf)	Avg. Shake Stress (psf)	Using SHAKE Data CSR eq	Using SHAKE Data FS liq	Using SHAKE Data FS liq	Simplified FS liq	Simplified FS liq
z	σ_v	$\sigma_{v\ with\ fill}$	u	σ'_v	$\sigma'_{v\ with\ fill}$	Alpha I	Beta I	$(N_1)_{60cs}$	CRR7.5	Ksigma	Kalpha		Design EQ		Design EQ	Design EQ	Design EQ	Design EQ	Design EQ	for plot	Design EQ	for plot
3.8	0.23	0.23	0.00	0.23	0.23	5.00	1.20	46	NA	1.000	1.000	0.95	NA	0.993	0.055	0	0	0.000	NA	10.0	NA	10.0
8.8	0.55	0.55	0.00	0.55	0.55	5.00	1.20	30	NA	1.000	1.000	0.95	NA	0.982	0.054	0	0	0.000	NA	10.0	NA	10.0
13.8	0.86	0.86	0.00	0.86	0.86	5.00	1.20	17	NA	1.000	1.000	0.95	NA	0.971	0.054	0	0	0.000	NA	10.0	NA	10.00
18.8	1.17	1.17	0.15	1.02	1.02	5.00	1.20	11	0.124	1.000	1.000	0.95	0.117	0.960	0.061	0	0	0.000	#DIV/0!	#DIV/0!	2.1	2.06
23.8	1.48	1.48	0.30	1.18	1.18	5.00	1.20	15	0.158	0.991	1.000	0.95	0.149	0.946	0.066	0	0	0.000	#DIV/0!	#DIV/0!	2.4	2.40
28.8	1.80	1.80	0.46	1.34	1.34	5.00	1.20	32	NA	0.966	1.000	0.95	NA	0.927	0.069	0	0	0.000	NA	10.0	NA	10.00
33.8	2.11	2.11	0.62	1.49	1.49	5.00	1.20	32	NA	0.950	1.000	0.95	NA	0.899	0.070	0	0	0.000	NA	10.0	NA	10.00
38.8	2.42	2.42	0.77	1.65	1.65	5.00	1.20	28	0.369	0.943	1.000	0.95	0.330	0.862	0.070	0	0	0.000	#DIV/0!	#DIV/0!	5.0	5.02
43.8	2.73	2.73	0.93	1.81	1.81	5.00	1.20	22	0.239	0.945	1.000	0.95	0.214	0.816	0.068	0	0	0.000	#DIV/0!	#DIV/0!	3.3	3.34
48.8	3.05	3.05	1.08	1.96	1.96	5.00	1.20	35	NA	0.899	1.000	0.95	NA	0.765	0.066	0	0	0.000	NA	10.0	NA	10.00
53.8	3.36	3.36	1.24	2.12	2.12	5.00	1.20	25	0.297	0.920	1.000	0.95	0.259	0.715	0.063	0	0	0.000	#DIV/0!	#DIV/0!	4.4	4.39
58.8	3.67	3.67	1.40	2.28	2.28	5.00	1.20	14	0.152	0.936	1.000	0.95	0.135	0.670	0.060	0	0	0.000	#DIV/0!	#DIV/0!	2.4	2.40
63.8	3.98	3.98	1.55	2.43	2.43	5.00	1.20	11	0.126	0.937	1.000	0.95	0.112	0.631	0.057	0	0	0.000	#DIV/0!	#DIV/0!	2.1	2.08
68.8	4.30	4.30	1.71	2.59	2.59	5.00	1.20	15	0.162	0.923	1.000	0.95	0.142	0.599	0.055	0	0	0.000	#DIV/0!	#DIV/0!	2.7	2.74
73.8	4.61	4.61	1.86	2.75	2.75	5.00	1.20	21	0.234	0.902	1.000	0.95	0.200	0.573	0.053	0	0	0.000	#DIV/0!	#DIV/0!	4.0	3.99
78.8	4.92	4.92	2.02	2.90	2.90	5.00	1.20	62	NA	0.697	1.000	0.95	NA	0.553	0.052	0	0	0.000	NA	10.0	NA	10.00

Clifty Creek AEP, Boring = SI-1, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts



Clifty Creek AEP, Boring = SI-1, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts



EQ Source	a max (g)	EQ Mag (Mw)
0	0.085	7.7

Event (MCE, OBE, etc.)	EQ Motion File
0	0

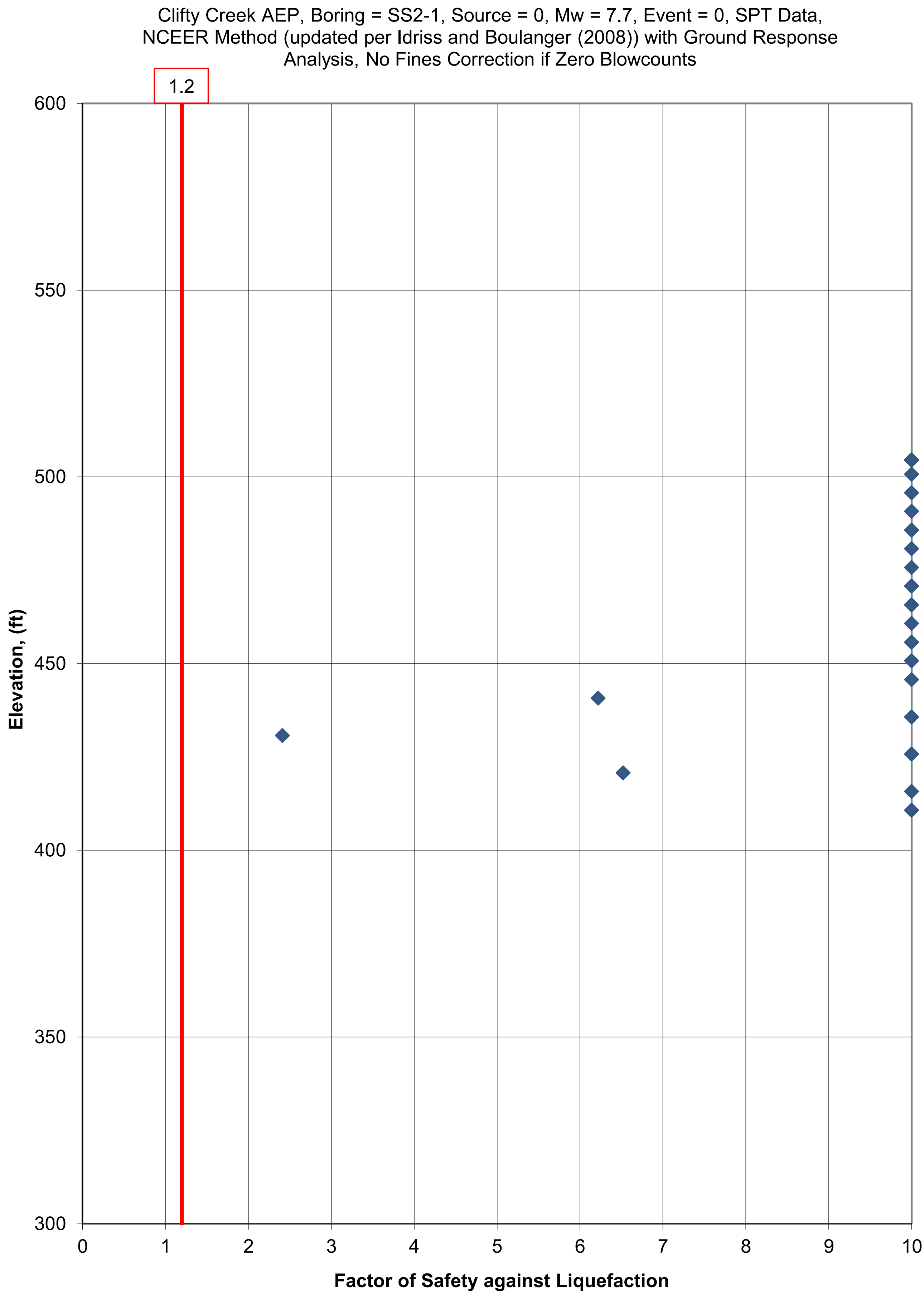
Shake Stress Curve Fit Parameters	
m4:	0
m3:	0
m2:	0
m1:	0

Boring ID:	**SS2-1**
Top of Fill Elevation:	504.5 ft *(if no fill, then set this equal to top of SPT hole elev.)*
Fill Height:	0.0 ft *(relative to ground surface during SPT)*
Fill Total Unit Weight:	125 pcf
Fill Total Stress:	0.00 tsf

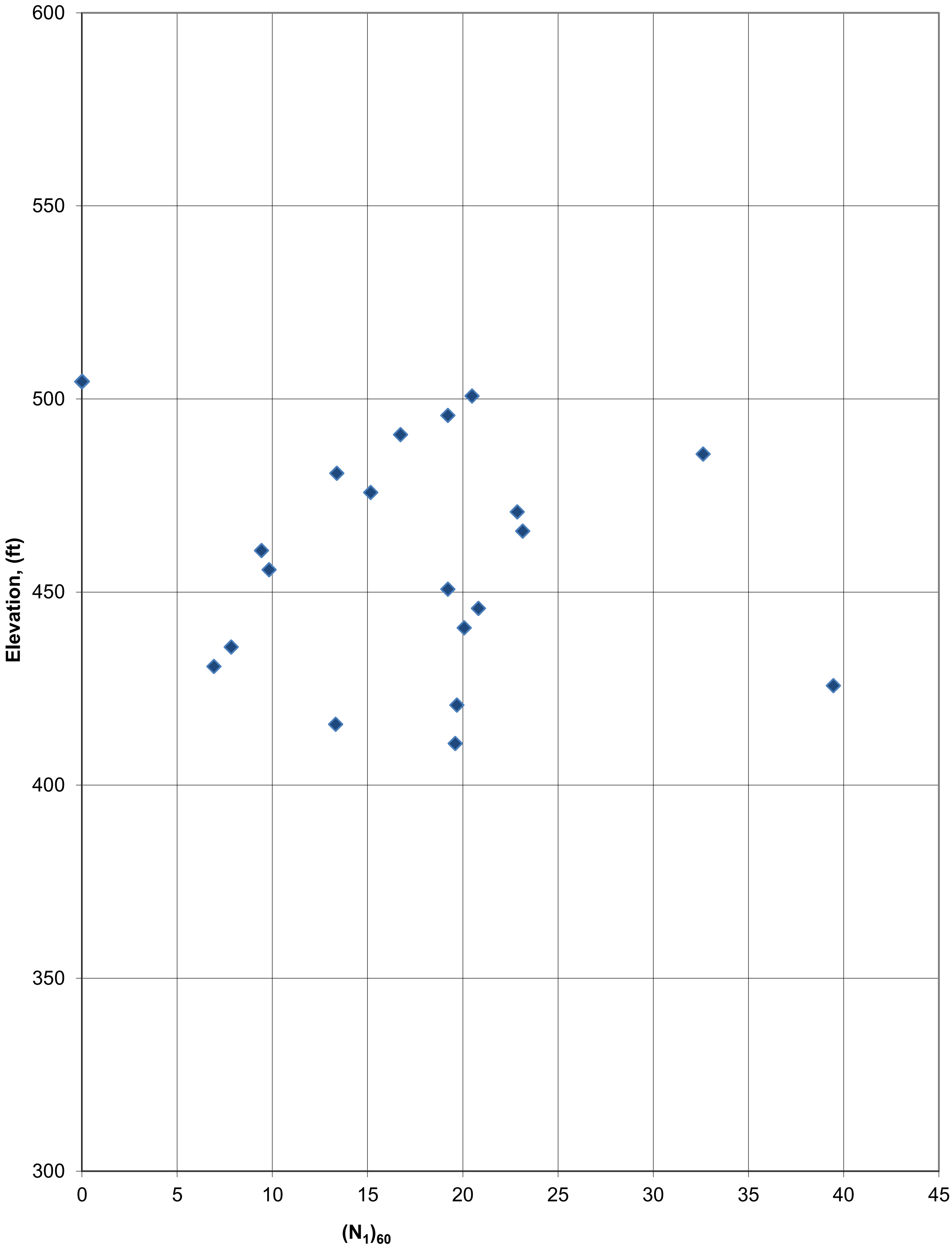
Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.

totstr-top	u-top	effstr-top
0.19	0.00	0.19

Depth of Mid. Pt. of Sample (ft.) z	Vert. Total Stress during EQ (tsf) σ_v	Vert. Total Stress during EQ w/ Fill (tsf) $\sigma_{v\ with\ fill}$	Static Pore Pressure during EQ (tsf) u	Vert. Eff. Stress during EQ (tsf) σ'_v	Vert. Eff. Stress during EQ w/ Fill (tsf) $\sigma'_{v\ with\ fill}$	Effective All-Around Stress during EQ (psf) σ'_m	Shear Modulus during EQ (ksf) G_{max}	Alpha I	Beta I	Equivalent Clean Sand N-Value $(N_1)_{60cs}$	CRR7.5	Ksigma	Kalpha	Mag. Scaling Factor (Cm)	CRR Design EQ	Simplified Stress Reduction Coeff., r_d	Simplified CSR eq Design EQ	Max. Shake Stress (psf) Design EQ	Avg. Shake Stress (psf) Design EQ	Using SHAKE Data: CSR eq Design EQ	Using SHAKE Data: FS liq Design EQ	Using SHAKE Data: FS liq for plot	Simplified: FS liq Design EQ	Simplified: FS liq for plot
3.8	0.23	0.23	0.00	0.23	0.23	312.50	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.993	0.055	0	0	0.000	NA	10.0	NA	10.00
8.8	0.55	0.55	0.00	0.55	0.55	729.17	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.982	0.054	0	0	0.000	NA	10.0	NA	10.00
13.8	0.86	0.86	0.12	0.74	0.74	989.83	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.971	0.062	0	0	0.000	NA	10.0	NA	10.00
18.8	1.17	1.17	0.27	0.90	0.90	1198.50	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.960	0.069	0	0	0.000	NA	10.0	NA	10.00
23.8	1.48	1.48	0.43	1.06	1.06	1407.17	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.946	0.074	0	0	0.000	NA	10.0	NA	10.00
28.8	1.80	1.80	0.59	1.21	1.21	1615.83	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.927	0.076	0	0	0.000	NA	10.0	NA	10.00
33.8	2.11	2.11	0.74	1.37	1.37	1824.50	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.899	0.077	0	0	0.000	NA	10.0	NA	10.00
38.8	2.42	2.42	0.90	1.52	1.52	2033.17	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.862	0.076	0	0	0.000	NA	10.0	NA	10.00
43.8	2.73	2.73	1.05	1.68	1.68	2241.83	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.816	0.073	0	0	0.000	NA	10.0	NA	10.00
48.8	3.05	3.05	1.21	1.84	1.84	2450.50	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.765	0.070	0	0	0.000	NA	10.0	NA	10.00
53.8	3.36	3.36	1.37	1.99	1.99	2659.17	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.715	0.067	0	0	0.000	NA	10.0	NA	10.00
58.8	3.67	3.67	1.52	2.15	2.15	2867.83	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.670	0.063	0	0	0.000	NA	10.0	NA	10.00
63.8	3.98	3.98	1.68	2.31	2.31	3076.50	#NUM!	5.00	1.20	29	0.414	0.896	1.000	0.95	0.352	0.631	0.060	0	0	0.000	#DIV/0!	#DIV/0!	6.2	6.22
68.8	4.30	4.30	1.83	2.46	2.46	3285.17	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.599	0.058	0	0	0.000	NA	10.0	NA	10.00
73.8	4.61	4.61	1.99	2.62	2.62	3493.83	#NUM!	5.00	1.20	13	0.144	0.928	1.000	0.95	0.126	0.573	0.056	0	0	0.000	#DIV/0!	#DIV/0!	2.4	2.41
78.8	4.92	4.92	2.15	2.78	2.78	3702.50	#NUM!	5.00	1.20	52	NA	0.711	1.000	0.95	NA	0.553	0.054	0	0	0.000	NA	10.0	NA	10.00
83.8	5.23	5.23	2.30	2.93	2.93	3911.17	#NUM!	5.00	1.20	29	0.393	0.869	1.000	0.95	0.324	0.536	0.053	0	0	0.000	#DIV/0!	#DIV/0!	6.5	6.52
88.8	5.55	5.55	2.46	3.09	3.09	4119.83	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.522	0.052	0	0	0.000	NA	10.0	NA	10.00
93.8	5.86	5.86	2.61	3.25	3.25	4328.50	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.511	0.051	0	0	0.000	NA	10.0	NA	10.00


Clifty Creek AEP, Boring = SS2-1, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts
1.2
600
550
500
450
400
350
300
0
1
2
3
4
5
6
7
8
9
10
Elevation, (ft)
Factor of Safety against Liquefaction

Clifty Creek AEP, Boring = SS2-1, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts



EQ Source
0
a max (g)
0.085
EQ Mag (Mw)
7.7

Event (MCE, OBE, etc.)
0
EQ Motion File
0

Shake Stress Curve Fit Parameters	
m4:	0
m3:	0
m2:	0
m1:	0

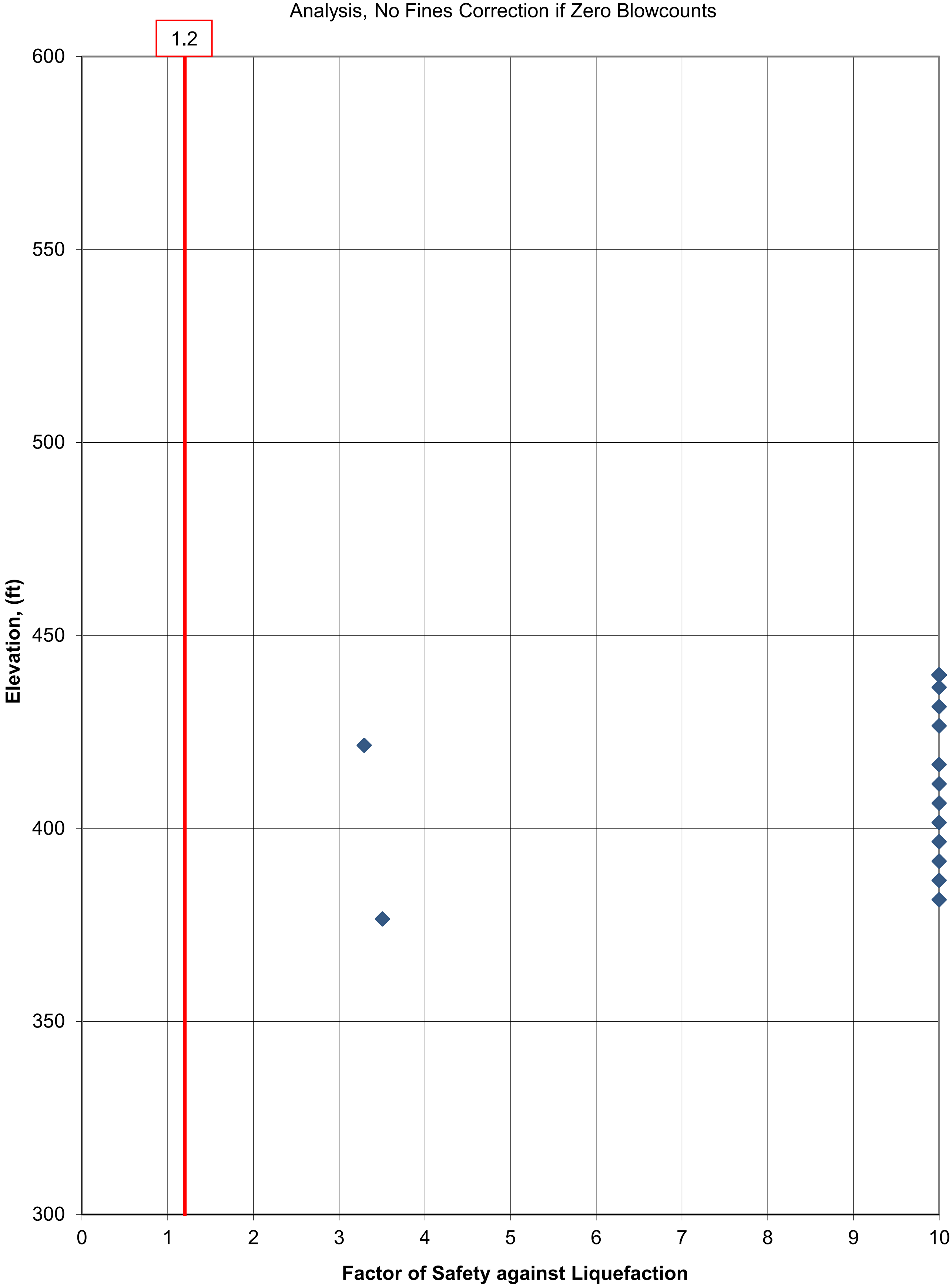
Boring ID:	SS2-4
Top of Fill Elevation:	439.8
Fill Height:	0.0
Fill Total Unit Weight:	125
Fill Total Stress:	0.00

Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.

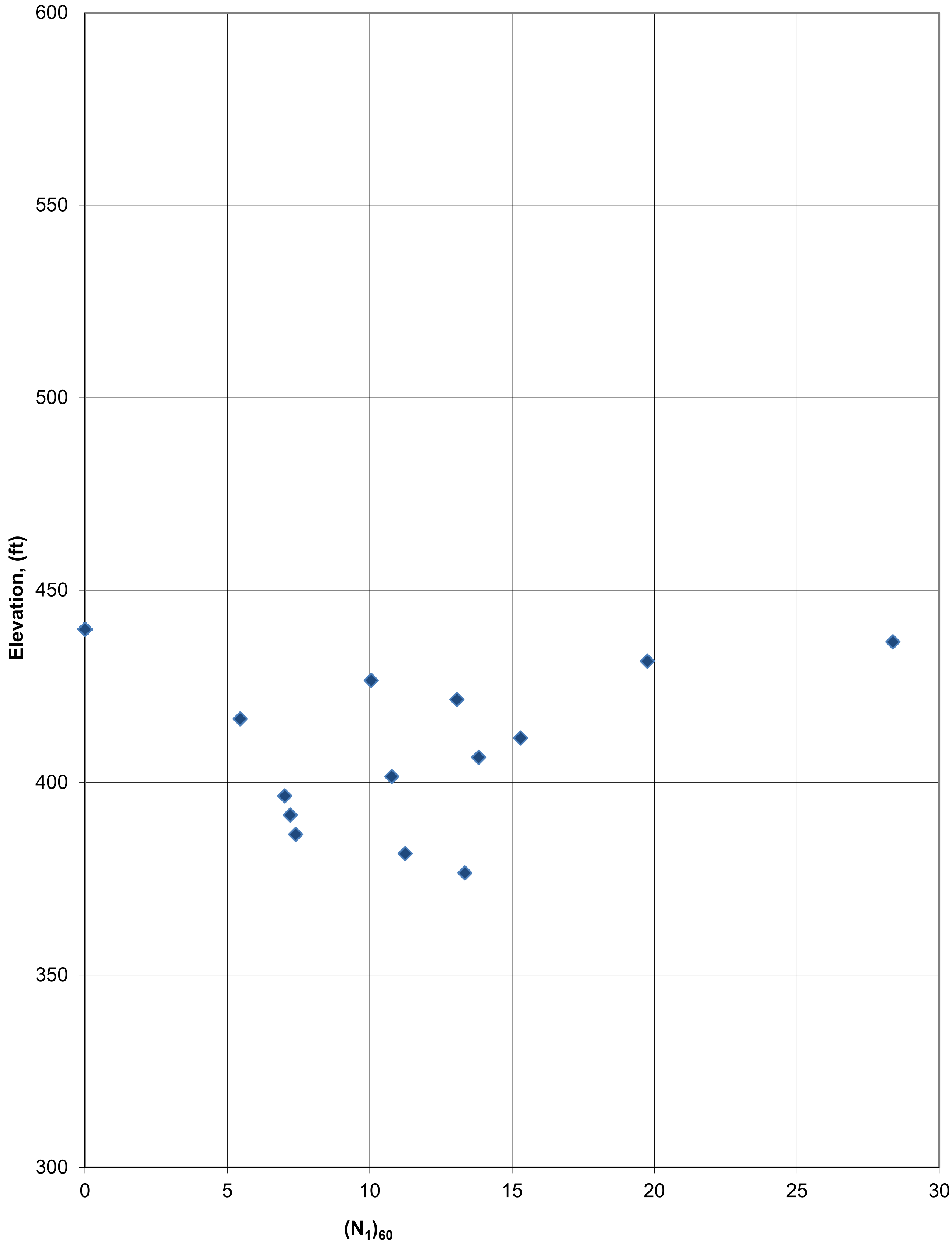
totstr-top	u-top	effstr-top
0.16	0.00	0.16

Depth of Mid. Pt. of Sample (ft.) z	Vert. Total Stress during EQ (tsf) σ_v	Vert. Total Stress during EQ w/ Fill (tsf) $\sigma_{v\ with\ fill}$	Static Pore Pressure during EQ (tsf) u	Vert. Eff. Stress during EQ (tsf) σ'_v	Vert. Eff. Stress during EQ w/ Fill (tsf) $\sigma'_{v\ with\ fill}$	Alpha I	Beta I	Equivalent Clean Sand N-Value $(N_1)_{60cs}$	CRR7.5	Ksigma	Kalpha	Mag. Scaling Factor (Cm)	CRR Design EQ	Simplified Stress Reduction Coeff., r_d	Simplified CSR eq Design EQ	Max. Shake Stress (psf) Design EQ	Avg. Shake Stress (psf) Design EQ	Using SHAKE Data CSR eq Design EQ	Using SHAKE Data FS liq Design EQ	Using SHAKE Data FS liq for plot	Simplified FS liq Design EQ	Simplified FS liq for plot
3.3	0.20	0.20	0.00	0.20	0.20	NA	NA	NA	NA	NA	NA	0.95	NA	0.994	0.055	0	0	0.000	NA	10.0	NA	10.00
8.3	0.52	0.52	0.00	0.52	0.52	NA	NA	NA	NA	NA	NA	0.95	NA	0.983	0.054	0	0	0.000	NA	10.0	NA	10.00
13.3	0.83	0.83	0.10	0.73	0.73	NA	NA	NA	NA	NA	NA	0.95	NA	0.972	0.061	0	0	0.000	NA	10.0	NA	10.00
18.3	1.14	1.14	0.26	0.88	0.88	5.00	1.20	21	0.224	1.000	1.000	0.95	0.212	0.961	0.069	0	0	0.000	#DIV/0!	#DIV/0!	3.3	3.29
23.3	1.45	1.45	0.41	1.04	1.04	NA	NA	NA	NA	NA	NA	0.95	NA	0.948	0.073	0	0	0.000	NA	10.0	NA	10.00
28.3	1.77	1.77	0.57	1.20	1.20	NA	NA	NA	NA	NA	NA	0.95	NA	0.929	0.076	0	0	0.000	NA	10.0	NA	10.00
33.3	2.08	2.08	0.73	1.35	1.35	NA	NA	NA	NA	NA	NA	0.95	NA	0.902	0.077	0	0	0.000	NA	10.0	NA	10.00
38.3	2.39	2.39	0.88	1.51	1.51	NA	NA	NA	NA	NA	NA	0.95	NA	0.866	0.076	0	0	0.000	NA	10.0	NA	10.00
43.3	2.70	2.70	1.04	1.67	1.67	NA	NA	NA	NA	NA	NA	0.95	NA	0.821	0.074	0	0	0.000	NA	10.0	NA	10.00
48.3	3.02	3.02	1.19	1.82	1.82	NA	NA	NA	NA	NA	NA	0.95	NA	0.771	0.070	0	0	0.000	NA	10.0	NA	10.00
53.3	3.33	3.33	1.35	1.98	1.98	NA	NA	NA	NA	NA	NA	0.95	NA	0.720	0.067	0	0	0.000	NA	10.0	NA	10.00
58.3	3.64	3.64	1.51	2.14	2.14	NA	NA	NA	NA	NA	NA	0.95	NA	0.674	0.063	0	0	0.000	NA	10.0	NA	10.00
63.3	3.95	3.95	1.66	2.29	2.29	5.00	1.20	21	0.228	0.920	1.000	0.95	0.199	0.634	0.060	0	0	0.000	#DIV/0!	#DIV/0!	3.5	3.50

Clifty Creek AEP, Boring = SS2-4, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts



Clifty Creek AEP, Boring = SS2-4, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts



EQ Source	a max (g)	EQ Mag (Mw)
0	0.085	7.7

Event (MCE, OBE, etc.): 0

EQ Motion File: 0

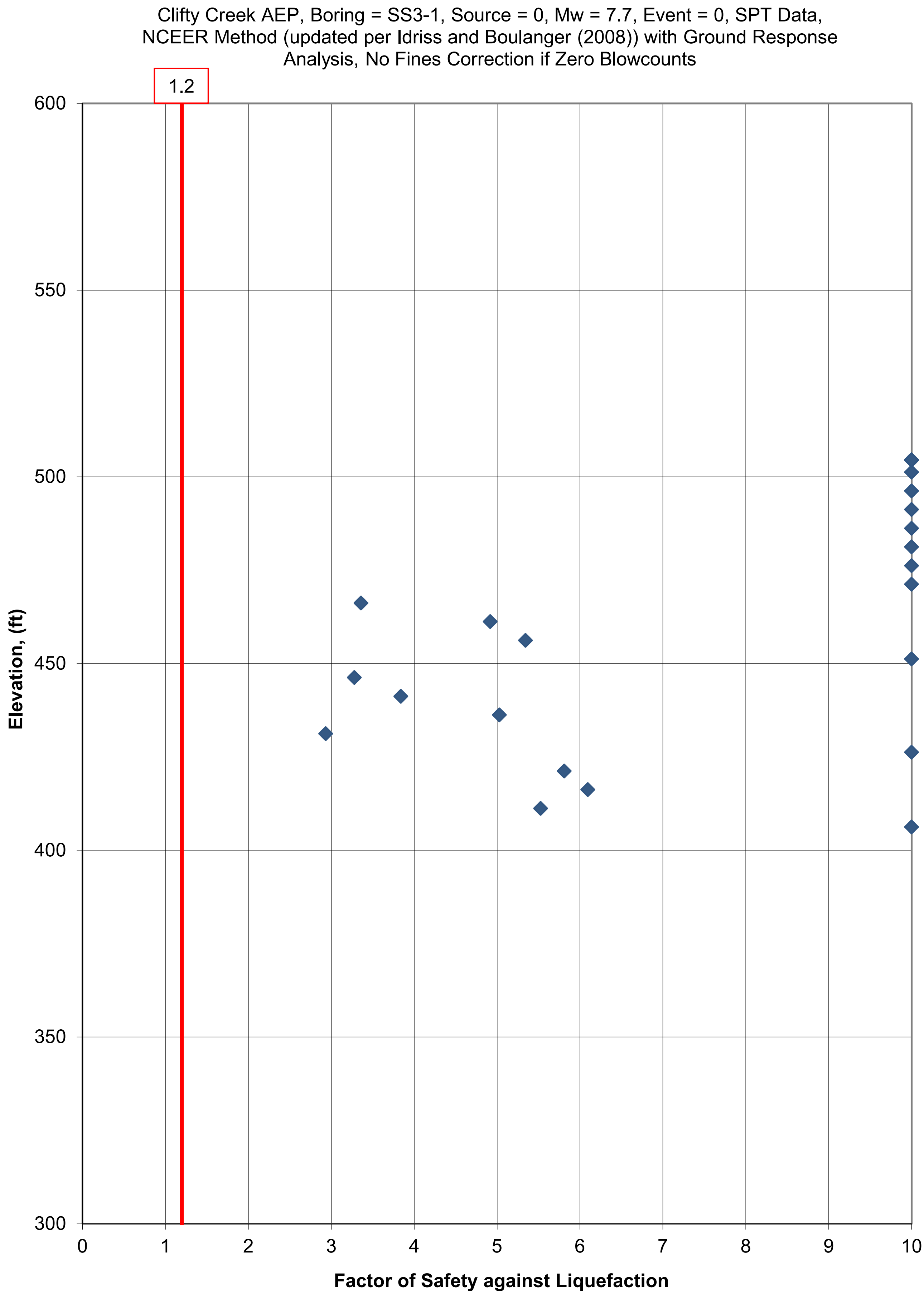
Shake Stress Curve Fit Parameters	
m4:	0
m3:	0
m2:	0
m1:	0

Boring ID:	**SS3-1**
Top of Fill Elevation:	504.5 ft *(if no fill, then set this equal to top of SPT hole elev.)*
Fill Height:	0.0 ft *(relative to ground surface during SPT)*
Fill Total Unit Weight:	125 pcf
Fill Total Stress:	0.00 tsf

Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.

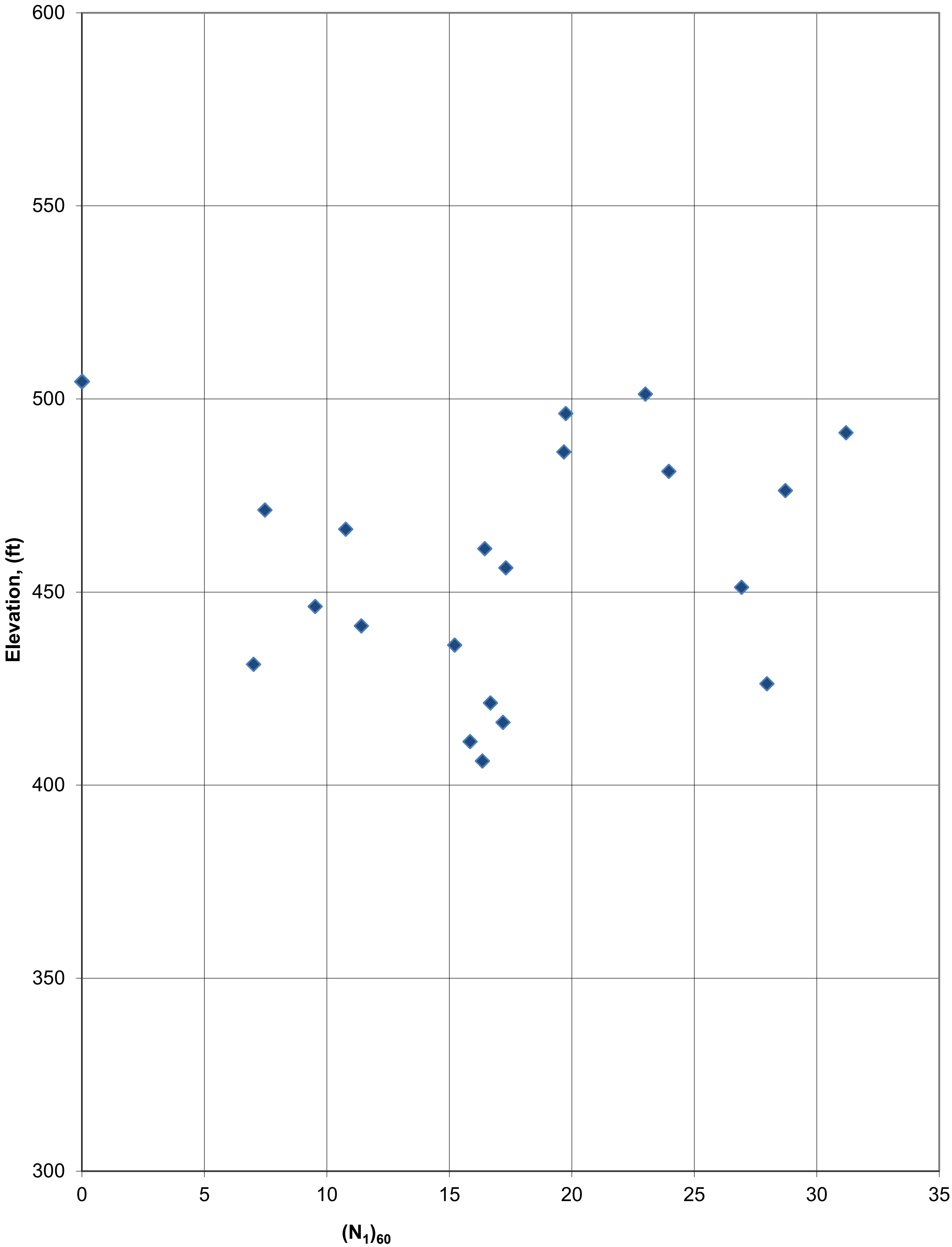
totstr-top	u-top	effstr-top
0.16	0.00	0.16

Depth of Mid. Pt. of Sample (ft.) z	Vert. Total Stress during EQ (tsf) σ_v	Vert. Total Stress during EQ w/ Fill (tsf) $\sigma_{v\ with\ fill}$	Static Pore Pressure during EQ (tsf) u	Vert. Eff. Stress during EQ (tsf) σ'_v	Vert. Eff. Stress during EQ w/ Fill (tsf) $\sigma'_{v\ with\ fill}$	Effective All-Around Stress during EQ (psf) σ'_m	Shear Modulus during EQ (ksf) G_{max}	Alpha I	Beta I	Equivalent Clean Sand N-Value $(N_1)_{60cs}$	CRR7.5	Ksigma	Kalpha	Mag. Scaling Factor (Cm)	CRR Design EQ	Simplified Stress Reduction Coeff., r_d	Simplified CSR eq Design EQ	Max. Shake Stress (psf) Design EQ	Avg. Shake Stress (psf) Design EQ	Using SHAKE Data CSR eq Design EQ	Using SHAKE Data FS liq Design EQ	Using SHAKE Data FS liq for plot	Simplified FS liq Design EQ	Simplified FS liq for plot
3.3	0.20	0.20	0.00	0.20	0.20	270.83	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.994	0.055	0	0	0.000	NA	10.0	NA	10.00
8.3	0.52	0.52	0.00	0.52	0.52	687.50	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.983	0.054	0	0	0.000	NA	10.0	NA	10.00
13.3	0.83	0.83	0.00	0.83	0.83	1104.17	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.972	0.054	0	0	0.000	NA	10.0	NA	10.00
18.3	1.14	1.14	0.00	1.14	1.14	1520.83	#NUM!	5.00	1.20	29	NA	0.990	1.000	0.95	NA	0.961	0.053	0	0	0.000	NA	10.0	NA	10.00
23.3	1.45	1.45	0.00	1.45	1.45	1937.50	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.948	0.052	0	0	0.000	NA	10.0	NA	10.00
28.3	1.77	1.77	0.00	1.77	1.77	2354.17	#NUM!	5.00	1.20	39	NA	0.909	1.000	0.95	NA	0.929	0.051	0	0	0.000	NA	10.0	NA	10.00
33.3	2.08	2.08	0.10	1.98	1.98	2635.63	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.902	0.052	0	0	0.000	NA	10.0	NA	10.00
38.3	2.39	2.39	0.26	2.13	2.13	2844.30	#NUM!	5.00	1.20	18	0.191	0.935	1.000	0.95	0.169	0.866	0.054	0	0	0.000	#DIV/0!	#DIV/0!	3.4	3.36
43.3	2.70	2.70	0.41	2.29	2.29	3052.97	#NUM!	5.00	1.20	25	0.287	0.911	1.000	0.95	0.248	0.821	0.054	0	0	0.000	#DIV/0!	#DIV/0!	4.9	4.92
48.3	3.02	3.02	0.57	2.45	2.45	3261.63	#NUM!	5.00	1.20	26	0.308	0.904	1.000	0.95	0.264	0.771	0.052	0	0	0.000	#DIV/0!	#DIV/0!	5.3	5.34
53.3	3.33	3.33	0.73	2.60	2.60	3470.30	#NUM!	5.00	1.20	37	NA	0.847	1.000	0.95	NA	0.720	0.051	0	0	0.000	NA	10.0	NA	10.00
58.3	3.64	3.64	0.88	2.76	2.76	3678.97	#NUM!	5.00	1.20	16	0.175	0.915	1.000	0.95	0.152	0.674	0.049	0	0	0.000	#DIV/0!	#DIV/0!	3.3	3.28
63.3	3.95	3.95	1.04	2.92	2.92	3887.63	#NUM!	5.00	1.20	19	0.200	0.906	1.000	0.95	0.172	0.634	0.048	0	0	0.000	#DIV/0!	#DIV/0!	3.8	3.84
68.3	4.27	4.27	1.19	3.07	3.07	4096.30	#NUM!	5.00	1.20	23	0.261	0.882	1.000	0.95	0.218	0.602	0.046	0	0	0.000	#DIV/0!	#DIV/0!	5.0	5.03
73.3	4.58	4.58	1.35	3.23	3.23	4304.97	#NUM!	5.00	1.20	13	0.144	0.908	1.000	0.95	0.124	0.576	0.045	0	0	0.000	#DIV/0!	#DIV/0!	2.9	2.93
78.3	4.89	4.89	1.51	3.39	3.39	4513.63	#NUM!	5.00	1.20	39	NA	0.794	1.000	0.95	NA	0.555	0.044	0	0	0.000	NA	10.0	NA	10.00
83.3	5.20	5.20	1.66	3.54	3.54	4722.30	#NUM!	5.00	1.20	25	0.292	0.861	1.000	0.95	0.239	0.538	0.044	0	0	0.000	#DIV/0!	#DIV/0!	5.8	5.81
88.3	5.52	5.52	1.82	3.70	3.70	4930.97	#NUM!	5.00	1.20	26	0.305	0.856	1.000	0.95	0.247	0.524	0.043	0	0	0.000	#DIV/0!	#DIV/0!	6.1	6.09
93.3	5.83	5.83	1.97	3.85	3.85	5139.63	#NUM!	5.00	1.20	24	0.274	0.857	1.000	0.95	0.222	0.512	0.043	0	0	0.000	#DIV/0!	#DIV/0!	5.5	5.53
98.3	6.14	6.14	2.13	4.01	4.01	5348.30	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.502	0.042	0	0	0.000	NA	10.0	NA	10.00



Clifty Creek AEP, Boring = SS3-1, Source = 0, Mw = 7.7, Event = 0, SPT Data,
NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response
Analysis, No Fines Correction if Zero Blowcounts
1.2
600
550
500
450
400
350
300
0
1
2
3
4
5
6
7
8
9
10
Elevation, (ft)
Factor of Safety against Liquefaction

Clifty Creek AEP, Boring = SS3-1, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts



EQ Source: 0
a max (g): 0.085
EQ Mag (Mw): 7.7

Event (MCE, OBE, etc.): 0
EQ Motion File: 0

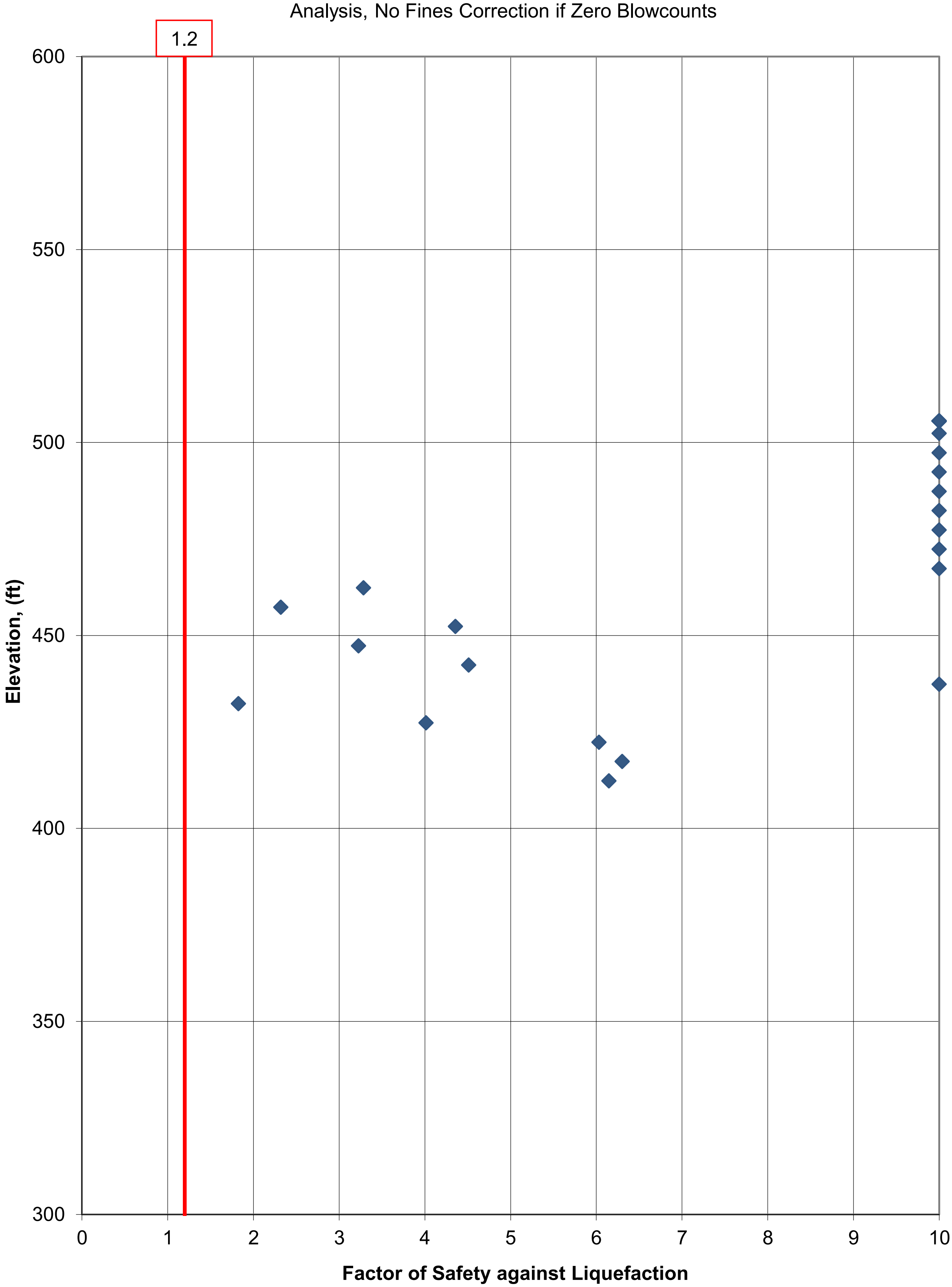
Shake Stress Curve Fit Parameters
m4: 0
m3: 0
m2: 0
m1: 0

Boring ID: **SS4-1**
Top of Fill Elevation: 505.6 ft *(if no fill, then set this equal to top of SPT hole elev.)*
Fill Height: 0.0 ft *(relative to ground surface during SPT)*
Fill Total Unit Weight: 125 pcf
Fill Total Stress: 0.00 tsf

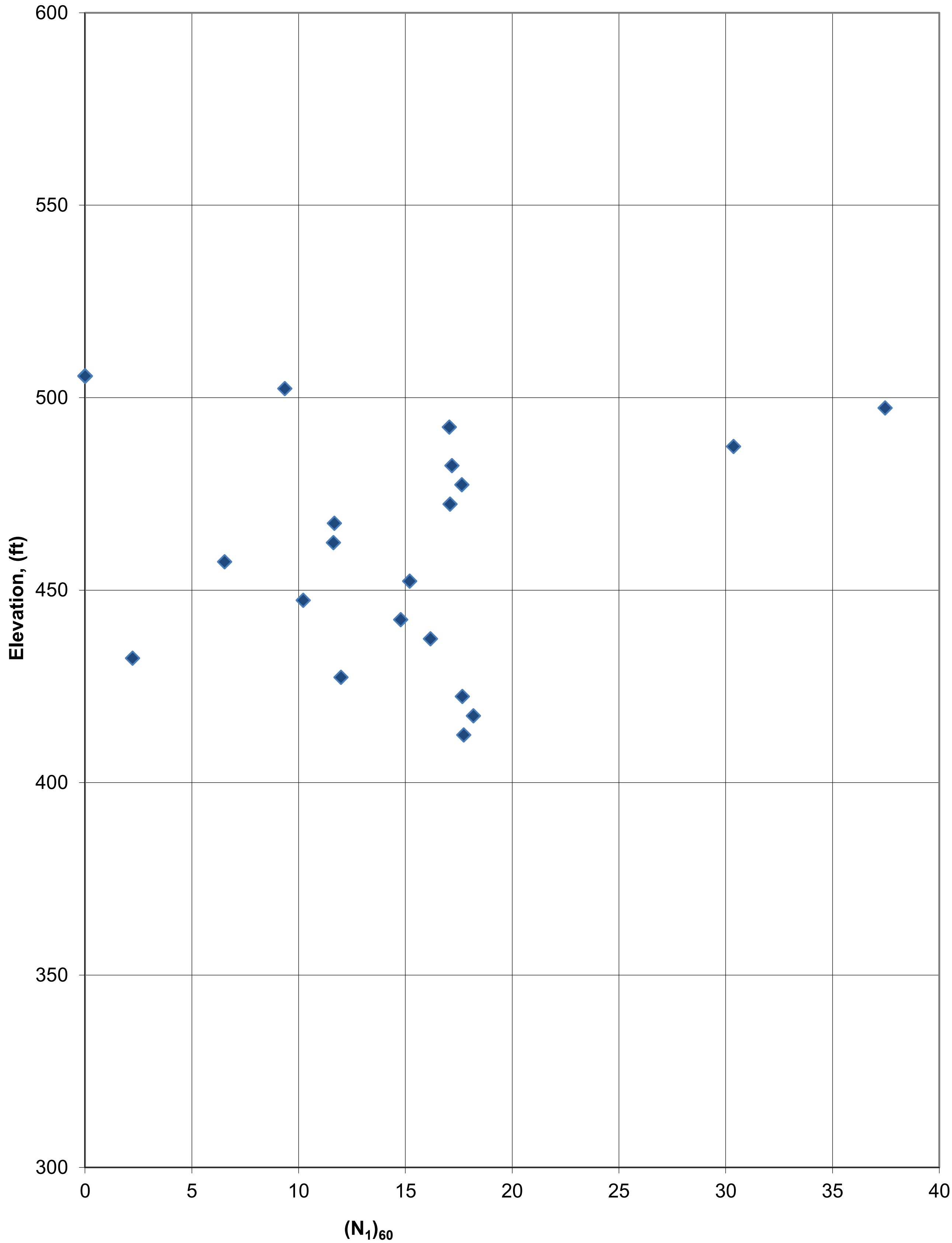
Note: A factor of safety shown as "NA" implies that the soil type is not appropriately evaluated using this methodology. This applies to soils classified as CL, CH, CL-ML and MH. These soils should be evaluated using methods for fine-grained soils. Also, "NA" implies that coarse grained soils with equivalent clean sand N-values greater than 30 are resistant to liquefaction.

Depth of Mid. Pt. of Sample (ft.)	Vert. Total Stress during EQ (tsf)	Vert. Total Stress during EQ w/ Fill (tsf)	Static Pore Pressure during EQ (tsf)	Vert. Eff. Stress during EQ (tsf)	Vert. Eff. Stress during EQ w/ Fill (tsf)	Effective All-Around Stress during EQ (psf)	Shear Modulus during EQ (ksf)			Equivalent Clean Sand N-Value				Mag. Scaling Factor (Cm)	CRR	Simplified Stress Reduction Coeff., r_d	Simplified CSR eq	Max. Shake Stress (psf)	Avg. Shake Stress (psf)	Using SHAKE Data CSR eq			Simplified FS liq	
z	σ_v	$\sigma_{v\ with\ fill}$	u	σ'_v	$\sigma'_{v\ with\ fill}$	σ'_m	G_{max}	Alpha I	Beta I	$(N_1)_{60cs}$	CRR7.5	Ksigma	Kalpha		Design EQ		Design EQ	Design EQ	Design EQ	Design EQ	FS liq Design EQ	FS liq for plot	FS liq Design EQ	FS liq for plot
	totstr-top 0.16		u-top 0.00	effstr-top 0.16																				
3.3	0.20	0.20	0.00	0.20	0.20	270.83	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.994	0.055	0	0	0.000	NA	10.0	NA	10.00
8.3	0.52	0.52	0.00	0.52	0.52	687.50	#NUM!	5.00	1.20	50	NA	1.000	1.000	0.95	NA	0.983	0.054	0	0	0.000	NA	10.0	NA	10.00
13.3	0.83	0.83	0.00	0.83	0.83	1104.17	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.972	0.054	0	0	0.000	NA	10.0	NA	10.00
18.3	1.14	1.14	0.00	1.14	1.14	1520.83	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.961	0.053	0	0	0.000	NA	10.0	NA	10.00
23.3	1.45	1.45	0.00	1.45	1.45	1937.50	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.948	0.052	0	0	0.000	NA	10.0	NA	10.00
28.3	1.77	1.77	0.13	1.63	1.63	2177.37	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.929	0.055	0	0	0.000	NA	10.0	NA	10.00
33.3	2.08	2.08	0.29	1.79	1.79	2386.03	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.902	0.058	0	0	0.000	NA	10.0	NA	10.00
38.3	2.39	2.39	0.44	1.95	1.95	2594.70	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.866	0.059	0	0	0.000	NA	10.0	NA	10.00
43.3	2.70	2.70	0.60	2.10	2.10	2803.37	#NUM!	5.00	1.20	19	0.203	0.937	1.000	0.95	0.180	0.821	0.058	0	0	0.000	#DIV/0!	#DIV/0!	3.3	3.28
48.3	3.02	3.02	0.76	2.26	2.26	3012.03	#NUM!	5.00	1.20	13	0.139	0.940	1.000	0.95	0.124	0.771	0.057	0	0	0.000	#DIV/0!	#DIV/0!	2.3	2.32
53.3	3.33	3.33	0.91	2.42	2.42	3220.70	#NUM!	5.00	1.20	23	0.261	0.908	1.000	0.95	0.225	0.720	0.055	0	0	0.000	#DIV/0!	#DIV/0!	4.4	4.36
58.3	3.64	3.64	1.07	2.57	2.57	3429.37	#NUM!	5.00	1.20	17	0.184	0.918	1.000	0.95	0.160	0.674	0.053	0	0	0.000	#DIV/0!	#DIV/0!	3.2	3.22
63.3	3.95	3.95	1.22	2.73	2.73	3638.03	#NUM!	5.00	1.20	23	0.253	0.899	1.000	0.95	0.216	0.634	0.051	0	0	0.000	#DIV/0!	#DIV/0!	4.5	4.51
68.3	4.27	4.27	1.38	2.89	2.89	3846.70	#NUM!	NA	NA	NA	NA	NA	NA	0.95	NA	0.602	0.049	0	0	0.000	NA	10.0	NA	10.00
73.3	4.58	4.58	1.54	3.04	3.04	4055.37	#NUM!	5.00	1.20	8	0.093	0.931	1.000	0.95	0.082	0.576	0.048	0	0	0.000	#DIV/0!	#DIV/0!	1.8	1.83
78.3	4.89	4.89	1.69	3.20	3.20	4264.03	#NUM!	5.00	1.20	19	0.208	0.898	1.000	0.95	0.177	0.555	0.047	0	0	0.000	#DIV/0!	#DIV/0!	4.0	4.01
83.3	5.20	5.20	1.85	3.35	3.35	4472.70	#NUM!	5.00	1.20	26	0.318	0.867	1.000	0.95	0.261	0.538	0.046	0	0	0.000	#DIV/0!	#DIV/0!	6.0	6.03
88.3	5.52	5.52	2.00	3.51	3.51	4681.37	#NUM!	5.00	1.20	27	0.334	0.852	1.000	0.95	0.270	0.524	0.045	0	0	0.000	#DIV/0!	#DIV/0!	6.3	6.30
93.3	5.83	5.83	2.16	3.67	3.67	4890.03	#NUM!	5.00	1.20	26	0.320	0.857	1.000	0.95	0.260	0.512	0.045	0	0	0.000	#DIV/0!	#DIV/0!	6.1	6.15

Clifty Creek AEP, Boring = SS4-1, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts



Clifty Creek AEP, Boring = SS4-1, Source = 0, Mw = 7.7, Event = 0, SPT Data, NCEER Method (updated per Idriss and Boulanger (2008)) with Ground Response Analysis, No Fines Correction if Zero Blowcounts



APPENDIX I

STABILITY ANALYSIS

BOILER SLAG POND DAM: 2015 CCR MANDATE

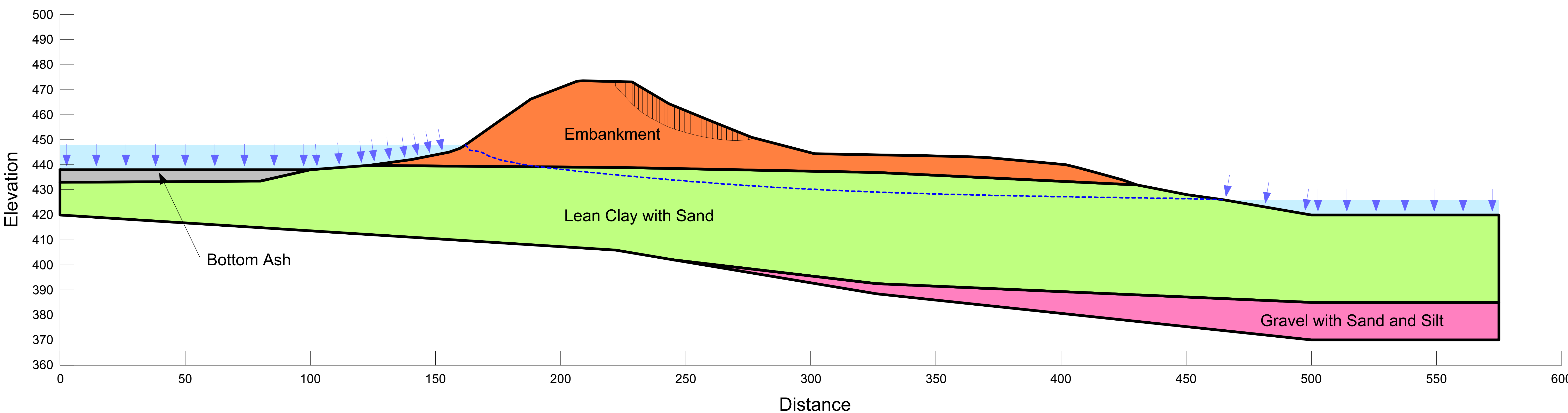
Factor of Safety = 2.30

American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

L01_Normal Pool, Downstream Slope Failure
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section A-A'

Material	Unit Weight (pcf)	Drained Strength Parameters Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay with Sand (Drained)	119	27.2	160
Gravel With Silt and Sand (Drained)	130	35	0
Bottom Ash (Drained)	115	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.



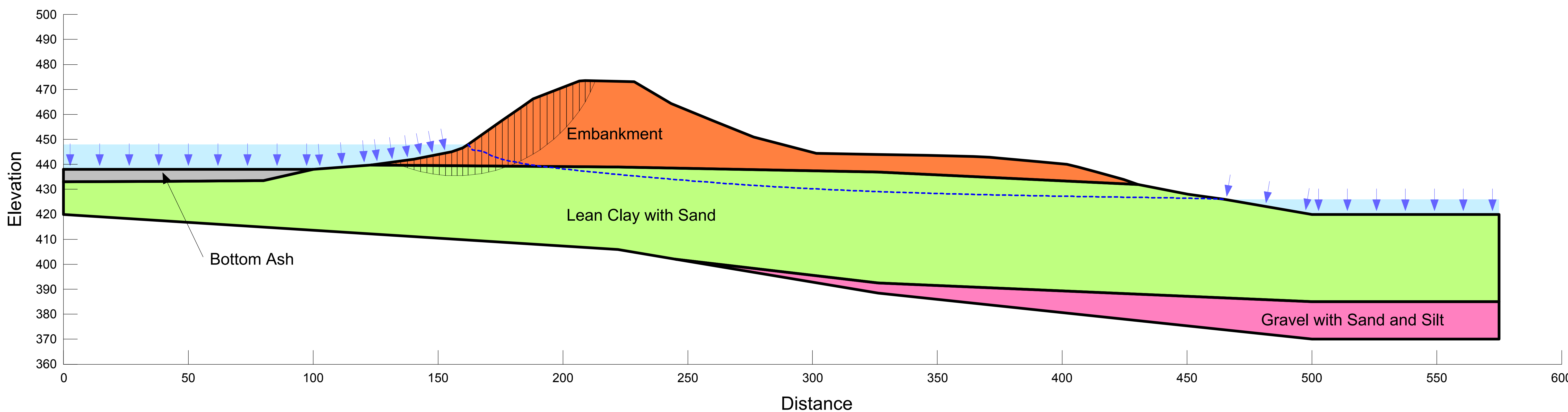
Factor of Safety = 1.88

American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Material	Unit Weight (pcf)	Drained Strength Parameters Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay with Sand (Drained)	119	27.2	160
Gravel With Silt and Sand (Drained)	130	35	0
Bottom Ash (Drained)	115	28	0

L02_Normal Pool, Upstream Slope Failure
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Incipient Motion in the Upstream Direction
Section A-A'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.



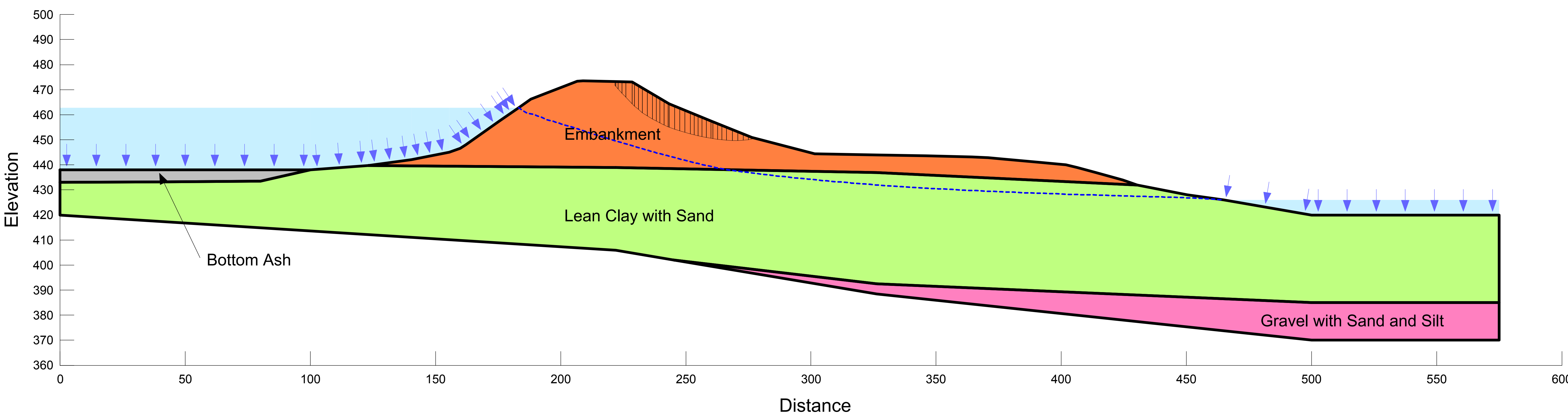
Factor of Safety = 2.30

American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

L03_50% PMF Pool, Downstream Slope Failure
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section A-A'

Material	Unit Weight (pcf)	Drained Strength Parameters Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay with Sand (Drained)	119	27.2	160
Gravel With Silt and Sand (Drained)	130	35	0
Bottom Ash (Drained)	115	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.



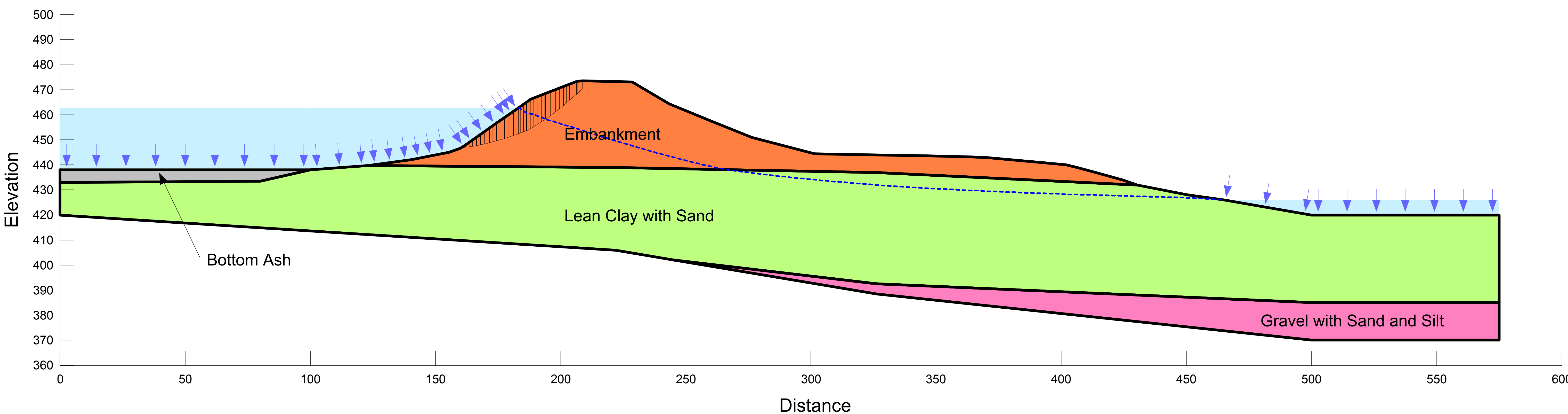
Factor of Safety = 2.13

American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

L04_50% PMF Pool, Upstream Slope Failure
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Incipient Motion in the Upstream Direction
Section A-A'

Material	Unit Weight (pcf)	Drained Strength Parameters Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay with Sand (Drained)	119	27.2	160
Gravel With Silt and Sand (Drained)	130	35	0
Bottom Ash (Drained)	115	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.



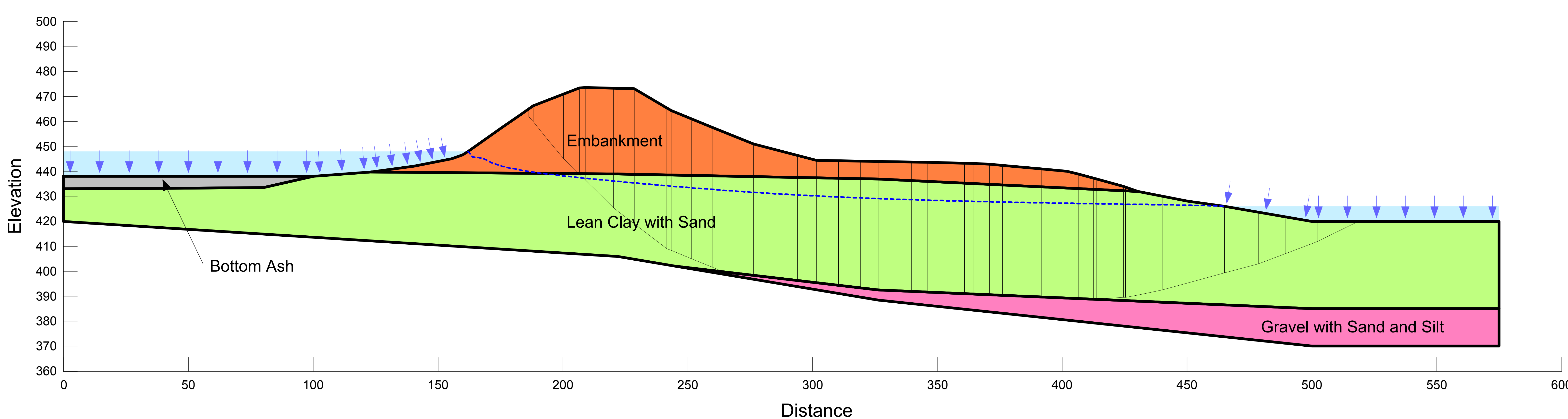
Factor of Safety = 1.35

American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

L05_Seismic_Normal Pool, Downstream Slope Failure
Normal Pool Elevation: 448 Feet
Undrained Static Strengths
Incipient Motion in the Downstream Direction
Horizontal Acc: 0.085g
Section A-A'

Material	Unit Weight (pcf)	Drained Strength Parameters Phi (deg.)	Drained Strength Parameters Cohesion (psf)	Undrained Strength Parameters Phi (deg.)	Undrained Strength Parameters Cohesion (psf)
Embankment (Seismic Undrained)	130	33.2	165	13	600
Lean Clay with Sand (Seismic Undrained)	119	27.2	160	5	1200
Gravel With Silt and Sand (Seismic Undrained)	130	35	0	35	0
Bottom Ash (Seismic Undrained)	115	28	0	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.



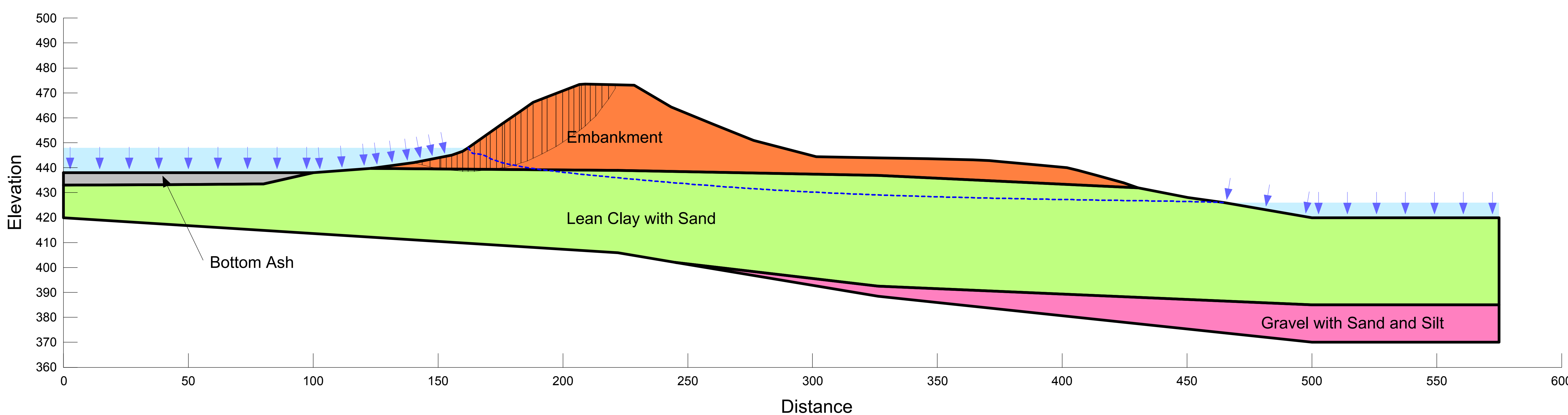
Factor of Safety = 1.34

American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

L06_Seismic_Normal Pool, Upstream Slope Failure
Normal Pool Elevation: 448 Feet
Undrained Static Strengths
Incipient Motion in the Upstream Direction
Horizontal Acc: 0.085g
Section A-A'

Material	Unit Weight (pcf)	Drained Strength Parameters Phi (deg.)	Drained Strength Parameters Cohesion (psf)	Undrained Strength Parameters Phi (deg.)	Undrained Strength Parameters Cohesion (psf)
Embankment (Seismic Undrained)	130	33.2	165	13	600
Lean Clay with Sand (Seismic Undrained)	119	27.2	160	5	1200
Gravel With Silt and Sand (Seismic Undrained)	130	35	0	35	0
Bottom Ash (Seismic Undrained)	115	28	0	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.



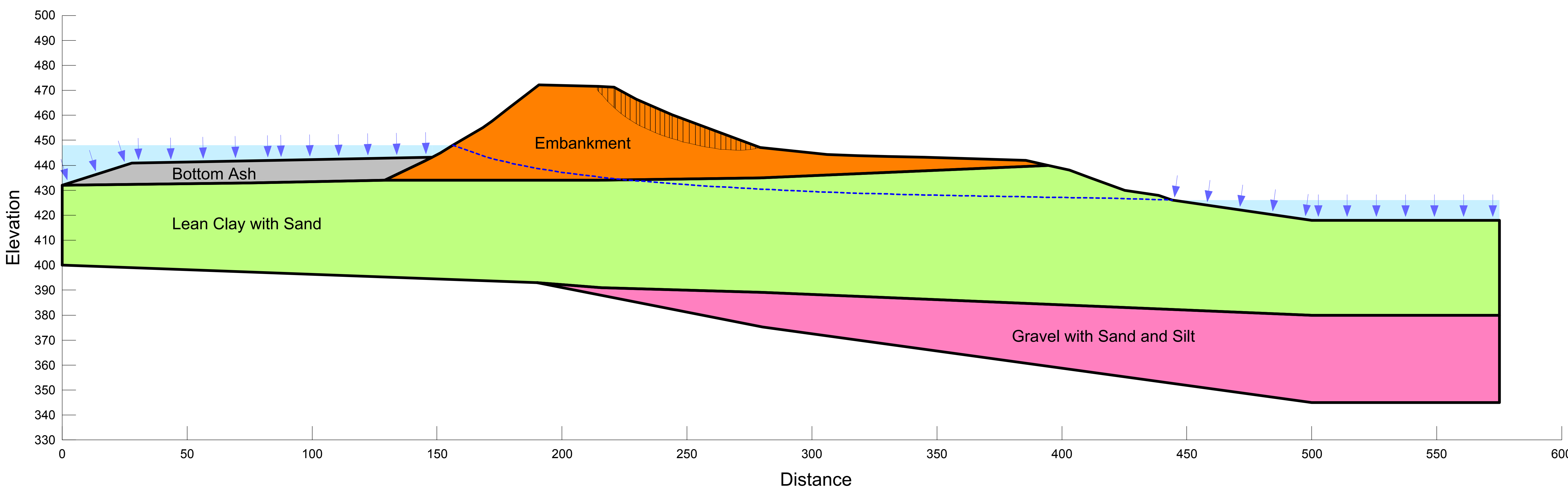
Factor of Safety = 2.44

American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

L01_Normal Pool, Downstream Slope Failure
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section B-B'

Material	Unit Weight (pcf)	**Drained Strength Parameters** Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay With Sand (Drained)	119	27.2	160
Gravel With Silt And Sand (Drained)	130	35	0
Bottom Ash (Drained)	115	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.



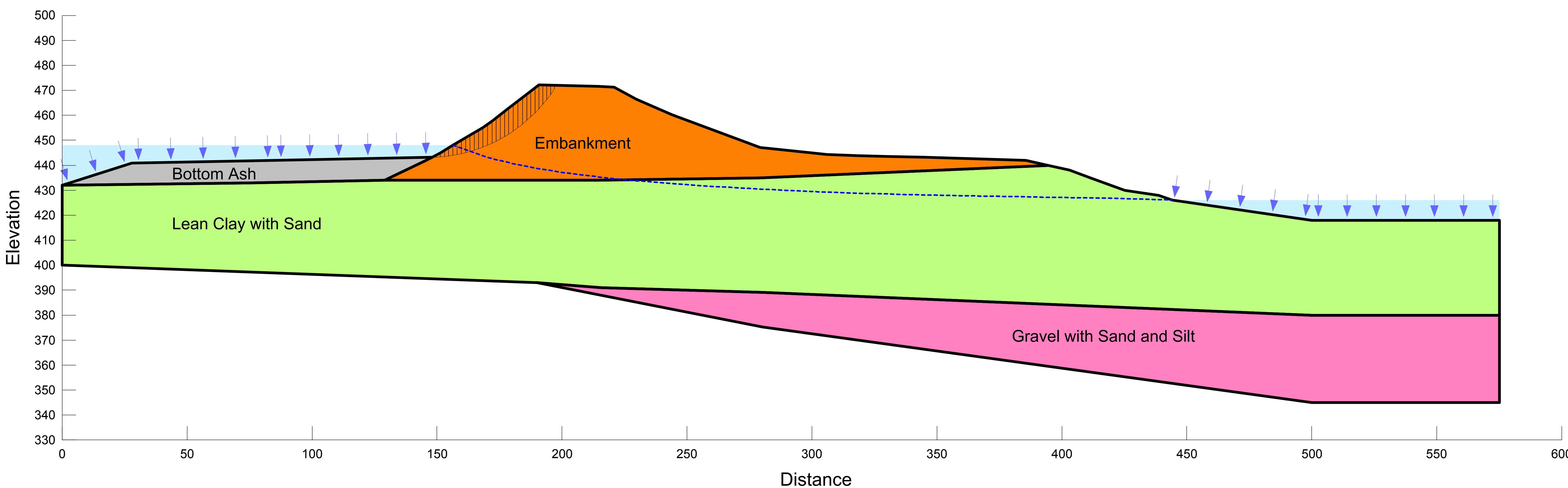
Factor of Safety = 1.63

American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

L02_Normal Pool, Upstream Slope Failure
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Incipient Motion in the Upstream Direction
Section B-B'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	Drained Strength Parameters Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay With Sand (Drained)	119	27.2	160
Gravel With Silt And Sand (Drained)	130	35	0
Bottom Ash (Drained)	115	28	0



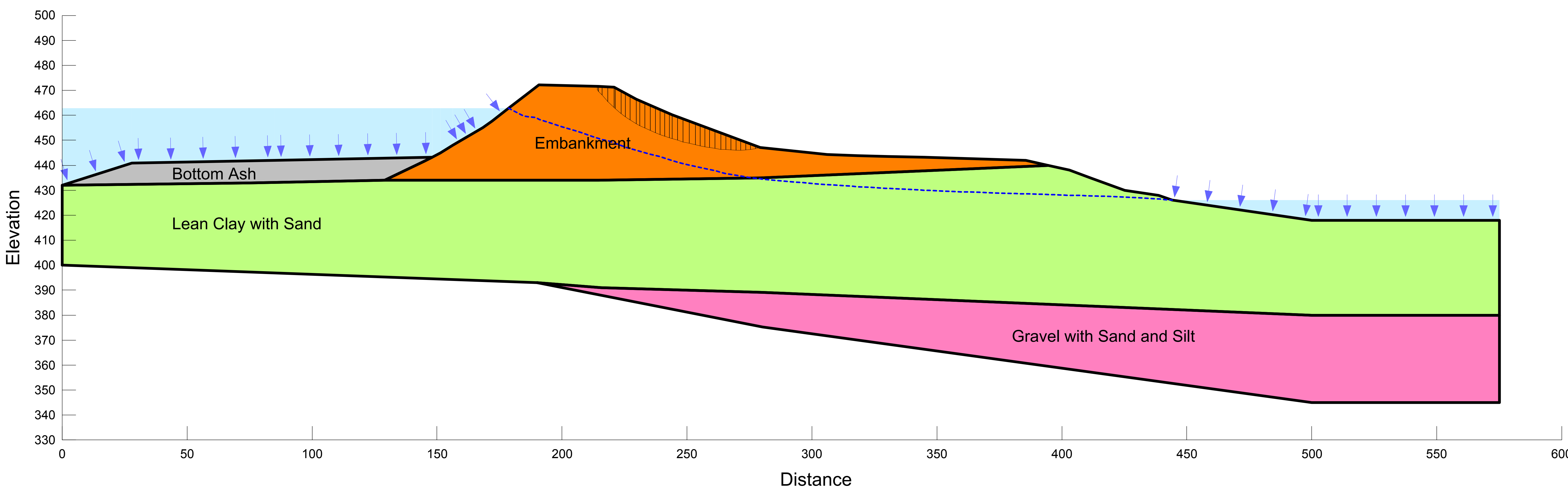
Factor of Safety = 2.44

American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

L03_50% PMF Pool, Downstream Slope Failure
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section B-B'

Material	Unit Weight (pcf)	Drained Strength Parameters Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay With Sand (Drained)	119	27.2	160
Gravel With Silt And Sand (Drained)	130	35	0
Bottom Ash (Drained)	115	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.



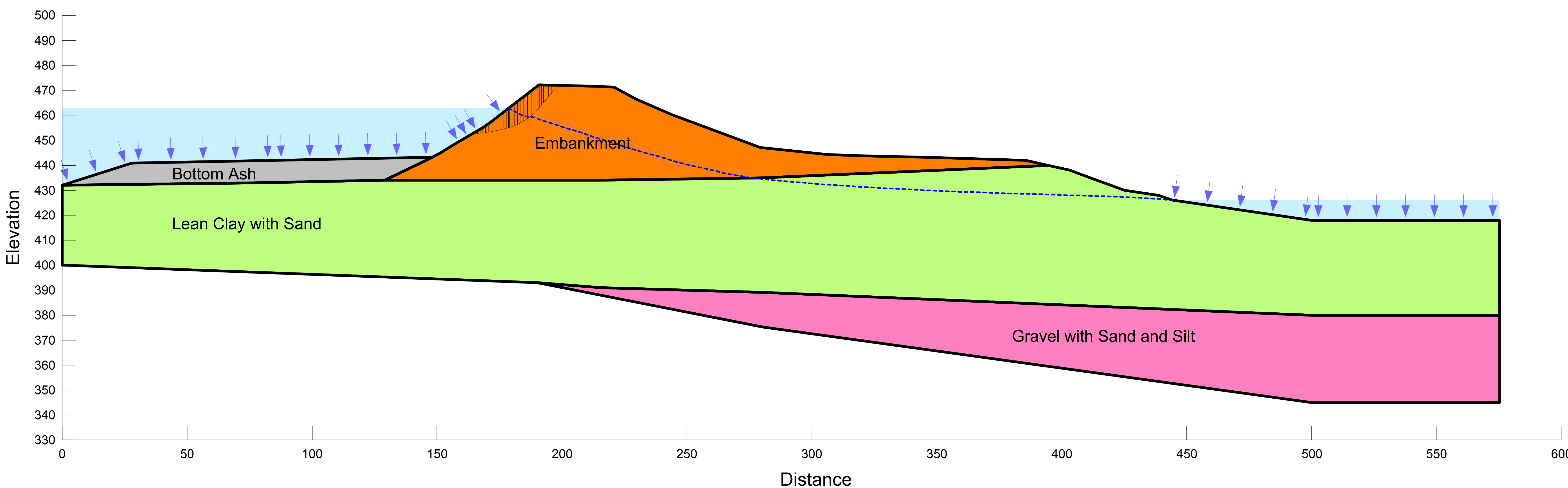
Factor of Safety = 1.95

American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

L04_50% PMF Pool, Upstream Slope Failure
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Incipient Motion in the Upstream Direction
Section B-B'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	Drained Strength Parameters Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay With Sand (Drained)	119	27.2	160
Gravel With Silt And Sand (Drained)	130	35	0
Bottom Ash (Drained)	115	28	0



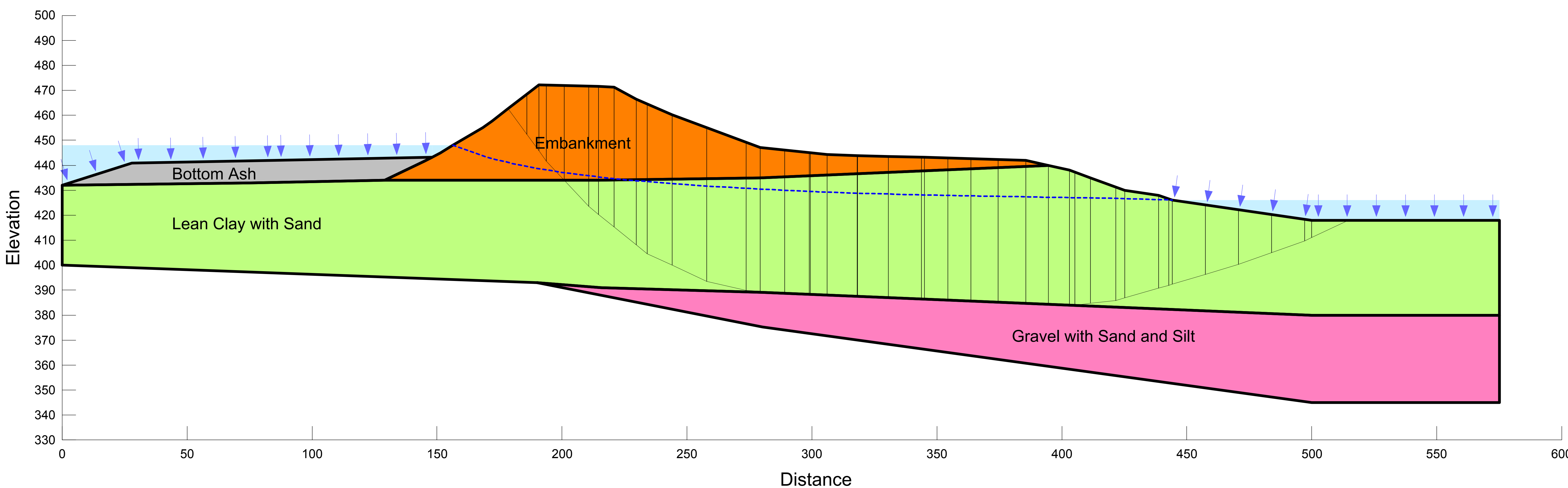
Factor of Safety = 1.30

American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

L05_Seismic_Normal Pool, Downstream Slope Failure
Normal Pool Elevation: 448 Feet
Undrained Static Strengths
Incipient Motion in the Downstream Direction
Horizontal Acc: 0.085g
Section B-B'

Material	Unit Weight (pcf)	**Drained Strength Parameters** Phi (deg.)	Cohesion (psf)	**Undrained Strength Parameters** Phi (deg.)	Cohesion (psf)
Embankment (Seismic Undrained)	130	33.2	165	13	600
Lean Clay With Sand (Seismic Undrained)	119	27.2	160	5	1200
Gravel With Silt And Sand (Seismic Undrained)	130	35	0	35	0
Bottom Ash (Seismic Undrained)	115	28	0	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.



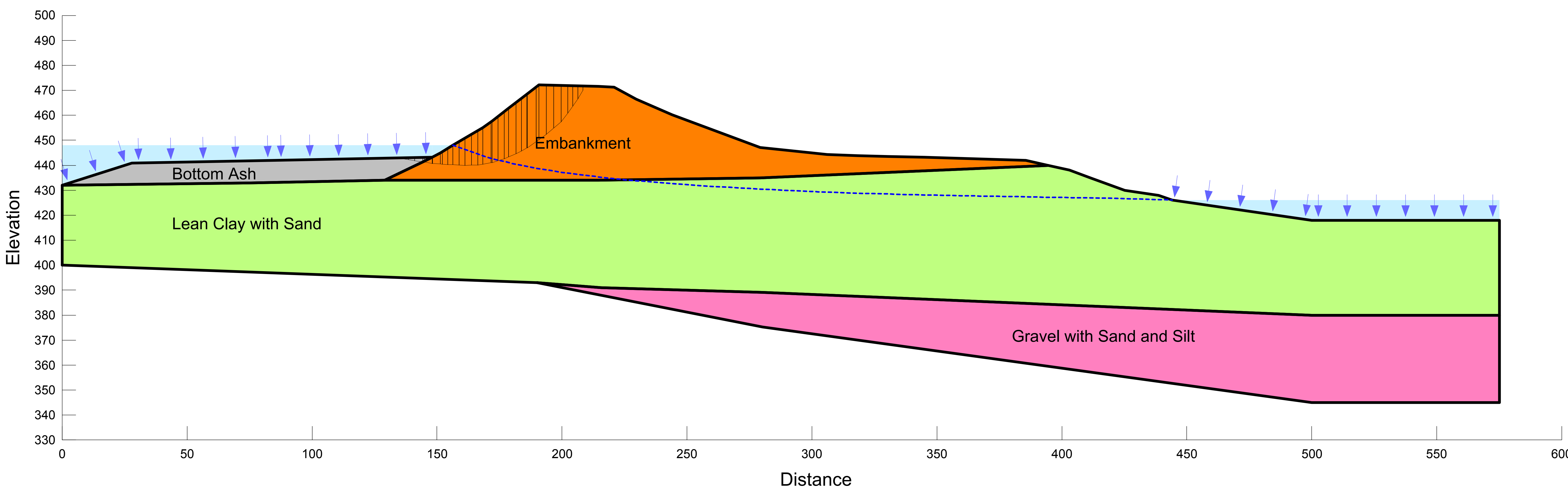
Factor of Safety = 1.30

American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

L06_Seismic_Normal Pool, Upstream Slope Failure
Normal Pool Elevation: 448 Feet
Undrained Static Strengths
Incipient Motion in the Upstream Direction
Horizontal Acc: 0.085g
Section B-B'

Material	Unit Weight (pcf)	Drained Strength Parameters: Phi (deg.)	Drained Strength Parameters: Cohesion (psf)	Undrained Strength Parameters: Phi (deg.)	Undrained Strength Parameters: Cohesion (psf)
Embankment (Seismic Undrained)	130	33.2	165	13	600
Lean Clay With Sand (Seismic Undrained)	119	27.2	160	5	1200
Gravel With Silt And Sand (Seismic Undrained)	130	35	0	35	0
Bottom Ash (Seismic Undrained)	115	28	0	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.



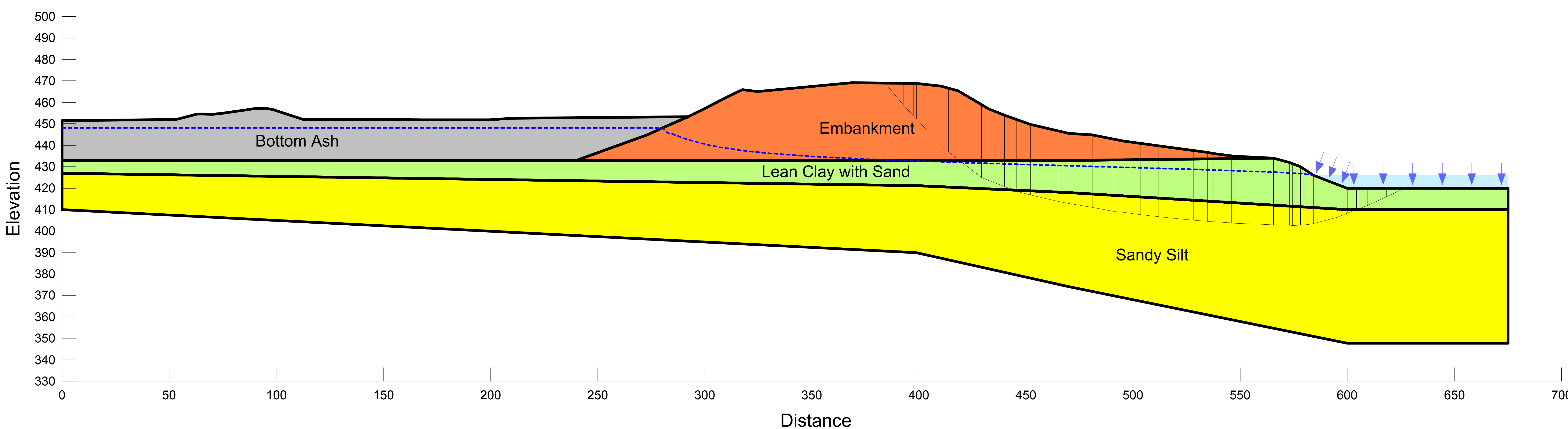
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Factor of Safety = 2.30

L01_Normal Pool, Downstream Slope Failure
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section C-C'

Material	Unit Weight (pcf)	Drained Strength Parameters Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay with Sand (Drained)	119	27.2	160
Sandy Silt (Drained)	130	30	0
Bottom Ash (Drained)	115	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.



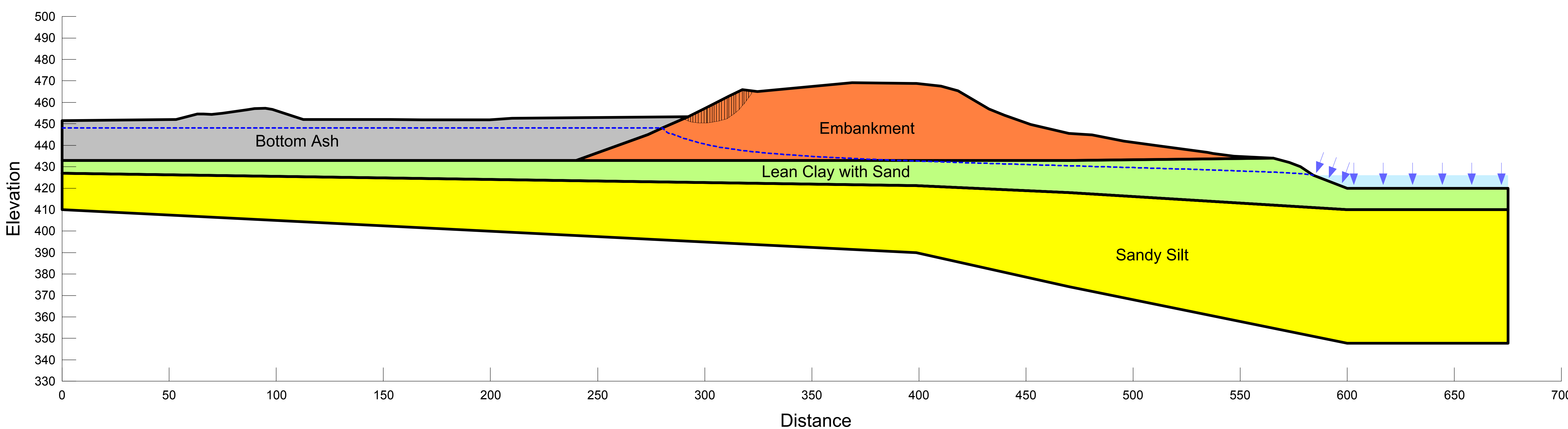
Factor of Safety = 2.73

American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

L02_Normal Pool, Upstream Slope Failure
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Incipient Motion in the Upstream Direction
Section C-C'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	Drained Strength Parameters Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay with Sand (Drained)	119	27.2	160
Sandy Silt (Drained)	130	30	0
Bottom Ash (Drained)	115	28	0



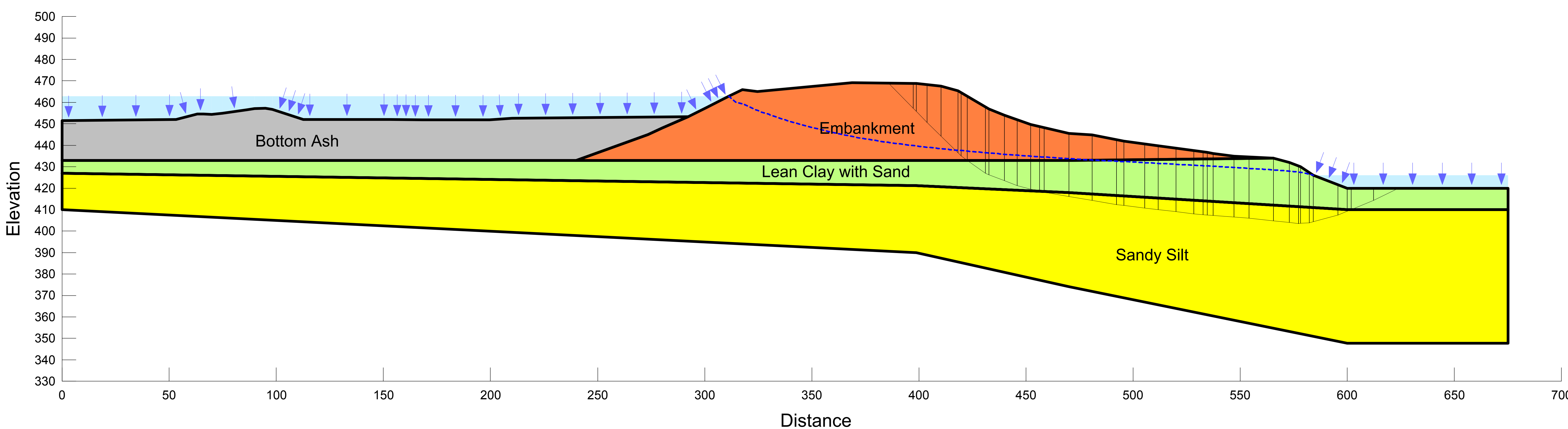
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Factor of Safety = 2.18

L03_50% PMF Pool, Downstream Slope Failure
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section C-C'

Material	Unit Weight (pcf)	Drained Strength Parameters Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay with Sand (Drained)	119	27.2	160
Sandy Silt (Drained)	130	30	0
Bottom Ash (Drained)	115	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.



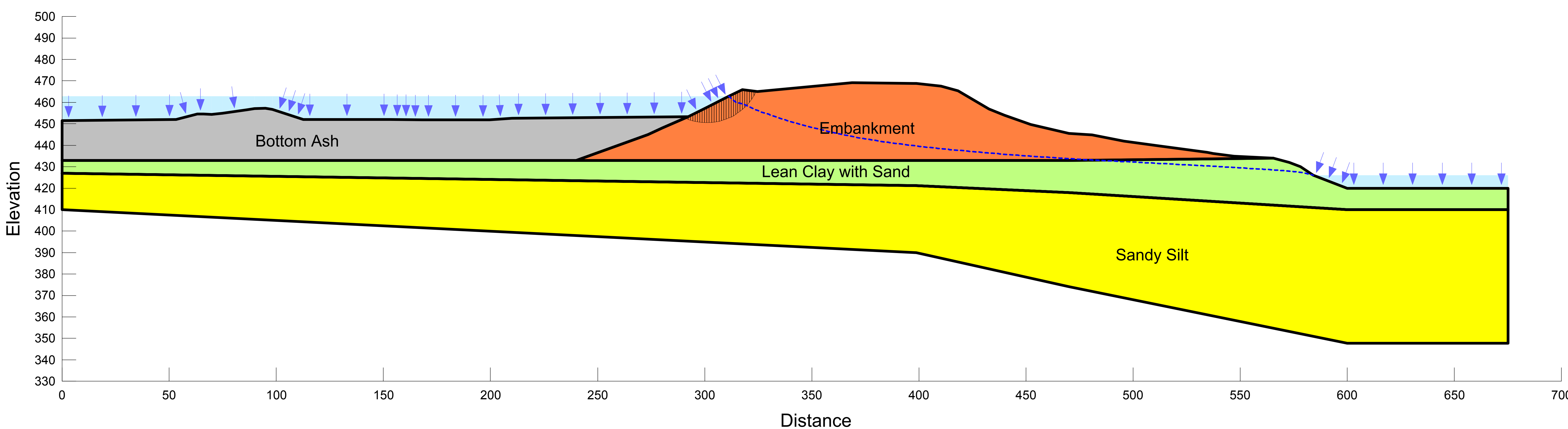
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Factor of Safety = 3.88

L04_50% PMF Pool, Upstream Slope Failure
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Incipient Motion in the Upstream Direction
Section C-C'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	Drained Strength Parameters Phi (deg.)	Cohesion (psf)
Embankment (Drained)	130	33.2	165
Lean Clay with Sand (Drained)	119	27.2	160
Sandy Silt (Drained)	130	30	0
Bottom Ash (Drained)	115	28	0



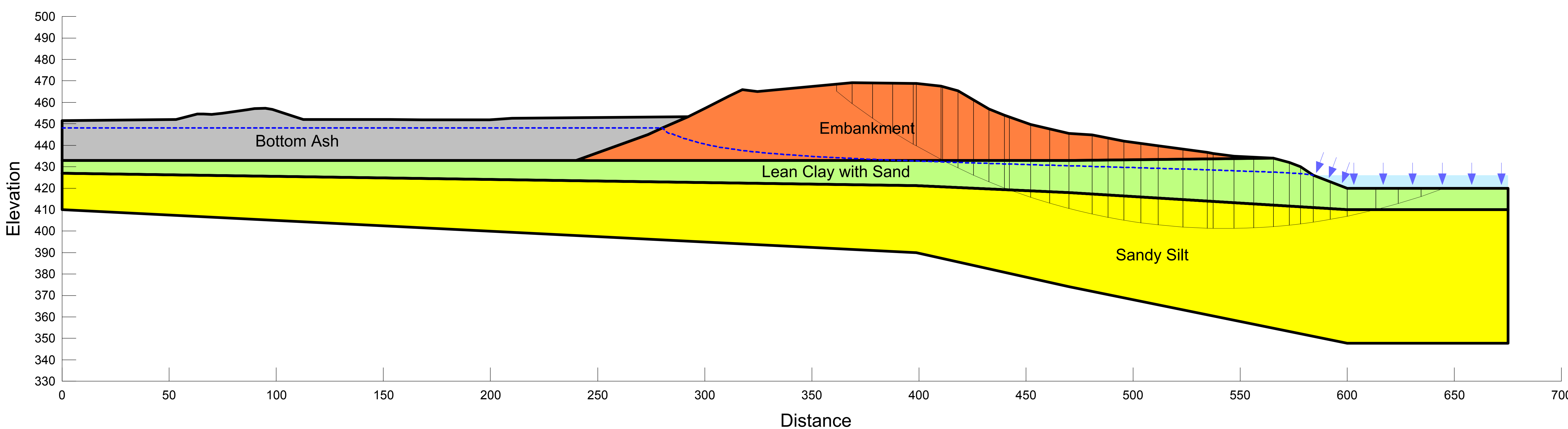
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Factor of Safety = 1.53

L05_Seismic_Normal Pool, Downstream Slope Failure
Normal Pool Elevation: 448 Feet
Undrained Static Strengths
Incipient Motion in the Downstream Direction
Horizontal Acc: 0.085g
Section C-C'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

		Drained Strength Parameters		**Undrained Strength Parameters**	
Material	Unit Weight (pcf)	Phi (deg.)	Cohesion (psf)	Phi (deg.)	Cohesion (psf)
Embankment (Seismic Undrained)	130	33.2	165	13	600
Lean Clay with Sand (Seismic Undrained)	119	27.2	160	5	1200
Sandy Silt (Seismic Undrained)	130	30	0	30	0
Bottom Ash (Seismic Undrained)	115	28	0	28	0



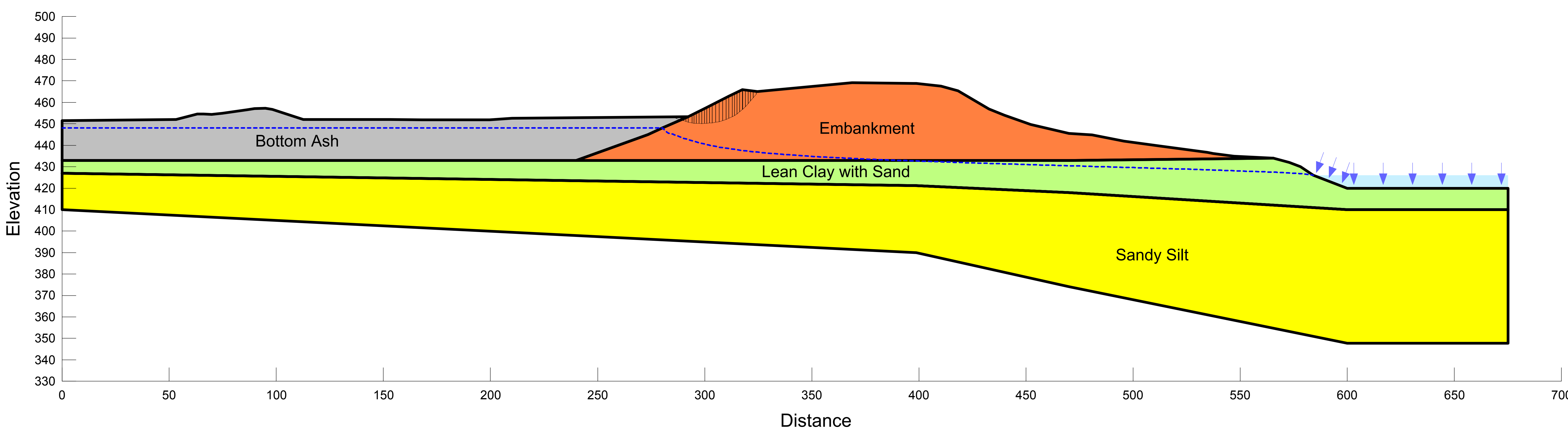
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Factor of Safety = 2.25

L06_Seismic_Normal Pool, Upstream Slope Failure
Normal Pool Elevation: 448 Feet
Undrained Static Strengths
Incipient Motion in the Upstream Direction
Horizontal Acc: 0.085g
Section C-C'

Material	Unit Weight (pcf)	Drained Strength Parameters Phi (deg.)	Drained Strength Parameters Cohesion (psf)	Undrained Strength Parameters Phi (deg.)	Undrained Strength Parameters Cohesion (psf)
Embankment (Seismic Undrained)	130	33.2	165	13	600
Lean Clay with Sand (Seismic Undrained)	119	27.2	160	5	1200
Sandy Silt (Seismic Undrained)	130	30	0	30	0
Bottom Ash (Seismic Undrained)	115	28	0	28	0

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.



LANDFILL RUNOFF COLLECTION POND: 2015 CCR MANDATE

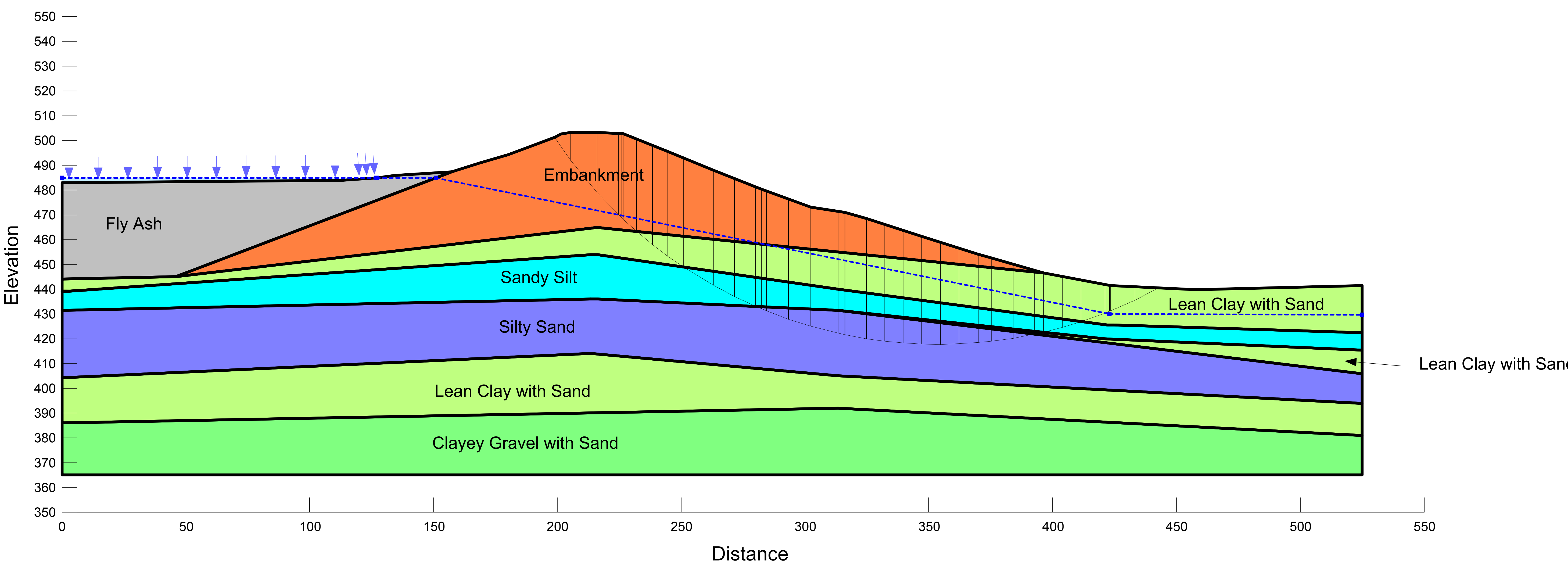
American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate

Factor of Safety = 1.85

L01_Normal Pool, Downstream Slope Failure
Normal Pool Elevation: 485 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section D-D'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	Drained Strength Parameters Phi (deg.)	Cohesion (psf)
Embankment (Drained)	129	27.5	198
Lean Clay with Sand (Drained)	127	28	206
Sandy Silt (Drained)	125	30	0
Silty Sand (Drained)	94	30	0
Clayey Gravel with Sand (Drained)	130	35	0
Fly Ash (Drained)	115	25	0



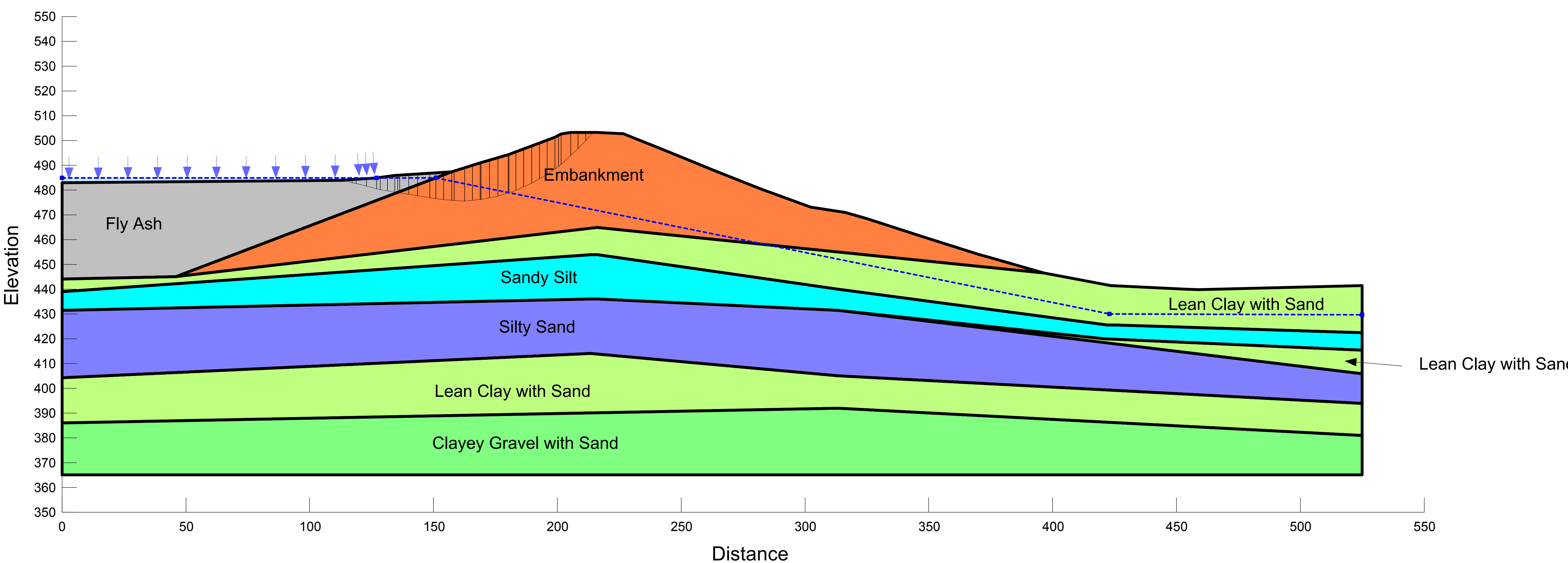
American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate

L02_Normal Pool, Upstream Slope Failure
Normal Pool Elevation: 485 Feet
Drained Static Strengths
Incipient Motion in the Upstream Direction
Section D-D'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Factor of Safety = 2.73

Material	Unit Weight (pcf)	Phi (deg.)	Cohesion (psf)
		Drained Strength Parameters	
Embankment (Drained)	129	27.5	198
Lean Clay with Sand (Drained)	127	28	206
Sandy Silt (Drained)	125	30	0
Silty Sand (Drained)	94	30	0
Clayey Gravel with Sand (Drained)	130	35	0
Fly Ash (Drained)	115	25	0



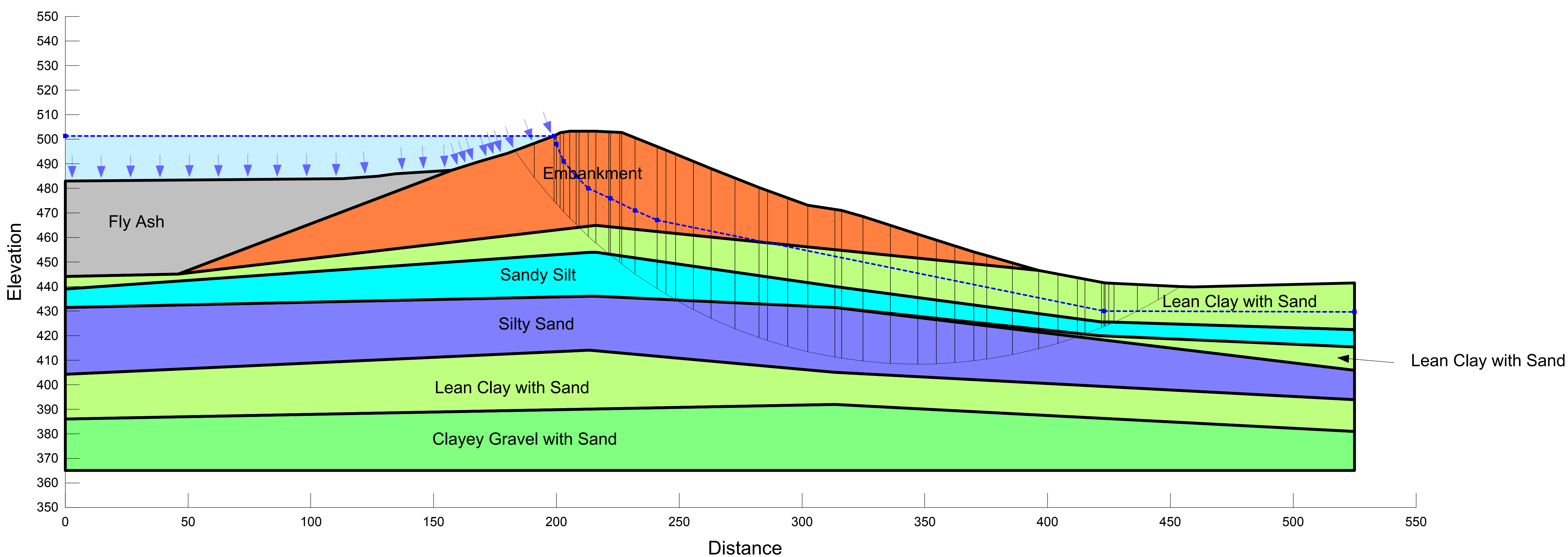
American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate

Factor of Safety = 1.81

L03_PMF Pool, Downstream Slope Failure
PMF Pool Elevation: 501.4 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section D-D'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	**Drained Strength Parameters** Phi (deg.)	Cohesion (psf)
Embankment (Drained)	129	27.5	198
Lean Clay with Sand (Drained)	127	28	206
Sandy Silt (Drained)	125	30	0
Silty Sand (Drained)	94	30	0
Clayey Gravel with Sand (Drained)	130	35	0
Fly Ash (Drained)	115	25	0



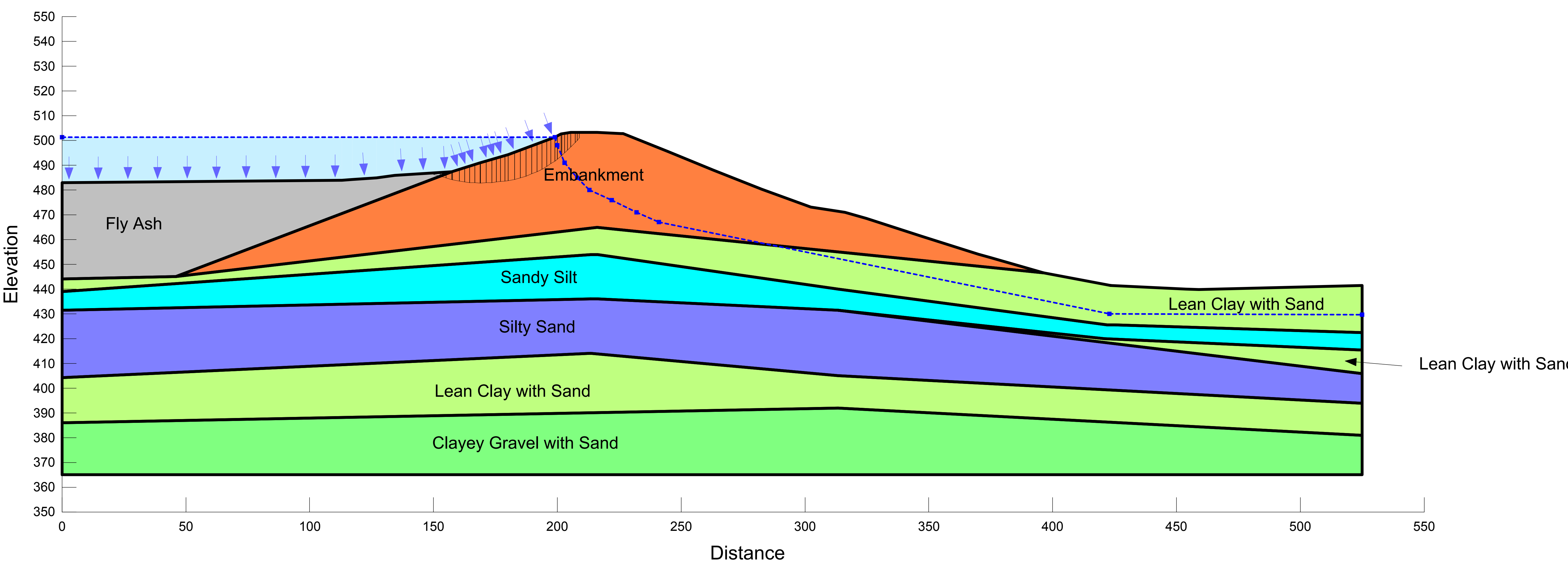
American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate

L04_PMF Pool, Upstream Slope Failure
PMF Pool Elevation: 501.4 Feet
Drained Static Strengths
Incipient Motion in the Upstream Direction
Section D-D'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Factor of Safety = 3.47

Material	Unit Weight (pcf)	**Drained Strength Parameters** Phi (deg.)	Cohesion (psf)
Embankment (Drained)	129	27.5	198
Lean Clay with Sand (Drained)	127	28	206
Sandy Silt (Drained)	125	30	0
Silty Sand (Drained)	94	30	0
Clayey Gravel with Sand (Drained)	130	35	0
Fly Ash (Drained)	115	25	0



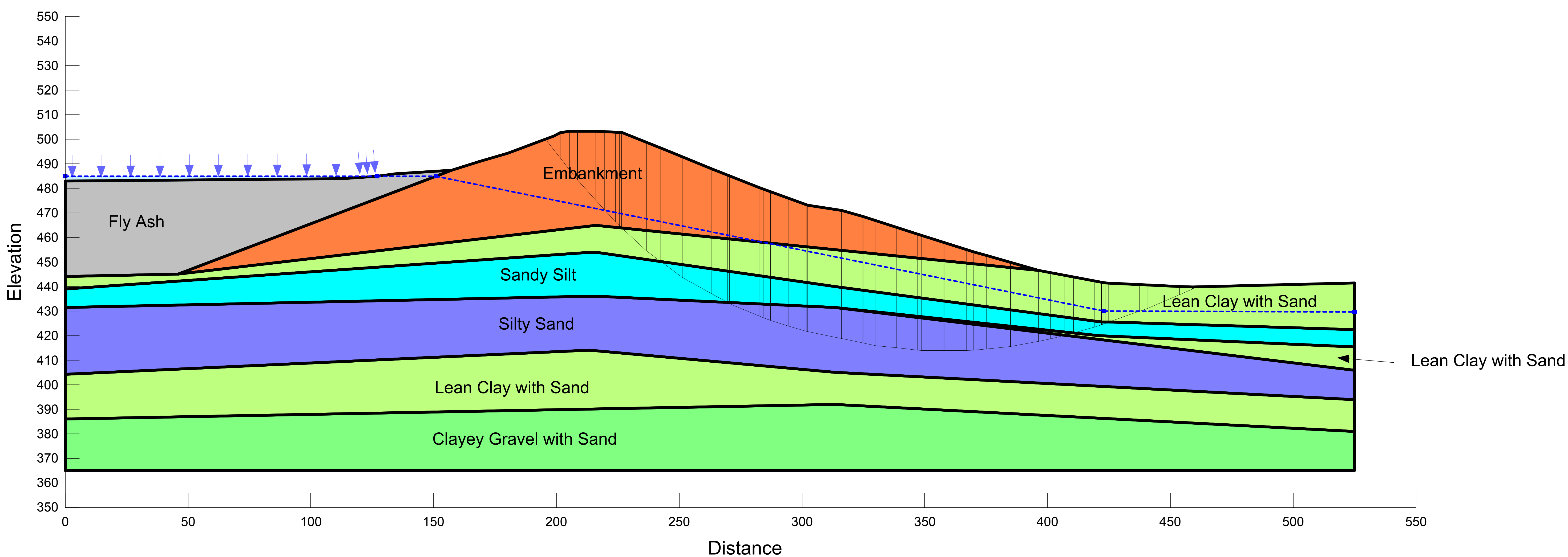
American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate

L05_Seismic_Normal Pool, Downstream Slope Failure
Normal Pool Elevation: 485 Feet
Undrained Static Strengths
Incipient Motion in the Downstream Direction
Horizontal Acc: 0.085g
Section D-D'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling. No warranties can be made regarding the continuity of subsurface conditions.

Factor of Safety = 1.42

		Drained Strength Parameters		**Undrained Strength Parameters**	
Material	Unit Weight (pcf)	Phi (deg.)	Cohesion (psf)	Phi (deg.)	Cohesion (psf)
Embankment (Seismic Undrained)	129	27.5	198	21	1400
Lean Clay with Sand (Seismic Undrained)	127	28	206	17	1200
Sandy Silt (Seismic Undrained)	125	30	0	30	0
Silty Sand (Seismic Undrained)	94	30	0	30	0
Clayey Gravel with Sand (Seismic Undrained)	130	35	0	35	0
Fly Ash (Seismic Undrained)	115	25	0	25	0



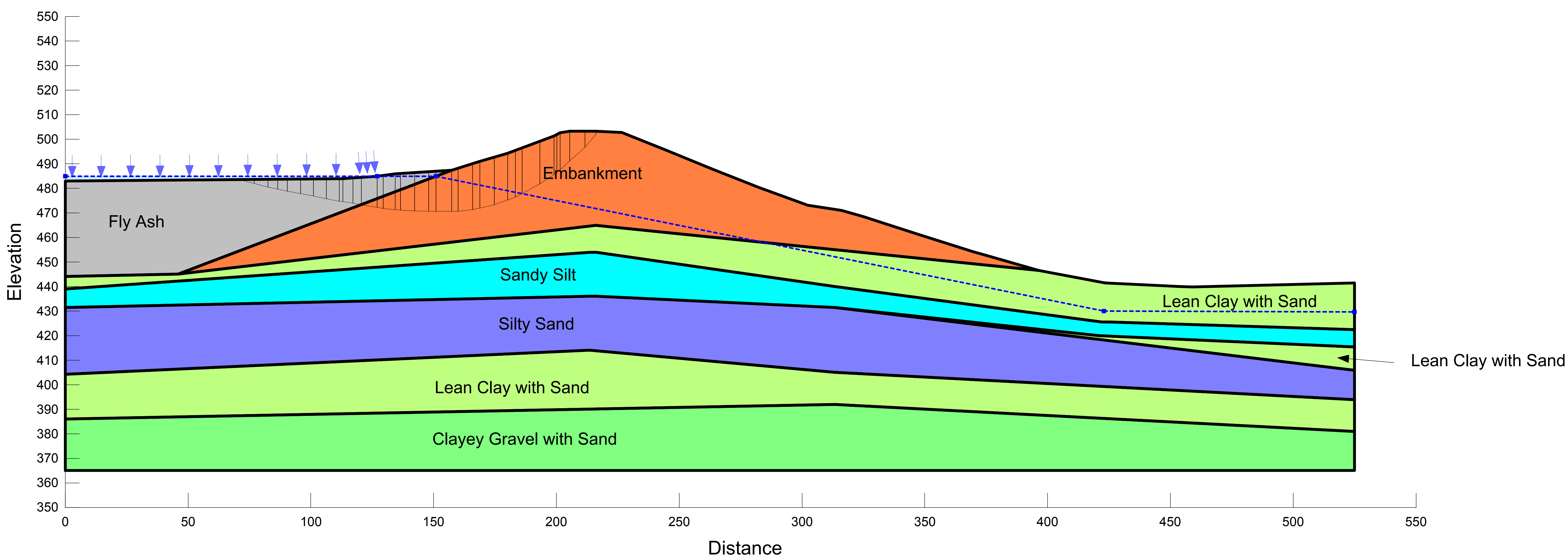
American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate

L06_Seismic_Normal Pool, Upstream Slope Failure
Normal Pool Elevation: 485 Feet
Undrained Static Strengths
Incipient Motion in the Upstream Direction
Horizontal Acc: 0.085g
Section D-D'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Factor of Safety = 1.94

Material	Unit Weight (pcf)	**Drained Strength Parameters** Phi (deg.)	Cohesion (psf)	**Undrained Strength Parameters** Phi (deg.)	Cohesion (psf)
Embankment (Seismic Undrained)	129	27.5	198	21	1400
Lean Clay with Sand (Seismic Undrained)	127	28	206	17	1200
Sandy Silt (Seismic Undrained)	125	30	0	30	0
Silty Sand (Seismic Undrained)	94	30	0	30	0
Clayey Gravel with Sand (Seismic Undrained)	130	35	0	35	0
Fly Ash (Seismic Undrained)	115	25	0	25	0



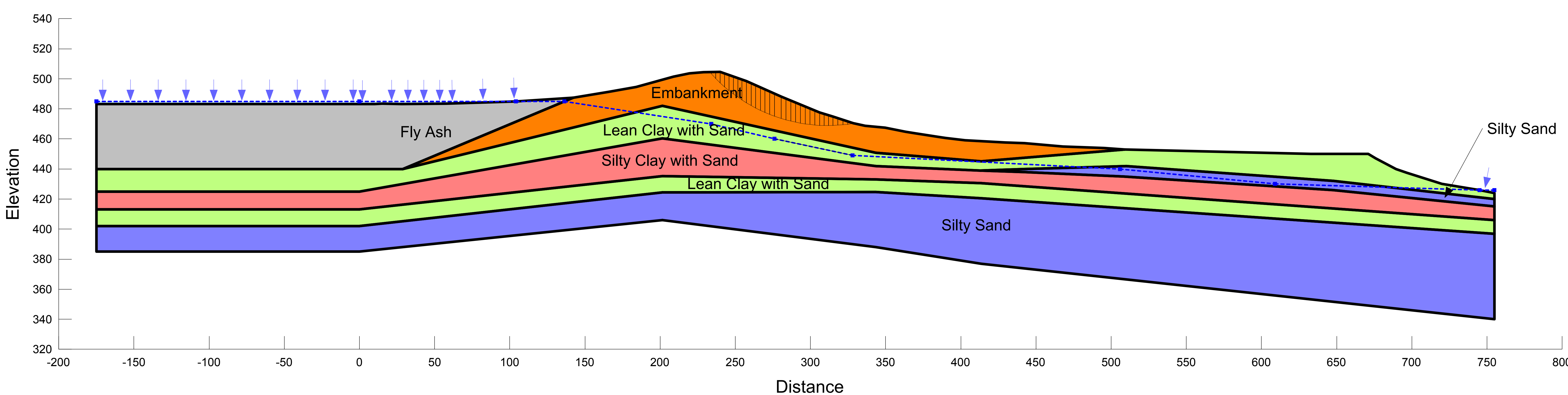
American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate

Factor of Safety = 1.99

L01_Normal Pool, Downstream Crest Loss
Normal Pool Elevation: 485 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section E-E'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	**Drained Strength Parameters** Phi (deg.)	Cohesion (psf)
Embankment (Drained)	129	27.5	198
Lean Clay with Sand (Drained)	127	28	206
Silty Sand (Drained)	94	30	0
Fly Ash (Drained)	115	25	0
Silty Clay with Sand (Drained)	118	34	152



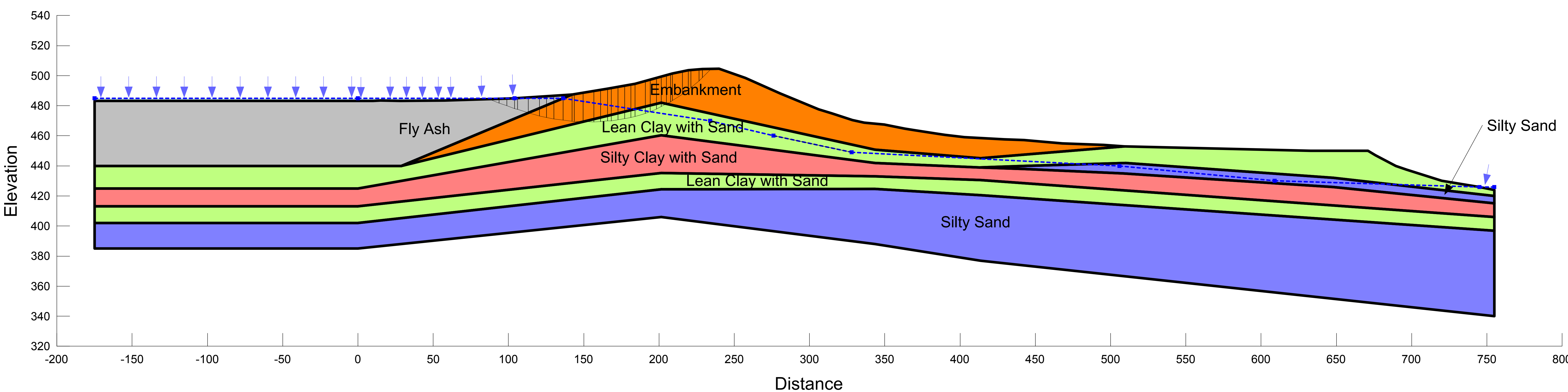
American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate

Factor of Safety = 3.51

L02_Normal Pool, Upstream Crest Loss
Normal Pool Elevation: 485 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section E-E'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	Drained Strength Parameters Phi (deg.)	Cohesion (psf)
Embankment (Drained)	129	27.5	198
Lean Clay with Sand (Drained)	127	28	206
Silty Sand (Drained)	94	30	0
Fly Ash (Drained)	115	25	0
Silty Clay with Sand (Drained)	118	34	152



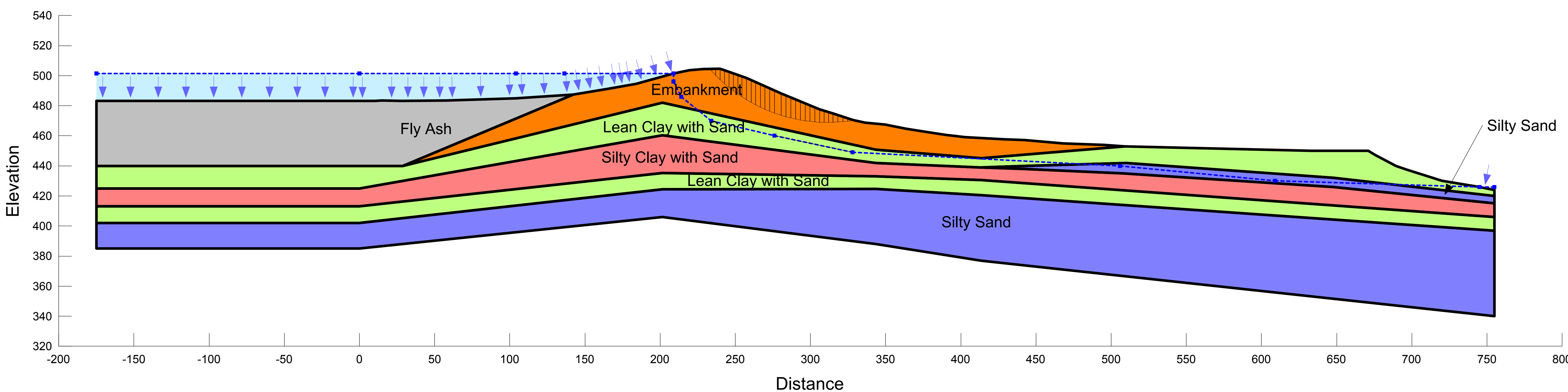
American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate

Factor of Safety = 1.99

L03_PMF Pool, Downstream Crest Loss
PMF Pool Elevation: 501.4 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section E-E'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	**Drained Strength Parameters** Phi (deg.)	Cohesion (psf)
Embankment (Drained)	129	27.5	198
Lean Clay with Sand (Drained)	127	28	206
Silty Sand (Drained)	94	30	0
Fly Ash (Drained)	115	25	0
Silty Clay with Sand (Drained)	118	34	152



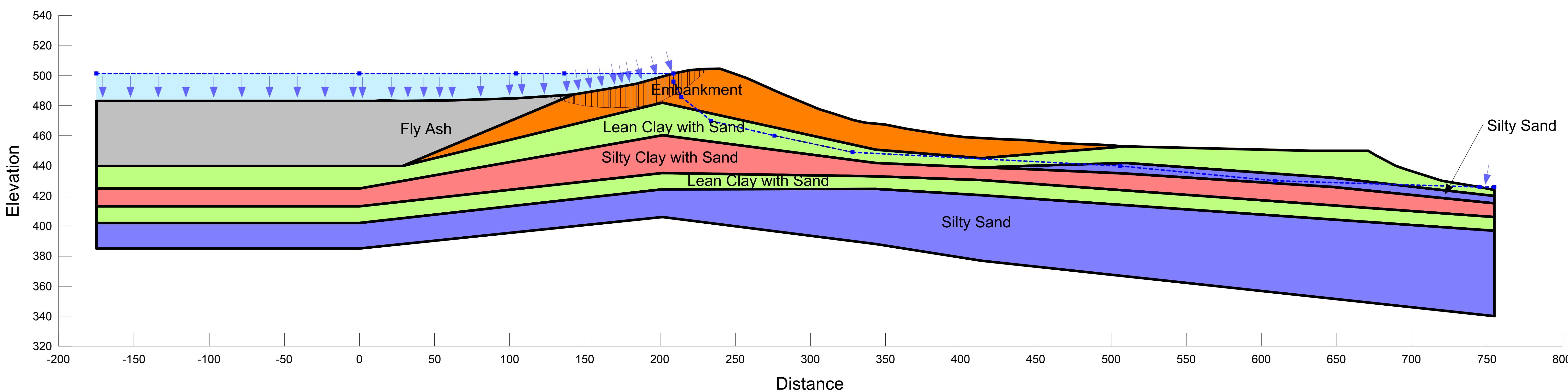
American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate

Factor of Safety = 4.51

L04_PMF Pool, Upstream Crest Loss
PMF Pool Elevation: 501.4 Feet
Drained Static Strengths
Incipient Motion in the Downstream Direction
Section E-E'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Unit Weight (pcf)	**Drained Strength Parameters** Phi (deg.)	Cohesion (psf)
Embankment (Drained)	129	27.5	198
Lean Clay with Sand (Drained)	127	28	206
Silty Sand (Drained)	94	30	0
Fly Ash (Drained)	115	25	0
Silty Clay with Sand (Drained)	118	34	152



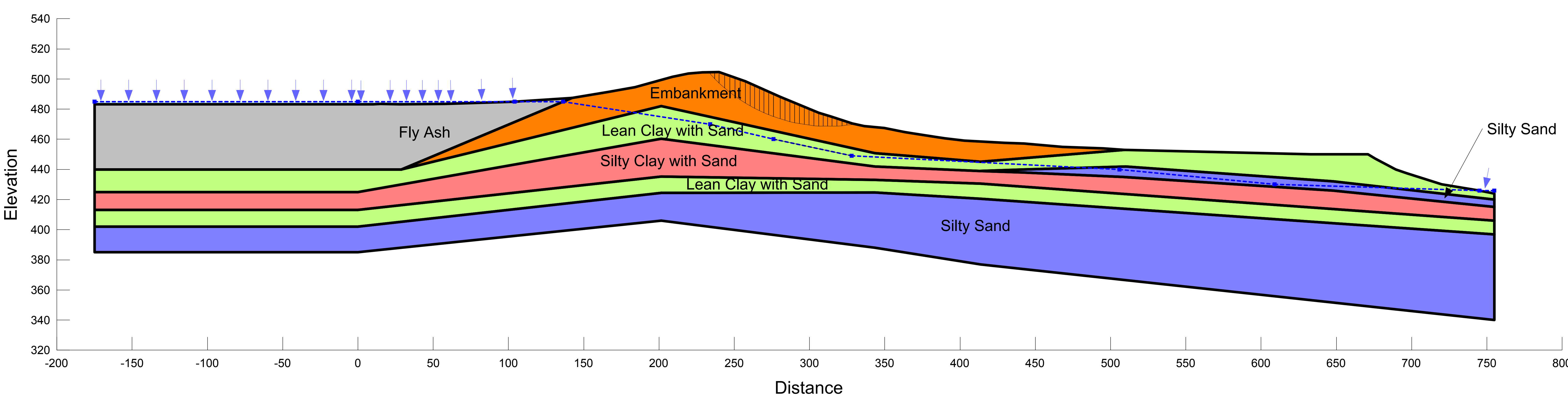
American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate

L05_Seismic_Normal Pool, Downstream Crest Loss
Normal Pool Elevation: 485 Feet
Undrained Static Strengths
Incipient Motion in the Downstream Direction
Horizontal Acc: 0.085g
Section E-E'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Factor of Safety = 1.64

Material	Unit Weight (pcf)	Drained Strength Parameters: Phi (deg.)	Drained Strength Parameters: Cohesion (psf)	Undrained Strength Parameters: Phi (deg.)	Undrained Strength Parameters: Cohesion (psf)
Embankment (Seismic Undrained)	129	27.5	198	21	1400
Lean Clay with Sand (Seismic Undrained)	127	28	206	17	1200
Silty Sand (Seismic Undrained)	94	30	0	30	0
Fly Ash (Seismic Undrained)	115	25	0	25	0
Silty Clay with Sand (Seismic Undrained)	118	34	152	20	1000



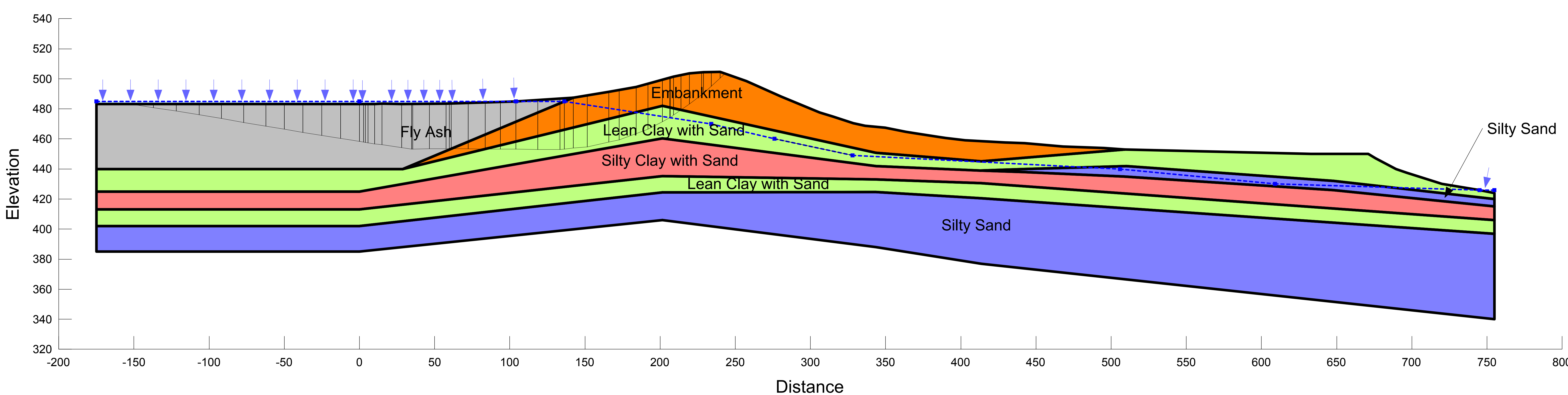
American Electric Power (AEP)
Clifty Creek Landfill Runoff Collection Pond Dam
Madison, Indiana
CCR Mandate

L06_Seismic_Normal Pool, Upstream Crest Loss
Normal Pool Elevation: 485 Feet
Undrained Static Strengths
Incipient Motion in the Upstream Direction
Horizontal Acc: 0.085g
Section E-E'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Factor of Safety = 2.28

Material	Unit Weight (pcf)	Drained Strength Parameters Phi (deg.)	Drained Strength Parameters Cohesion (psf)	Undrained Strength Parameters Phi (deg.)	Undrained Strength Parameters Cohesion (psf)
Embankment (Seismic Undrained)	129	27.5	198	21	1400
Lean Clay with Sand (Seismic Undrained)	127	28	206	17	1200
Silty Sand (Seismic Undrained)	94	30	0	30	0
Fly Ash (Seismic Undrained)	115	25	0	25	0
Silty Clay with Sand (Seismic Undrained)	118	34	152	20	1000



SEEP MODELS, 2015

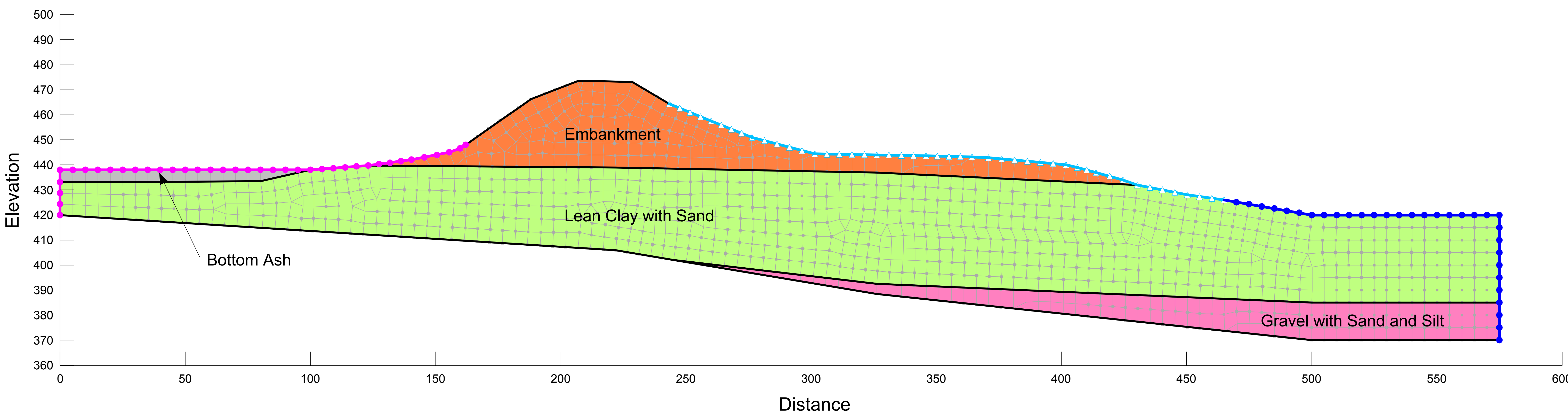
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Seepage Analysis
Boundary Condition and Mesh

SEEP Steady State Normal Pool
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Section A-A'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft^3/ft^3	Res. Water Content ft^3/ft^3
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay with Sand (Drained)	2.83e-007	0.1	0.41	0.09
Gravel With Silt and Sand (Drained)	0.00164	0.2	0.23	0.01
Bottom Ash (Drained)	0.0115	1	0.3548	0.027



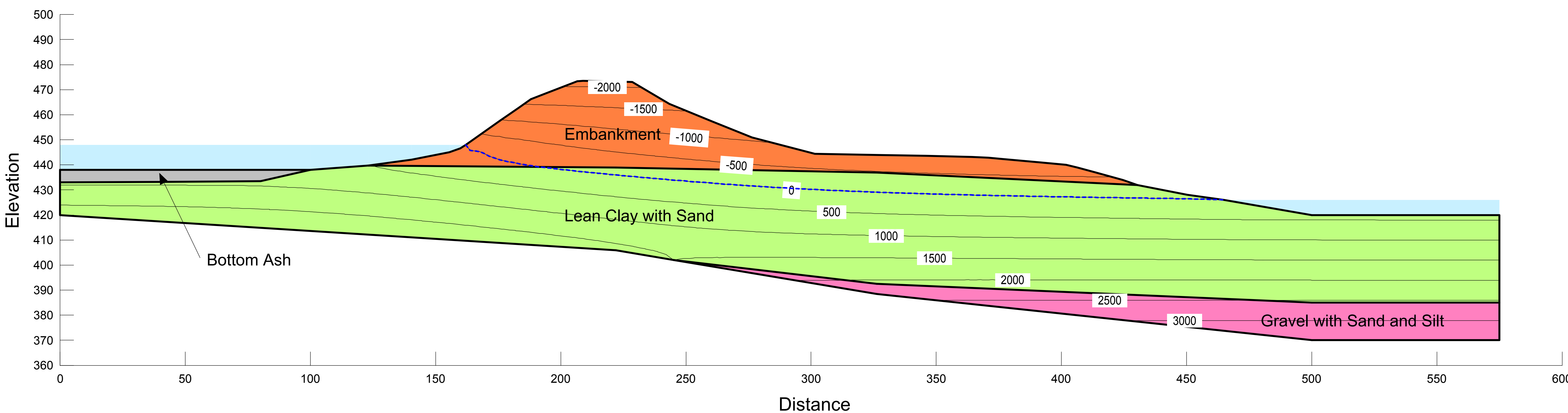
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Seepage Analysis
Pore Water Pressure Contour (psf)

SEEP Steady State Normal Pool
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Section A-A'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft^3/ft^3	Res. Water Content ft^3/ft^3
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay with Sand (Drained)	2.83e-007	0.1	0.41	0.09
Gravel With Silt and Sand (Drained)	0.00164	0.2	0.23	0.01
Bottom Ash (Drained)	0.0115	1	0.3548	0.027



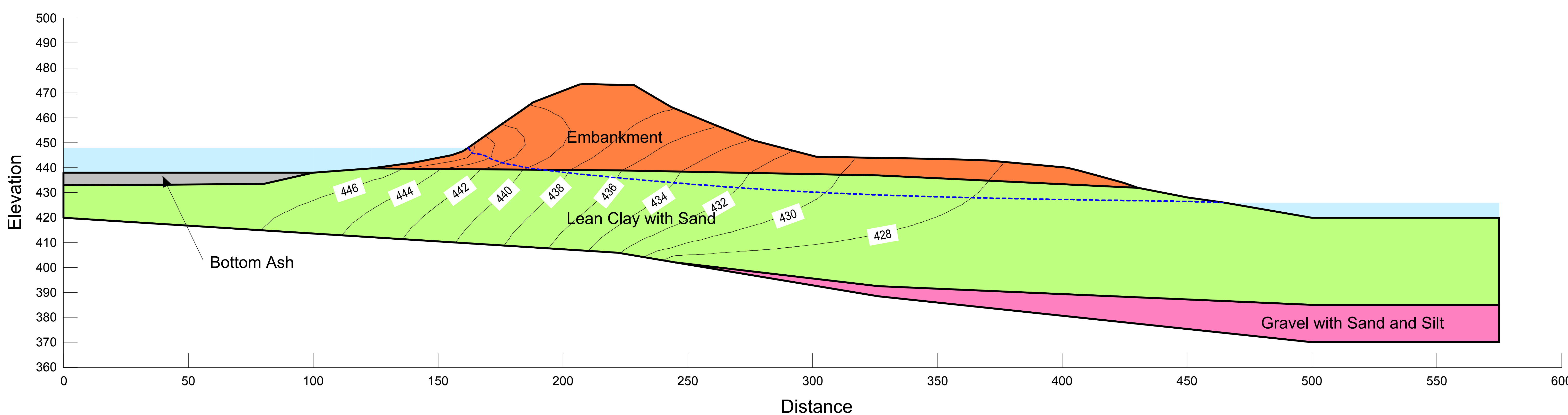
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Seepage Analysis
Total Head Contour (feet)

SEEP Steady State Normal Pool
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Section A-A'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft^3/ft^3	Res. Water Content ft^3/ft^3
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay with Sand (Drained)	2.83e-007	0.1	0.41	0.09
Gravel With Silt and Sand (Drained)	0.00164	0.2	0.23	0.01
Bottom Ash (Drained)	0.0115	1	0.3548	0.027



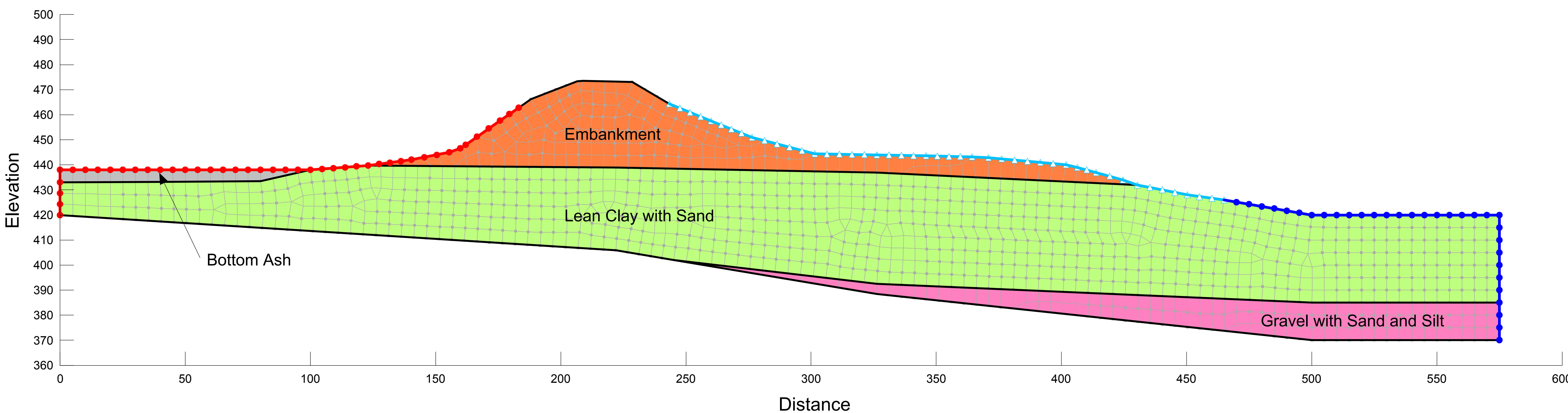
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Seepage Analysis
Boundary Condition and Mesh

SEEP Steady State 50% PMF Pool
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Section A-A'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft^3/ft^3	Res. Water Content ft^3/ft^3
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay with Sand (Drained)	2.83e-007	0.1	0.41	0.09
Gravel With Silt and Sand (Drained)	0.00164	0.2	0.23	0.01
Bottom Ash (Drained)	0.0115	1	0.3548	0.027



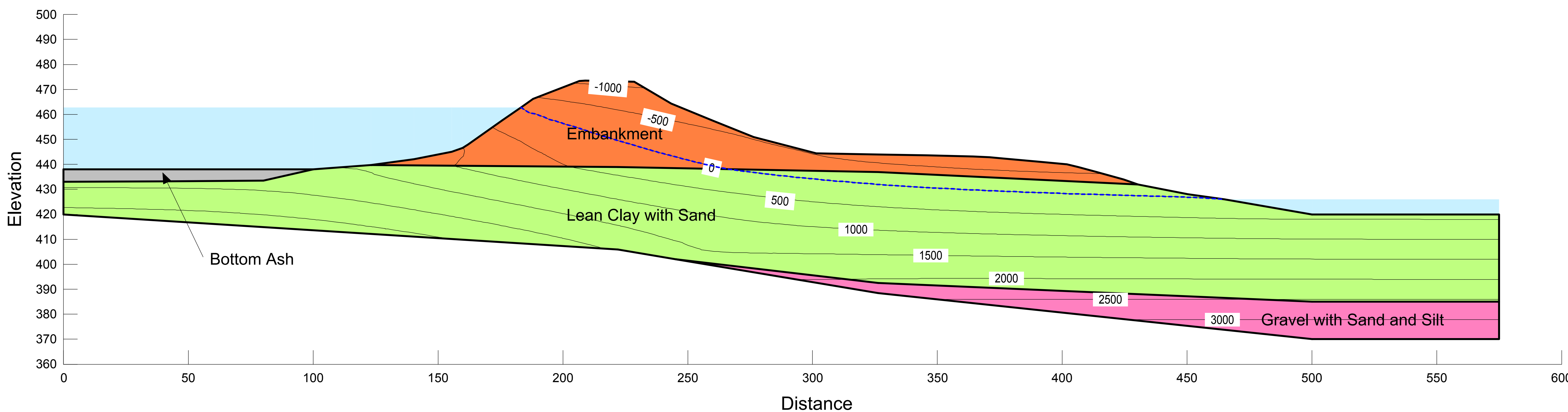
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Seepage Analysis
Pore Water Pressure Contour (psf)

SEEP Steady State 50% PMF Pool
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Section A-A'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft^3/ft^3	Res. Water Content ft^3/ft^3
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay with Sand (Drained)	2.83e-007	0.1	0.41	0.09
Gravel With Silt and Sand (Drained)	0.00164	0.2	0.23	0.01
Bottom Ash (Drained)	0.0115	1	0.3548	0.027



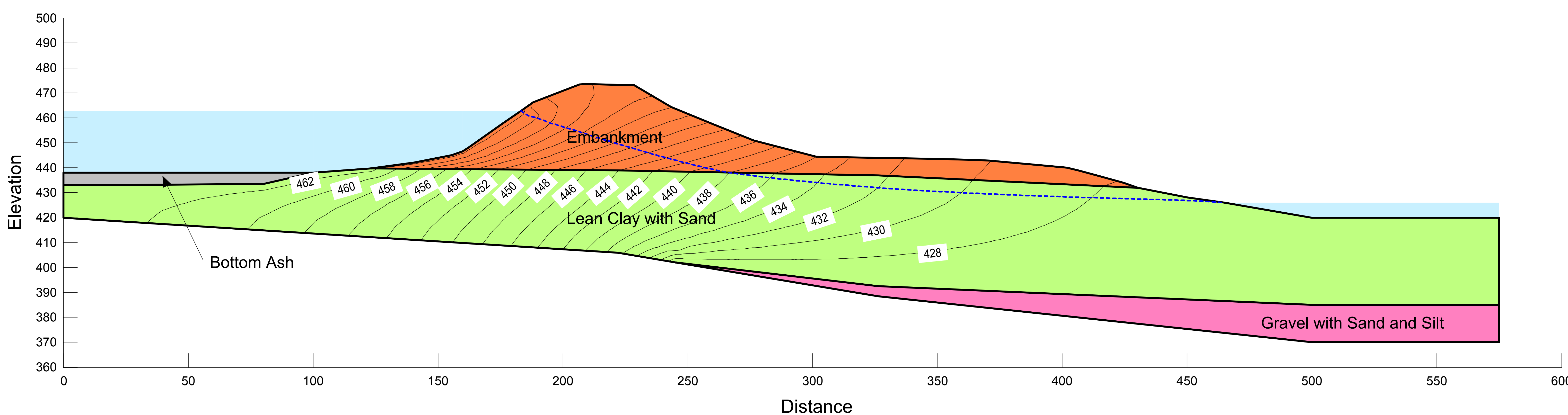
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Seepage Analysis
Total Head Contour (feet)

SEEP Steady State 50% PMF Pool
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Section A-A'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft^3/ft^3	Res. Water Content ft^3/ft^3
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay with Sand (Drained)	2.83e-007	0.1	0.41	0.09
Gravel With Silt and Sand (Drained)	0.00164	0.2	0.23	0.01
Bottom Ash (Drained)	0.0115	1	0.3548	0.027



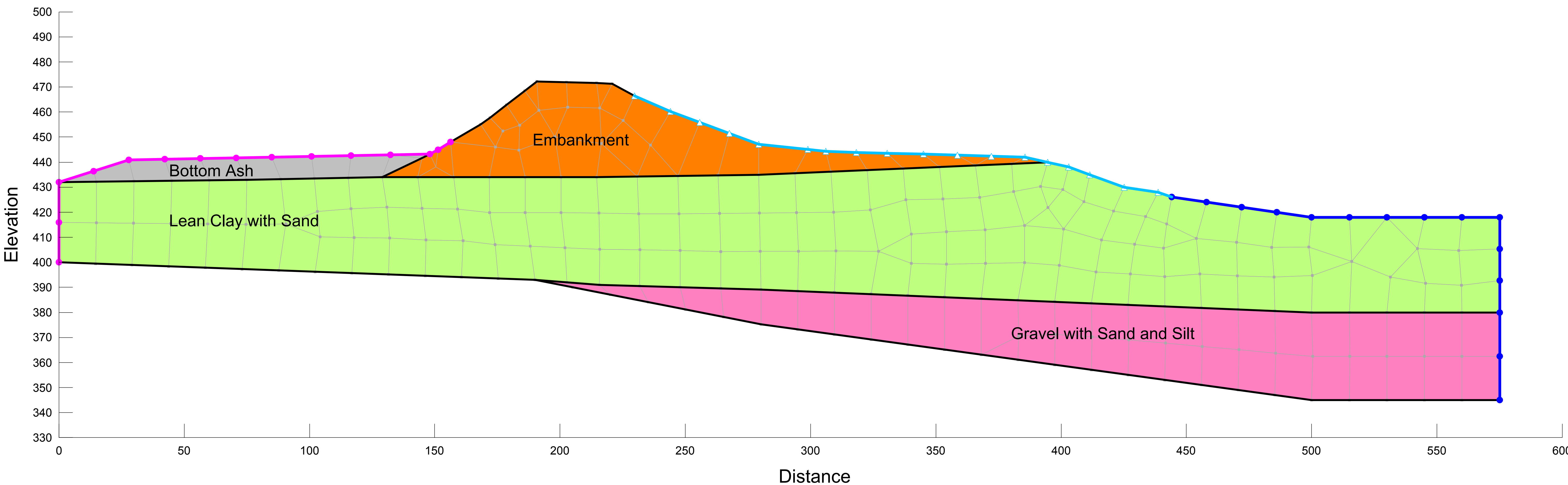
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Seepage Analysis
Boundary Condition and Mesh

SEEP Steady State Normal Pool
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Section B-B'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft^3/ft^3	Res. Water Content ft^3/ft^3
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay With Sand (Drained)	2.83e-007	0.1	0.38	0.09
Gravel With Silt And Sand (Drained)	0.00164	0.2	0.23	0.01
Bottom Ash (Drained)	0.0115	1	0.3548	0.027



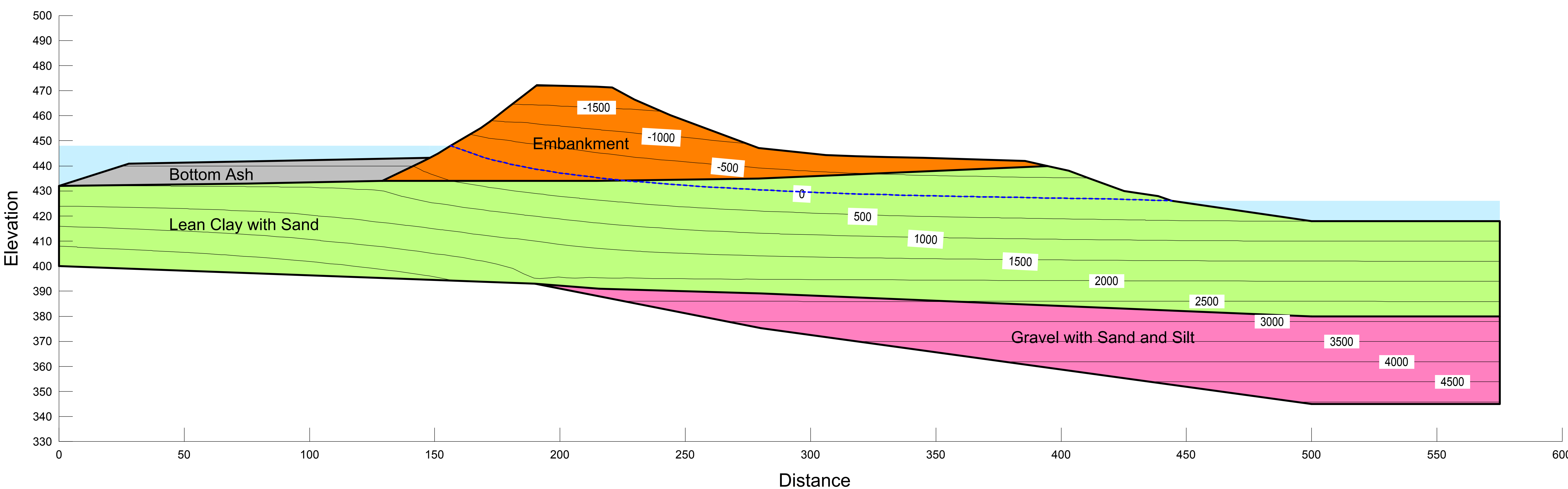
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Seepage Analysis
Pore Water Pressure Contour (psf)

SEEP Steady State Normal Pool
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Section B-B'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft^3/ft^3	Res. Water Content ft^3/ft^3
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay With Sand (Drained)	2.83e-007	0.1	0.38	0.09
Gravel With Silt And Sand (Drained)	0.00164	0.2	0.23	0.01
Bottom Ash (Drained)	0.0115	1	0.3548	0.027



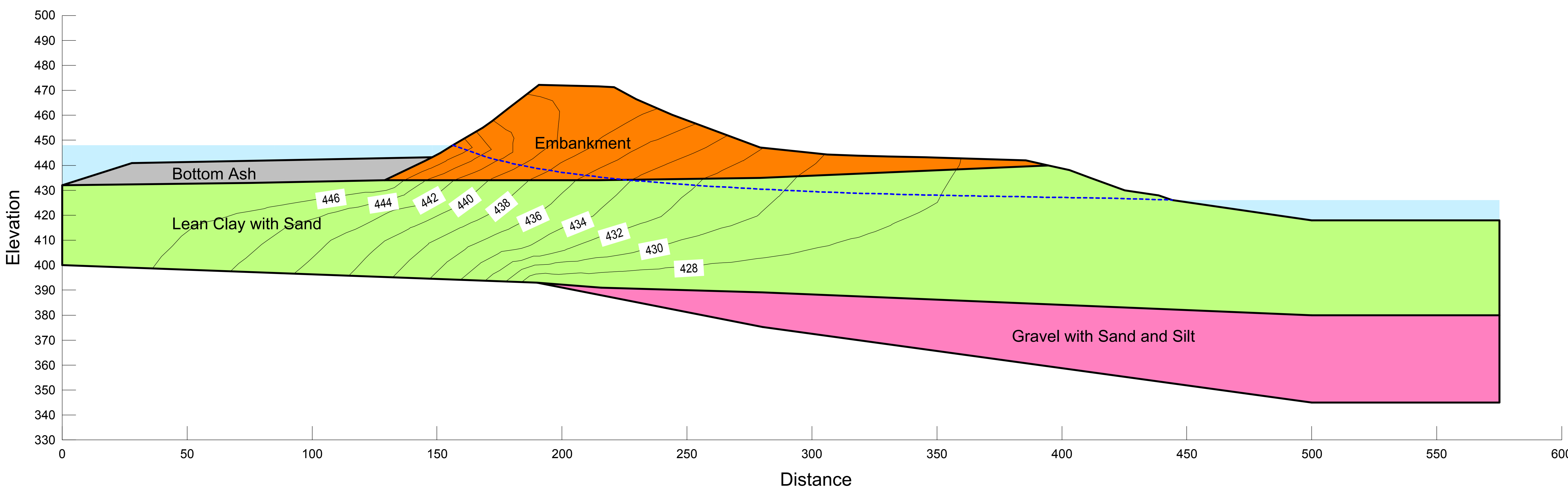
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Seepage Analysis
Total Head Contour (feet)

SEEP Steady State Normal Pool
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Section B-B'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft^3/ft^3	Res. Water Content ft^3/ft^3
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay With Sand (Drained)	2.83e-007	0.1	0.38	0.09
Gravel With Silt And Sand (Drained)	0.00164	0.2	0.23	0.01
Bottom Ash (Drained)	0.0115	1	0.3548	0.027



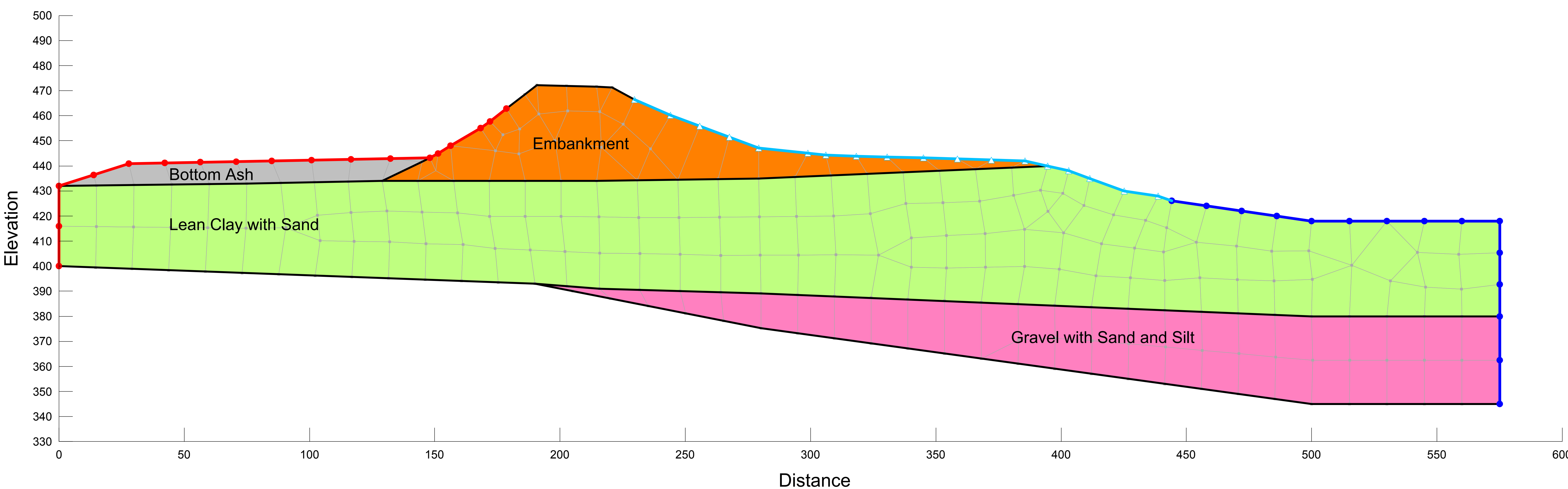
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Seepage Analysis
Boundary Condition and Mesh

SEEP Steady State 50% PMF Pool
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Section B-B'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft^3/ft^3	Res. Water Content ft^3/ft^3
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay With Sand (Drained)	2.83e-007	0.1	0.38	0.09
Gravel With Silt And Sand (Drained)	0.00164	0.2	0.23	0.01
Bottom Ash (Drained)	0.0115	1	0.3548	0.027



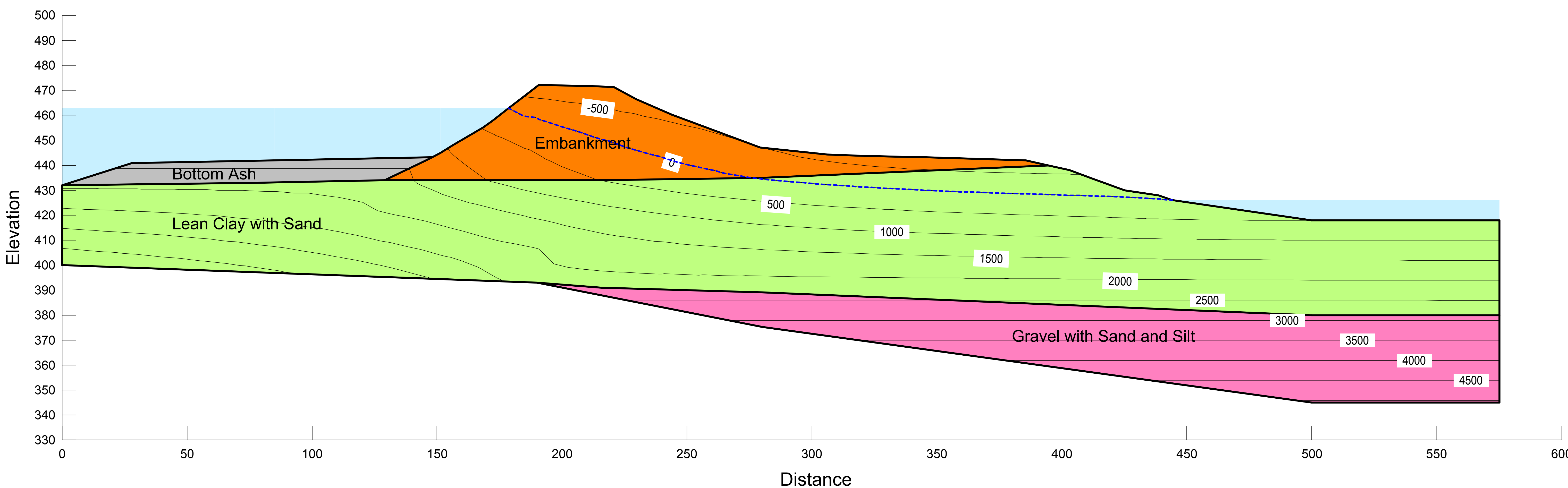
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Seepage Analysis
Pore Water Pressure Contour (psf)

SEEP Steady State 50% PMF Pool
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Section B-B'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft^3/ft^3	Res. Water Content ft^3/ft^3
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay With Sand (Drained)	2.83e-007	0.1	0.38	0.09
Gravel With Silt And Sand (Drained)	0.00164	0.2	0.23	0.01
Bottom Ash (Drained)	0.0115	1	0.3548	0.027



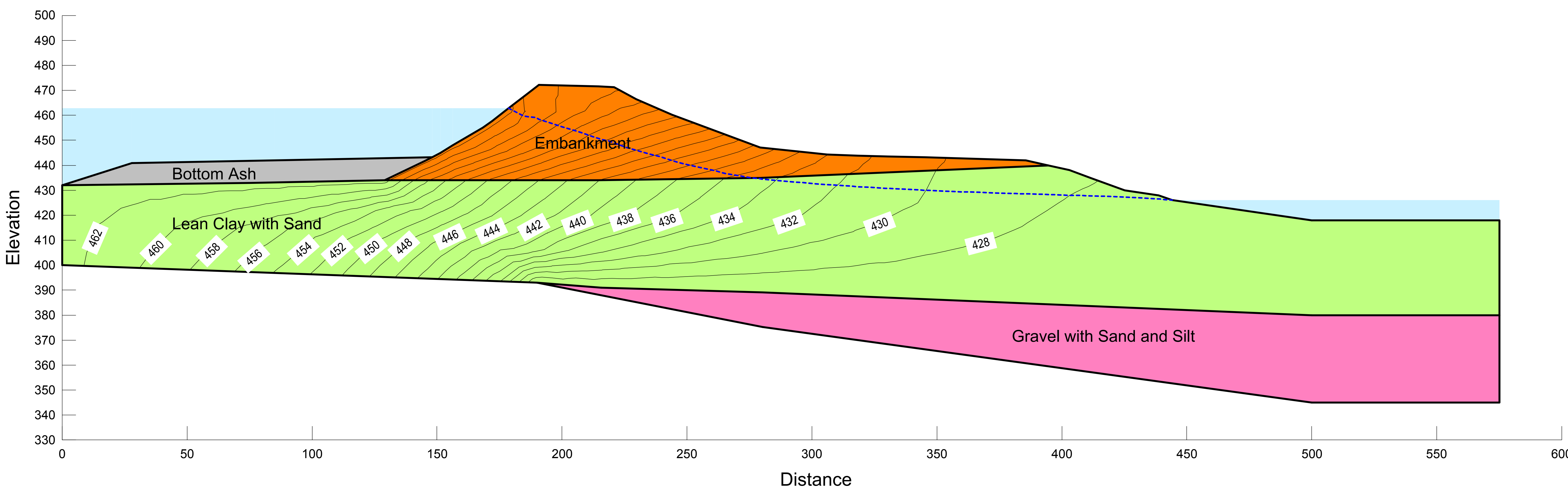
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Seepage Analysis
Total Head Contour (feet)

SEEP Steady State 50% PMF Pool
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Section B-B'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft^3/ft^3	Res. Water Content ft^3/ft^3
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay With Sand (Drained)	2.83e-007	0.1	0.38	0.09
Gravel With Silt And Sand (Drained)	0.00164	0.2	0.23	0.01
Bottom Ash (Drained)	0.0115	1	0.3548	0.027



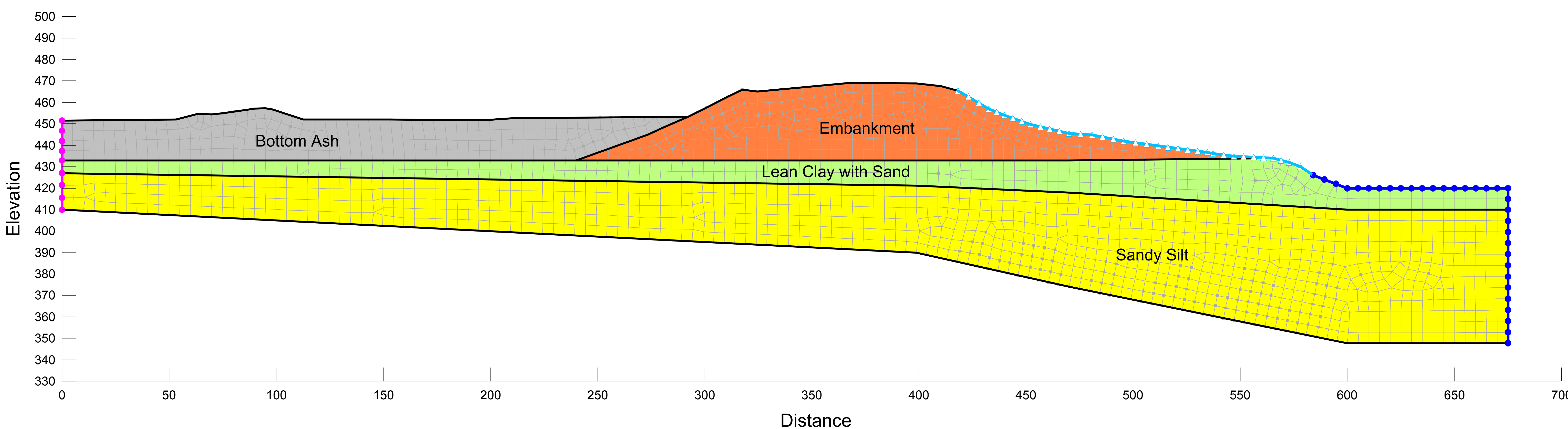
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Seepage Analysis
Boundary Condition and Mesh

SEEP Steady State Normal Pool
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Section C-C'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft^3/ft^3	Res. Water Content ft^3/ft^3
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay with Sand (Drained)	2.83e-007	0.1	0.41	0.09
Sandy Silt (Drained)	1.64e-005	0.2	0.29	0.01
Bottom Ash (Drained)	0.0115	1	0.3548	0.027



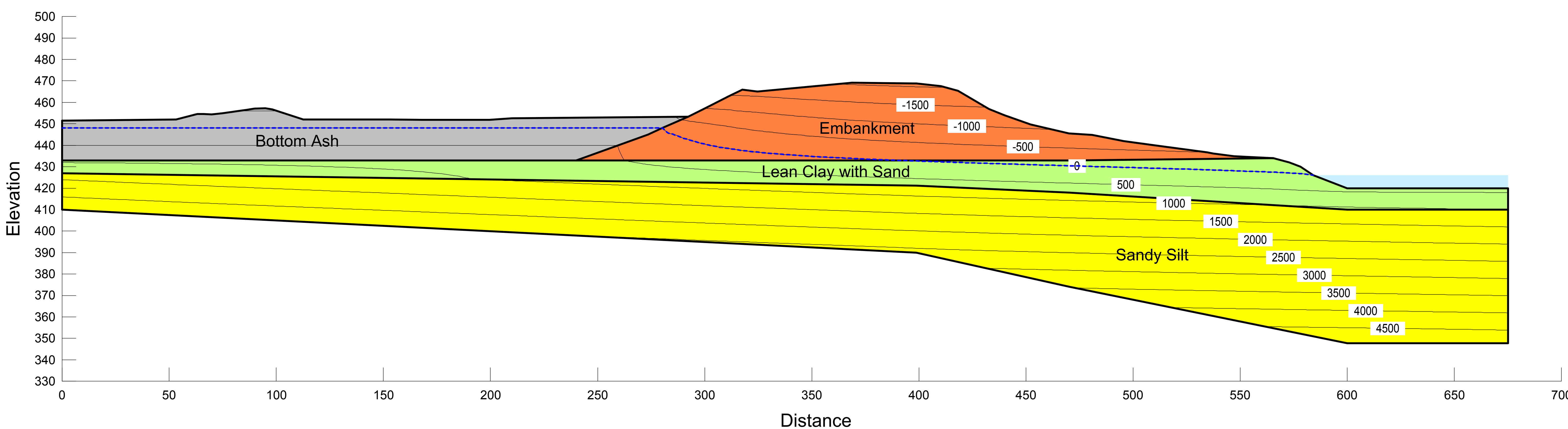
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Seepage Analysis
Pore Water Pressure Contour (psf)

SEEP Steady State Normal Pool
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Section C-C'

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft^3/ft^3	Res. Water Content ft^3/ft^3
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay with Sand (Drained)	2.83e-007	0.1	0.41	0.09
Sandy Silt (Drained)	1.64e-005	0.2	0.29	0.01
Bottom Ash (Drained)	0.0115	1	0.3548	0.027

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.



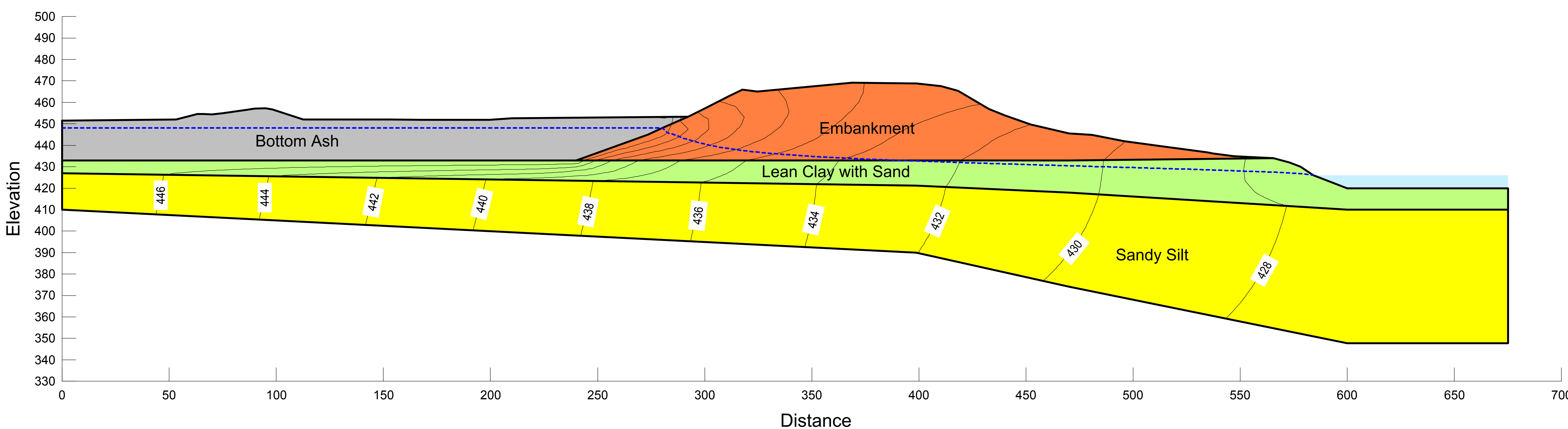
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Seepage Analysis
Total Head Contour (feet)

SEEP Steady State Normal Pool
Normal Pool Elevation: 448 Feet
Drained Static Strengths
Section C-C'

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft^3/ft^3	Res. Water Content ft^3/ft^3
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay with Sand (Drained)	2.83e-007	0.1	0.41	0.09
Sandy Silt (Drained)	1.64e-005	0.2	0.29	0.01
Bottom Ash (Drained)	0.0115	1	0.3548	0.027

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.



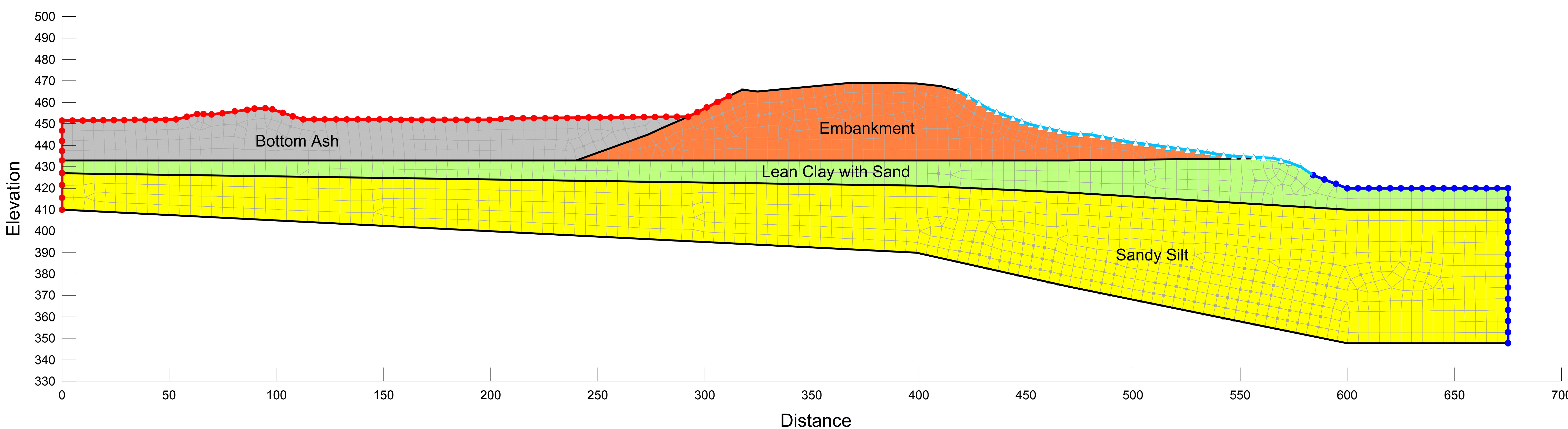
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Seepage Analysis
Boundary Condition and Mesh

SEEP Steady State 50% PMF Pool
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Section C-C'

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft^3/ft^3	Res. Water Content ft^3/ft^3
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay with Sand (Drained)	2.83e-007	0.1	0.41	0.09
Sandy Silt (Drained)	1.64e-005	0.2	0.29	0.01
Bottom Ash (Drained)	0.0115	1	0.3548	0.027

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.



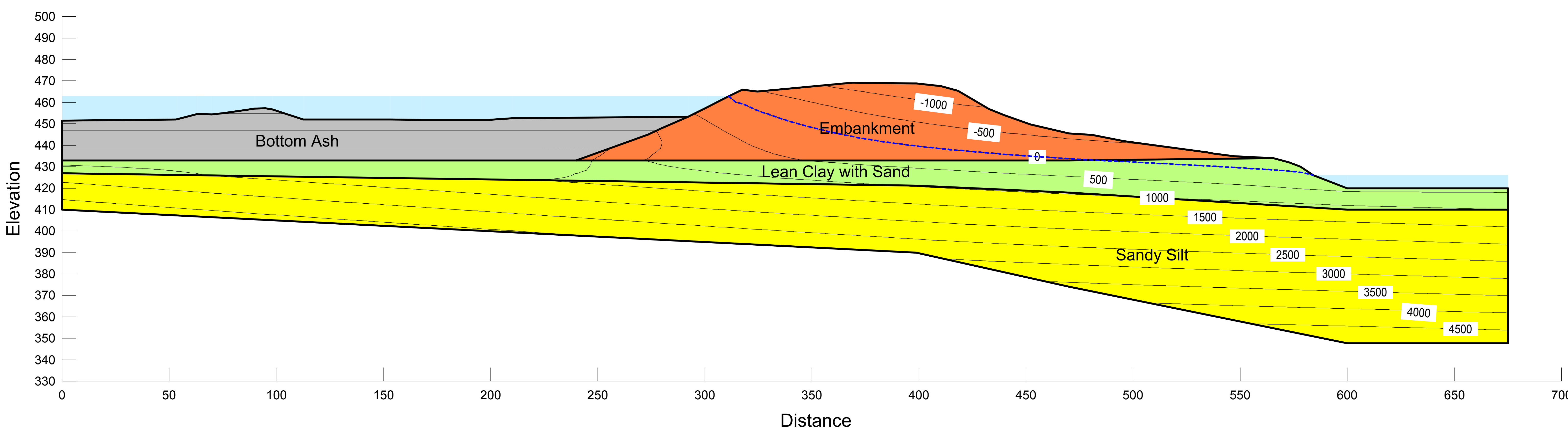
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Seepage Analysis
Pore Water Pressure Contour (psf)

SEEP Steady State 50% PMF Pool
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Section C-C'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft^3/ft^3	Res. Water Content ft^3/ft^3
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay with Sand (Drained)	2.83e-007	0.1	0.41	0.09
Sandy Silt (Drained)	1.64e-005	0.2	0.29	0.01
Bottom Ash (Drained)	0.0115	1	0.3548	0.027



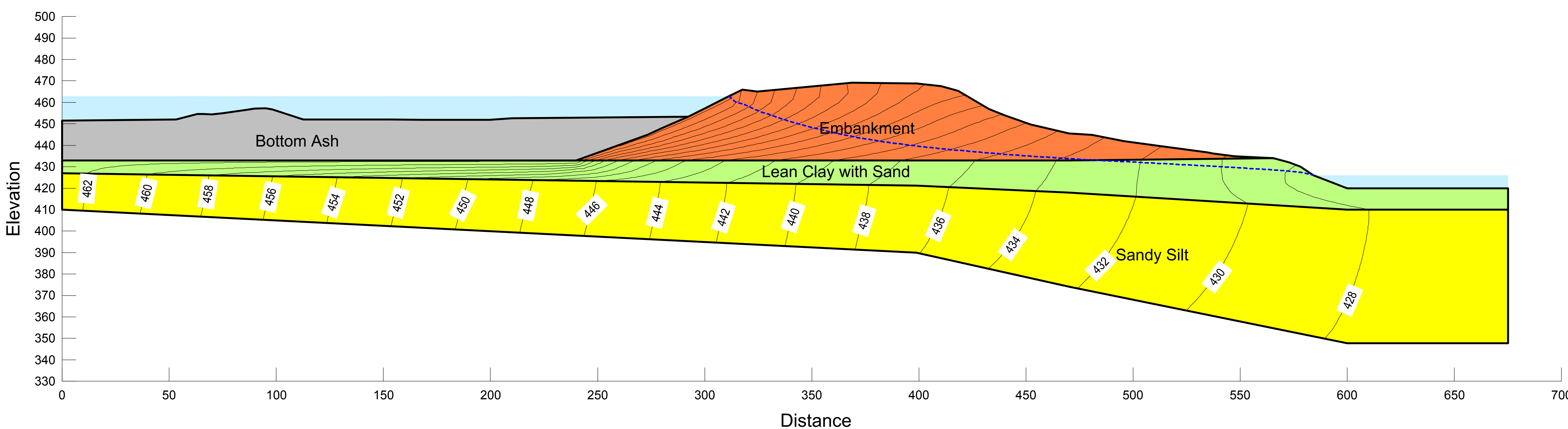
American Electric Power (AEP)
Clifty Creek West Boiler Slag Pond Dam
Madison, Indiana
CCR Mandate

Seepage Analysis
Total Head Contour (feet)

SEEP Steady State 50% PMF Pool
50% PMF Pool Elevation: 462.8 Feet
Drained Static Strengths
Section C-C'

Note: The results of the analysis shown here are based on available subsurface information, laboratory test results and approximate soil properties. The drawing depicts approximate subsurface conditions based on historical drawings or specific borings at the time of drilling.
No warranties can be made regarding the continuity of subsurface conditions.

Material	Kh-sat (ft/sec)	Kratio Kv/Kh	Sat. Water Content ft^3/ft^3	Res. Water Content ft^3/ft^3
Embankment (Drained)	4.72e-008	0.1	0.38	0.109
Lean Clay with Sand (Drained)	2.83e-007	0.1	0.41	0.09
Sandy Silt (Drained)	1.64e-005	0.2	0.29	0.01
Bottom Ash (Drained)	0.0115	1	0.3548	0.027



APPENDIX J

PARAMETER DERIVATIONS

BOILER SLAG POND DAM: 2010 PARAMETER DERIVATIONS

WEST BOTTOM ASH DAM GEOTECHNICAL ANALYSIS

CALCULATION SHEET

I. Subsurface Exploration Program Development:

Three cross sections across the dam were analyzed with two borings on each section: On the crest and at the toe.

II. Laboratory Testing Program:

The program was developed based on visual classifications done in the field during subsurface exploration.

- USCS Soil Classification Tests
- CU Triaxial Compression Tests
- Permeability Tests.
- Moisture Density tests.

III. Geotechnical Analysis:

A soil tests summary was developed to select soil parameters to use in the geotechnical analysis. Engineering properties that were not directly tested were determined using typical soil parameter values from NAVFAC DM7-02 Foundations and Earth Structures (Table 1 on Page 39) and the Center For Geotechnical Practice and Research, Performance and Use of the Standard Penetration Test in Geotechnical Engineering Practice report (Figures 34 and 35 on pages 71 and 72 respectively). The two tables are attached at the end of the parameter derivation notes.

Permeability k values that were not tested in the laboratory were selected from typical values provided in the table below and those provided in NAVFAC DM7.02, table 1: Typical Properties of Compacted soils

Soil Type	k_v(cm/s)
Coarse Sand	$>10^{-1}$
Fine Sand	10^{-1} to 10^{-3}
Silty Sand	10^{-3} to 10^{-5}
Silt	10^{-5} to 10^{-7}
Clay	$<10^{-7}$

Soils from the West Bottom Ash Dam were classified into 5 main soil layers.

The following table shows how pertinent parameters were selected and which sections they were applied to.

Soil name	USCS class	Classification Samples	Shear Strength Parameters	Permeability Parameters	Section
Embankment fill	CL	B-1,(10-11.5)(12.5-14)	Triaxial Test No 1	Test ID 7A	A / B / C
Lean Clay with Sand	CL	B-2,(32.5-34)(35-36.5)	Triaxial Test No 2	Average of test ID 48A & 82A	A / B / C
Gravel With Silt and Sand	GW-GM	B-4,(57.5-59)(60-61.5)	Typical values *	Typical values *	A / B
Sand Silt/ Silt with Sand	ML	B-5,(55-56.5)(57.5-59)	Typical values *	Typical values *	C
Bottom Ash		Averaged results from WBAP trench testing.**	Typical values *	Averaged results from WBAP trench testing.	A / B / C

* Typical values as determined from referenced tables.
** Table attached at end of appendix

Soil name	Unit Weight	C	ϕ	K_v (cm/sec)	K_h/K_v	g	e
Embankment fill	130	165	33	1.44 E-07	10	2.72 (ST sample)	0.609 (ST sample)
Lean Clay with Sand	119	160	24	8.62 E-07	10	2.69 (ST sample)	0.700 (ST sample
Gravel With Silt and Sand	130	0	35	1.00 E-02	5	2.70	0.300
Sand Silt/ Silt with Sand	130	0	30	1.00 E-04	5	2.70	0.400
Bottom Ash	115	0	28	3.5E-01	1		

1. SEEPAGE ANALYSIS.

Geoslope Seep W analysis was used to analyze the model for Seepage. Field piezometer readings were compared to the model's results. The model was calibrated to approximate field water elevations.

Residual and saturated water contents and coefficients of volume compressibility were assumed for all soil layers based on previous experiences and soils' normal values.

Water elevations used were:

- Existing (normal) water elevation in the pond: 442 feet.
- Maximum possible impounded water elevation (spillway highest grate): 457.7 feet
- Ohio River water elevation 426 feet.

Seepage analysis results were used in the slope stability analysis to model pore water pressures.

2. STABILITY ANALYSIS.

Geoslope Slope W was used for the slope stability analysis.

The Spencer Analysis Method was used.

Slip circle method and siding wedge method were modeled by the circular failure plane and the block specified; the circular failure plane produced lower Factors of Safety.

The peak ground acceleration used for the seismic analysis was obtained from US Geological Survey website. The PGA used is 0.08g (USGS indicates 0.07677g). The method selected to do the seismic analysis was the pseudostatic analysis per the project scope.

Loading conditions:

Static Slope Stability Loading Conditions:

- Steady state Seepage normal pool (upstream and downstream slopes): 442 feet
- Steady state seepage maximum pool (upstream and downstream slopes): 457.7 feet
- Rapid drawdown: normal pool steady-state seepage conditions with empty pond and dredged conditions above elevation 433 feet (upstream slope)
- PMF event (upstream and downstream slopes). The flood water was considered as a surcharge and the maximum pool steady state pore pressure line was used, as the water elevation selected for the PMF event is the result of a flood occurring while the dam had the maximum water pool. PMF event water elevation in the pond is: 468.4 feet.

Seismic Slope Stability Loading Conditions:

- Steady state seepage normal pool (upstream and downstream slopes): 442 feet
- Steady state seepage maximum pool (upstream and downstream slopes): 457.7 feet

3. LIQUEFACTION ANALYSIS.

Research and methodology:

- Earthquake intensity: USGS website used to determine the Peak Ground Acceleration and earthquake intensity for an earthquake event of a mean return period of 2,475 years. PGA = 0.07677g, the value used in the analysis is 0.08g and M_L = 7.7.

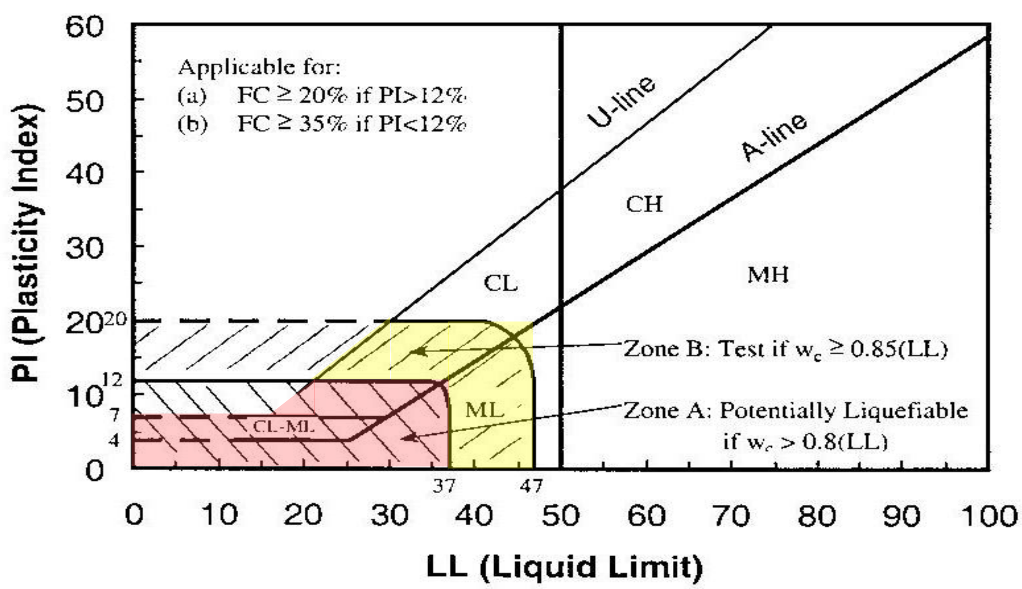
- Groundwater table: Normal (current) steady state water elevations were considered as the groundwater elevation. Unsaturated soil located above the groundwater table will not liquefy.

- Soil Type:

  The dam soil materials, being constructed of engineered fill located above the groundwater table, are not considered liquefiable.

  Cohesionless materials are considered liquefiable. The majority of cohesive soils will not liquefy. Cohesive soils susceptible to liquefaction should fall in either zone A or zone B of the following chart.

Screening Criteria for Liquefiable Fine-Grained Soils (Seed et al. 2003)



- Soil relative density (Dr): Soils in a loose relative density state are susceptible to liquefaction. Soils with an SPT-N value of 30 or higher were considered not liquefiable.

Liquefaction Assessment

To assess liquefaction potential for the WBAD, the boring logs from the geotechnical borings and laboratory test data from Shelby tubes and SPT samples were used. The boring logs include the SPT blow counts and soil lithologic descriptions with depth.

Soil characteristics (grain size, plasticity, unit weight, moisture content) from SPT and Shelby tube samples obtained from the geotechnical borings were used in the liquefaction assessment.

Method Used: Simplified Method based on using correlations to blow counts from Standard Penetration Tests (SPTs) as set forth in Youd et al (2001) and discussed in NRC (1985).

The Simplified Method requires estimating the Cyclic Stress Ratio (CSR) and Cyclic Resistance Ratio (CRR) of the soil. The CRR can be estimated using information from SPT tests, corrected to account for various effects. To use the Simplified Method, the SPT N value is normalized to an overburden pressure of approximately 100 kiloPascals (kPa) and a hammer energy ratio of 60% and procedural effects (rod length, sample configuration and borehole diameter).

The $(N_1)_{60}$ may also be corrected for the percent of fines using the relationship:

$$(N_1)_{60cs} = \alpha + \beta (N_1)_{60}$$

It is important to note that the fines correction is an approximation and is only valid for nonplastic fines and with a fines content between 0 and 35%. This correction factor, although widely used, is considered as a rough approximation only.

Once the corrected value for $(N_1)_{60}$ is found, the CRR is calculated as:

$$CRR_{7.5} = \frac{1}{34 - (N_1)_{60}} + \frac{(N_1)_{60}}{135} + \frac{50}{[10 * (N_1)_{60} + 45]^2} - \frac{1}{200}$$

Note that the value calculated is the CRR normalized to a 7.5 magnitude earthquake, hence the $CRR_{7.5}$ notation. When evaluating the liquefaction potential of soil, the $CRR_{7.5}$ must be corrected to the magnitude earthquake of interest.

The CSR is independent of soil properties and may be approximated using the equation:

$$CSR = 0.65(\frac{a_{\max}}{g})(\frac{\sigma_v}{\sigma'_v})r_d$$

where:

a_{max} is the maximum ground acceleration.
g is the acceleration of gravity.
σ_v is the total vertical stress.
σ_v' is the effective vertical stress.

r_d is a stress reduction coefficient.

Liquefaction potential for a soil unit is evaluated by dividing $CRR_{7.5}$ by CSR and then correcting to the magnitude earthquake of interest, as:

$$FS = \frac{CRR_{7.5}}{CSR} * MSF$$

Field experience has shown that the Simplified Method is somewhat conservative; so many designers consider FS values close to unity as an indication of no liquefaction.

B-1

Elevation	Depth	Soil class	N	Remarks
470.2	3.25	CL	11	Not liquefiable. Embankment and located above ground water
467.7	5.75	CL	10	
462.7	10.75	CL	10	
460.2	13.25	CL	7	
455.2	18.25	CL	15	
452.7	20.75	CL	15	
450.2	23.25	CL	14	
447.7	25.75	CL	8	
445.2	28.25	CL	12	
442.7	30.75	CL	11	
440.2	33.25	CL	9	
437.7	35.75	CL	10	
435.2	38.25	CL	6	
432.7	40.75	CL	5	
427.7	45.75	CL	2	Evaluated for liquefaction
425.2	48.25	CL	3	
422.7	50.75	CL	4	
420.2	53.25	CL	2	
417.7	55.75	CL	4	
415.2	58.25	CL	4	
412.7	60.75	CL	5	
410.2	63.25	CL	6	
407.7	65.75	CL	7	

B-2

Elevation	Depth	Soil class	N-field	Remarks
440.8	3.25	CL	19	Not liquefiable as layer is above ground water
438.3	5.75	CL	7	
435.8	8.25	CL	7	
430.8	13.25	CL	5	
428.3	15.75	CL	4	
425.8	18.25	CL	2	Evaluated for liquefaction
423.3	20.75	CL	4	

418.3	25.75	CL	4	
415.8	28.25	CL	9	
413.3	30.75	CL	6	
410.8	33.25	CL	6	
408.3	35.75	CL	5	
405.8	38.25	CL	4	
403.3	40.75	CL	6	
398.3	45.75	CL	2	
393.3	50.75	GW - GM	50	Not liquefiable

B-3

Elevation	Depth	Soil class	N-field	Remarks
468.4	3.25	CL	11	Not liquefiable. Embankment and located above ground water
465.9	5.75	CL	8	
463.4	8.25	CL	10	
458.4	13.25	CL	9	
455.9	15.75	CL	10	
453.4	18.25	CL	12	
448.4	23.25	CL	12	
445.9	25.75	CL	9	
443.4	28.25	CL	15	
440.9	30.75	CL	10	
438.4	33.25	CL	17	
435.9	35.75	CL	16	
433.4	38.25	CL	18	
430.9	40.75	CL	4	Evaluated for liquefaction
428.4	43.25	CL	4	
425.9	45.75	CL	6	
420.9	50.75	CL	4	
418.4	53.25	CL	2	
415.9	55.75	CL	5	
413.4	58.25	CL	2	
410.9	60.75	CL	8	
408.4	63.25	CL	6	
405.9	65.75	CL	7	
403.4	68.25	CL	9	
400.9	70.75	CL	8	

B-4

Elevation	Depth	Soil class	N-field	Remarks
443.5	3.25	CL	16	Not liquefiable as located above ground water
441.0	5.75	CL	15	
436.0	10.75	CL	11	
433.5	13.25	CL	7	
431.0	15.75	CL	5	

426.0	20.75	CL	4	Evaluated for liquefaction
424.5	22.25	CL	5	
421.0	25.75	CL	6	
418.5	28.25	CL	5	
416.0	30.75	CL	3	
413.5	33.25	CL	4	
411.0	35.75	CL	9	
406.0	40.75	CL	4	
403.5	43.25	CL	5	
401.0	45.75	CL	8	
398.5	48.25	CL	6	
396.0	50.75	CL	7	
393.5	53.25	CL	5	
391.0	55.75	CL	7	
388.5	58.25	GW - GM	39	Not liquefiable as layer is very dense
386.0	60.75	GW - GM	46	
381.5	65.25	GW - GM	50	
376.0	70.75	GW - GM	52	

B-5

Elevation	Depth	Soil class	N-field	Remarks
465.5	3.25	CL	19	Not liquefiable. Embankment and located above ground water
463.0	5.75	CL	9	
458.0	10.75	CL	15	
455.5	13.25	CL	10	
453.0	15.75	CL	7	
450.5	18.25	CL	16	
448.0	20.75	CL	7	
443.0	25.75	CL	8	
440.5	28.25	CL	7	
438.0	30.75	CL	12	
435.5	33.25	CL	8	
433.0	35.75	CL	16	
430.5	38.25	CL	6	
428.0	40.75	CL	3	Evaluated for liquefaction
423.0	45.75	CL	4	
420.5	48.25	ML	4	Evaluated for liquefaction
418.0	50.75	ML	6	
415.5	53.25	ML	2	
413.0	55.75	ML	4	
410.5	58.25	ML	5	
408.0	60.75	ML	7	
405.5	63.25	ML	9	
403.0	65.75	ML	11	
400.5	68.25	ML	9	
398.0	70.75	ML	13	

B-6

Elevation	Depth	Soil class	N-field	Remarks
442.3	3.25	CL	8	Not liquefiable as layer is above ground water
439.8	5.75	CL	10	
434.8	10.75	CL	18	
432.3	13.25	CL	4	
429.8	15.75	CL	3	
424.8	20.75	CL	1	Evaluated for liquefaction
422.3	23.25	CL	2	
419.8	25.75	CL	4	
417.3	28.25	ML	5	Evaluated for liquefaction
414.8	30.75	ML	3	
412.3	33.25	ML	3	
409.8	35.75	ML	1	
407.3	38.25	ML	1	
402.3	43.25	ML	2	
399.8	45.75	ML	1	
397.3	48.25	ML	1	
394.8	50.75	ML	5	
392.3	53.25	ML	11	
389.8	55.75	ML	4	
387.3	58.25	ML	9	
384.8	60.75	ML	11	
379.8	65.75	ML	9	
374.8	70.75	ML	10	

TABLE 1
Typical Properties of Compacted Soils

Group Symbol	Soil Type	Range of Maximum Dry Unit Weight, pcf	Range of Optimum Moisture, Percent	Typical Value of Compression: At 1.4 tsf (20 psi) — Percent of Original Height	Typical Value of Compression: At 3.6 tsf (50 psi) — Percent of Original Height	Typical Strength Characteristics: Cohesion (as compacted) psf	Typical Strength Characteristics: Cohesion (saturated) psf	Typical Strength Characteristics: ϕ (Effective Stress Envelope Degrees)	Typical Strength Characteristics: Tan ϕ	Typical Coefficient of Permeability ft./min.	Range of CBR Values	Range of Subgrade Modulus k lbs/cu in.
GW	Well graded clean gravels, gravel-sand mixtures.	125 - 135	11 - 8	0.3	0.6	0	0	>38	>0.79	5×10^{-2}	40 - 80	300 - 500
GP	Poorly graded clean gravels, gravel-sand mix	115 - 125	14 - 11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30 - 60	250 - 400
GM	Silty gravels, poorly graded gravel-sand-silt.	120 - 135	12 - 8	0.5	1.1	.....	.....	>34	>0.67	$>10^{-6}$	20 - 60	100 - 400
GC	Clayey gravels, poorly graded gravel-sand-clay.	115 - 130	14 - 9	0.7	1.6	.....	.....	>31	>0.60	$>10^{-7}$	20 - 40	100 - 300
SW	Well graded clean sands, gravelly sands.	110 - 130	16 - 9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20 - 40	200 - 300
SP	Poorly graded clean sands, sand-gravel mix.	100 - 120	21 - 12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10 - 40	200 - 300
SM	Silty sands, poorly graded sand-silt mix.	110 - 125	16 - 11	0.8	1.6	1050	420	34	0.67	$5 \times >10^{-5}$	10 - 40	100 - 300
SM-SC	Sand-silt clay mix with slightly plastic fines.	110 - 130	15 - 11	0.8	1.4	1050	300	33	0.66	$2 \times >10^{-6}$	5 - 30	100 - 300
SC	Clayey sands, poorly graded sand-clay-mix.	105 - 125	19 - 11	1.1	2.2	1550	230	31	0.60	$5 \times >10^{-7}$	5 - 20	100 - 300
ML	Inorganic silts and clayey silts.	95 - 120	24 - 12	0.9	1.7	1400	190	32	0.62	$>10^{-5}$	15 or less	100 - 200
ML-CL	Mixture of inorganic silt and clay.	100 - 120	22 - 12	1.0	2.2	1350	460	32	0.62	$5 \times >10^{-7}$	.....	
CL	Inorganic clays of low to medium plasticity.	95 - 120	24 - 12	1.3	2.5	1800	270	28	0.54	$>10^{-7}$	15 or less	50 - 200
OL	Organic silts and silt-clays, low plasticity.	80 - 100	33 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	50 - 100
MH	Inorganic clayey silts, elastic silts.	70 - 95	40 - 24	2.0	3.8	1500	420	25	0.47	$5 \times >10^{-7}$	10 or less	50 - 100
CH	Inorganic clays of high plasticity	75 - 105	36 - 19	2.6	3.9	2150	230	19	0.35	$>10^{-7}$	15 or less	50 - 150
OH	Organic clays and silty clays	65 - 100	45 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	25 - 100

Notes:

1. All properties are for condition of "Standard Proctor" maximum density, except values of k and CBR which are for "modified Proctor" maximum density.
2. Typical strength characteristics are for effective strength envelopes and are obtained from USBR data.
3. Compression values are for vertical loading with complete lateral confinement.
4. (>) indicates that typical property is greater than the value shown.
(..) indicates insufficient data available for an estimate.

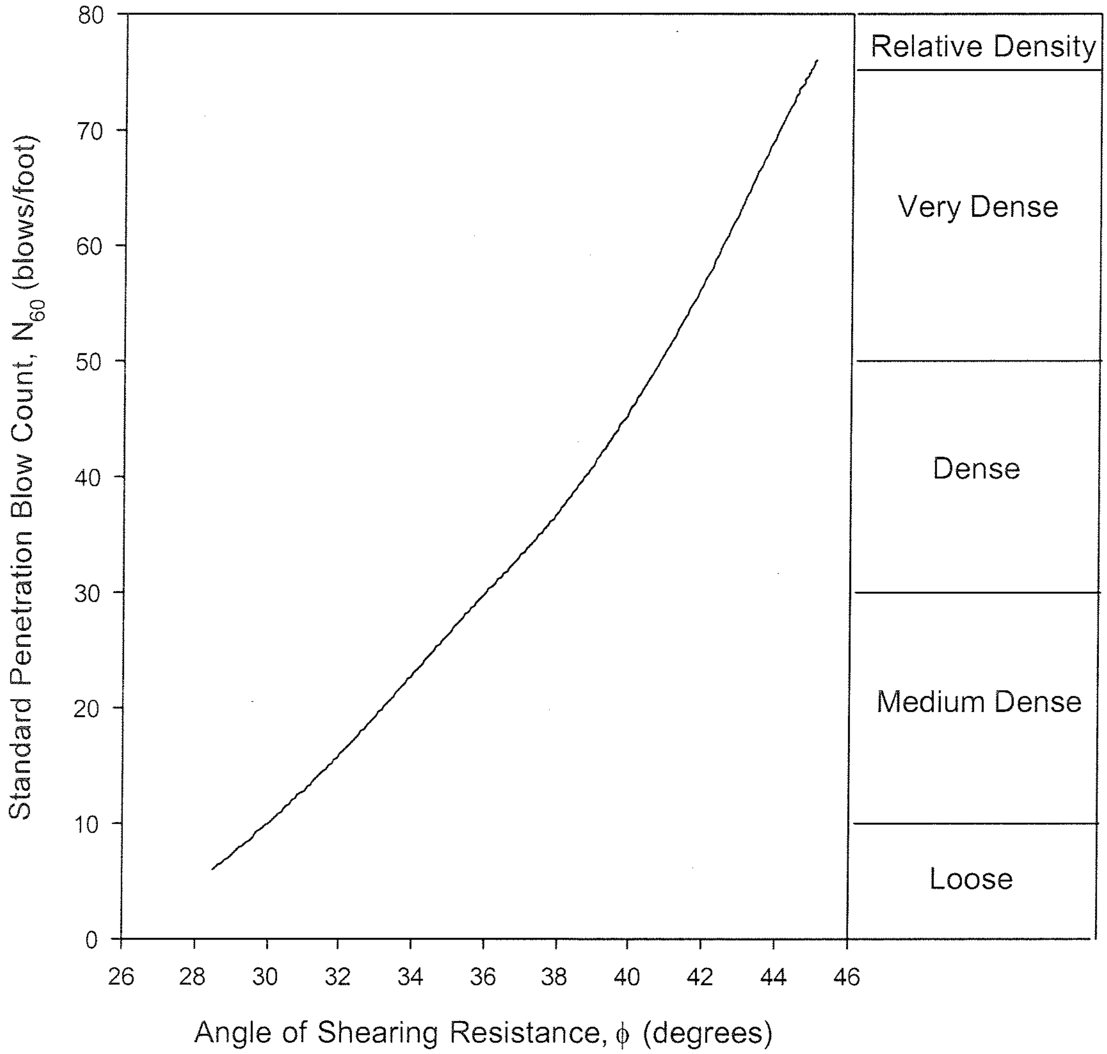


Figure 35. Estimation of the angle of shearing resistance of granular soils from standard penetration test results (Originally from Peck et al., 1974, modified by Carter and Bentley, 1991).

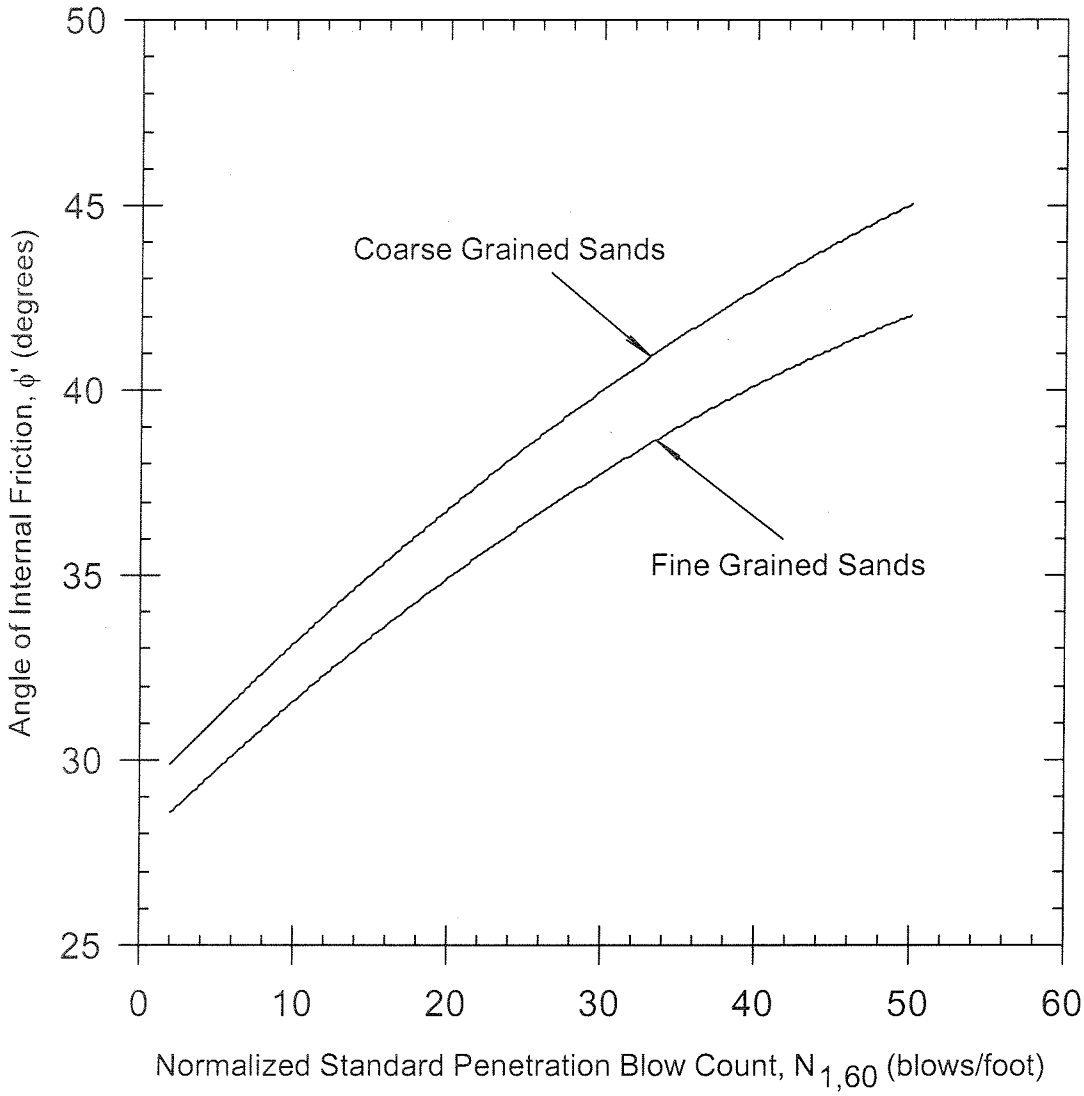


Figure 34. Empirical correlation between friction angle of sands and normalized standard penetration blow count (after Terzaghi et al., 1996)

WBAP Trench Testing (Bottom Ash Testing)

ASTM D 422, C 136

Sample	Classification	ω (%)	D_{10} (mm)	D_{30} (mm)	D_{60} (mm)	Cu	Cc	Sieve Size (% Passing) 3" 75	1 1/2" 37.5	1" 25.0	3/4" 19.0	3/8" 9.5	No. 4 4.75	No. 10 2	No. 40 0.425	No. 200 0.075	Pan 0.01	% Gravel	% Sand	% Fines	K(cm/s) 20o C	Fines Classification
1	Well Graded Sand (SW) with Gravel	6.2	0.3798	1.1724	3.2161	8.47	1.13	100.0	100.0	96.9	95.0	84.8	74.1	42.9	11.8	1.8	0.0	25.9	72.2	1.7	4.1E-01	
2	Poorly Graded Sand (SP) with Gravel	5.6	0.5766	1.4565	3.4443	5.97	1.07	100.0	100.0	96.1	93.8	85.2	72.9	38.2	5.5	0.8	0.0	27.1	72.1	0.8	1.1E+00	
3	Well Graded Sand (SW)	7.5	0.3386	0.9936	2.6258	7.76	1.11	100.0	100.0	100.0	100.0	95.1	85.9	50.4	12.2	2.2	0.0	14.1	83.8	1.9	3.0E-01	
4	Poorly Graded Sand (SP) with Gravel	5.9	0.5081	1.2732	3.0405	5.98	1.05	100.0	100.0	100.0	95.9	89.7	78.9	42.5	7.3	1.3	0.0	21.1	77.6	1.2	5.9E-01	
5	Poorly Graded Sand (SP) with Gravel	6.0	0.5210	1.2514	2.9512	5.66	1.02	100.0	100.0	100.0	98.7	91.7	80.6	43.7	6.5	1.2	0.0	19.4	79.5	1.1	8.4E-01	
6	Well Graded Sand (SW) with Gravel	7.1	0.3792	1.0490	2.7409	7.23	1.06	100.0	100.0	97.7	94.4	90.1	81.6	47.6	11.0	2.2	0.0	18.4	79.3	2.1	3.6E-01	
7	Poorly Graded Sand (SP-SC) with Clay	23.1	0.0757	0.1599	0.5429	7.17	0.62	100.0	100.0	100.0	100.0	98.4	94.7	80.6	56.1	9.8	0.0	5.3	84.9	10.0	5.6E-02	
8	Well Graded Sand with Gravel (SW), gray	8.7	0.1868	0.8464	2.6959	14.44	1.42	100.0	100.0	100.0	99.5	94.8	84.4	47.1	17.1	2.1	0.0	15.6	82.4	2.1	3.0E-01	
9	Well Graded Sand (SW) with Gravel	5.4	0.3714	1.4341	3.9659	10.68	1.40	100.0	100.0	93.7	89.1	77.9	66.1	36.5	11.3	1.0	0.0	33.9	65.1	1.0	2.9E-01	
10	Well Graded Sand (SW) with Gravel	4.4	0.2954	1.3526	4.3012	14.56	1.44	100.0	100.0	94.8	87.9	76.3	63.1	36.3	12.3	1.4	0.0	36.9	61.7	1.4	1.7E-01	
11	Well Graded Sand (SW) with Gravel	4.4	0.3771	1.1624	3.2364	8.58	1.11	100.0	100.0	100.0	96.3	87.8	75.2	41.0	10.6	1.8	0.0	24.8	73.3	1.8	3.9E-01	
12	Poorly Graded Sand (SP) with Gravel	2.7	0.4552	1.1566	3.1130	6.84	0.94	100.0	100.0	97.9	96.4	86.8	76.9	42.4	8.5	1.4	0.0	23.1	75.5	1.4	4.7E-01	
13	Well Graded Sand (SW) with Gravel	12.5	0.1642	0.7368	2.4777	15.09	1.33	100.0	100.0	100.0	100.0	93.1	84.1	53.4	20.4	3.7	0.0	15.9	80.4	3.7	2.4E-01	
14	Well Graded Sand (SW-SC) with Clay and Gravel	14.0	0.1021	0.9001	3.1464	30.82	2.52	100.0	90.3	90.3	89.1	84.2	75.4	44.5	20.0	7.8	0.0	24.6	67.6	7.8	2.5E-01	CH
15		7.7	0.1110	0.6950	2.4690	22.24	1.76	100.0	100.0	100.0	99.1	93.7	83.3	53.8	21.7	6.6	0.0	16.7	76.7	6.6		
16		8.4	0.0934	0.6601	2.3445	25.10	1.99	100.0	100.0	100.0	100.0	95.3	86.1	54.9	22.4	8.4	0.0	13.9	77.7	8.4		
17		6.8	0.1413	0.7713	2.6062	18.44	1.62	100.0	100.0	100.0	98.3	93.1	81.3	51.6	20.1	6.1	0.0	18.7	75.2	6.1		
18	Silty Sand (SM), with Gravel	8.5						100.0	100.0	94.4	91.5	85.3	76.4	49.5	46.6	33.3	0.0	23.6	43.1	33.3	8.6E-02	
19		8.2	0.1425	0.7675	2.6682	18.72	1.55	100.0	100.0	100.0	98.5	90.6	81.2	50.8	19.8	6.1	0.0	18.8	75.1	6.1		
20	Silty Sand (SM), gray	13.3						100.0	100.0	100.0	100.0	94.3	87.5	61.4	30.9	14.3	0.0	12.5	73.2	14.3	1.9E-02	
21	Silty Sand (SM), gray	16.8						100.0	100.0	100.0	100.0	96.5	89.5	62.2	34.4	17.1	0.0	10.5	72.4	17.1	1.8E-02	
22	Well Graded Sand (SW-SM) with Silt and Gravel	5.8	0.1552	1.0052	2.9060	18.73	2.24	100.0	100.0	100.0	97.1	93.3	84.0	43.5	18.6	5.6	0.0	16.0	78.4	5.6		ML
23	Well Graded Sand (SW-SM) with Silt and Gravel	6.8	0.1053	0.6226	2.6016	24.71	1.42	100.0	100.0	100.0	97.0	89.4	81.0	52.3	23.5	6.7	0.0	19.0	74.3	6.7		ML
24	Well Graded Sand (SW-SM) with Silt	4.5	0.1541	0.8266	2.6141	16.96	1.70	100.0	100.0	100.0	97.7	92.9	86.8	49.2	19.4	5.3	0.0	13.2	81.5	5.3		ML
25	Well Graded Sand (SW-SM) with Silt and Gravel	6.8	0.0972	0.5461	2.4056	24.74	1.28	100.0	100.0	98.4	96.7	90.2	81.0	54.5	26.1	7.2	0.0	19.0	73.8	7.2		ML
	max		0.5766	1.4565	4.3012	30.82	2.52	100.0	100.0	100.0	100.0	98.4	94.7	80.6	56.1	33.3	0.0	36.9	84.9	33.3	1.1E+00	
	min		0.0757	0.1599	0.5429	5.66	0.62	100.0	90.3	90.3	87.9	76.3	63.1	36.3	5.5	0.8	0.0	5.3	43.1	0.8	1.8E-02	
	average		0.2605	0.9472	2.8233	14.50	1.40	100.0	99.6	98.4	96.5	90.0	80.5	49.2	19.8	6.2	0.0	19.5	74.3	6.2	3.5E-01	

LANDFILL RUNOFF COLLECTION POND

FLY ASH DAM GEOTECHNICAL ANALYSIS

PARAMETER DERIVATION

I. Subsurface Exploration Program Development:

The scope determined two sections across the dam. Two borings will be drilled on each section, on the crest and at the toe, only Sheby tube samples were collected that will be used to supplement available historic borings data in the development of the soil profile.

II. Laboratory Testing Program:

The program was developed to provide additional soil data to available historic data.

- USCS Soil Classification Tests.
- Triaxial tests.
- Permeability tests
- Moisture-density tests.

III. Geotechnical Analysis:

A soil tests summary was developed to select soil parameters to use in the geotechnical analysis. Engineering properties that were not directly tested were determined using typical soil parameter values from NAVFAC DM7-02 Foundations and Earth Structures (Table 1 on Page 39) and the Center For Geotechnical Practice and Research, Performance and Use of the Standard Penetration Test in Geotechnical Engineering Practice report (Figures 34 and 35 on pages 72 and 77 respectively). The two tables are attached at the end of the parameter derivation notes.

Permeability k values that were not tested in the laboratory were selected from typical values provided in the table below and those provided in NAVFAC DM7.02, table 1: Typical Properties of Compacted soils

Soil Type	k_v(cm/s)
Coarse Sand	$>10^{-1}$
Fine Sand	10^{-1} to 10^{-3}
Silty Sand	10^{-3} to 10^{-5}
Silt	10^{-5} to 10^{-7}
Clay	$<10^{-7}$

Historic boring and graphic logs were used to develop the dam's soil horizons for soil layers on which soil sampling was not done.

Soils from the Flay Ash Dam were classified into 7 main soil layers.

The following table shows how pertinent parameters were selected and which sections they were applied to.

Soil name	USGS class	Classification Samples	Shear results sample	Permeability k-value sample	Section
Embankment fill	**CL**	B-9 sample (20.2' – 20.8')	Average Triaxial Test B-7 & B-9	Average K tests B-7 & B-9	D/E
Lean Clay With Sand	**CL**	B-8 sample (25.5' – 25.8')	Average Triaxial Test B-8 & B-10	Permeability test B-8	D/E
Clayey Sand and Gravel	**GC**	Fly Ash Dam Raising report logs	Typical values *	Typical values *	D
Sandy Silts	**ML**	Fly Ash Dam Raising report logs	Typical values *	Typical values *	D
Silty Clay With Sand	**CL-ML**	B-10 sample (16.2' – 16.8')	Typical values *	Permeability test B-10	E
Silty Sand	**SM**	B-10 sample (14.2' – 14.8')	Typical values *	Typical values *	D/E
Fly Ash	**NA**	NA	Typical values *	Hydrogeologic study report	D/E

* Typical values as determined from referenced tables.

Soil name	Unit Weight	C	ϕ	kv (cm/sec)	Typical kh/kv	g	e
Embankment fill	129	198	27.5	7.30E-08	10	2.63 B-7 (27.2-27.8)	0.609 (ST sample)
Lean Clay With Sand	127	205.92	28	3.40E-08	10	2.65 B-8 (29.7-30.3)	0.700 (ST sample)
Clayey Sand and Gravel	130	0	35	1.00E-02	10	2.70	0.5
Sandy Silts	125	0	30	1.00E-04	5	2.65 B-8 (29.7-30.3)	0.4
Silty Clay With Sand	118	151.92	34.1	1.40E-07	10	2.68 B-10 (14.2-14.8)	0.43

Silty Sand	94	0	30	1.00E-04	5	2.66 B-10 (16.2-16.8)	0.4
Fly Ash	115	0	25	4.75E-04	50	NA	NA

1. SEEPAGE ANALYSIS.

Geoslope Seep W analysis was used to analyze the model for seepage. Historic Field piezometer readings (Hydrogeologic Study Report, Clifty Creek Coal Ash Landfill, AGES. November 2006) were compared to the model's results. The model results were inconsistent with available piezometer readings. This was due to a lack of enough soil property data.

Water elevations used were:

- Existing (normal) water elevation in the pond: 485 feet.
- Ohio River water elevation 426 feet.

Seepage analysis results were not used in slope stability analyses.

2. STABILITY ANALYSIS.

Geoslope Slope W was used for the slope stability analysis.

The Spencer Analysis Method was used.

Slip circle method and siding wedge method were modeled by the circular failure plane and the block specified; the circular failure plane produced lower Factors of Safety.

The peak ground acceleration used for the seismic analysis was obtained from US Geological Survey website. The PGA used is 0.08g. The method selected to do the seismic analysis was the pseudostatic analysis per the project scope.

Loading conditions:

During a period from 2004 to 2006, groundwater readings from different piezometers and wells across the dam and toe area were taken. The results of these readings provide were used for steady state analysis. (Hydrogeologic Study Report, Clifty Creek Coal Ash Landfill, AGES. November 2006)

Static Slope Stability Loading Conditions:

- Steady state Seepage normal pool (upstream and downstream slopes): 485 feet
- PMF event (upstream and downstream slopes). The flood water was considered as a surcharge above the water pool for steady state. PMF event water elevation in the pond: 501.4 feet.

Seismic Slope Stability Loading Conditions:

- Steady state seepage normal pool (upstream and downstream slopes): 485 feet.

3. <u>LIQUEFACTION ANALYSIS</u>.

<u>Research and methodology:</u>

- Earthquake intensity: USGS website used to determine the Peak Ground Acceleration and earthquake intensity for an earthquake event of a mean return period of 2,475 years. PGA = 0.07677g (used 0.08g) and M_L = 7.7.

- Groundwater elevation date from 2004 through 2006 provide a steady state water elevation through the dam and the foundation soil materials. Unsaturated soil located above the groundwater table will not liquefy.

- Soil Type:

  The dam soil materials, being constructed of engineered fill are not considered liquefiable.

  Cohesionless materials are considered liquefiable. The majority of cohesive soils will not liquefy, cohesive soils susceptible to liquefy should have an liquid limit less than 37 and the water content of the soil must be greater than about 85% of the liquid limit.

  Due to the absence of USCS classification laboratory results, cohesive foundation materials were considered potentially liquefiable and Factors of Safety against liquefaction were calculated.

- Soil relative density (Dr): Soils in a loose relative density state are susceptible to liquefaction. Soils with an SPT-N value of 30 or higher were considered not liquefiable.

<u>Liquefaction Assessment</u>

Data from nine historical borings (SI-1, SS1-1, SS2-1, SS2-4, SS3-1, SS3-4, SS4-1, SS4-4, and SS5-1) were used to assess liquefaction potential. These borings were drilled in 1984 as part of the AEP Fly Ash Dam Raising Feasibility Project (1985). Soil characteristics included on the borings include the visually-estimated soil classifications per the USCS and SPT N-values.

In order to analyze the dam and foundation materials against liquefaction, it was necessary to assume the percent fines, or percent silt and clay, for many of the soils due to lack of particle size distribution data for the historic borings. Correlating current laboratory classification results with historic logs was done and where data was not available, typical values were assumed based on the visual USCS classifications on the historical boring logs.

Method Used: Simplified Method based on using correlations to blow counts from Standard Penetration Tests (SPTs) as set forth in Youd et al (2001) and discussed in NRC (1985).

The Simplified Method requires estimating the Cyclic Stress Ratio (CSR) and Cyclic Resistance Ratio (CRR) of the soil. The CRR can be estimated using information from SPT tests, corrected to account for various effects. To use the Simplified Method, the SPT N value is normalized to an overburden pressure of approximately 100 kiloPascals (kPa) and a hammer energy ratio of 60% and procedural effects (rod length, sample configuration and borehole diameter).

The $(N_1)_{60}$ may also be corrected for the percent of fines using the relationship:

$$(N_1)_{60cs} = \alpha + \beta (N_1)_{60}$$

It is important to note that the fines correction is an approximation and is only valid for nonplastic fines and with a fines content between 0 and 35%. This correction factor, although widely used, is considered as a rough approximation only.

Once the corrected value for $(N_1)_{60}$ is found, the CRR is calculated as:

$$CRR_{7.5} = \frac{1}{34-(N_1)_{60}} + \frac{(N_1)_{60}}{135} + \frac{50}{[10*(N_1)_{60}+45]^2} - \frac{1}{200}$$

Note that the value calculated is the CRR normalized to a 7.5 magnitude earthquake, hence the $CRR_{7.5}$ notation. When evaluating the liquefaction potential of soil, the $CRR_{7.5}$ must be corrected to the magnitude earthquake of interest.

The CSR is independent of soil properties and may be approximated using the equation:

$$CSR = 0.65(\frac{a_{\max}}{g})(\frac{\sigma_v}{\sigma'_v})r_d$$

where:

a_{max} is the maximum ground acceleration.
g is the acceleration of gravity.
σ_v is the total vertical stress.
σ_v' is the effective vertical stress.
r_d is a stress reduction coefficient.

Liquefaction potential for a soil unit is evaluated by dividing $CRR_{7.5}$ by CSR and then correcting to the magnitude earthquake of interest, as:

$$FS = \frac{CRR_{7.5}}{CSR} * MSF$$

Field experience has shown that the Simplified Method is somewhat conservative; so many designers consider FS values close to unity as an indication of no liquefaction.

SI-1

Elevation	Depth	Soil class	N	Remarks
452.8	3.75	SC	16	Not liquefiable, above ground water.
447.8	8.75	SC	13	
442.8	13.75	ML	8	
437.8	18.75	ML	5	Evaluated for liquefaction
432.8	23.75	ML	9	
427.8	28.75	SC	23	
422.8	33.75	SC	24	
417.8	38.75	SM	22	
412.8	43.75	ML	18	
407.8	48.75	ML	28	
402.8	53.75	ML	22	
397.8	58.75	ML	12	
392.8	63.75	ML	9	
387.8	68.75	ML	14	
382.8	73.75	ML	21	
377.8	78.75	ML	50	

SS1-1

Elevation	Depth	Soil class	N-field	Remarks
502.3	3.25	CL	17	Not liquefiable Embankment as layer is above ground water
497.3	8.25	CL	12	
492.3	13.25	CL	17	
487.3	18.25	CL	15	
482.3	23.25	CL-ML	17	
477.3	28.25	CL	15	
472.3	33.25	CL	21	
467.3	38.25	CL	23	
462.3	43.25	ML	30	
457.3	48.25	ML	24	Evaluated for liquefaction
452.3	53.25	CL	23	
447.3	58.25	CL	35	
442.3	63.25	CL	27	
437.3	68.25	SC	8	
432.3	73.25	CL	20	
427.3	78.25	CL	24	
422.3	83.25	CL	30	
417.3	88.25	SC	46	

SS2-1

Elevation	Depth	Soil class	N-field	Remarks
500.7	3.75	CL	10	Not liquefiable. Embankment and located above ground water
495.7	8.75	CL	12	
490.7	13.75	CL	13	
485.7	18.75	CL-ML	26	
480.7	23.75	CL	14	
475.7	28.75	CL	17	
470.7	33.75	CL	24	
465.7	38.75	CL	25	
460.7	43.75	CL	13	
455.7	48.75	CL	14	Evaluated for liquefaction
450.7	53.75	CL	24	
445.7	58.75	CL	26	
440.7	63.75	ML	26	
435.7	68.75	CL	13	
430.7	73.75	SM	12	
425.7	78.75	SM	43	
420.7	83.75	SM	28	
415.7	88.75	CL	22	
410.7	93.75	CL	29	

SS2-4

Elevation	Depth	Soil class	N-field	Remarks
436.6	3.25	CL	13	Evaluated for liquefaction
431.6	8.25	CL	12	
426.6	13.25	CL	8	
421.6	18.25	SM	12	
416.6	23.25	CL	6	
411.6	28.25	CL	17	
406.6	33.25	CL	17	
401.6	38.25	CL	15	
396.6	43.25	CL	11	
391.6	48.25	CL	12	
386.6	53.25	CL	13	
381.6	58.25	CL	19	
376.6	63.25	GC	22	

SS3-1

Elevation	Depth	Soil class	N-field	Remarks
501.2	3.25	CL	11	Not liquefiable. Embankment and located above ground water
496.2	8.25	CL-ML	12	
491.2	13.25	CL	22	
486.2	18.25	ML	17	
481.2	23.25	CL	22	
476.2	28.25	SC	27	Evaluated for liquefaction
471.2	33.25	CL	10	
466.2	38.25	ML	15	
461.2	43.25	ML	22	
456.2	48.25	SP	24	
451.2	53.25	SC	33	
446.2	58.25	SP	17	
441.2	63.25	SP	20	
436.2	68.25	SM	25	
431.2	73.25	SP	14	
426.2	78.25	SP	37	
421.2	83.25	SP	28	
416.2	88.25	SM	29	
411.2	93.25	SM	28	
406.2	98.25	CL	29	

SS3-4

Elevation	Depth	Soil class	N-field	Remarks
448.1	3.75	CL	10	Not liquefiable, above ground water
443.1	8.75	CL	11	
438.1	13.75	SM	5	Evaluated for liquefaction
433.1	18.75	SM	7	
428.1	23.75	SC	2	
423.1	28.75	ML	11	
418.1	33.75	ML	9	
413.1	38.75	CL	2	
408.1	43.75	CL	19	
403.1	48.75	CL	22	
398.1	53.75	CL	15	
393.1	58.75	CL	16	
388.1	63.75	CL	19	
383.1	68.75	CL	21	
378.1	73.75	CL	20	
373.1	78.75	CL	34	

SS4-1

Elevation	Depth	Soil class	N-field	Remarks
502.4	3.25	CL	5	Not liquefiable. Embankment and above ground water
497.4	8.25	ML	23	
492.4	13.25	CL	13	
487.4	18.25	CL	24	
482.4	23.25	CL	17	
477.4	28.25	CL	19	
472.4	33.25	CL	20	
467.4	38.25	CL	16	Evaluated for liquefaction
462.4	43.25	ML	17	
457.4	48.25	SM	11	
452.4	53.25	SM	23	
447.4	58.25	SM	18	
442.4	63.25	SM	24	
437.4	68.25	CL	26	
432.4	73.25	SC	5	
427.4	78.25	ML	22	
422.4	83.25	ML	29	
417.4	88.25	ML	30	
412.4	93.25	ML	30	

SS4-4

Elevation	Depth	Soil class	N-field	Remarks
447.0	3.75	CL	13	Not liquefiable, above ground water
442.0	8.75	CL	7	
437.0	13.75	SM	2	Evaluated for liquefaction
432.0	18.75	CL	4	
427.0	23.75	GC	50	
422.0	28.75	GC	29	

SS5-1

Elevation	Depth	Soil class	N-field	Remarks
501.6	3.25	CL	8	Not liquefiable, Embankment and above ground water N-values more than 30.
496.6	8.25	CL	20	
491.6	13.25	CL	20	
486.6	18.25	SC	22	
481.6	23.25	SM	25	
476.6	28.25	SM	50	
471.6	33.25	SM	50	
466.6	38.25	SM	50	

TABLE 1
Typical Properties of Compacted Soils

Group Symbol	Soil Type	Range of Maximum Dry Unit Weight, pcf	Range of Optimum Moisture, Percent	Typical Value of Compression: At 1.4 tsf (20 psi) — Percent of Original Height	Typical Value of Compression: At 3.6 tsf (50 psi) — Percent of Original Height	Typical Strength Characteristics: Cohesion (as compacted) psf	Typical Strength Characteristics: Cohesion (saturated) psf	Typical Strength Characteristics: ϕ (Effective Stress Envelope Degrees)	Typical Strength Characteristics: Tan ϕ	Typical Coefficient of Permeability ft./min.	Range of CBR Values	Range of Subgrade Modulus k lbs/cu in.
GW	Well graded clean gravels, gravel-sand mixtures.	125 - 135	11 - 8	0.3	0.6	0	0	>38	>0.79	5×10^{-2}	40 - 80	300 - 500
GP	Poorly graded clean gravels, gravel-sand mix	115 - 125	14 - 11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30 - 60	250 - 400
GM	Silty gravels, poorly graded gravel-sand-silt.	120 - 135	12 - 8	0.5	1.1	.....	.....	>34	>0.67	$>10^{-6}$	20 - 60	100 - 400
GC	Clayey gravels, poorly graded gravel-sand-clay.	115 - 130	14 - 9	0.7	1.6	.....	.....	>31	>0.60	$>10^{-7}$	20 - 40	100 - 300
SW	Well graded clean sands, gravelly sands.	110 - 130	16 - 9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20 - 40	200 - 300
SP	Poorly graded clean sands, sand-gravel mix.	100 - 120	21 - 12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10 - 40	200 - 300
SM	Silty sands, poorly graded sand-silt mix.	110 - 125	16 - 11	0.8	1.6	1050	420	34	0.67	$5 \times >10^{-5}$	10 - 40	100 - 300
SM-SC	Sand-silt clay mix with slightly plastic fines.	110 - 130	15 - 11	0.8	1.4	1050	300	33	0.66	$2 \times >10^{-6}$	5 - 30	100 - 300
SC	Clayey sands, poorly graded sand-clay-mix.	105 - 125	19 - 11	1.1	2.2	1550	230	31	0.60	$5 \times >10^{-7}$	5 - 20	100 - 300
ML	Inorganic silts and clayey silts.	95 - 120	24 - 12	0.9	1.7	1400	190	32	0.62	$>10^{-5}$	15 or less	100 - 200
ML-CL	Mixture of inorganic silt and clay.	100 - 120	22 - 12	1.0	2.2	1350	460	32	0.62	$5 \times >10^{-7}$	.....	
CL	Inorganic clays of low to medium plasticity.	95 - 120	24 - 12	1.3	2.5	1800	270	28	0.54	$>10^{-7}$	15 or less	50 - 200
OL	Organic silts and silt-clays, low plasticity.	80 - 100	33 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	50 - 100
MH	Inorganic clayey silts, elastic silts.	70 - 95	40 - 24	2.0	3.8	1500	420	25	0.47	$5 \times >10^{-7}$	10 or less	50 - 100
CH	Inorganic clays of high plasticity	75 - 105	36 - 19	2.6	3.9	2150	230	19	0.35	$>10^{-7}$	15 or less	50 - 150
OH	Organic clays and silty clays	65 - 100	45 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	25 - 100

Notes:

1. All properties are for condition of "Standard Proctor" maximum density, except values of k and CBR which are for "modified Proctor" maximum density.
2. Typical strength characteristics are for effective strength envelopes and are obtained from USBR data.
3. Compression values are for vertical loading with complete lateral confinement.
4. (>) indicates that typical property is greater than the value shown.
(..) indicates insufficient data available for an estimate.

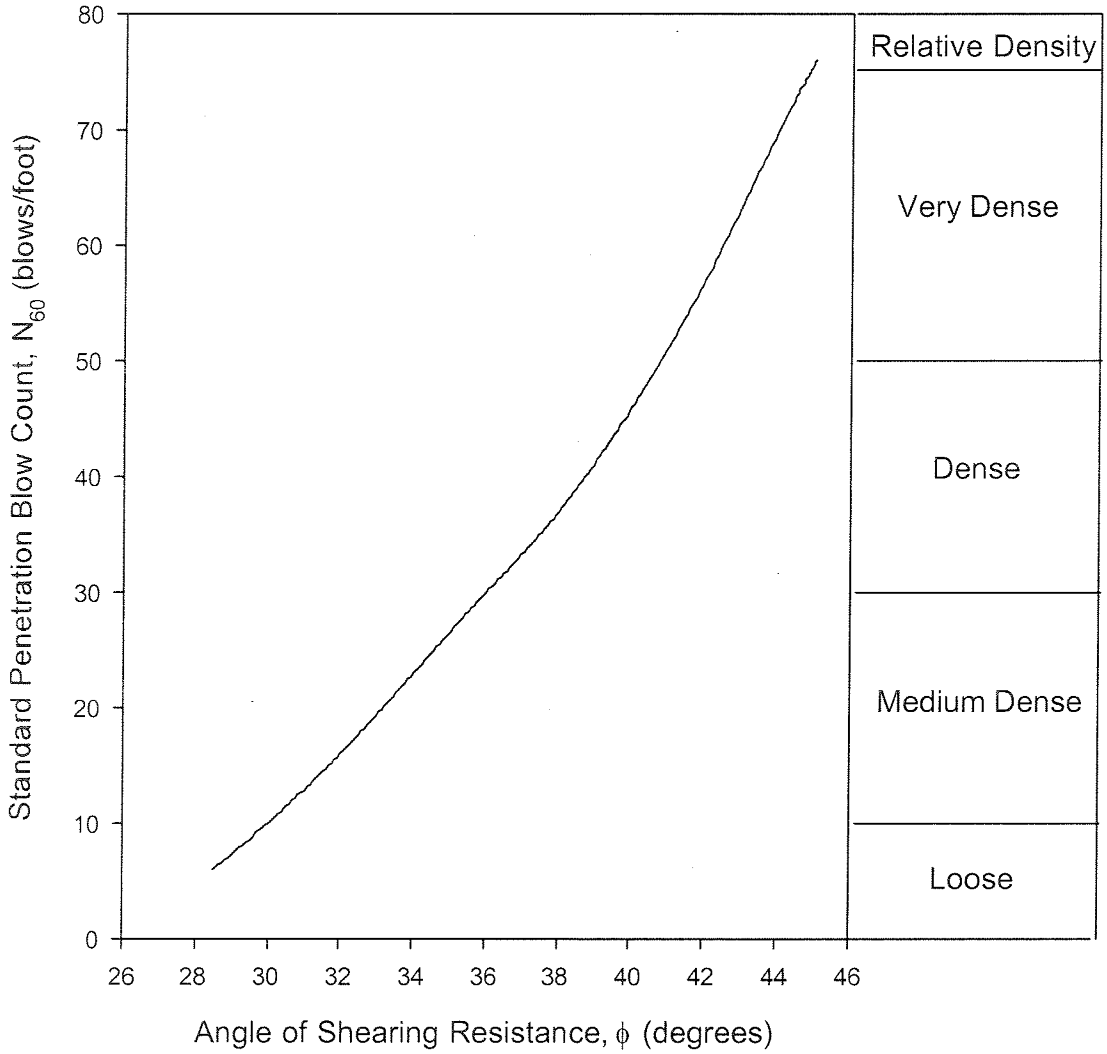


Figure 35. Estimation of the angle of shearing resistance of granular soils from standard penetration test results (Originally from Peck et al., 1974, modified by Carter and Bentley, 1991).

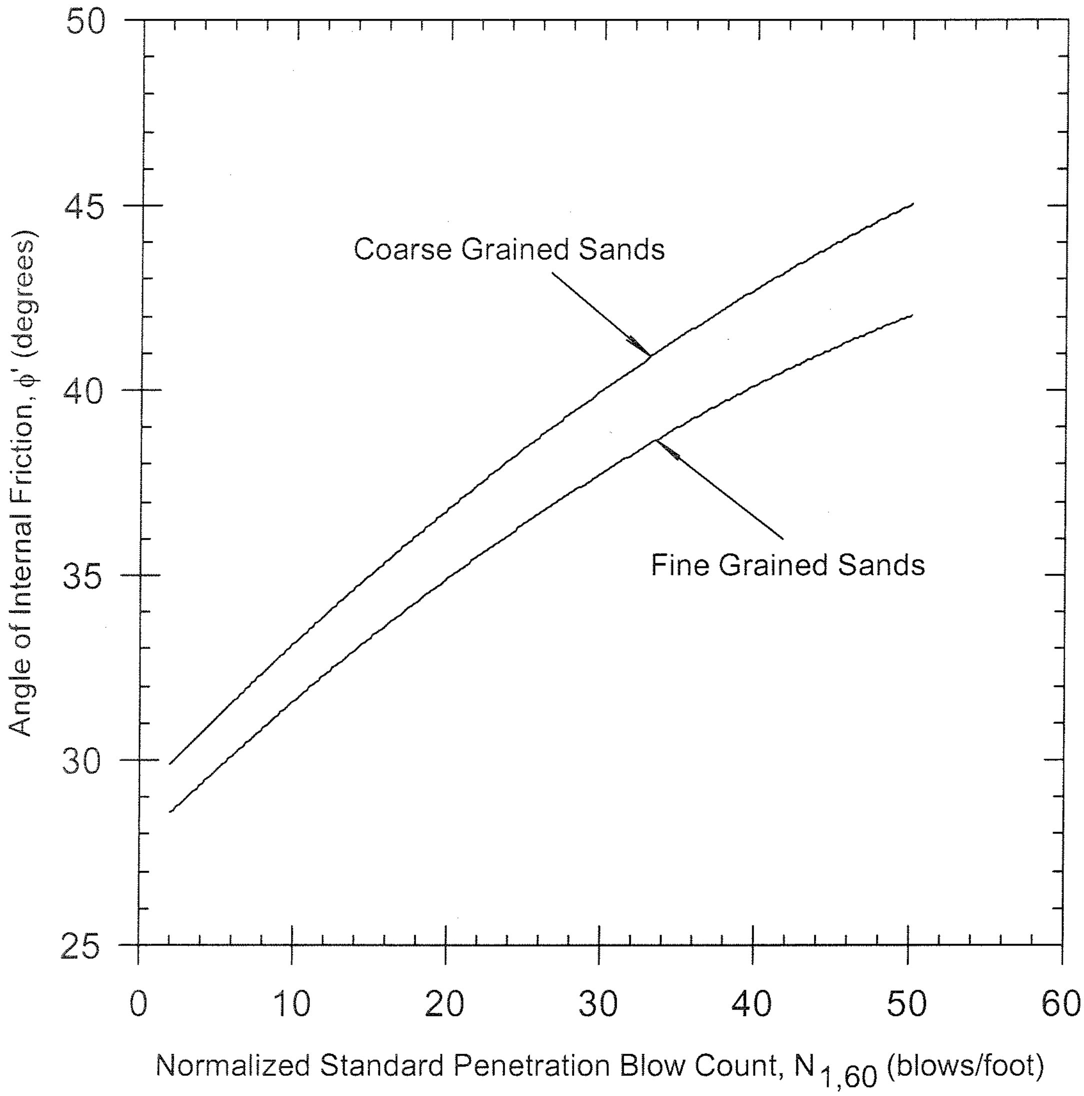
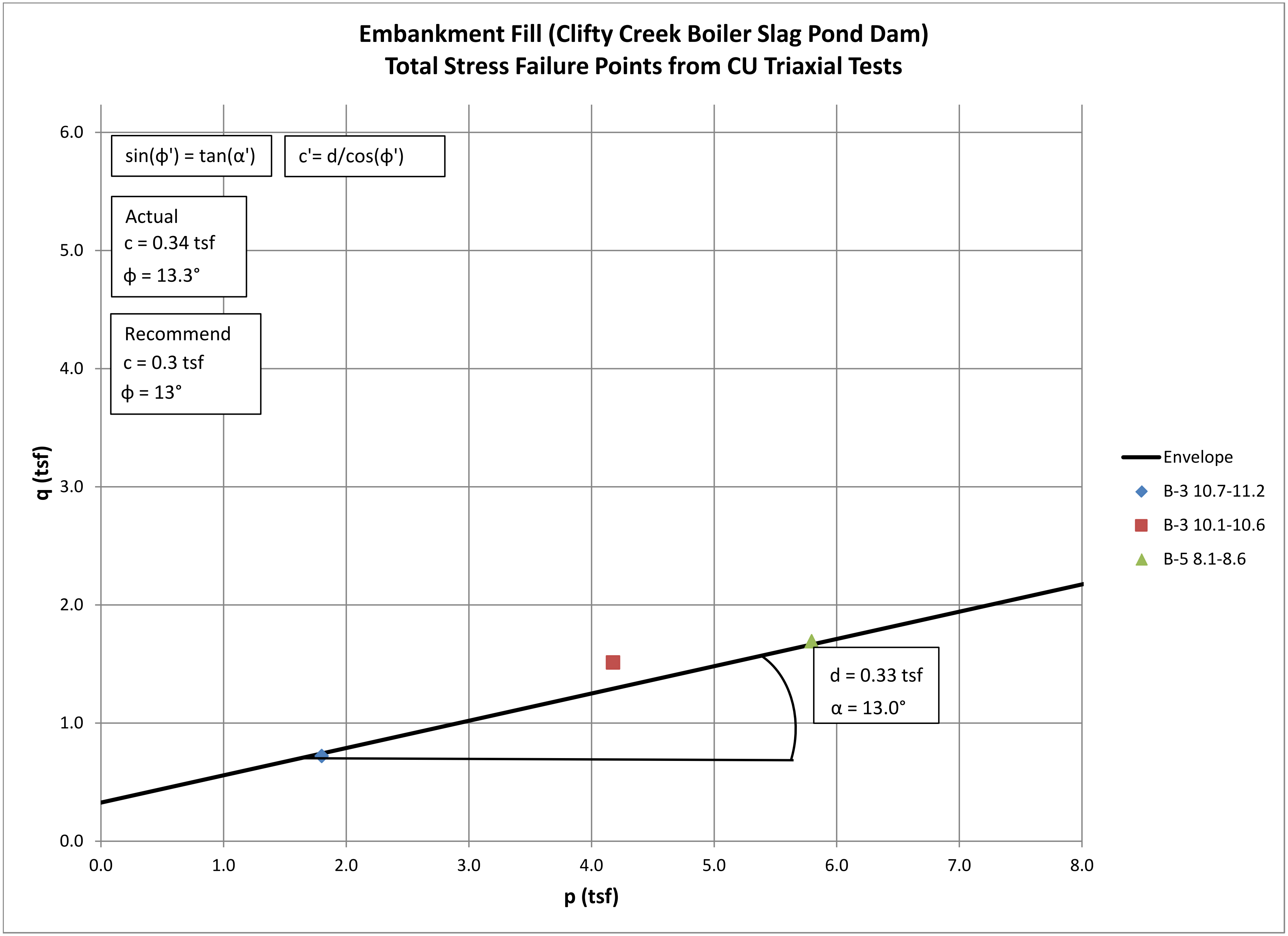
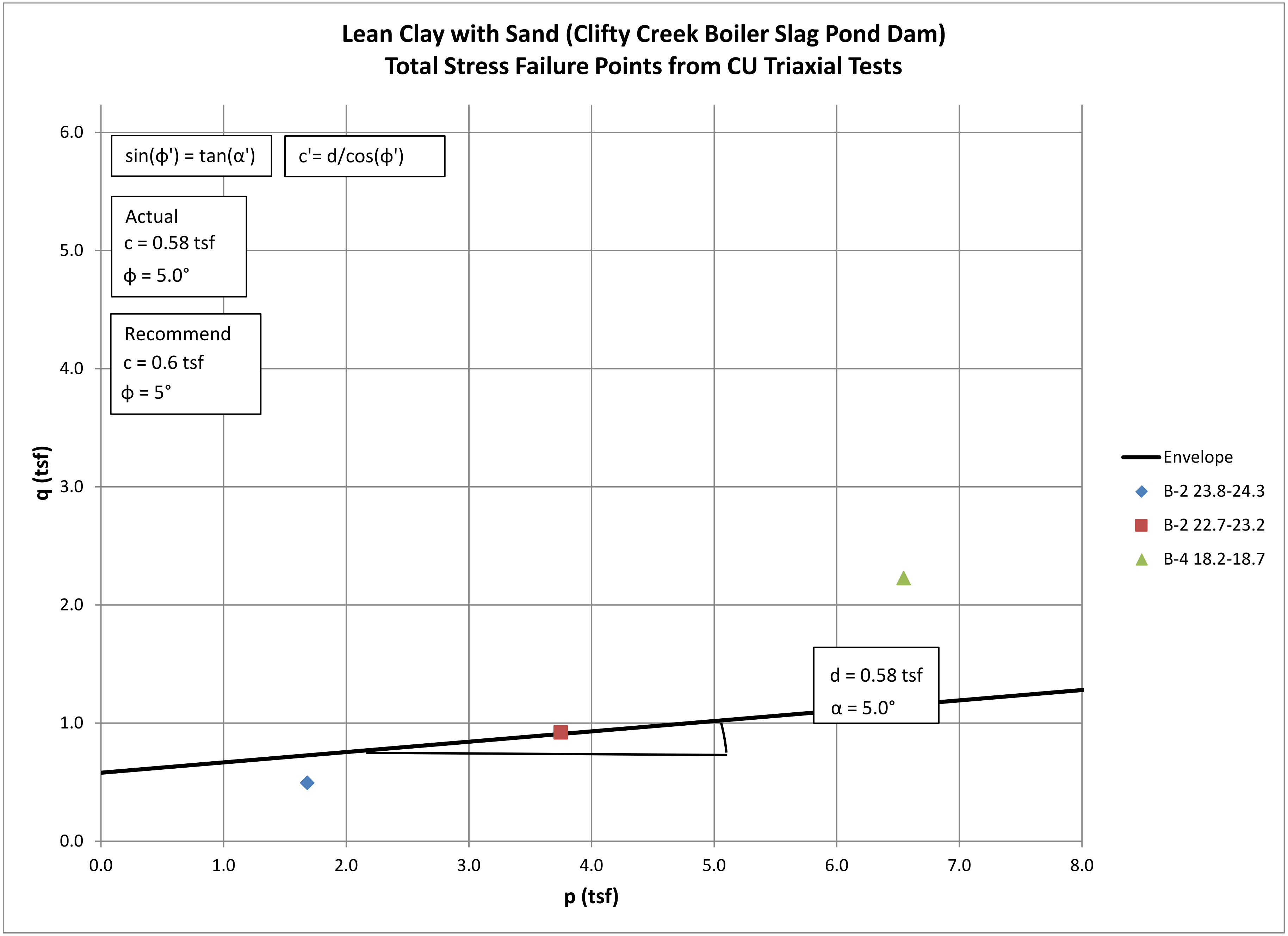


Figure 34. Empirical correlation between friction angle of sands and normalized standard penetration blow count (after Terzaghi et al., 1996)

UNDRAINED CALCULATIONS: BOILER SLAG POND DAM



Embankment Fill (Clifty Creek Boiler Slag Pond Dam)
Total Stress Failure Points from CU Triaxial Tests
sin(ϕ') = tan(α')
c'= d/cos(ϕ')
Actual
c = 0.34 tsf
ϕ = 13.3°
Recommend
c = 0.3 tsf
ϕ = 13°
d = 0.33 tsf
α = 13.0°
q (tsf)
p (tsf)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Envelope
B-3 10.7-11.2
B-3 10.1-10.6
B-5 8.1-8.6



Lean Clay with Sand (Clifty Creek Boiler Slag Pond Dam)
Total Stress Failure Points from CU Triaxial Tests
sin(ϕ') = tan(α')
c'= d/cos(ϕ')
Actual
c = 0.58 tsf
ϕ = 5.0°
Recommend
c = 0.6 tsf
ϕ = 5°
d = 0.58 tsf
α = 5.0°
q (tsf)
p (tsf)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Envelope
B-2 23.8-24.3
B-2 22.7-23.2
B-4 18.2-18.7

PLANT: CLIFTY CREEK
FACILITY: BOILER SLAG POND DAM

MATERIAL: EMBANKMENT FILL

$\sigma_1' - \sigma_3'$ (plot) (psi)	σ_3' (lab request) (psi)	σ_1' (psi)	u (plot) (psi)	σ_1 (psi)	σ_3 (psi)
20	10	30	5	35	15
42	20	62	17	79	37
47	30	77	27	104	57

MATERIAL: LEAN CLAY w/ SAND

$\sigma_1' - \sigma_3'$ (plot) (psi)	σ_3' (lab request) (psi)	σ_1' (psi)	u (plot) (psi)	σ_1 (psi)	σ_3 (psi)
14	10	24	7	31	17
26	20	46	19	65	39
62	30	92	30	122	60

CALCULATED BY: J. SWINDLER

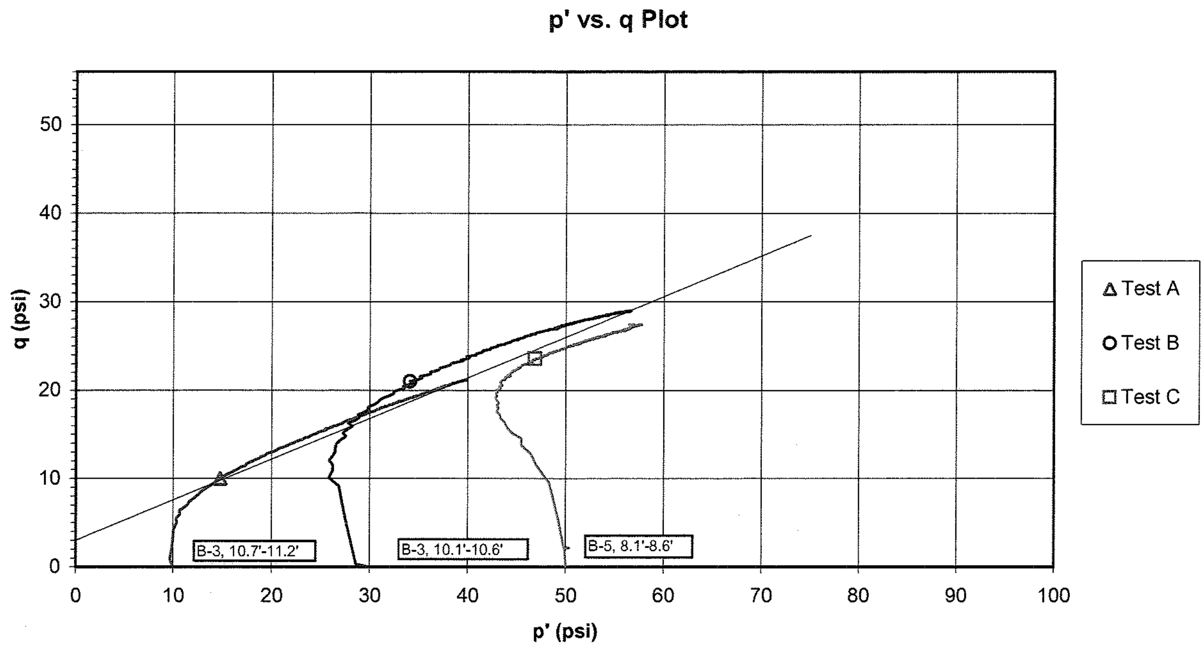
Stantec

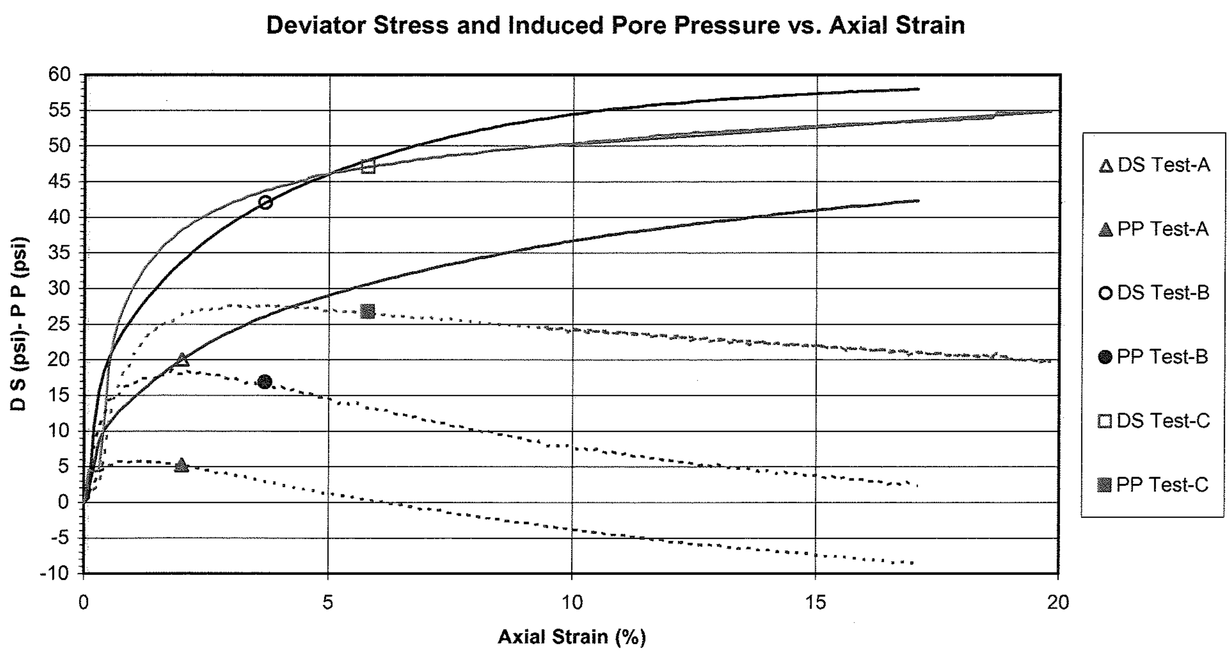
Consolidated Undrained Triaxial Test
ASTM D4767-04

Project	AEP-Clifty Creek-West Bottom and Fly Ash Ponds subsurface exploration	Project No.	175539022
Sample ID	B-3, 10.7'-11.2' & B-3, 10.1'-10.6' & B-5, 8.1'-8.6'	Test Number	1

ϕ' = 27.4 deg. c' = 490 psf

Failure Criterion: Maximum Effective Principal Stress Ratio





Stantec

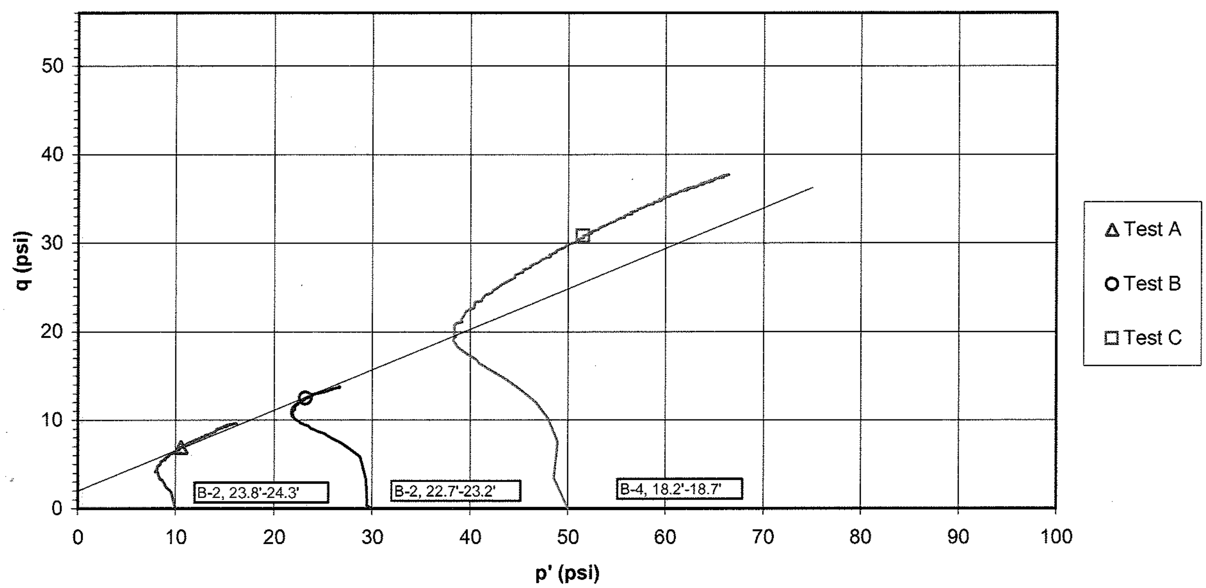
Consolidated Undrained Triaxial Test
ASTM D4767-04

Project	AEP-Clifty Creek-West Bottom Ash and Fly Ash Ponds subsurface exploration	Project No.	175539022
Sample ID	B-2, 23.8'-24.3' & B-2, 22.7'-23.2' & B-4, 18.2'-18.7'	Test Number	2

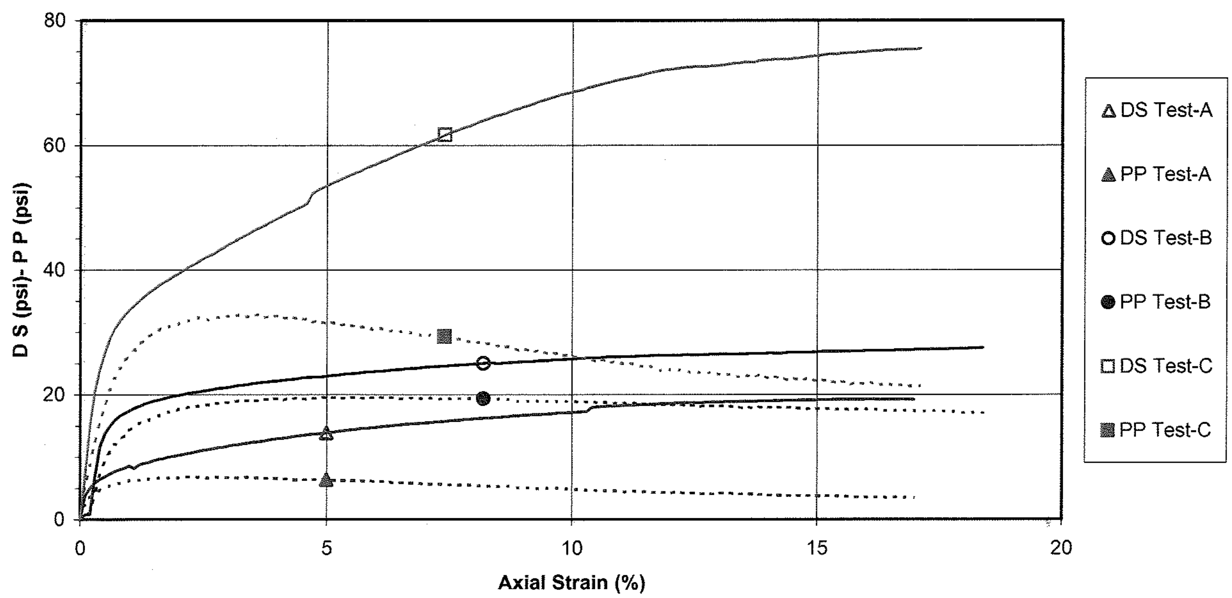
ϕ' = 27.2 deg. c' = 320 psf

Failure Criterion: Maximum Effective Principal Stress Ratio

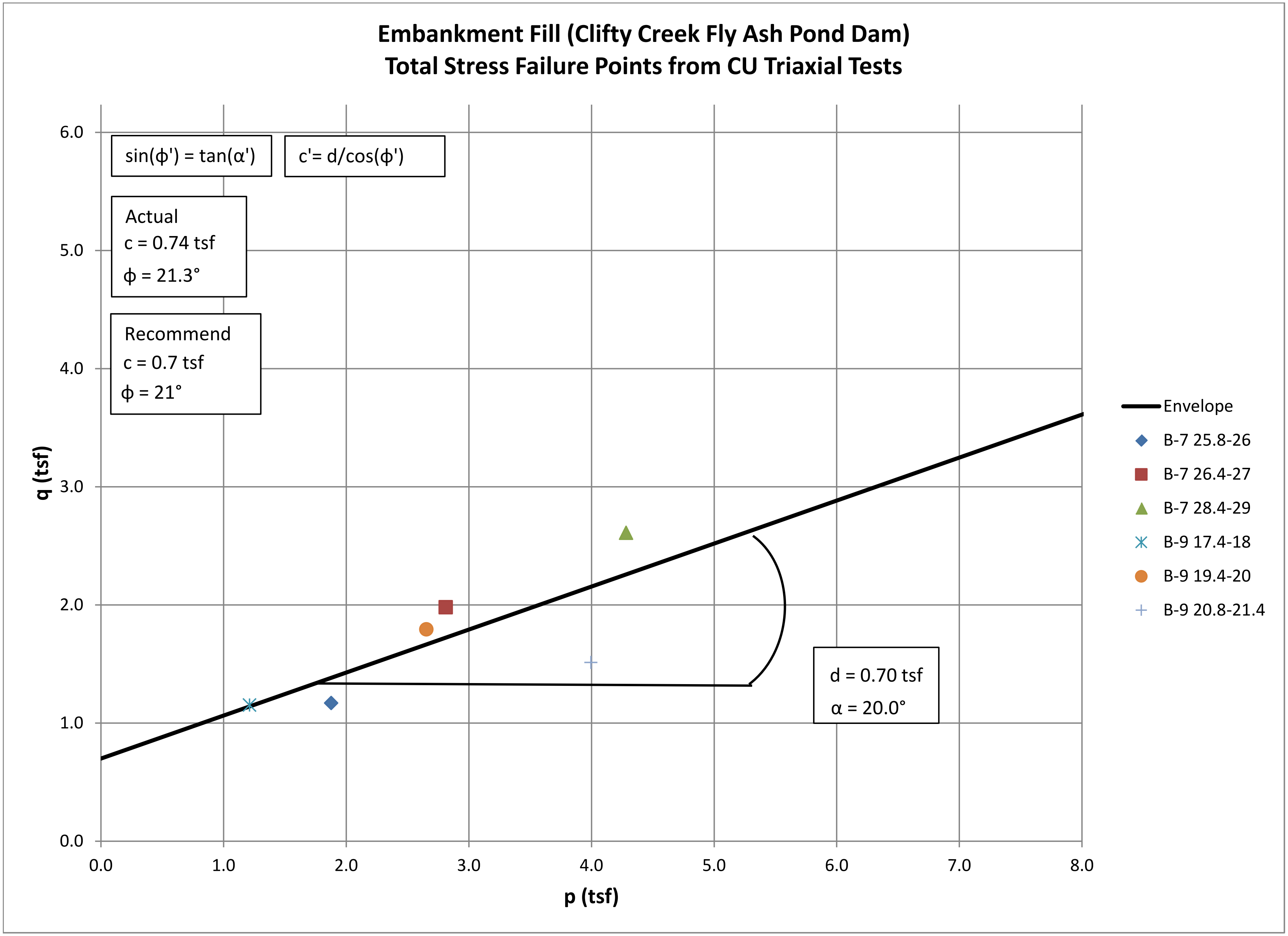
p' vs. q Plot

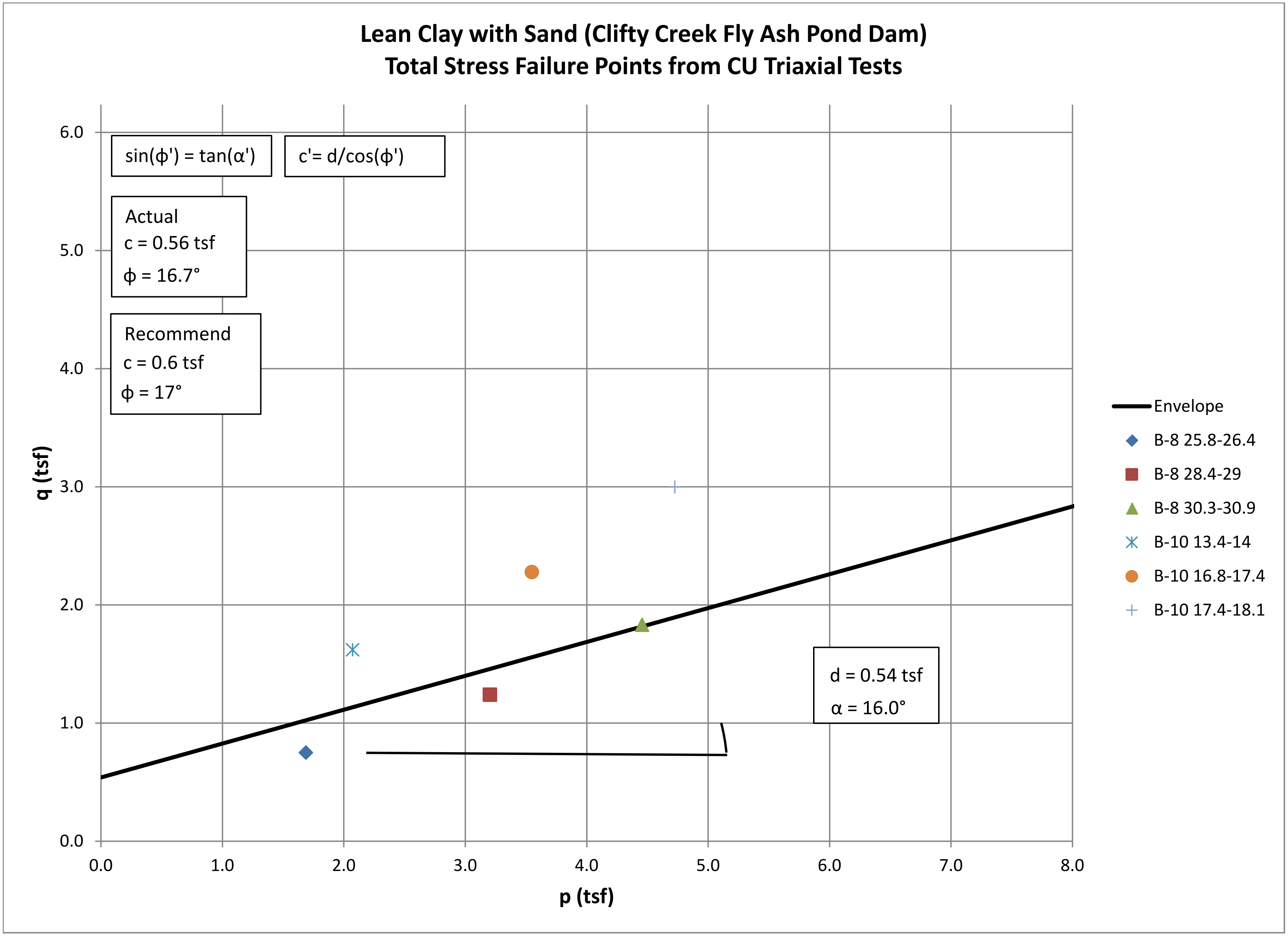


Deviator Stress and Induced Pore Pressure vs. Axial Strain



UNDRAINED CALCULATIONS: LANDFILL RUNOFF COLLECTION POND


Embankment Fill (Clifty Creek Fly Ash Pond Dam)
Total Stress Failure Points from CU Triaxial Tests
sin(ϕ') = tan(α')
c'= d/cos(ϕ')
Actual
c = 0.74 tsf
ϕ = 21.3°
Recommend
c = 0.7 tsf
ϕ = 21°
d = 0.70 tsf
α = 20.0°
q (tsf)
p (tsf)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Envelope
B-7 25.8-26
B-7 26.4-27
B-7 28.4-29
B-9 17.4-18
B-9 19.4-20
B-9 20.8-21.4


Lean Clay with Sand (Clifty Creek Fly Ash Pond Dam)
Total Stress Failure Points from CU Triaxial Tests
sin(ϕ') = tan(α')
c'= d/cos(ϕ')
Actual
c = 0.56 tsf
ϕ = 16.7°
Recommend
c = 0.6 tsf
ϕ = 17°
d = 0.54 tsf
α = 16.0°
q (tsf)
p (tsf)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
Envelope
B-8 25.8-26.4
B-8 28.4-29
B-8 30.3-30.9
B-10 13.4-14
B-10 16.8-17.4
B-10 17.4-18.1

PLANT: CLIFTY CREEK
FACILITY: LANDFILL RUNOFF COLLECTION POND

MATERIAL: EMBANKMENT

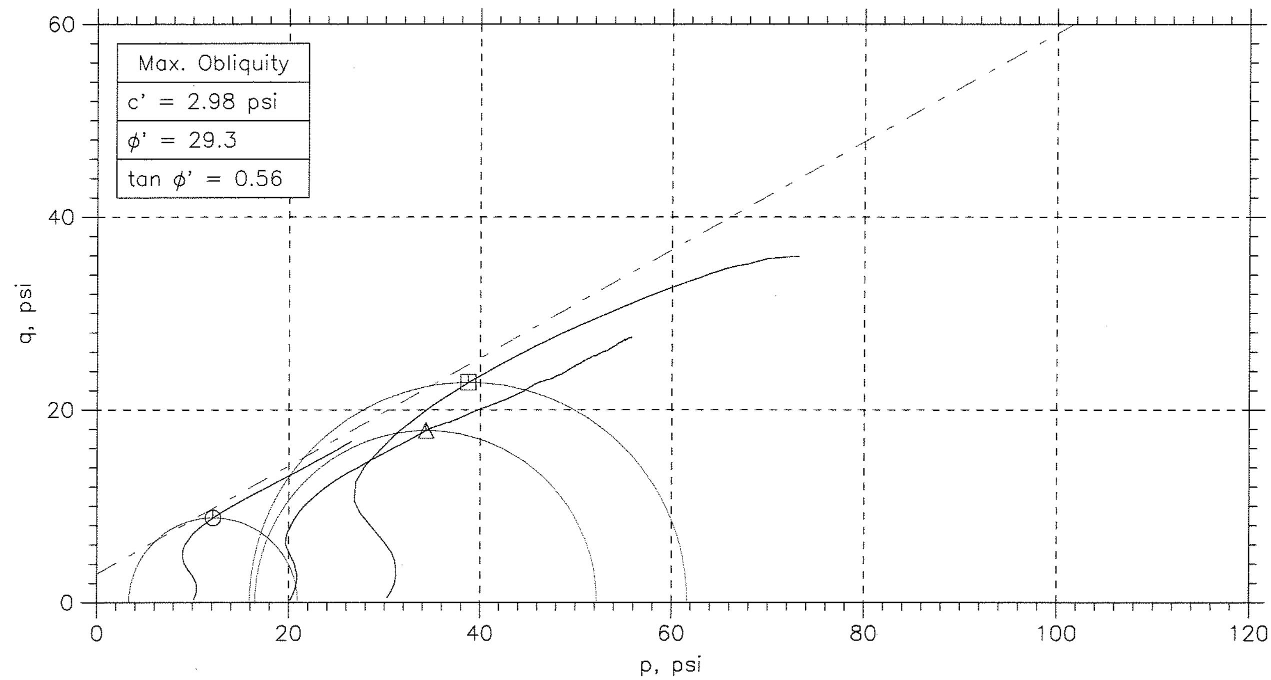
	$\sigma_1' - \sigma_3'$ (plot) (psi)	σ_3' (table) (psi)	σ_1' (psi)	u (plot) (psi)	σ_1 (psi)	σ_3 (psi)
B-7	32.50	9.83	42.33	0.00	42.33	9.83
B-7	55.00	19.88	74.88	-8.33	66.55	11.55
B-7	72.50	29.80	102.30	-6.57	95.73	23.23
B-9	32.00	10.00	42.00	-9.15	32.85	0.85
B-9	49.81	19.96	69.77	-8.00	61.77	11.96
B-9	42.00	29.88	71.88	4.62	76.50	34.50

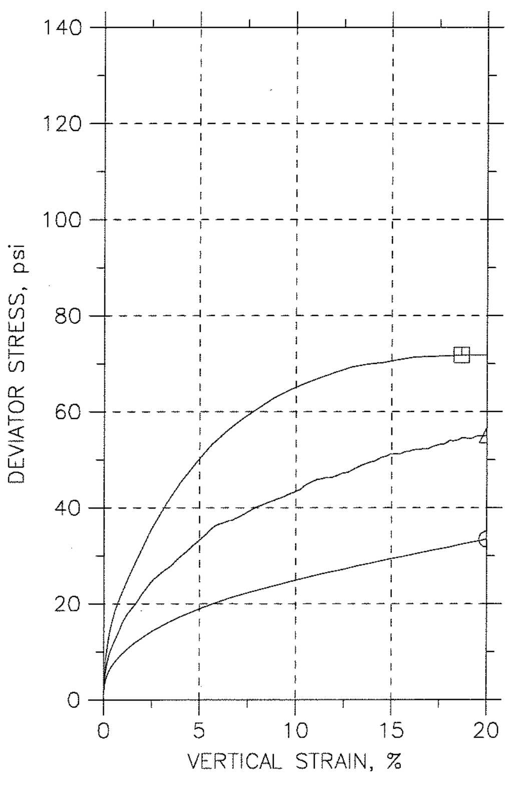
MATERIAL: LEAN CLAY WITH SAND

	$\sigma_1' - \sigma_3'$ (plot) (psi)	σ_3' (table) (psi)	σ_1' (psi)	u (plot) (psi)	σ_1 (psi)	σ_3 (psi)
B-8	20.84	9.97	30.81	3.05	33.86	13.02
B-8	34.42	19.98	54.42	7.30	61.72	27.28
B-8	50.88	29.96	80.84	6.50	87.34	36.46
B-10	45.00	10.00	55.00	-3.72	51.28	6.28
B-10	63.26	19.99	83.25	-2.33	80.92	17.66
B-10	83.26	30.00	113.26	-6.00	107.26	24.00

CALCULATED BY: J. SWINDLER

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





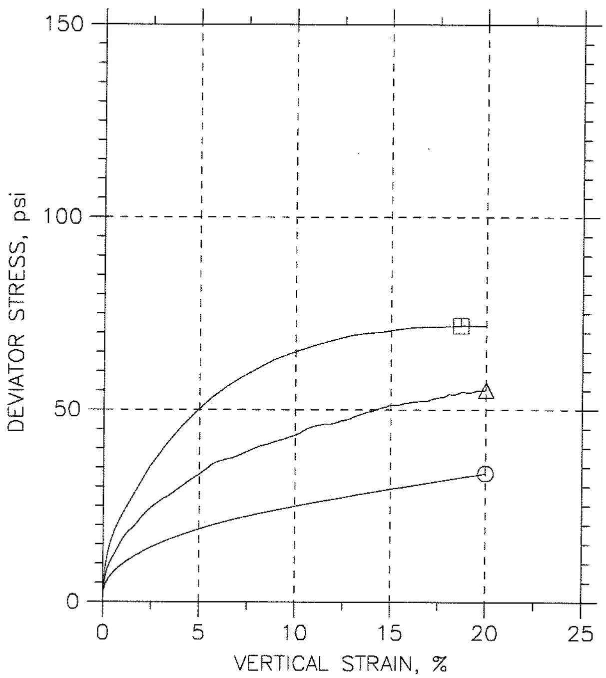
	Symbol	○	△	□	
	Sample No.	---	---	---	
	Test No.	1.1	1.2	1.3	
	Depth	25.8-26.0	26.4-27.0	28.4-29.0	
Initial	Diameter, in	2.835	2.834	2.832	
Initial	Height, in	6.314	5.928	5.929	
Initial	Water Content, %	20.2	21.0	19.0	
Initial	Dry Density, pcf	109.	107.5	111.3	
Initial	Saturation, %	99.8	99.6	99.7	
Initial	Void Ratio	0.546	0.568	0.515	
Before Shear	Water Content, %	21.0	21.6	19.1	
Before Shear	Dry Density, pcf	107.7	106.5	111.2	
Before Shear	Saturation*, %	100.0	100.0	100.0	
Before Shear	Void Ratio	0.566	0.583	0.515	
Before Shear	Back Press., psi	137.2	125.1	116.2	
	Ver. Eff. Cons. Stress, psi	9.834	19.88	29.8	
	Shear Strength, psi	16.74	27.57	35.9	
	Strain at Failure, %	20	20	18.7	
	Strain Rate, %/min	0.08	0.08	0.08	
	B-Value	0.96	0.95	0.95	
	Estimated Specific Gravity	2.7	2.7	2.7	
	Liquid Limit	---	---	---	
	Plastic Limit	---	---	---	

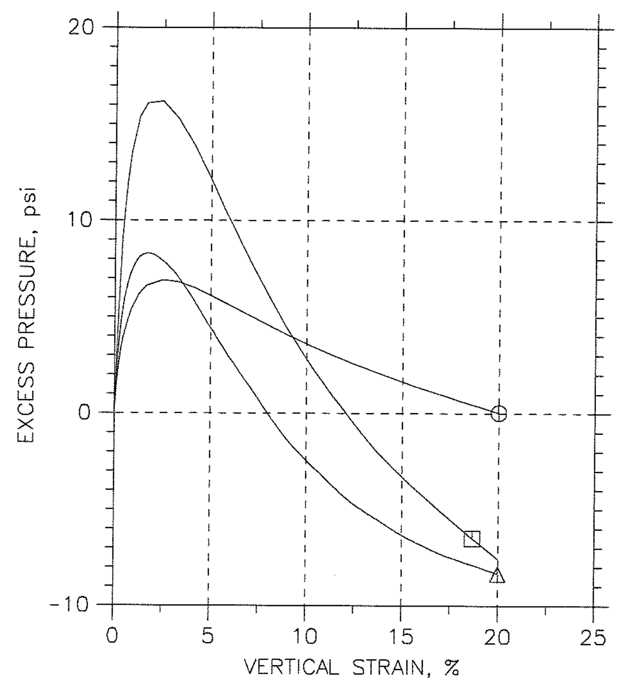
GeoTesting express
a subsidiary of Geocomp Corporation

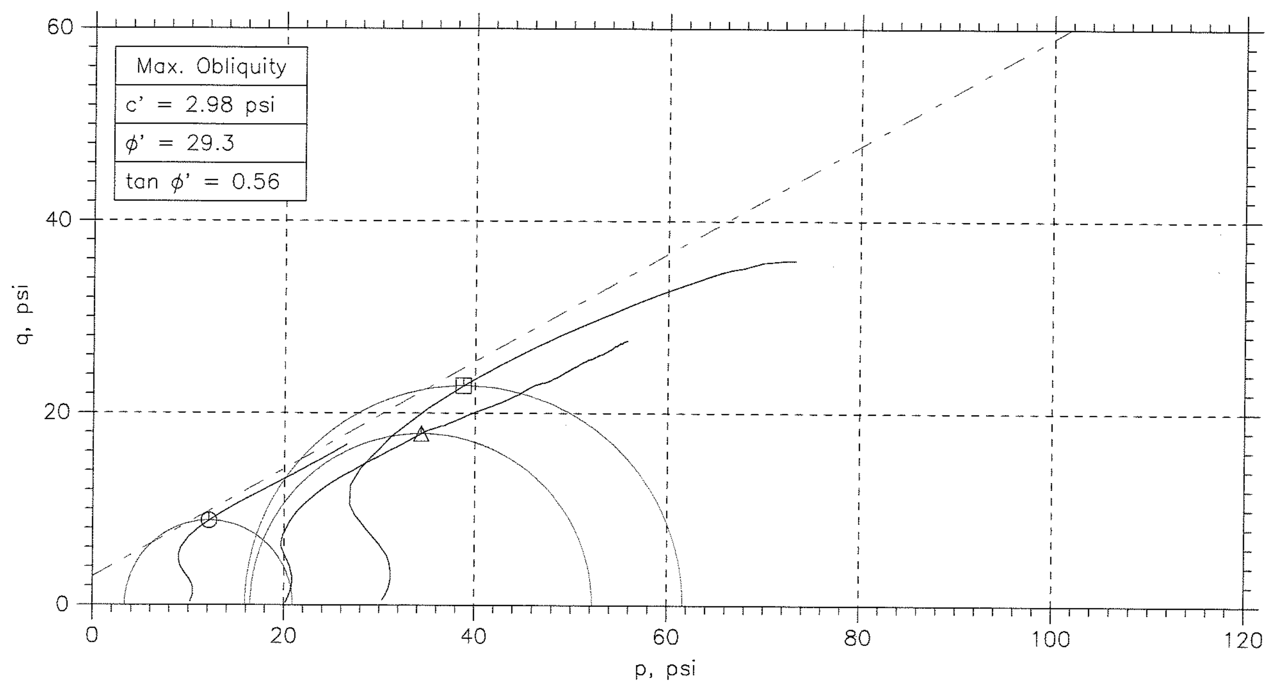
Project: Clifty Creek
Location: Jefferson, IN
Project No.: GTX-1516
Boring No.: B-7
Sample Type: UD
Description: Light Brown
Remarks: System 1062

Mon, 18-JAN-2010 16:57:15

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





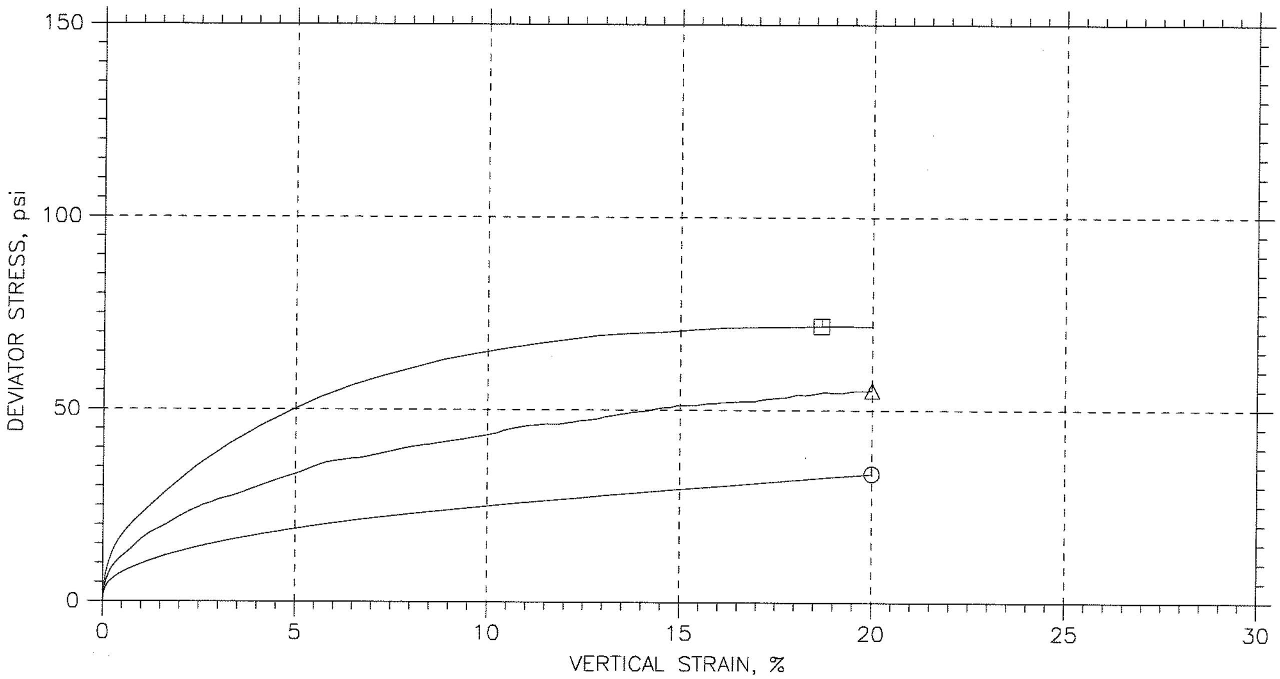


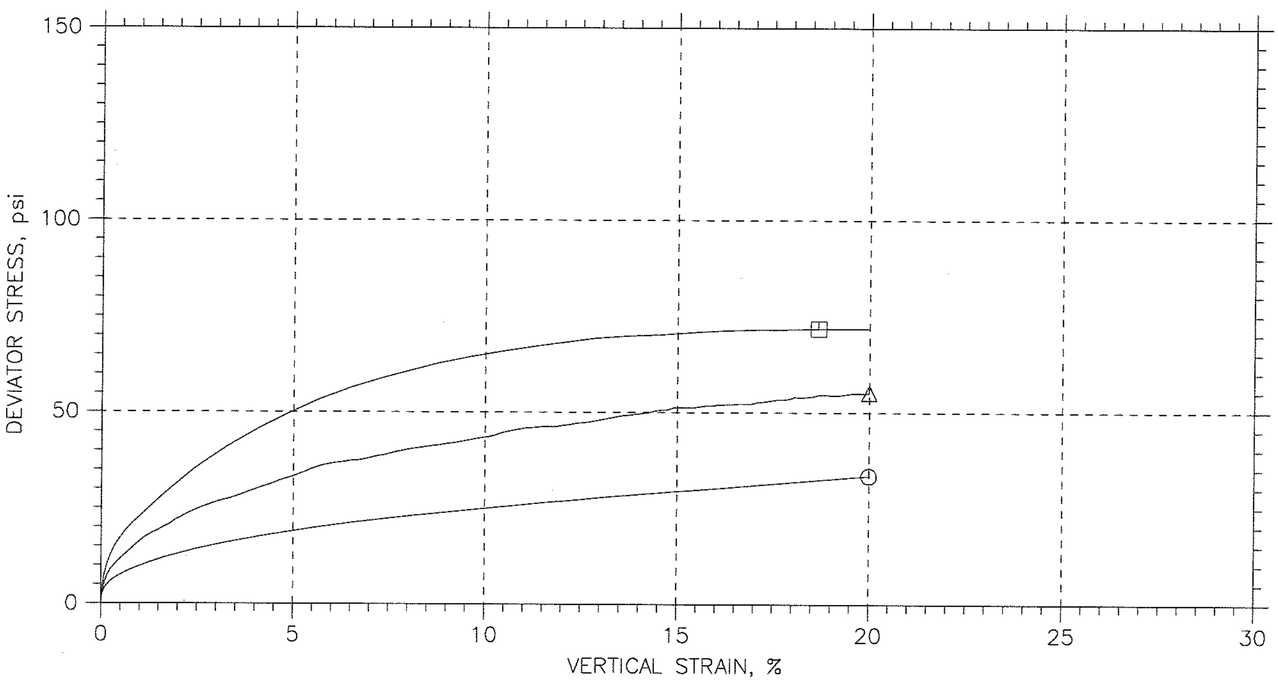
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	1.1	25.8-26.0	jm	12/10/09	mm		1516-1.1.dat
△	---	1.2	26.4-27.0	jm	12/10/09	mm		1516-1.2.dat
□	---	1.3	28.4-29.0	jm	12/9/09	mm		1516-1.3.dat

GeoTesting express a subsidiary of Geocomp Corporation			
	Project: Clifty Creek	Location: Jefferson, IN	Project No.: GTX-1516
	Boring No.: B-7	Sample Type: UD	
	Description: Light Brown		
	Remarks: System 1062		

Mon, 18-JAN-2010 16:57:17

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





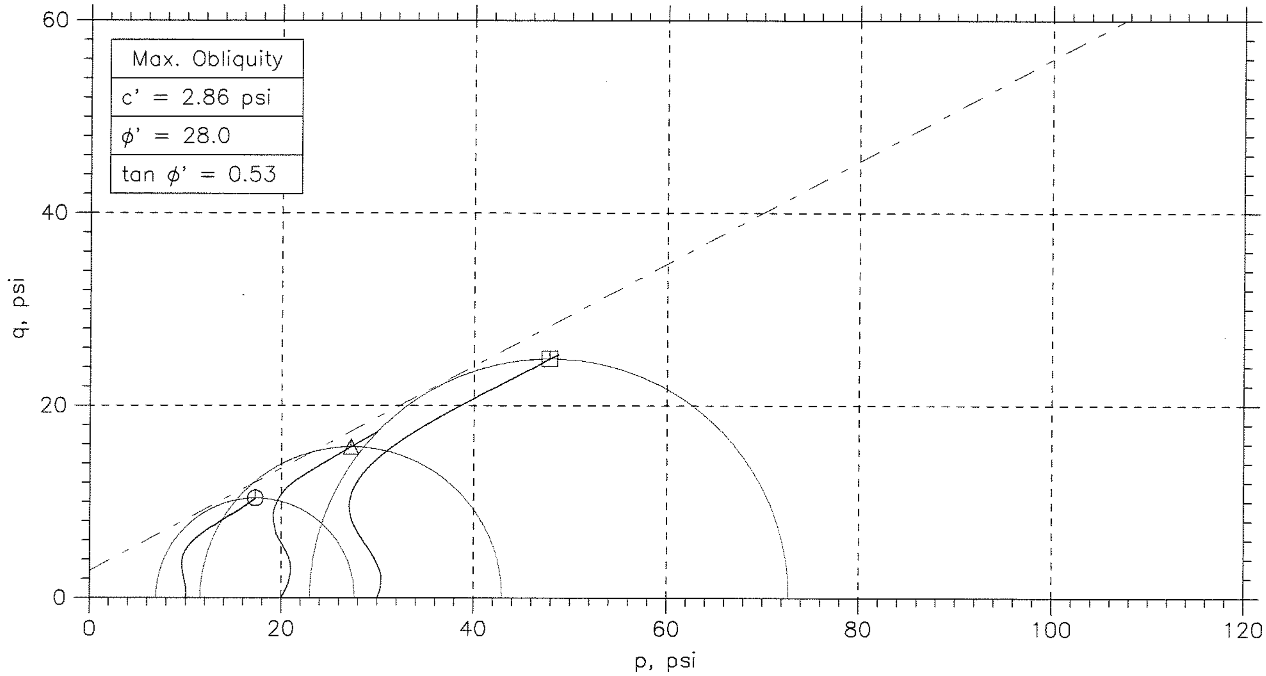
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	1.1	25.8-26.0	jm	12/10/09	mm		1516-1.1.dat
△	---	1.2	26.4-27.0	jm	12/10/09	mm		1516-1.2.dat
□	---	1.3	28.4-29.0	jm	12/9/09	mm		1516-1.3.dat

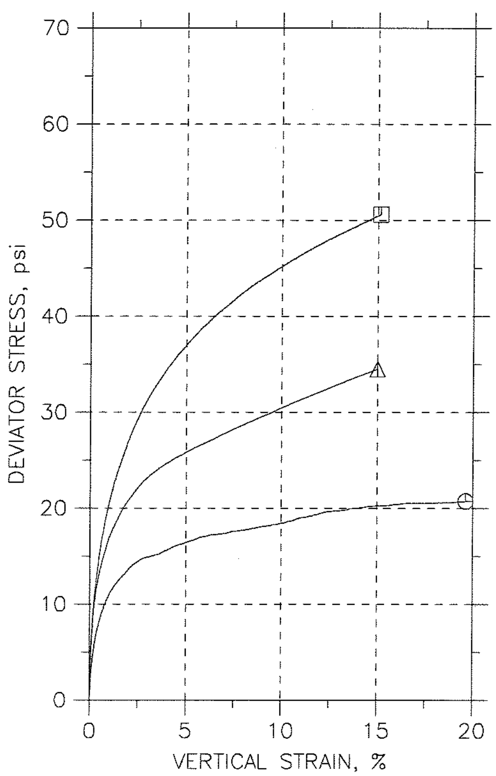
GeoTesting express
a subsidiary of Geocomp Corporation

Project: Clifty Creek	Location: Jefferson, IN	Project No.: GTX-1516
Boring No.: B-7	Sample Type: UD	
Description: Light Brown		
Remarks: System 1062		

Mon, 18-JAN-2010 16:57:18

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



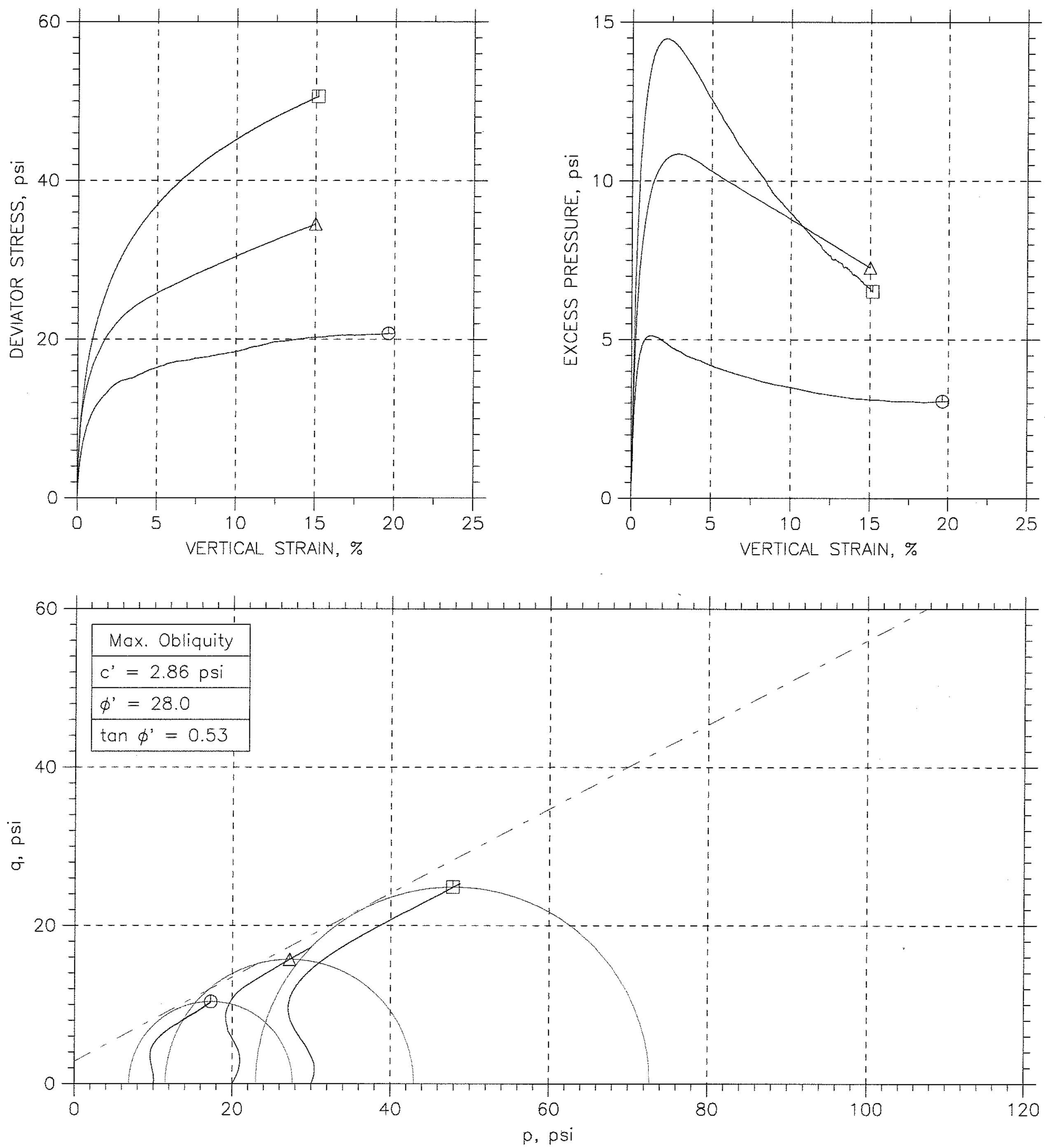


Symbol		○	△	□	
Sample No.		---	---	---	
Test No.		2.1	2.2	2.3	
Depth		25.8-26.4	28.4-29.0	30.3-30.9'	
Initial	Diameter, in	2.82	2.824	2.838	
	Height, in	5.82	6.027	6.001	
	Water Content, %	21.0	20.7	20.9	
	Dry Density, pcf	107.2	107.6	107.6	
	Saturation, %	99.2	98.7	99.6	
	Void Ratio	0.572	0.567	0.567	
Before Shear	Water Content, %	20.5	19.8	19.0	
	Dry Density, pcf	108.5	109.8	111.4	
	Saturation*, %	100.0	100.0	100.0	
	Void Ratio	0.554	0.535	0.513	
	Back Press., psi	59.25	124.8	56.31	
Ver. Eff. Cons. Stress, psi		9.968	19.98	29.96	
Shear Strength, psi		10.37	17.25	25.3	
Strain at Failure, %		19.6	15	15.2	
Strain Rate, %/min		0.016	0.016	0.016	
B-Value		0.95	0.96	0.95	
Estimated Specific Gravity		2.7	2.7	2.7	
Liquid Limit		---	---	---	
Plastic Limit		---	---	---	

GeoTesting express a subsidiary of Geocomp Corporation	Project: Clifty Creek
	Location: Jefferson, IN.
	Project No.: GTX-1516
	Boring No.: B-8
	Sample Type: UD
	Description: Greenish brown lean clay with sand
	Remarks: 2054

Tue, 19-JAN-2010 09:45:51

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767

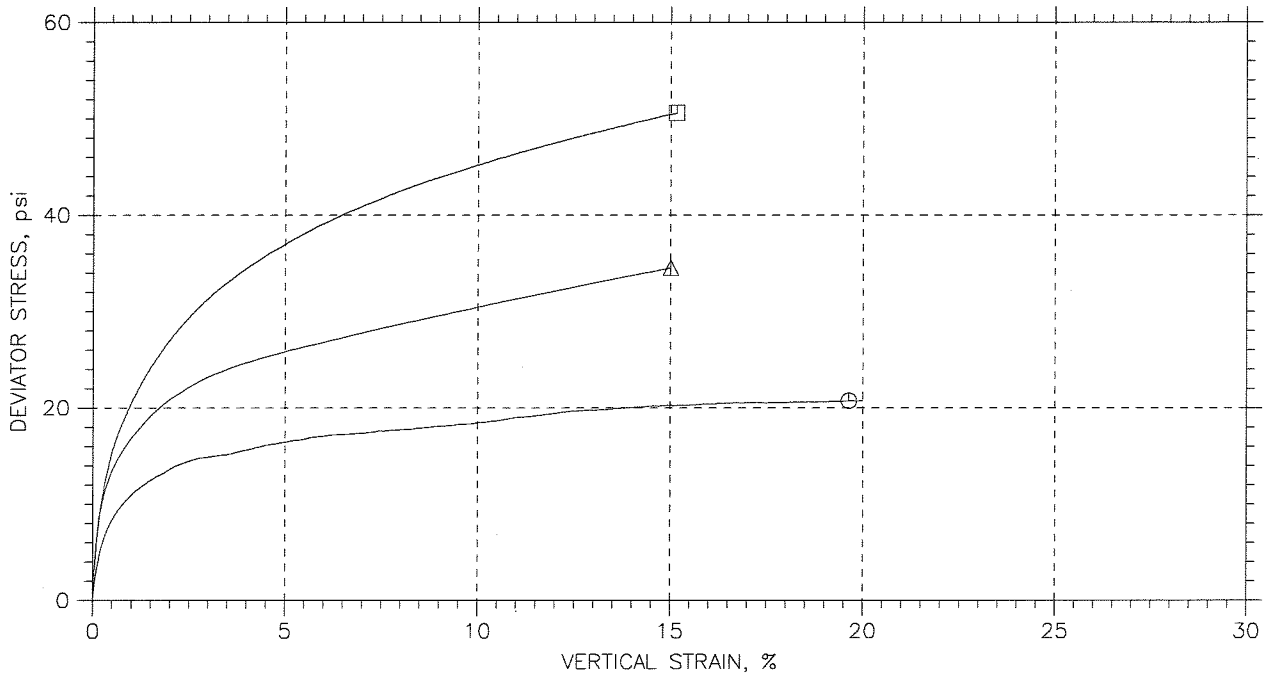


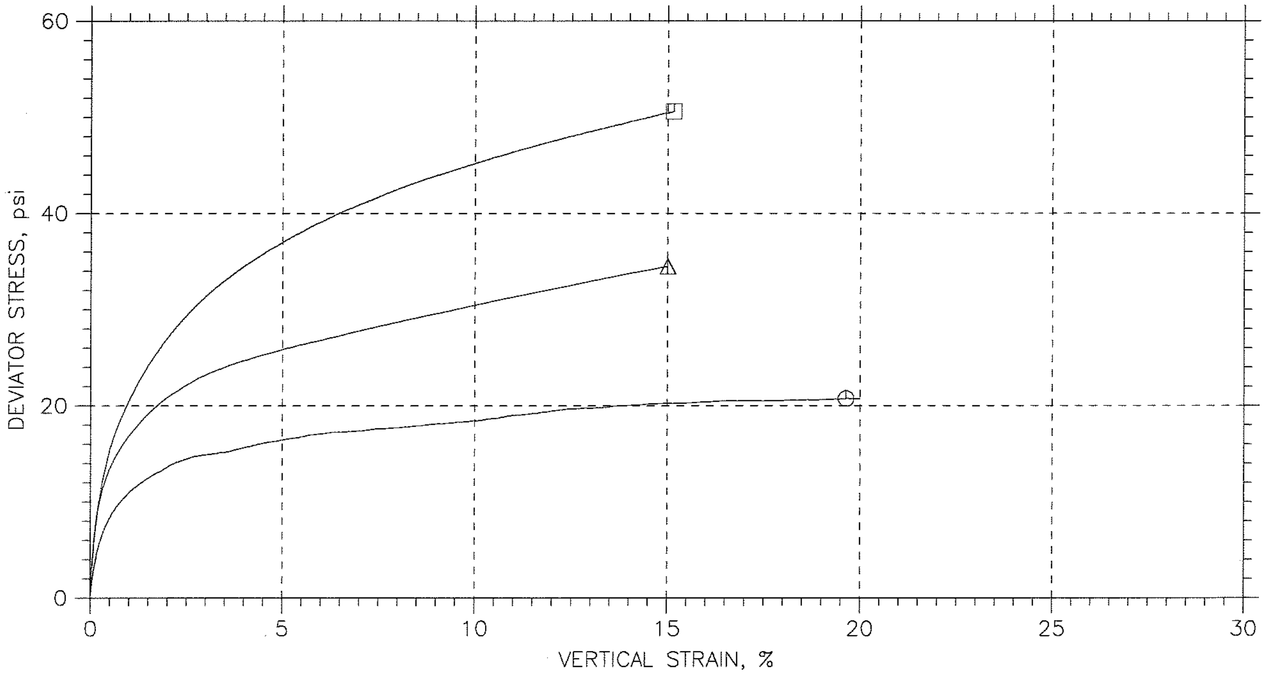
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	2.1	25.8-26.4	jm	12/11/09	mm		1516-2.1.dat
△	---	2.2	28.4-29.0	jm	12/11/09	mm		1516-2.2A.dat
□	---	2.3	30.3-30.9'	jm	12/09/09	mm		1516-2.3.dat

GeoTesting express, a subsidiary of Geocomp Corporation			
	Project: Clifty Creek	Location: Jefferson, IN.	Project No.: GTX-1516
	Boring No.: B-8	Sample Type: UD	
	Description: Greenish brown lean clay with sand		
	Remarks: 2054		

Tue, 19-JAN-2010 09:45:53

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





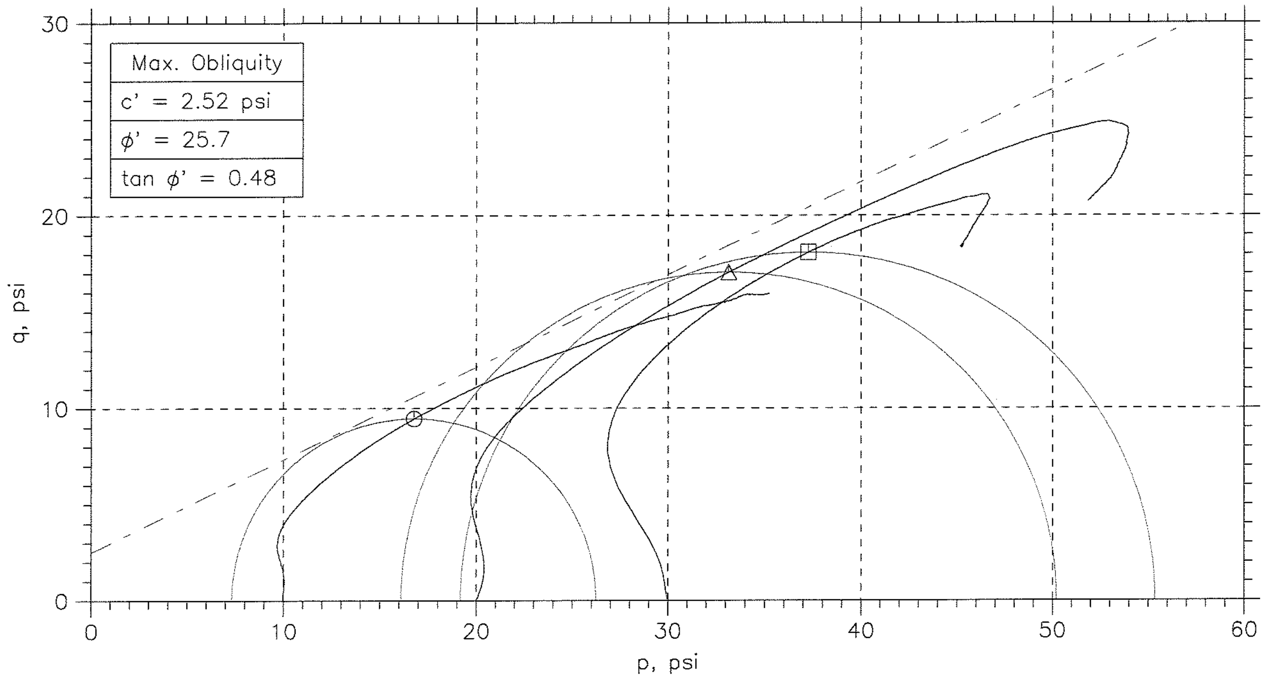
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
⊖	---	2.1	25.8-26.4	jm	12/11/09	mm		1516-2.1.dat
△	---	2.2	28.4-29.0	jm	12/11/09	mm		1516-2.2A.dat
◫	---	2.3	30.3-30.9'	jm	12/09/09	mm		1516-2.3.dat

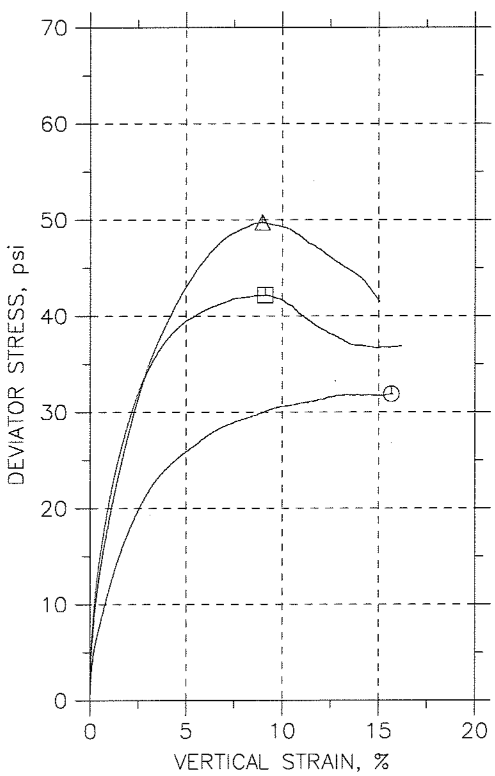
GeoTesting express
a subsidiary of Geocomp Corporation

Project: Clifty Creek	Location: Jefferson, IN.	Project No.: GTX-1516
Boring No.: B-8	Sample Type: UD	
Description: Greenish brown lean clay with sand		
Remarks: 2054		

Tue, 19-JAN-2010 09:45:54

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





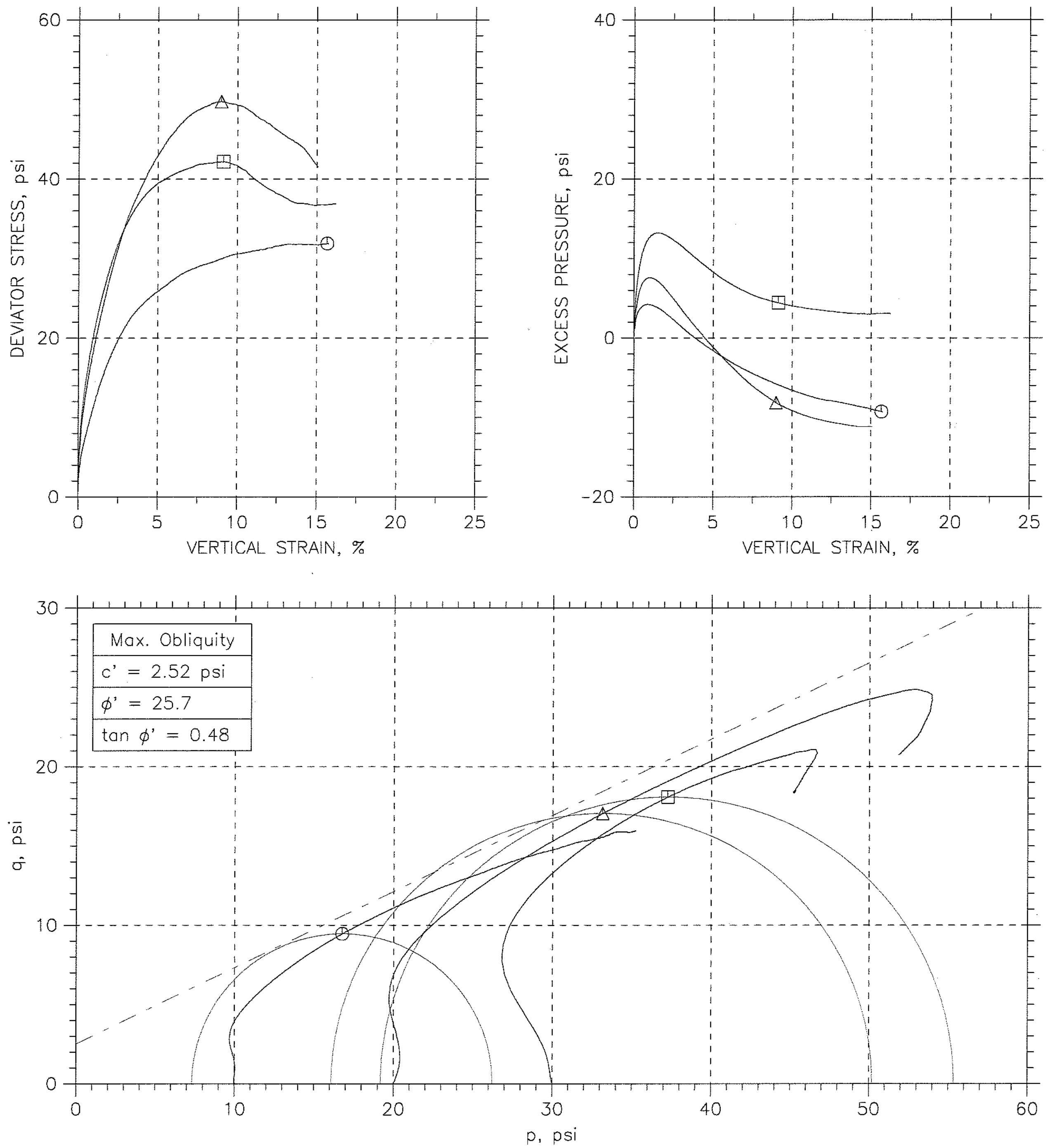
Symbol		○	△	□	
Sample No.		---	---	---	
Test No.		3.1	3.2	3.3	
Depth		17.4-18.0	19.4-20.0	20.8--21.4	
Initial	Diameter, in	2.835	2.835	2.837	
	Height, in	6.319	6.281	6.177	
	Water Content, %	19.4	18.4	20.8	
	Dry Density, pcf	109.7	111.4	107.3	
	Saturation, %	97.8	96.9	98.6	
	Void Ratio	0.536	0.514	0.571	
Before Shear	Water Content, %	19.2	18.9	22.7	
	Dry Density, pcf	111.	111.7	104.5	
	Saturation*, %	100.0	100.0	100.0	
	Void Ratio	0.518	0.509	0.613	
	Back Press., psi	136.8	122	116.2	
Ver. Eff. Cons. Stress, psi		9.997	19.96	29.88	
Shear Strength, psi		15.94	24.86	21.08	
Strain at Failure, %		15.7	8.98	9.12	
Strain Rate, %/min		0.016	0.016	0.016	
B-Value		0.95	0.96	0.95	
Estimated Specific Gravity		2.7	2.7	2.7	
Liquid Limit		---	---	---	
Plastic Limit		---	---	---	

GeoTesting express
a subsidiary of Geocomp Corporation

Project: Clifty Creek	
Location: Jefferson, IN	
Project No.: GTX-1516	
Boring No.: B-9	
Sample Type: UD	
Description: Brown lean clay with sand	
Remarks: System 1057	

Tue, 19-JAN-2010 10:34:11

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



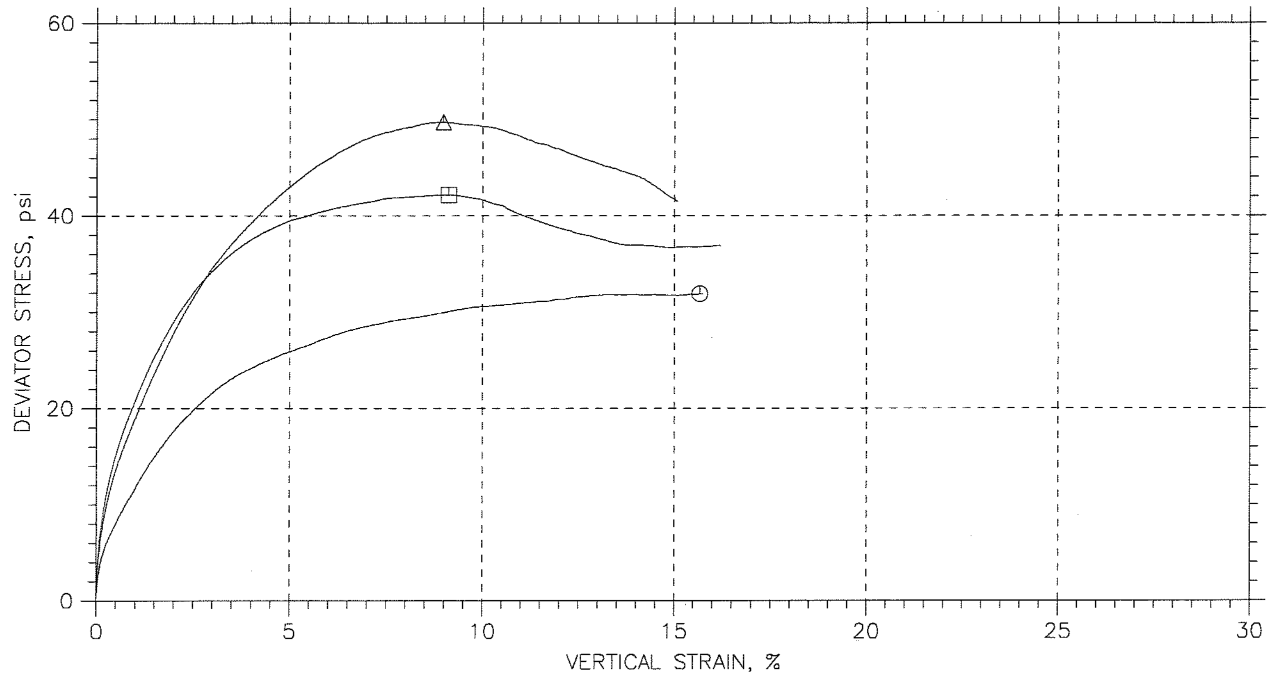
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	3.1	17.4-18.0	jm	12/15/09	mm		1516-3.1.dat
△	---	3.2	19.4-20.0	jm	12/16/09	mm		1516-3.2Adat.dat
□	---	3.3	20.8--21.4	jm	12/10/09	mm		1516-3.3.dat

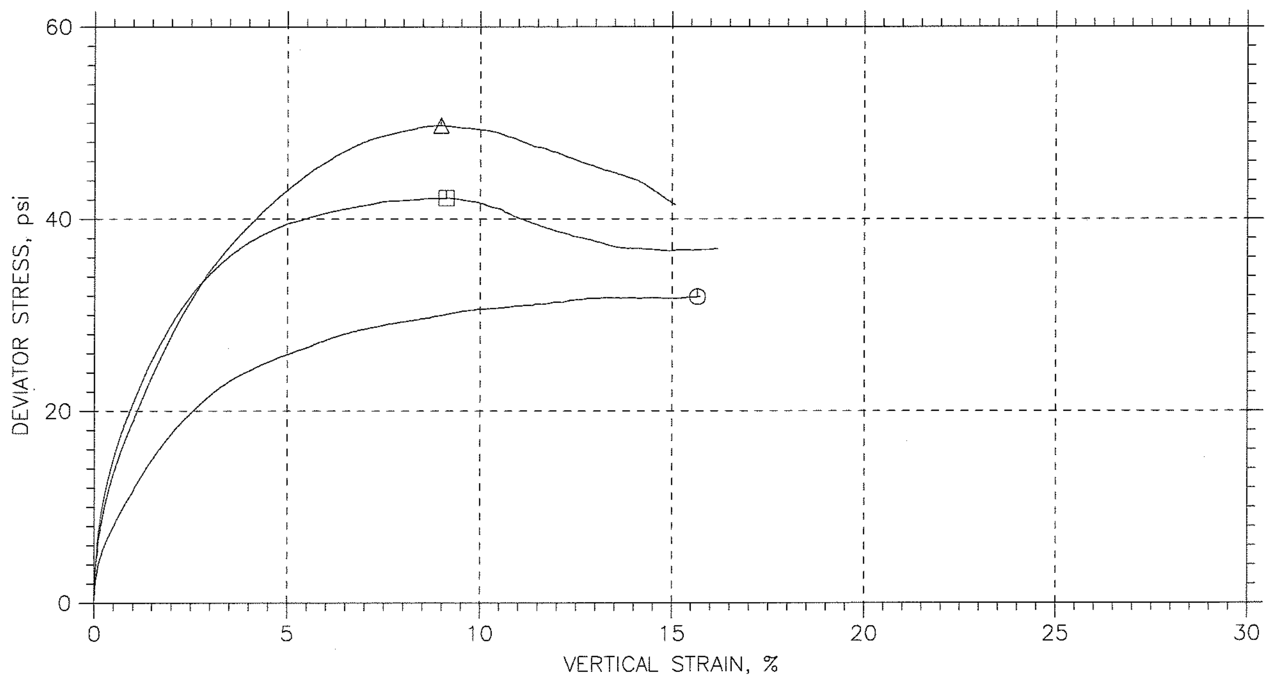
GeoTesting express
a subsidiary of Geocomp Corporation

Project: Clifty Creek	Location: Jefferson, IN	Project No.: GTX-1516
Boring No.: B-9	Sample Type: UD	
Description: Brown lean clay with sand		
Remarks: System 1057		

Tue, 19-JAN-2010 10:34:12

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





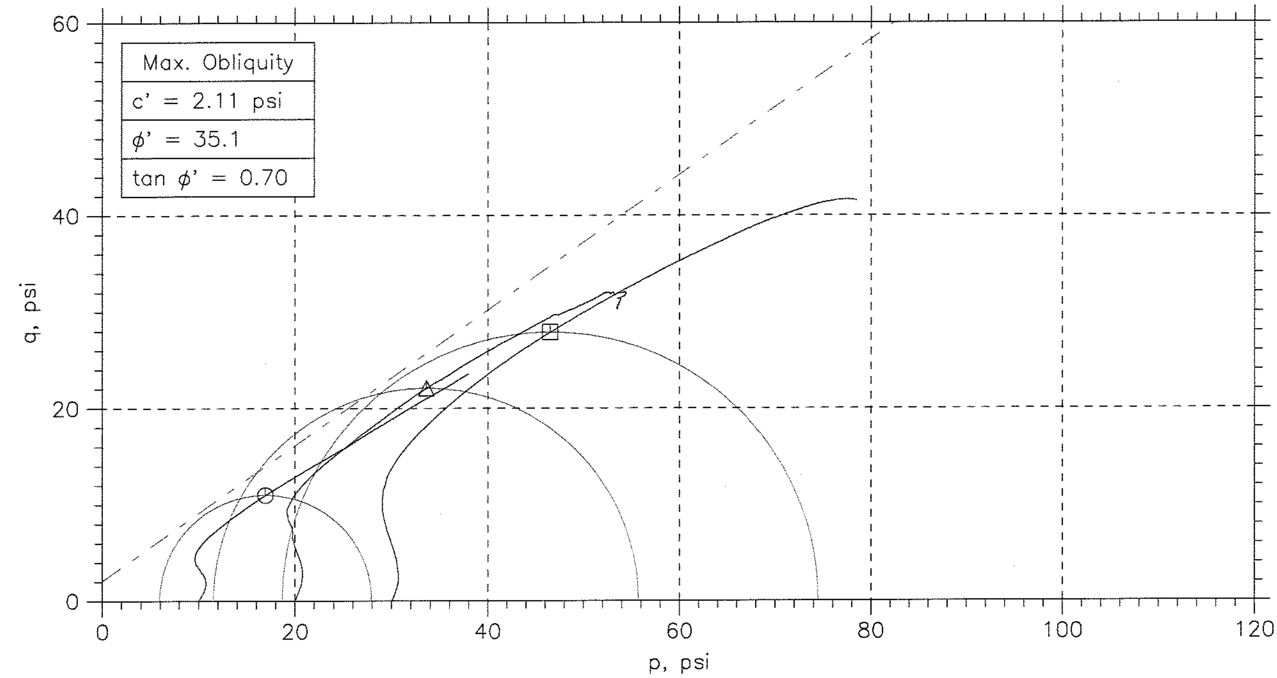
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	3.1	17.4-18.0	jm	12/15/09	mm		1516-3.1.dat
△	---	3.2	19.4-20.0	jm	12/16/09	mm		1516-3.2Adat.dat
□	---	3.3	20.8--21.4	jm	12/10/09	mm		1516-3.3.dat

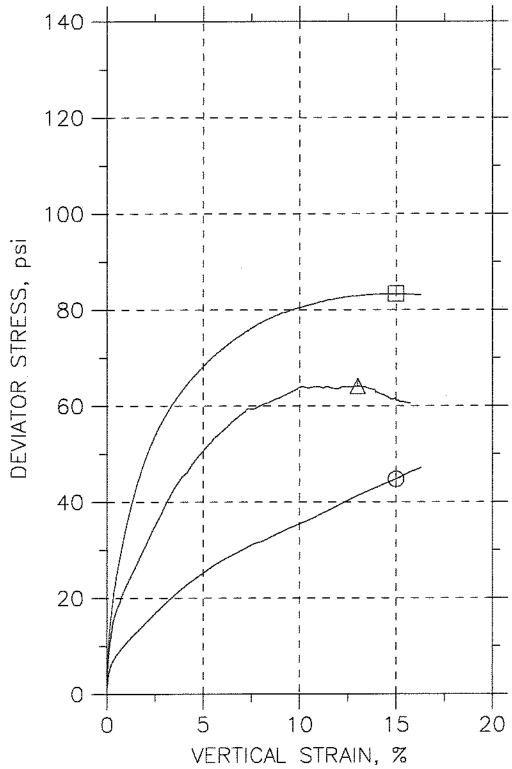
GeoTesting express
a subsidiary of Geocomp Corporation

Project: Clifty Creek	Location: Jefferson, IN	Project No.: GTX-1516
Boring No.: B-9	Sample Type: UD	
Description: Brown lean clay with sand		
Remarks: System 1057		

Tue, 19-JAN-2010 10:34:14

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767



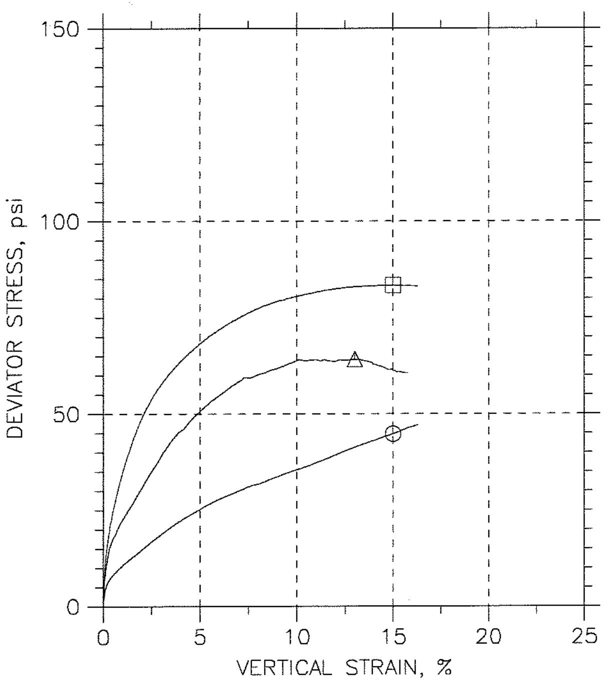


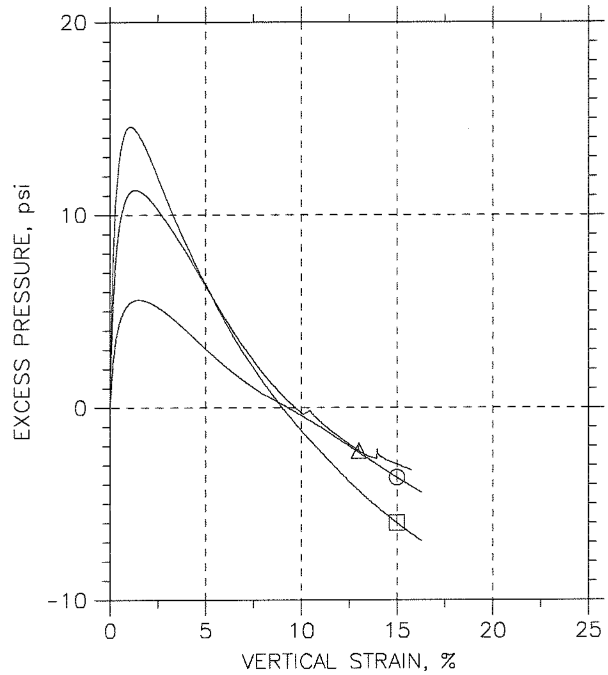
		○	△	□	
Symbol		○	△	□	
Sample No.		---	----	----	
Test No.		CU-4.1	CU-4.2	CU-4.3	
Depth		13.4-14.0'	16.8-17.4'	17.4-18.'	
Initial	Diameter, in	2.83	2.71	2.72	
	Height, in	5.78	5.52	5.51	
	Water Content, %	14.2	27.4	26.6	
	Dry Density, pcf	102.9	93.8	93.72	
	Saturation, %	59.9	93.0	89.9	
	Void Ratio	0.638	0.797	0.798	
Before Shear	Water Content, %	23.2	18.5	19.2	
	Dry Density, pcf	103.7	112.4	111.	
	Saturation*, %	100.0	100.0	100.0	
	Void Ratio	0.625	0.5	0.519	
	Back Press., psi	27.99	73	84.99	
Ver. Eff. Cons. Stress, psi		10	19.99	30	
Shear Strength, psi		22.37	32.06	41.66	
Strain at Failure, %		15	13	15	
Strain Rate, %/min		0.032	0.032	0.032	
B-Value		0.95	0.95	0.96	
Estimated Specific Gravity		2.7	2.7	2.7	
Liquid Limit		---	---	---	
Plastic Limit		---	---	---	

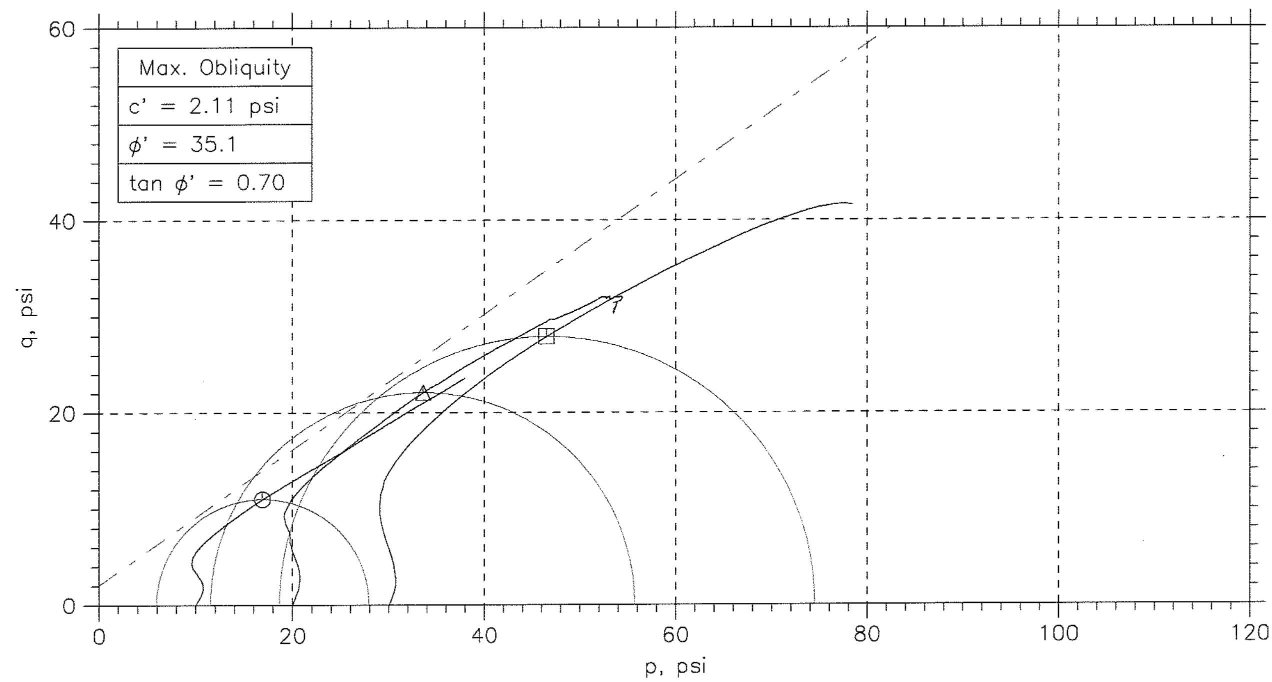
GeoTesting express a subsidiary of Geocomp Corporation	Project: Clifty Creek
	Location: ----
	Project No.: GTX-1516
	Boring No.: B-10
	Sample Type: UD
	Description:
	Remarks: 2054

Tue, 19-JAN-2010 11:56:28

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767







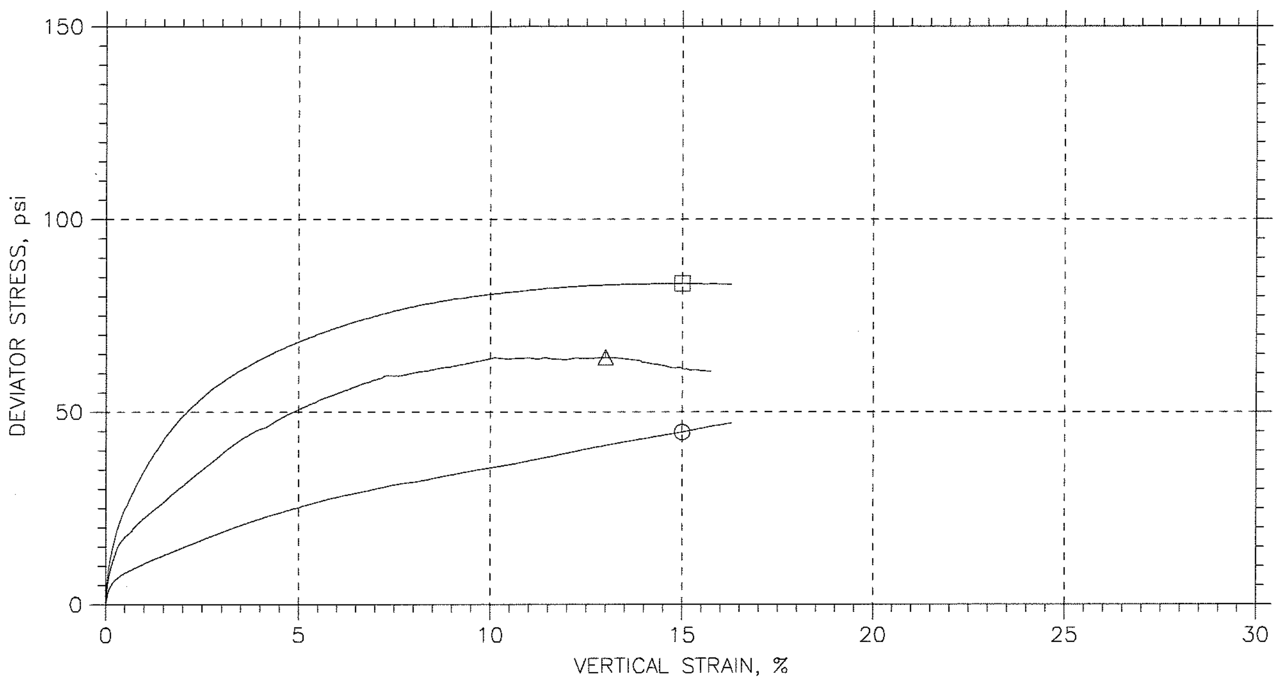
	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	CU-4.1	13.4-14.0'	JM	12/12/09	MM		1516-4.1.dat
△	----	CU-4.2	16.8-17.4'	JM	12/13/09	MM		1516-4.2.dat
□	----	CU-4.3	17.4-18.'	JM	12/12/09	MM		1516-4.3.dat

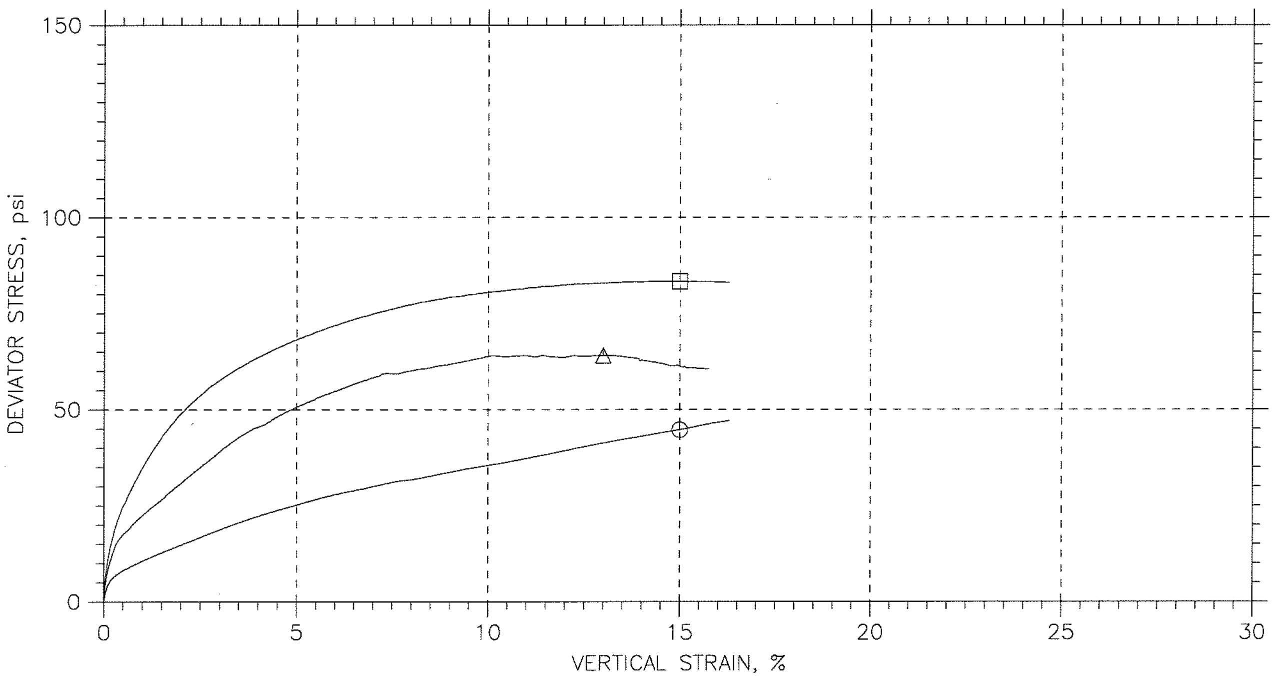
GeoTesting express
a subsidiary of Geocomp Corporation

Project: Clifty Creek	Location: ----	Project No.: GTX-1516
Boring No.: B-10	Sample Type: UD	
Description:		
Remarks: 2054		

Tue, 19-JAN-2010 11:56:29

CONSOLIDATED UNDRAINED TRIAXIAL TEST by ASTM D4767





	Sample No.	Test No.	Depth	Tested By	Test Date	Checked By	Check Date	Test File
○	---	CU-4.1	13.4-14.0'	JM	12/12/09	MM		1516-4.1.dat
△	----	CU-4.2	16.8-17.4'	JM	12/13/09	MM		1516-4.2.dat
□	----	CU-4.3	17.4-18.'	JM	12/12/09	MM		1516-4.3.dat

GeoTesting express
a subsidiary of Geocomp Corporation

Project: Clifty Creek	Location: ----	Project No.: GTX-1516
Boring No.: B-10	Sample Type: UD	
Description:		
Remarks: 2054		

Tue, 19-JAN-2010 11:56:31