REPORT ON EARTHQUAKE-INDUCED LIQUEFACTION FOR EASTERN DIKE OF FLY ASH DISPOSAL FACILITY PHILIP SPORN POWER PLANT NEW HAVEN, MASON COUNTY, WEST VIRGINIA NPDES NO. WV0001058

Prepared For:
American Electric Power Service Corporation
1 Riverside Plaza
Columbus, Ohio 43215

Prepared By:
Geo/Environmental Associates, Inc.
3502 Overlook Circle
Knoxville, TN 37909

GA File No. 09-387
July 23, 2010

GA

STATEMENT OF CERTIFICATION

I certify that the information contained or accompanying this submission is true, accurate, and complete.

As to the identified portion(s) of this submission for which I cannot personally verify its truth and accuracy, I certify as the company official having supervisory responsibility for the person(s) who, acting under my direct instructions made the verification, that this information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment.

By Thomas R Zylenia
(Signature)

Director Civil Engineering
(Title)

August 23, 2010
(Date)

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APPENDICES

Geo/Environmental Associates, Inc.

3502 Overlook Circle • Knoxville, TN 37909 • 865-584-0344 • Fax 865-584-0778 • www.geoe.com

July 23, 2010

American Electric Power
1 Riverside Plaza
Columbus, Ohio 43215-2373

ATTN.: Mr. Pedro J. Amaya, P.E.

RE: Report on Earthquake-Induced Liquefaction for
Eastern Dike of Fly Ash Disposal Facility
Philip Sporn Power Plant
New Haven, Mason County, West Virginia
NPDES No. WV0001058
GA File No. 09-387

Dear Mr. Amaya:

At the request of American Electric Power (AEP), Geo/Environmental Associates, Inc. (GA) has prepared a report summarizing our assessment regarding the potential for liquefaction of foundation fly ash due to earthquake-induced ground vibrations beneath the Eastern Dike of the Fly Ash Disposal Facility at the Philip Sporn Power Plant. Specifically, this report is in response to the United States Environmental Protection Agency's (USEPA) request for information, Items 1a through 1r, issued in a letter dated November 13, 2009. Provided herein are a site background, a discussion of GA's approach for the liquefaction assessment, and responses addressing each of the USEPA's information requests for Items 1a through 1r. A copy of the November 13, 2009, letter in which the USEPA requests information is provided in Appendix I. Additionally, field and laboratory testing data, seepage analyses, dynamic finite element analyses, slope stability analyses, drawings, and references are provided in Appendices II through VII, respectively.

BACKGROUND

General

The Philip Sporn Fly Ash Facility is maintained and operated by American Electric Power to support disposal of ash generated at the Philip Sporn Power Plant. The site is located near the town of New Haven in Mason County, West Virginia. The Fly Ash Disposal Facility – Eastern Dike is located at approximate coordinates North 38° 58' 29", West 81° 55' 47". The Fly Ash Disposal Facility is bounded by the Mountaineer Power Plant on its northern side, the Ohio

River on its eastern side, the Bottom Ash Disposal Facility and coal yard on its southern side, and the CSX Rail Line and West Virginia State Route 62 on its western side.

Fly Ash Disposal Facility

The Philip Sporn Plant Fly Ash Disposal Facility generally consists of an above ground fly ash pond contained by four dikes (i.e., the Northern, Eastern, Southern, and Western dikes). Original construction of the dikes was conducted in 1959. Dike raisings and/or extensions were conducted at the Fly Ash Disposal Facility in 1965, 1968, and in 1972. The Southern, Western, and Northern Dikes are founded primarily on residual clay and silt materials. The *original* construction for the Eastern Dike was also founded primarily on residual clay and silt materials. However, the upper portion of the Eastern Dike was constructed/founded primarily on fly ash that was hydraulically placed in the pond prior to 1972. Between 1996 and 2002, AEP implemented modifications to the Eastern Dike to address seepage observed on the exterior face of the dike and to improve the overall stability conditions of the slopes. In general, for the improvements, the company installed drainage collection provisions and regraded/buttressed the exterior slopes. A detailed historical review and design related to the 1996 through 2002 modifications to the Fly Ash Disposal Facility were provided in the AEP report *Philip Sporn Electric Generation Plant, Unit 5 Fly Ash Facility*, prepared in 1996. As indicated by the as-built topography shown on the Site Map drawing in Appendix VI: (1) the Northern Dike has an as-built crest ranging in elevation from about 612 feet, NGVD to about 620 feet, NGVD; (2) the Eastern Dike has an as-built crest elevation of about 620 feet, NGVD; (3) the Southern Dike has an as-built crest ranging in elevation from about 612 feet, NGVD to about 620 feet, NGVD; and (4) the Western Dike has an as-built crest ranging in elevation from about 610 feet, NGVD to about 612 feet, NGVD.

Fly ash generated at the Philip Sporn Power Plant – Unit 5 is sluiced to and temporarily disposed in the Fly Ash Disposal Facility; where after, it is excavated and hauled for dry disposal into AEP's Little Broad Run Landfill. AEP maintains an operating pool level of approximately 605 feet, NGVD in the fly ash pond. A plan view drawing (i.e. Site Map) of the Fly Ash Disposal Facility is provided in Appendix VI.

APPROACH TO LIQUEFACTION ASSESSMENT

In order to provide additional information for the USEPA pursuant to their November 13, 2009, letter, AEP has requested that GA evaluate the potential for liquefaction of fly ash foundation materials below the Fly Ash Disposal Facility – Eastern Dike due to earthquake induced vibrations. Correspondingly, we have conducted detailed field testing at the Sporn site and we performed engineering analyses on three critical sections. Specifically, we have performed a comprehensive, site specific liquefaction assessment for Fly Ash Disposal Facility – Eastern Dike Sections K-K, L-L, and M-M. Provided herein is a description of GA's assessment approach.

Field Reconnaissance and Geophysical Study

In December of 2009 and January of 2010, GA coordinated drilling operations for the Fly Ash Disposal Facility Eastern Dike. Specifically, boreholes were drilled at three pre-determined critical sections: Section K-K, Section L-L, and Section M-M. Sampling and classification of soils were performed through the dike sections and into foundation materials. Laboratory testing was performed on-site, concurrent with the drilling operations, in order to determine in-situ properties of the fly ash for use in laboratory cyclic triaxial testing performed by the Ohio State University.

In addition to drilling, sampling, and materials testing; GA coordinated a subsurface geophysical study performed by Dr. Michael Kalinski, of the University of Kentucky. Specifically, Dr. Kalinski and a representative from GA performed crosshole seismic testing (ASTM D 4428/D 4428M) at Section K-K of the Fly Ash Disposal Facility – Eastern Dike. The crosshole seismic testing was used to measure surface and compression wave velocities for the material layers present within the embankment and the foundation.

Engineering Analyses

In order to determine the liquefaction potential of fly ash foundation materials below the Eastern Dike of the Fly Ash Disposal Facility, GA performed a comprehensive dynamic analysis of each critical cross section using the *GeoStudio 2007* software suite developed by GEO-SLOPE International, Ltd. of Calgary, Alberta, Canada. The *GeoStudio 2007* software suite includes the *SEEP/W*, *QUAKE/W*, and *SLOPE/W* computer programs. Appendix VII contains the reference *Procedures and Methods for a Liquefaction Assessment using GeoStudio 2007*, which generally describes the methodology used herein. The *GeoStudio 2007* computer programs are fully compatible, thus allowing a sequential/coupled analysis to model the seepage, induced stresses and strains, and slope stability during a design earthquake event. Material parameters used in the analyses were based on: (1) site specific data accumulated during this study, (2) site specific data previously developed by AEP, and (3) published data related to site specific materials. Following, is a description of the analysis sequence used for each cross section:

1.) The *SEEP/W* program is used to determine the initial phreatic level and pore pressure conditions based on permeability values and embankment geometry. Using a value of total head at an inlet condition (i.e., the normal operating pool level of 605 feet) and review nodes on the downstream face (i.e., boundary conditions), the *SEEP/W* program adjusts the total head and the amount of flow at each of the nodal points until equilibrium is reached. Equilibrium conditions are then shown as a final free water (phreatic) surface.

2.) *QUAKE/W* incorporates the results of the *SEEP/W* analysis to perform an initial static stress analysis. This estimates the in-situ static total and effective stresses within the embankment.

3.) *QUAKE/W* is again used to perform a dynamic finite element stress analysis for a given seismic event. The *QUAKE/W* dynamic analysis uses the stress conditions from the previous initial static analysis to determine the dynamic stress conditions and liquefaction potential of the embankment/foundation materials during earthquake shaking.

4.) Finally, a *SLOPE/W* slope stability analysis is performed on both upstream and downstream slopes for each of the critical sections to model of the stress conditions that are developed during the design earthquake. Specifically, a Newmark-type analysis is used to calculate the stability factor during each time step throughout the seismic event.

CONCLUSION OF STUDY

Based on the results of the site specific subsurface exploration and field testing program, laboratory testing on fly ash samples taken from the site, and detailed engineering analyses; we do not predict liquefaction of the fly ash foundation materials beneath the Fly Ash Disposal Facility – Eastern Dike during the design earthquake event. Moreover, slope stability analyses conducted using site specific material parameters and stress conditions developed for the design earthquake indicate that the Fly Ash Disposal Facility – Eastern Dike will have adequate slope stability factors, that are in excess of 1.5.

RESPONSES TO USEPA REQUEST FOR INFORMATION – ITEMS 1a TO 1r

Provided herein are USEPA Information Request Items 1a through 1r and corresponding responses prepared by GA. For completeness, the November 13, 2009, letter containing the information requests is provided in Appendix I. Supporting field and laboratory testing data, seepage analyses, dynamic finite element analyses, slope stability analyses, drawings, and references are provided in Appendices II through VII, respectively.

<u>Information Request 1a</u>
Provide a description of background information and approach of the study.

<u>Response to Item 1a</u>
A detailed description of the background information and the approach of the study are provided in the preceding Background and Approach to Liquefaction Assessment sections of this document.

<u>Information Request 1b</u>
Provide a description of the methodology and procedures used in the analysis.

<u>Response to Item 1b</u>
<u>General</u>
The computer programs *SEEP/W*, *QUAKE/W*, and *SLOPE/W* were used to analyze the stress conditions and subsequent stability under dynamic loading conditions along Sections K-K, L-L, and M-M of the Eastern Dike of the Fly Ash Disposal Facility. Specifically, a finite element analysis was used to evaluate stress conditions of the Eastern Dike and its foundation at each section. Initial phreatic levels used in the analyses were based on *SEEP/W* finite element analyses and site specific, field measured piezometric levels. *QUAKE/W* dynamic results were used in conjunction with *SLOPE/W* slope stability analyses to develop stability factors given the stress conditions that may occur during earthquake induced vibrations.

<u>Initial Pore Pressure Conditions (*SEEP/W* Analyses)</u>
Given material permeability values and embankment geometry and using a value of total head at an inlet condition (i.e. the maximum operating pool level of 605 feet) and review nodes on the downstream face (i.e., boundary conditions), the *SEEP/W* program adjusts the total head and the amount of flow at each of the nodal points within the finite element mesh until equilibrium is reached. Approximated equilibrium conditions are then shown as a final free water (phreatic) surface. Detailed documentation of the seepage analyses and graphical output files generated with *SEEP/W* are provided in Appendix III.

<u>Selection of Earthquake</u>
The analyses were performed using time-acceleration data for an earthquake centered in Giles County, Virginia, (approximately 130 miles southeast of the Philip Sporn Power Plant). The earthquake was scaled to the peak earthquake ground acceleration value of 0.06g, as specified in the USEPA request for information. The Giles County earthquake was chosen because of its

proximity to the Philip Sporn Power Plant, the area's history of producing measureable earthquakes, and the availability of time-acceleration data for the area. The time-acceleration data for the Giles County earthquake used in the analyses was provided in *Research Report KTC-96-4 Source Zones, Recurrence Rates, and Time Histories for Earthquakes Affecting Kentucky*.

Finite Element Stress Conditions (*QUAKE/W* Liquefaction Analyses)
A *QUAKE/W* finite element analysis was used to model stresses in the Eastern Dike and its foundation under static and dynamic loading conditions for each critical cross section. The initial stress conditions were calculated during the initial static analysis using pore pressure conditions from the *SEEP/W* results. Then, using time-acceleration data from the Giles County earthquake record, the *QUAKE/W* program was used to calculate the stress conditions at specified time steps throughout the earthquake event. The resulting stress conditions were used to predict whether or not liquefaction is likely to occur during the design earthquake event. During an earthquake event, ground motions cause an increase in the effective stress; if this increase in effective stress overcomes the shear strength of the soil, liquefaction can occur. At the Philip Sporn Plant site, during the design earthquake event and using site specific material parameters for the Fly Ash Disposal Facility – Eastern Dike, the analyses predict that no zones will liquefy in the fly ash foundation materials. Appendix VII contains the reference *Procedures and Methods for a Liquefaction Assessment using GeoStudio 2007* (*GeoStudio 2007* includes SEEP/W, QUAKE/W, and SLOPE/W) published by GEO-SLOPE International, which generally describes the methodology used. Detailed documentation of the liquefaction analyses and graphical *QUAKE/W* output files are provided Appendix IV.

Slope Stability Analysis (*SLOPE/W*)
Once the stress conditions from the earthquake event were developed, the *SLOPE/W* computer program was used to analyze the stability of the embankment at intervals throughout the design earthquake event. Specifically, a Newmark-type analysis was used to estimate a slope stability factor affected by the permanent deformations caused by earthquake induced stresses. Detailed documentation of the slope stability analyses and graphical *SLOPE/W* output files are provided in Appendix V.

Information Request 1c
Provide a description of any additional field testing performed and the results obtained.

Response to Item 1c

GA coordinated subsurface exploration, instrumentation installation, and field testing for the Eastern Dike of the Fly Ash Disposal Facility to use in the liquefaction assessment. Specifically, GA coordinated subsurface exploration and instrumentation installation performed by Horn and Associates, Inc. (Horn) from December 10, 2009, through December 18, 2009. GA coordinated field geophysical testing (i.e., on January 6 and 7, 2010) and laboratory testing conducted by Dr. Kalinski. GA conducted on-site laboratory testing concurrent with the drilling operations, as well as laboratory testing at its office in Knoxville, Tennessee. Additionally, in our liquefaction assessment, we applied subsurface exploration data and laboratory testing data that was previously developed for the site by AEP. A summary of the subsurface exploration, instrumentation, field testing, and laboratory testing as related to the liquefaction assessment is provided herein. Field data from the subsurface exploration conducted by Horn, laboratory data developed by GA, and field and laboratory data developed Dr. Kalinski and AEP are provided in Appendix II.

Subsurface Exploration

As coordinated by GA, Horn drilled six boreholes at the Fly Ash Disposal Facility – Eastern Dike. Boreholes GA-1A, GA-1B, GA-1C, and GA-1D were drilled at the crest of the Fly Ash Disposal Facility in the general vicinity of Eastern Dike Section K-K. Boreholes GA-2 and GA-3 were drilled in the Fly Ash Disposal Facility-Eastern Dike in the locations of Section M-M and Section L-L, respectively. Borehole locations are shown on the site map and section drawings provided in Appendix VI. In general, the boreholes were sampled in accordance with ASTM D1586 (Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils) at specified sampling intervals. Additionally, field vane shear testing was conducted on selected intervals within the fly ash deposit, in accordance with ASTM D2573 (Standard Test Method for Field Vane Shear Test in Cohesive Soil). Undisturbed soil samples were obtained from the fly ash foundation / embankment materials, in accordance with ASTM D6519 (Standard Practice for Sampling of Soil Using the Hydraulically Operated Stationary Piston Sampler). Upon retrieval, selected fly ash samples were immediately subjected to on-site laboratory testing. Thereafter, all soil and fly ash samples were prepared and transported to GA's laboratory in Knoxville, Tennessee, for additional testing. Detailed tabular and graphical logs were developed for each of the boreholes and are provided in Appendix II.

Instrumentation

At the completion of drilling for boreholes GA-1A, GA-1B, and GA-1C; Horn installed 70 mm Durham Geo Slope Indicator (DGSI) inclinometer casing in each hole in order to implement crosshole seismic testing. The DGSI inclinometer casing was installed and grouted full length (i.e., in accordance with ASTM D4428 – Standard Test Methods for Crosshole Seismic Testing). Thereafter, GA conducted a downhole inclinometer survey to evaluate the orientation and deviation in the boreholes. The results of the downhole inclinometer survey are provided in Appendix II. Additionally, Horn installed a 1-inch diameter standpipe piezometer in borehole GA-1D. In order to measure the potential piezometric level through the fly ash deposit in which it was installed, standpipe piezometer GA-1D consisted of a pre-packed sand screen that extended through the complete fly ash interval. Initial piezometric level readings for the standpipe piezometer in GA-1D are provided on the borehole logs provided in Appendix II.

Geophysical Field Testing

GA coordinated geophysical field testing conducted by Dr. Kalinski at the site on January 6 and 7, 2010. Specifically, Dr. Kalinski conducted crosshole seismic testing (i.e., in general accordance with ASTM D4428– Standard Test Methods for Crosshole Seismic Testing) between boreholes GA-1A, GA-1B, and GA-1C through the Eastern Dike of the Fly Ash Disposal Facility. The crosshole seismic testing was performed to develop shear wave and compression wave velocities as well as Poisson's ratio data for the embankment cross-sections. Detailed documentation and results of the geophysical field testing conducted by Dr. Kalinski are provided in Appendix II.

Information Request 1d

Provide a description of any additional laboratory testing performed and the results obtained.

Response to Item 1d

Laboratory testing was conducted on field samples obtained during the subsurface exploration phase of the program. Specifically, split-spoon and undisturbed piston samples obtained during the drilling operations were subjected to testing both at an on-site laboratory and at GA's laboratory in Knoxville, Tennessee. In general, the laboratory testing consisted of:

1. in-place moisture and density determination of undisturbed fly ash piston samples;
2. specific gravity determination of undisturbed fly ash piston samples;
3. void ratio determination of undisturbed fly ash piston samples;
4. grain-size analyses on fly ash and foundation soils;
5. Atterburg limit determination on fly ash and foundation soils;
6. permeability testing on fly ash and foundation soils; and

7. consolidated undrained triaxial strength testing with pore pressure measurements on fly ash and foundation soils.

Laboratory testing summary sheets and data developed by GA are provided in Appendix II. Additional laboratory testing data used in the liquefaction assessment is described below.

1. Damping ratio measurements were conducted by Dr. Kalinski at the University of Kentucky. Specifically, Dr. Kalinski conducted free-free resonant column testing to measure the damping ratio for fly ash and foundation soils collected during drilling operations. Measured damping ratios are presented in Dr. Kalinski's March 8, 2010, report provided in Appendix II.

2. Cyclic triaxial testing data was developed by the Ohio State University using reconstituted fly ash bulk samples obtained from the site. For the testing, the fly ash materials were reconstituted to an initial minimum density of 61 pounds per cubic foot, as measured for the minimum in-place density during on-site laboratory testing of undisturbed fly ash piston tube samples. The report of the Ohio State University *Evaluation of Liquefaction Potential of Impounded Fly Ash : Philip Sporn Power Plant*, including the Cyclic Stress Ratio (CSR) graph developed during the cyclic triaxial strength testing of Sporn fly ash material is provided in Appendix II.

3. Laboratory data provided by AEP from historical sampling and laboratory testing performed on site specific materials was used in the analyses as needed. For reference, copies of the pertinent AEP laboratory data, as used in the liquefaction assessment, are provided in Appendix II.

<u>Information Request 1e</u>

Provide a description of the site(s) including site map(s) depicting planimetric and topographic features and the location of critical section(s) selected for analysis.

<u>Response to Item 1e</u>

A site description is provided in the preceding Background section of this document. A Site Map depicting the location of the Eastern Dike, critical sections, field testing locations, and other planimetric and topographic features is provided in Appendix VI.

Information Request 1f

Provide a description of the subsurface conditions at the critical sections and illustration of the analysis profiles.

Response to Item 1f

In general the original construction for the Eastern Dike is founded primarily on residual clay and silt materials. This original dike consists of a low permeability, silty clay starter dike with a coarse grained, sandy gravel downstream shell. The upper portion of the Eastern Dike is constructed/founded primarily on fly ash that was hydraulically placed in the pond prior to 1972. The upper portions of the dike are constructed primarily of silty clay and gravelly sands. A general summary of the subsurface conditions is provided in Table 1.

TABLE 1
SUMMARY OF SUBSURFACE CONDITIONS AT SECTIONS K-K, L-L, AND M-M

Cross Section	Bore Hole	Soil Depth Measured from Surface (ft)	General Soil Description	Initial Water Level Encountered (ft)	Instrumentation
K-K	GA-1A GA-1B GA-1C GA-1D	0 – 16	Gravelly Sand	592	Inclinometer in GA-1A, GA-1B, and GA-1C. Standpipe piezometer in GA-1D
		16 – 22	Clayey Sand		
		22 – 26.5	Bottom Ash and Sand		
		26.5 – 59	Fly Ash		
		59 – 70.5	Silty Clay		
L-L	GA-3	0 – 13	Gravelly Sand	596	None
		13 – 17	Clayey Sand		
		17 – 26.5	Sandy Clay		
		26.5 – 59	Fly Ash		
		59 – 72	Silty Clay		
		72 – 81.5	Sandy Clay		
M-M	GA-2	0 – 17	Gravelly Sand	591	None
		17 – 27	Sand		
		27 – 59	Fly Ash		
		59 – 71.5	Clayey Sand		

Detailed borehole logs for Section K-K, Section L-L, and Section M-M are located in Appendix II. Cross-section drawings of the critical sections are provided in Appendix VI.

Information Request 1g

Provide a discussion of the design soil and ash properties and parameters and the basis of selection of these values or the source of the values.

Response to Item 1g

Material parameters used in the *SEEP/W* finite element seepage analyses, the *QUAKE/W* finite element stress analyses, and the *SLOPE/W* stability analyses were based on site specific data or from using accepted reference materials in relation to the site specific soils/conditions. In

general, material properties were derived from field and laboratory testing performed by AEP, GA, Ohio State University, and Dr. Kalinski.

Material Properties Used for *SEEP/W* Seepage Analyses

Material parameters used in the seepage models for critical Sections K-K, L-L, and M-M are based on site specific field and laboratory measurements performed by AEP and GA. For the analyses, we conservatively assumed a horizontal permeability to vertical permeability (k_h:k_v) ratio of 9 for the dike and foundation materials and a k_h:k_v ratio of 10 for the hydraulically placed fly ash material. Tables 2, 3, and 4 show the specific soil permeability values and their respective sources. A summary of the material properties and procedures used in the *SEEP/W* analyses is provided in Appendix III. Supporting field testing and laboratory test data are provided in Appendix II.

TABLE 2
SUMMARY OF PERMEABILITY PARAMETERS FOR SECTION K-K SEEPAGE ANALYSES

Soil Layer Number	Material Type	Location	Horizontal Permeability k_h (ft/sec)	Vertical Permeability k_v (ft/sec)	Material Parameter Source
1	Silty Clay	1972 Embankment Extension	4.4×10^{-7}	4.92×10^{-8}	From AEP Seepage Analysis for K-K in July 1998 Report
2	Gravelly Silty Sand	1972 Embankment Extension	1.6×10^{-4}	1.77×10^{-5}	From AEP Seepage Analysis for K-K in July 1998 Report
3	Sand & Gravel	1972 Embankment Extension	1.4×10^{-3}	1.6×10^{-4}	Using Hazen Formula on GSC for B-107 (11.6')
4	Bottom Ash (68)	1968 Embankment Extension	5.7×10^{-5}	9.5×10^{-6}	Using Hazen Formula on GSC for PZ-0901 (3.5')
5	Gravelly Silty Sand	1968 Embankment Extension	1.6×10^{-4}	1.77×10^{-5}	From AEP Seepage Analysis for K-K in July 1998 Report
6	Silty Clay	1965 Embankment Extension	1.1×10^{-7}	1.2×10^{-8}	From AEP Permeability Test on PZ-0902 (26.0')
7	Bottom Ash (65)	1965 Embankment Extension	8.6×10^{-5}	9.5×10^{-6}	Using Hazen Formula on GSC for PZ-0901 (3.5')
8	Fly Ash	Fly Ash Pond	2.2×10^{-5}	2.2×10^{-6}	From GA Permeability Test on GA-1A ST-4
9	Sandy Silt	1972 Embankment Extension	1.2×10^{-5}	1.3×10^{-6}	From AEP Seepage Analysis for K-K in July 1998 Report
10	Clay Foundation	Upper Foundation Soil	3.2×10^{-8}	3.6×10^{-9}	From AEP Permeability Test on PZ-0903 (46.0')
11	Clay Foundation	Upper Foundation Soil	1.4×10^{-7}	1.6×10^{-8}	From GA Permeability Test on GA-1C ST-2
12	Silty Clay Foundation	Mid-Level Foundation Soil	3.2×10^{-8}	3.6×10^{-9}	From AEP Permeability Test on PZ-0903 (46.0')
13	Silty Clay	Original Dike	1.1×10^{-7}	1.2×10^{-8}	From AEP Permeability Test on PZ-0902 (26.0')
14	Foundation Soil	Lower Foundation Soil	3.2×10^{-8}	3.6×10^{-9}	From AEP Permeability Test on PZ-0903 (46.0')

TABLE 3
SUMMARY OF PERMEABILITY PARAMETERS FOR SECTION L-L SEEPAGE ANALYSES

Soil Layer Number	Material Type	Location	Horizontal Permeability k_h (ft/sec)	Vertical Permeability k_v (ft/sec)	Material Parameter Source
1	Sandy Silty Clay	1972 Embankment Extension	$1.8x10^{-6}$	$2.0x10^{-7}$	From AEP Seepage Analysis for L-L in July 1998 Report
2	Road Fill	1972 Embankment Extension	$1.9x10^{-3}$	$2.1x10^{-4}$	Using Hazen Formula on GSC for B-109 (8.5')
3	Gravelly Silty Sand	1972 Embankment Extension	$1.9x10^{-3}$	$2.1x10^{-4}$	Using Hazen Formula on GSC for B-109 (8.5')
4	Gravelly Silty Sand	1972 Embankment Extension	$1.9x10^{-3}$	$2.1x10^{-4}$	Using Hazen Formula on GSC for B-109 (8.5')
5	Bottom Ash	1968 Embankment Extension	$8.6x10^{-5}$	$9.5x10^{-6}$	Using Hazen Formula on GSC for PZ-0901 (3.5')
6	Silty Sand & Gravel	1968 Embankment Extension	$5.9x10^{-4}$	$6.6x10^{-5}$	Using Hazen Formula on GSC for PZ-0902 (8.5')
7	Silty Sandy Clay	1965 Embankment Extension	$1.1x10^{-7}$	$1.2x10^{-8}$	From AEP Permeability Test on PZ-0902 (26.0')
8	Silty Clay	1965 Embankment Extension	$1.1x10^{-7}$	$1.2x10^{-8}$	From AEP Permeability Test on PZ-0902 (26.0')
9	Fly Ash	Fly Ash Pond	$2.2x10^{-5}$	$2.2x10^{-6}$	From GA Permeability Test on GA-1A ST-4
10	Clay Foundation	Upper Foundation Soil	$1.4x10^{-7}$	$1.6x10^{-8}$	From GA Permeability Test on GA-1C ST-2
11	Clay Foundation	Upper Foundation Soil	$3.2x10^{-8}$	$3.6x10^{-9}$	From AEP Permeability Test on PZ-0903 (46.0')
12	Silty Clay Foundation	Lower Foundation Soil	$3.2x10^{-8}$	$3.6x10^{-9}$	From AEP Permeability Test on PZ-0903 (46.0')

TABLE 4 SUMMARY OF PERMEABILITY PARAMETERS FOR SECTION M-M SEEPAGE ANALYSES					
Soil Layer Number	**Material Type**	**Location**	**Horizontal Permeability k_h (ft/sec)**	**Vertical Permeability k_v (ft/sec)**	**Material Parameter Source**
1	Sandy Silty Clay	1972 Embankment Extension	1.8×10^{-6}	2.0×10^{-7}	From AEP Seepage Analysis for L-L in July 1998 Report
2	Gravelly Silty Sand	1972 Embankment Extension	1.9×10^{-3}	2.1×10^{-4}	Using Hazen Formula on GSC for B-109 (8.5')
3	Bottom Ash	1995 Embankment Modifications	8.6×10^{-5}	9.5×10^{-6}	Using Hazen Formula on GSC for PZ-0901 (3.5')
4	Silty Sand w/ Gravel	1968 Embankment Extension	5.9×10^{-4}	6.6×10^{-5}	Using Hazen Formula on GSC for PZ-0902 (8.5')
5	Sandy Silt	1965 Embankment Extension	1.2×10^{-5}	1.3×10^{-6}	From AEP Seepage Analysis for K-K in July 1998 Report
6	Silty Clay	Original Soil Dike	1.1×10^{-7}	1.2×10^{-8}	From AEP Permeability Test on PZ-0902 (26.0')
7	Fly Ash [(1)]	Fly Ash Pond	2.2×10^{-5}	2.2×10^{-6}	From GA Permeability Test on GA-1A ST-4
8	Brown Clay	Upper Foundation Soil	1.4×10^{-7}	1.6×10^{-8}	From GA Permeability Test on GA-1C ST-2
9	Silty Clay	Lower Foundation Soil	1.1×10^{-7}	1.2×10^{-8}	From AEP Permeability Test on PZ-0902 (26.0')
10	Sandstone	Foundation			
11	Bottom Ash 2	1972 Embankment Extension	8.6×10^{-5}	9.5×10^{-6}	Using Hazen Formula on GSC for PZ-0901 (3.5')

Material Parameters Used for *QUAKE/W* Finite Element Stress Analysis

Material parameters used in the *QUAKE/W* finite element stress analyses were based on site specific data or from accepted reference materials in relation to the site specific soils/conditions. In general, material properties used in the *QUAKE/W* liquefaction assessment were derived from field and laboratory tests performed by AEP, GA, and Dr. Kalinski. Tables 5, 5.1, 6, and 7 summarize the material parameters, and the respective sources, for each cross section. A detailed summary of the material properties and procedures used in the *QUAKE/W* analyses is provided in Appendix IV. Supporting field testing and laboratory test data are provided in Appendix II.

TABLE 5. *QUAKE/W* MATERIAL PARAMETERS FOR SECTION K-K FINITE ELEMENT/LIQUEFACTION ANALYSIS

	Silty Clay (1)	Gravelly Silty Sand (2)	Sand and Gravel (3)	Bottom Ash (4)	Gravelly Silty Sand (5)	Silty Clay (6)	Bottom Ash 65 (7)	Fly Ash (8)	Sandy Silt (9)	Clay Foundation (10)	Clay Foundation (11)	Silty Clay Foundation (12)
Unit Weight γ (pcf)	125	108	114	100	110	128	90	98	100	125	130	125
Source	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)
Damping Ratio λ (%)	10	10	10	10	10	10	10	4.5	10	7	7	7
Source(5)	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Kalinski Report	Seed-Idriss, Kokusho	Kalinski Report	Kalinski Report	Kalinski Report
Small Strain Shear Modulus G_{max} (psf)	3,718,376	3,212,677	3,391,159	2,974,701	3,272,171	1,914,578	1,246,188	690,304	2,974,701	1,869,705	1,944,493	1,869,705
Source(3)	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report
Poisson's Ratio ν	.45	0.352	0.352	0.352	0.352	0.45	0.45	0.495	0.352	0.45	0.45	0.45
Source	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report
Cyclic Number Function(4)	None	None	None	None	None	None	None	OSU	None	None	None	None

Notes:

(1) AEP Philip Sporn Electric Generating Plant Bottom Ash Facility - Engineering Report, 1996
(2) AEP Philip Sporn Power Plant Bottom Ash Disposal Facility - Stability Analysis, 2009
(3) G_{max} derived from shear wave velocities from cross hole measurements
(4) Cyclic Number Function for fly ash based on cyclic triaxial data prepared by Ohio State University (OSU)
(5) Damping Ratios From:
- Kalinski Report - for the fly ash and foundation soils
- Seed Idriss (SHAKE91 Users Manual)
- Kokusho (Geotechnical Earthquake Engineering by Kuo Towhata)

TABLE 5.1. *QUAKE/W* MATERIAL PARAMETERS FOR SECTION K-K FINITE ELEMENT/LIQUEFACTIONANALYSIS

	Original Dike (13)	**Foundation Soil (14)**
Unit Weight γ (pcf)	130	130
Source	AEP[1,2]	AEP[1,2]
Damping Ratio λ (%)	10	7
Source[5]	Seed-Idriss, Kokusho	Kalinski Report
Small Strain Shear Modulus G_{max} (psf)	3,867,111	1,944,493
Source[3]	Kalinski Report	Kalinski Report
Poisson's Ratio ν	0.45	0.45
Source	Kalinski Report	Kalinski Report
Cyclic Number Function[4]	None	None

Notes:

(1) AEP Philip Sporn Electric Generating Plant Bottom Ash Facility - Engineering Report, 1996
(2) AEP Philip Sporn Power Plant Bottom Ash Disposal Facility - Stability Analysis, 2009
(3) G_{max} derived from shear wave velocities from cross hole measurements
(4) Cyclic Number Function for fly ash based on cyclic triaxial data prepared by Ohio State University (OSU)
(5) Damping Ratios From:
- Kalinski Report - for the fly ash and foundation soils
- Seed Idriss (SHAKE91 Users Manual)
- Kokusho (Geotchnical Earthquake Engineering by Kuo Towhata)

TABLE 6. *QUAKE/W* MATERIAL PARAMETERS FOR SECTION L-L FINITE ELEMENT/LIQUEFACTIONANALYSIS

	Sandy Silty Clay (1)	Road Fill (2)	Gravelly Silty Sand (3)	Gravelly Silty Sand (4)	Bottom Ash (5)	Silty Sand and Gravel (6)	Silty Sandy Clay (7)	Silty Clay (8)	Fly Ash (9)	Clay Foundation (10)	Clay Foundation (11)	Silty Clay Foundation (12)
Unit Weight γ (pcf)	130	110	110	100	65	115	130	130	110	125	125	130
Source	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]
Damping Ratio λ (%)	10	10	10	10	10	10	10	10	4.5	7	7	7
Source[5]	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report
Small Strain Shear Modulus G_{max} (psf)	3,867,112	3,272,171	3,272,171	2,974,701	1,933,556	3,420,906	3,867,112	3,867,112	774,831	1,869,705	1,869,705	1,944,493
Source[3]	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report
Poisson's Ratio ν	0.45	0.352	0.352	0.352	0.352	0.352	0.45	0.45	0.495	0.45	0.45	0.45
Source	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report
Cyclic Number Function[4]	None	None	None	None	None	None	None	None	OSU	None	None	None

Notes:

(1) AEP Philip Sporn Electric Generating Plant Fly Ash Facility - Engineering Report, 1998
(2) AEP Philip Sporn Power Plant Fly Ash Disposal Facility - Stability Analysis, 2009
(3) G_{max} derived from shear wave velocities from cross hole measurements
(4) Cyclic Number Function for fly ash based on cyclic triaxial data prepared by Ohio State University (OSU)
(5) Damping Ratios From:
- Kalinski Report - for the fly ash and foundation soils
- Seed Idriss (SHAKE91 Users Manual)
- Kokusho (Geotchnical Earthquake Engineering by Kuo Towhata)

TABLE 7. *QUAKE/W* MATERIAL PARAMETERS FOR SECTION M-M FINITE ELEMENT/LIQUEFACTIONANALYSIS

	Sandy Silty Clay (1)	Gravelly Silty Sand (2)	Bottom Ash (3)	Silty Sand and Gravel (4)	Sandy Silt (5)	Silty Clay (6)	Fly Ash (7)	Brown Clay (8)	Silty Clay (9)	Sandstone (10)	Bottom Ash 2 (11)
Unit Weight γ (pcf)	125	125	65	115	115	130	110	125	126	140	90
Source	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	-	AEP[1,2]
Damping Ratio λ (%)	10	10	10	10	10	10	4.5	7	7	1	10
Source[5]	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Kalinski Report	Kalinski Report	Kalinski Report	-	Seed-Idriss, Kokusho
Small Strain Shear Modulus G_{max} (psf)	3,718,376	3,718,376	1,933,556	3,420,906	3,867,112	3,867,112	774,831	1,869,705	1,884,663	78,000,000	2,677,231
Source[3]	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Bowles Hoek	Kalinski Report
Poisson's Ratio ν	0.45	0.352	0.352	0.352	0.45	0.45	0.495	0.45	0.45	0.2	0.45
Source	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Bowles	Kalinski Report
Cyclic Number Function[4]	None	None	None	None	None	None	OSU	None	None	None	None

Notes:

(1) AEP Philip Sporn Electric Generating Plant Fly Ash Facility - Engineering Report, 1998
(2) AEP Philip Sporn Power Plant Fly Ash Disposal Facility - Stability Analysis, 2009
(3) G_{max} derived from shear wave velocities from cross hole measurements or referenced value
(4) Cyclic Number Function for fly ash based on cyclic triaxial data prepared by Ohio State University (OSU)
(5) Damping Ratios From:
- Kalinski Report - for the fly ash and foundation soils
- Seed Idriss (SHAKE91 Users Manual)
- Kokusho (Geotchnical Earthquake Engineering by Kuo Towhata)

Material Parameters Used for *SLOPE/W* Slope Stability Analyses

Material parameters used in the *SLOPE/W* slope stability analyses were based on site specific data from field and laboratory testing. In general, the material properties were derived from field and laboratory testing performed by GA and AEP. Tables 8, 8.1, 9, and 10 summarize the material parameters and their sources for each cross section. A detailed summary of the material properties and procedures used in the *SLOPE/W* analyses is provided in Appendix V. Supporting field testing and laboratory test data are provided in Appendix II.

TABLE 8. ***SLOPE/W* MATERIAL PARAMETERS FOR SECTION K-K SLOPE STABILITY ANALYSIS**

	Silty Clay (1)	Gravelly Silty Sand (2)	Sand and Gravel (3)	Bottom Ash (4)	Gravelly Silty Sand (5)	Silty Clay (6)	Bottom Ash 65 (7)	Fly Ash (8)	Sandy Silt (9)	Clay Foundation (10)	Clay Foundation (11)	Silty Clay Foundation (12)
Unit Weight γ (pcf)	125	108	114	100	110	128	90	98	100	125	130	125
Source	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]
Phi Angle φ	34	33	36	31	35	34	29	27	31	33	39	37
Source	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]

Notes:
(1) AEP Philip Sporn Electric Generating Plant Bottom Ash Facility - Engineering Report, 1996
(2) AEP Philip Sporn Power Plant Bottom Ash Disposal Facility - Stability Analysis, 2009

TABLE 8.1. ***SLOPE/W* MATERIAL PARAMETERS FOR SECTION K-K SLOPE STABILITY ANALYSIS**

	Original Dike (13)	Foundation Soil (14)
Unit Weight γ (pcf)	130	130
Source	AEP[1,2]	AEP[1,2]
Phi Angle φ	33	32
Source	AEP[1,2]	AEP[1,2]

Notes:
(1) AEP Philip Sporn Electric Generating Plant Bottom Ash Facility - Engineering Report, 1996
(2) AEP Philip Sporn Power Plant Bottom Ash Disposal Facility - Stability Analysis, 2009

TABLE 9. *SLOPE/W* MATERIAL PARAMETERS FOR SECTION L-L SLOPE STABILITY ANALYSIS

	Sandy Silty Clay (1)	Road Fill (2)	Gravelly Silty Sand (3)	Gravelly Silty Sand (4)	Bottom Ash (5)	Silty Sand and Gravel (6)	Silty Sandy Clay (7)	Silty Clay (8)	Fly Ash (9)	Clay Foundation (10)	Clay Foundation (11)	Silty Clay Foundation (12)
Unit Weight γ (pcf)	130	110	110	100	65	115	130	130	110	125	125	130
Source	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]
Phi Angle φ	34	35	34	32	35	32	34	33	27	39	37	32
Source	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]

Notes:
(1) AEP Philip Sporn Electric Generating Plant Fly Ash Facility - Engineering Report, 1998
(2) AEP Philip Sporn Power Plant Fly Ash Disposal Facility - Stability Analysis, 2009

TABLE 10. *SLOPE/W* MATERIAL PARAMETERS FOR SECTION M-M SLOPE STABILITY ANALYSIS

	Sandy Silty Clay (1)	Gravelly Silty Sand (2)	Bottom Ash (3)	Silty Sand and Gravel (4)	Sandy Silt (5)	Silty Clay (6)	Fly Ash (7)	Brown Clay (8)	Silty Clay (9)	Sandstone (10)	Bottom Ash 2 (11)
Unit Weight γ (pcf)	125	125	65	115	115	130	110	125	126	140	90
Source	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	-	AEP[1,2]
Phi Angle φ	34	35	36	32	34	33	27	39	31.2	Impenetrable	32
Source	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	-	AEP[1,2]

Notes:
(1) AEP Philip Sporn Electric Generating Plant Fly Ash Facility - Engineering Report, 1998
(2) AEP Philip Sporn Power Plant Fly Ash Disposal Facility - Stability Analysis, 2009

Information Request 1h

Present the results of analysis, including appropriate charts and graphs illustrating the results, and discussion of the results.

Response to Item 1h

Detailed documentation including graphical output illustrating the results of the liquefaction analyses are provided in Appendix IV. As shown in the *QUAKE/W* graphical output files, no liquefaction zones are predicted for Sections K-K, L-L, or M-M of the Fly Ash Disposal Facility – Eastern Dike when subjected to the design earthquake. Based on the results of the site specific field and laboratory testing and the results of the liquefaction analyses, we believe that liquefaction of the fly ash foundation material below the upper section of the Fly Ash Disposal Facility – Eastern Dike is unlikely. Additionally, results of *SLOPE/W* slope stability analyses provided in Appendix V indicate stability factors in excess of 1.5 for both upstream and downstream analysis of each critical cross section. Table 11 provides a summary of the results from both the QUAKE/W liquefaction assessments and the SLOPE/W stability analyses.

TABLE 11
SUMMARY OF RESULTS FROM QUAKE/W LIQUEFATION ASSESSMENT AND SLOPE/W SLOPE STABILITY ANALYSES

Critical Section	Liquefaction of Fly Ash Foundation Predicted?	Condition	Stability Factor
Fly Ash Disposal Facility Section K-K	NO	Downstream	1.64
		Upstream	2.17
Fly Ash Disposal Facility Section L-L	NO	Downstream	2.35
		Upstream	2.32
Fly Ash Disposal Facility Section M-M	NO	Downstream	1.75
		Upstream	1.93

Information Request 1i

Present conclusions regarding liquefaction potential under design earthquake loading conditions at the Philip Sporn Fly Ash Pond Dike.

Response to Item 1i

Appendix IV contains output files from *QUAKE/W* finite element stress analyses performed on the three critical cross sections, Section K-K; Section L-L; and Section M-M, of the Philip Sporn

Fly Ash Disposal Facility Eastern Dike. Based on the *QUAKE/W* results using site specific parameters, liquefaction of fly ash foundation materials during the design earthquake is not predicted. Additionally, results of SLOPE/W dynamic analyses based on the stress conditions from the QUAKE/W liquefaction assessment indicate stability factors in excess of 1.5 for Sections K-K, L-L, and M-M in both the upstream and downstream directions. Based on the results, we do not predict liquefaction of the fly ash foundation materials and we believe that the Fly Ash Disposal Facility – Eastern Dike will exhibit adequate slope stability during the design earthquake.

Information Request 1j

Provide recommendations for remedial action to eliminate or minimize liquefaction potential should the foundation ash be found susceptible to liquefaction under design earthquake loading.

Response to Item 1j

As described in Response to Item 1i and in Appendices VI, no liquefaction zones are predicted for the foundation fly ash during the design earthquake. Therefore, no remedial actions specifically related to liquefaction potential are currently recommended.

Information Request 1k

Provide a list of references.

Response to Item 1k

A list of references is provided in Appendix VII.

Information Request 1l

Provide tables as needed to facilitate presentation of data.

Response to Item 1l

Pertinent tables have been provided in the body of this document and as needed in the appendices to facilitate presentation of the data.

Information Request 1m

Provide figures as needed for illustration purposes.

Response to Item 1m

Applicable figures are provided in the appendices to this document.

<u>Information Request 1n</u>

Provide an appendix containing summary description of field and laboratory test procedures that may be used to develop additional soil and ash data as needed for the study.

<u>Response to Item 1n</u>

Summary descriptions related to the field geophysical studies are provided in Appendix II. Laboratory testing procedures were conducted in accordance with ASTM standards. Laboratory testing data and summaries are provided in Appendix II. Listings of applicable ASTM standards used in the sampling and testing of site specific soil and ash materials are listed in the references provided in Appendix VII.

<u>Information Request 1o</u>

Provide an appendix containing all test boring logs and other field data considered in the study, including existing data and additional data that may be obtained to fully characterize the analysis profiles.

<u>Response to Item 1o</u>

Field geophysical data, subsurface exploration data, and field testing data used to characterize the materials for the analysis profiles are provided in Appendix II.

<u>Information Request 1p</u>

Provide an appendix containing all laboratory test data considered in the study, including existing data and additional data developed for the study.

<u>Response to Item 1p</u>

Laboratory test data is provided in Appendix II.

<u>Information Request 1q</u>

Provide an appendix containing calculations, including analysis calculations, e.g., program SHAKE runs, and calculations for calculated values used in the analysis, e.g., calculation of shear modulus values (G_{max}).

<u>Response to Item 1q</u>

Appendix II contains hand calculations for shear modulus (G_{max}) values. *SEEP/W* seepage/initial pore pressure analysis output are provided in Appendix III, *<u>QUAKE/W</u>* finite element stress analysis output are provided in Appendix IV, and *SLOPE/W* slope stability analysis output are provided in Appendix V.

<u>Information Request 1r</u>

Provide a certification of the study and report by a professional engineer registered in the state of West Virginia.

<u>Response to Item 1r</u>

A certification of the assessment and report presented herein is provided at the front of this document.

Geo/Environmental Associates, Inc. appreciates this opportunity to be of continuing service to American Electric Power. If you have comments or questions regarding this report, we may be reached at (865) 584-0344.

Sincerely,
Geo/Environmental Associates, Inc.

Seth W. Frank

Seth W. Frank, E.I.
Project Coordinator

Roger W Cecil

Roger W. Cecil, P.E.
Senior Geotechnical Engineer
West Virginia R.P.E. No. 14,367

ROGER W. CECIL
REGISTERED
14367
STATE OF
WEST VIRGINIA
PROFESSIONAL ENGINEER

APPENDIX I

USEPA LETTER DATED NOVEMBER 13, 2009
REQUESTING ADDITIONAL INFORMATION

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D C. 20460

OFFICE OF
ENFORCEMENT AND
COMPLIANCE ASSURANCE

CERTIFIED MAIL-RETURN RECEIPT REQUESTED

NOV 13 2003

Alan R. Wood, PE
Manager
Water & Ecological Resource Services Section
Environmental Services Division
American Electric Power
1 Riverside Plaza
Columbus, OH 43215-2373

Re: Request for Information Pursuant to Section 308 of the Clean Water Act (33 U.S.C. § 1318)

Dear Mr. Wood:

Enclosed is an Information Request issued pursuant to Section 308(a) of the Clean Water Act, 33 U.S.C. § 1318(a). Section 308 of the Clean Water Act authorizes the Administrator of the United States Environmental Protection Agency ("EPA") to require those subject to the Act to furnish information, conduct monitoring, provide entry to the Administrator or authorized representatives, and make reports as may be necessary to carry out the objectives of the Act This authority has been re-delegated to the undersigned Director of the Water Enforcement Division in the Office of Enforcement and Compliance Assurance. The enclosures, which are hereby made part of this letter, provide details of the information the American Electric Power ("AEP") Philip Sporn Generating Plant ("Facility") must provide to EPA and contain instructions on how this information is to be submitted to EPA.

Section 308(a) of the Clean Water Act, 33 U.S.C. § 1318(a) authorizes EPA to require any person to provide information required to carry out the objectives of the Clean Water Act. Accordingly, you are requested to respond to the enclosed Information Request (Enclosure 1). Please read the instructions in the enclosure carefully before preparing your response. Answer each request as clearly and completely as possible. To the extent that AEP has any of the requested data currently on file, that data may be submitted in the requested format as part of your response. Your response to this request must be accompanied by a certificate that is signed and dated by you or the person who is authorized by you to respond to the request The certification must state that the response is complete and contains all information and documentation available to you pursuant to the request A Statement of Certification is enclosed with this letter (Enclosure 2).

Please submit your written responses in accordance with the deadlines set forth in the request to:

Ginny Phillips
U.S. Environmental Protection Agency
Water Enforcement Division
1200 Pennsylvania Avenue, NW
Mail Code 2243A; Room 4118A
Washington, DC 20460
(For deliveries by courier use the Zip Code 20004)

You are entitled to assert a business confidentiality claim pursuant to the regulations set forth in 40 C.F.R. Part 2, Subpart B. If EPA determines the information you have designated meets the criteria in 40 C.F.R. § 2.208, the information will be disclosed only to the extent and by means of the procedures specified in Subpart B. Unless a confidentiality claim is asserted at the time the requested information is submitted, EPA may make the information available to the public without further notice to you.

Compliance with the provisions of this Information Request is mandatory. If you do not respond fully and truthfully to this Information Request or adequately justify your failure to do so, you may be subject to civil penalties or criminal fines under Section 309 of the Clean Water Act, 33 U.S.C. § 1319.

We appreciate your cooperation and prompt attention to this matter. Please contact Ginny Phillips of my staff at 202-564-6139 (phillips.ginny@epa.gov) within 72 hours of receipt this Information Request to inform us of your intention to comply with this request If you or your staff would like an opportunity to confer, have any questions, or would like to schedule a meeting relating to this Information Request, please contact Ginny Phillips. Thank you for your cooperation in this matter.

Sincerely,

Mark Pollins, Director
Water Enforcement Division

Enclosures

cc: Michael Zeto, West Virginia Department of Environmental Protection
Brian Long, West Virginia Department of Environmental Protection
Rick Rogers, EPA Region 3

Enclosure 1

INFORMATION REQUEST

I. STATUTORY AUTHORITY

1. This information is requested pursuant to Section 308 of the Clean Water Act, 33 U.S.C. § 1318.

II. INSTRUCTIONS

1. Respond to Each Request Completely. Provide a separate report for each of the three reports requested. Within each report, indicate the subpart of the request being addressed.

2. Provide the Best Information Available. If any request or subpart of the request cannot be responded to in full, respond to the extent possible along with an explanation of why the request cannot be responded to in full.

3. Source(s) of Response. Include with each report, the name, position, and title of each person(s) who participated in developing the report.

4. Source(s) of Data. Any existing field and laboratory data relied upon by you to develop the reports required by this Information Request must be identified in the report and include an explanation of how the data are representative of the conditions at the site.

5. Indicate Objections to Requests. While you may indicate that you object to certain requests contained in this Information Request, you must provide responsive information notwithstanding those objections. To object without providing responsive information may subject you to the penalties discussed in the cover letter.

6. Claims of Privilege. If you claim that an entire document submitted in response to this Information Request is privileged communication, identify the document and provide the basis for the privilege. If you claim that any particular section of a document is privileged communication, identify that section and provide the basis for the privilege. Regardless of the assertion of a privilege, you must respond to the Information Request in full.

7. New Information. If you become aware of any information not previously known or not available to you as of the date of submission of your response to this Information Request, you must supplement your response to EPA within five (5) business days. Moreover, should you find, at any time after the submission of your response, that any portion of the submitted information is false or misrepresents the truth, you must notify EPA of this fact immediately and provide a corrected response within two (2) business days.

8. Submission of Response by U.S. Mail. Submit a paper copy and an electronic .pdf file on CD of your response to:

Ginny Phillips
U.S. Environmental Protection Agency
Water Enforcement Division
1200 Pennsylvania Avenue, NW
Mail Code 2243A; Rm. 4118A
Washington, DC 20460
202-564-6139
(For deliveries by courier use the Zip Code 20004)

9. Submission of Response by E-mail. Submit an electronic .pdf file of your response to phillips.ginny@epa.gov.

10. Retention of Records. All records and documents that were created and/or relied upon in responding to any part of this request must be maintained until EPA informs you that maintenance is no longer required.

11. Inclusion of Statement of Certification. The Statement of Certification found in Enclosure 2 must be submitted along with each submission made pursuant to this Information Request. This statement must be signed by you or a person authorized by you to respond to the Information Request.

III. DEFINITIONS

Unless otherwise defined herein, terms used in this request shall have the meaning given to those terms in the Act, 33 U.S.C. § 1251 et seq., the regulations promulgated thereunder at 40 CFR § 122, and in AEP's NPDES Permit, No. WV0001058.

1. The terms "and" and "or" shall be construed either disjunctively or conjunctively as necessary to bring within the scope of this Information Request any information which might otherwise be construed to be outside its scope.

2. The term "any," as in "any documents," for example, shall mean "any and all."

3. The term "describe" means to detail, depict, or give an account of the requested information, or to report the content of any oral and/or written correspondence, communication, or conversation, or to report the contents of any document, including the title, the author, the position or title of the author, the addressee, the position or title of the addressee, indicated or blind copies, date, subject matter, number of pages, attachment or appendices, and all persons to whom the document was distributed, shown, or explained.

4. "State" shall mean the State of West Virginia.

5. "Person" means an individual, trust, firm, joint stock company, corporation (including a government corporation), partnership, association, State, municipality, commission, political subdivision of a State, or an interstate body.

6. "Facility" is defined as:

   AEP Philip Sporn, State Route 62, New Haven, WV 25265

7. "Permit" is defined as AEP Philip Sporn, National Pollutant Discharge Elimination System Permit Number WV0001058. Expiration Date: June 30, 2013.

IV. SUPPLEMENTAL REPORTS TO BE SUBMITTED

AEP shall develop supplemental reports for the requests below to ensure that the coal combustion waste impoundments at the Facility are structurally sound and will continue in safe and reliable operation. AEP shall develop and submit a supplemental report for the following requests in accordance with this section:

1. Site-specific study of the potential for liquefaction of foundation ash under design earthquake loading conditions for the raised eastern dike at the Fly Ash Pond;
2. Site-specific assessment of the effect of railway-induced ground vibrations on the embankments at both the Fly Ash Pond and the Bottom Ash Pond; and
3. Analysis of slope stability under design earthquake loading conditions for the upper sections of the eastern dike of the Fly Ash Pond.

1. Report on Earthquake-Induced Liquefaction for Eastern Dike of Fly Ash Pond: Within ninety (90) days of receipt of this request, AEP shall perform a study and submit an engineering report to EPA addressing the potential for earthquake-induced liquefaction of sluiced ash deposits upon which the raised eastern dike of the Fly Ash Pond was constructed at the Facility. The study shall be based on the specific site characteristics, subsurface conditions, material properties and parameters existing at the raised Fly Ash Pond dike, as determined by field exploration and laboratory tests. Existing field and laboratory data may be used to the extent that the data are representative of the conditions at the ash pond dike. Additional test borings and laboratory tests shall be performed if needed to adequately and accurately characterize the subsurface profiles and evaluate the densities, strengths, moisture contents, classification and index properties of the soil and ash layers that comprise the subsurface profiles. The Experimental Investigation approach used in The Ohio State University Research Project # 60005876 reported in *"Draft Final Report of Evaluation of Liquefaction Potential of Impounded Fly Ash,"* dated October 17, 2005 and adapted from The Indian Institute of Technology (Madras, India) *"Liquefaction Analysis of Pond Ash"* contained in the Proceedings of the 15th International Conference on Solid Waste Technology & Management held on December 12-15, 1999 in Philadelphia, Pennsylvania, may be used in this study to evaluate the liquefaction potential of foundation ash supporting the raised dike of the Fly Ash

Pond at the Facility. However, the cyclic triaxial testing shall be on representative samples of Philip Sporn fly ash remolded to relative densities that bracket the in-situ relative densities of the fly ash. Alternatively, semi-empirical procedures may be used to evaluate liquefaction potential of the foundation ash, such as those presented in the paper "*Semi-Empirical Procedures for Evaluating Liquefaction Potential During Earthquakes*," by I. M. Idriss and R.W. Boulanger, Proceedings of The Joint 11th International Conference on Soil Dynamics & Earthquake Engineering (ICSDEE) & 3rd International Conference on Earthquake Geotechnical Engineering (ICEGE) (pp. 32-56), January 7-9, 2004. The design earthquake ground acceleration shall be at least 0 06g. At a minimum, the report shall include the following:

(a) description of background information and approach of the study;
(b) description of the methodology and procedures used in the analysis;
(c) description of any additional field testing performed and the results obtained;
(d) description of any additional laboratory testing performed and the results obtained;
(e) description of the site(s) including site map(s) depicting planimetric and topographic features and the location of critical section(s) selected for analysis;
(f) description of the subsurface conditions at the critical sections and illustration of the analysis profiles;
(g) discussion of the design soil and ash properties and parameters and the basis of selection of these values or the source of the values;
(h) presentation of analysis results, including appropriate charts and graphs illustrating the results, and discussion of the results;
(i) conclusions regarding liquefaction potential under design earthquake loading conditions at the Philip Sporn Fly Ash Pond dike;
(j) recommendations for remedial action to eliminate or minimize liquefaction potential should the foundation ash be found susceptible to liquefaction under design earthquake loading;
(k) list of references;
(l) tables as needed to facilitate presentation of data;
(m) figures as needed for illustration purposes;
(n) an appendix containing summary descriptions of field and laboratory test procedures that may be used to develop additional soil and ash data as needed for the study;
(o) an appendix containing all test boring logs and other field data considered in the study, including existing data and additional data that may be obtained to fully characterize the analysis profiles;
(p) an appendix containing all laboratory test data considered in the study, including existing data and additional data developed for the study;
(q) an appendix containing calculations, including analysis calculations, *e.g.*, program SHAKE runs, and calculations for calculated values used in the analysis, *e.g.*, calculation of shear modulus values (G_{max}); and

(r) certification of the study and report by a professional engineer registered in the state of West Virginia.

2 Report on Railway-Induced Ground Vibration for Fly Ash Pond Dike and Bottom Ash Pond Dike: Within ninety (90) days of receipt of this request, AEP shall perform assessment and submit a report to EPA addressing the effect of railway-induced ground vibrations on the slope stability at the Fly Ash Pond dike and the Bottom Ash Pond dike located at the Facility. In addition, the study shall evaluate the potential for liquefaction of foundation ash under the raised eastern dike of the Fly Ash Pond due to railway-induced ground vibrations. The study shall be based on the specific site characteristics, railway loading conditions, subsurface conditions, material properties and parameters existing at the Fly Ash Pond dike and at the Bottom Ash Pond dike, as determined by field measurement, field exploration and laboratory tests. Existing field and laboratory data may be used to the extent that the data are representative of the conditions at the ash pond dikes. The study shall also examine the cause of apparently shallow sloughing of the dike slopes and determine whether the root cause of the sloughing is railway-induced ground vibration or some other cause, such as saturation of the thick topsoil layer on the relatively steep slopes and consequential loss of its nominal cohesive strength, leading to failure due to insufficient frictional shearing resistance, or a combination of causes. In light of the results of this examination, the study shall review plans for repairs of the sloughing and determine whether modifications to the plans ought to be made to ensure long-term success of the repair. At a minimum, the report shall include the following:

(a) a description of the site including a site map depicting the location of the railway superstructure, embankments and other planimetric and topographic features;
(b) description, procedures and summary of field measurements of railway-induced ground vibrations generated by loaded railway traffic under dynamic conditions at various speeds and stopping conditions;
(c) description, procedures and summary of field exploration and laboratory tests of in-situ subsurface conditions, including, but not limited to:
    (i) soil test & instrumentation location map;
    (ii) cross-sectional geometry of embankment sections depicting phreatic surface; and
    (iii) soil test boring logs and laboratory analyses of soil testing.
(d) description, procedures and summary of slope stability analysis including, but not limited to:
    (i) soil strength parameters modeled and basis of values used;
    (ii) loading conditions modeled from measured railway-induced ground vibrations generated by railway traffic;
    (iii) factors of safety against shallow slope failures and global slope instability.
(e) evaluation of the potential liquefaction of fly ash under the raised eastern dike of the Fly Ash Pond from instantaneous, as well as long term exposure, to railway induced ground vibrations from the west side of the Fly Ash Pond;

(f) evaluation of the potential liquefaction of fly ash under the raised eastern dike of the Fly Ash Pond from train collision and derailment on the west side of the Fly Ash Pond;

(g) determination of the root cause of apparently shallow sloughing of the dike slopes;

(h) evaluation of the plans for sloughing repairs in consideration of the determination of the root cause and description of potential changes, if any, that may need to be made to the plans to ensure long-term success of the repair;

(i) conclusions regarding railway vibrations and their effect on slope stability and liquefaction potential at the Philip Sporn Fly Ash Pond dikes and on slope stability at the Bottom Ash Pond dike;

(j) conclusions regarding train wreck and its effect on liquefaction potential at the raised eastern dike of the Philip Sporn Fly Ash Pond;

(k) recommendations for remedial action to enhance slope stability to acceptable safety margins and/or eliminate or minimize liquefaction potential, as may be required, depending on the results of the assessment;

(l) list of references;

(m) tables as needed to facilitate presentation of data;

(n) figures as needed for illustration purposes;

(o) an appendix containing summary descriptions of field and laboratory test procedures that may be used to develop vibration data and additional soil and ash data as needed for the assessment;

(p) an appendix containing the vibration monitoring data and all test boring logs and other field data considered in the study, including existing data and additional data that may be obtained;

(q) an appendix containing all laboratory test data considered in the assessment, including existing data and additional data developed for the assessment;

(r) an appendix containing all calculations, including slope stability analyses and liquefaction analyses; and

(s) certification of the assessment and report by a professional engineer registered in the state of West Virginia.

3. <u>Report on Analysis of Seismic Slope Stability of Fly Ash Pond Eastern Dike Upper Section</u>: Within ninety (90) days of receipt of this request, AEP shall submit a report to EPA of the "Seismic Slope Stability Analysis" to characterize the seismic stability of the Upper Section of the Fly Ash Pond eastern dike, which was constructed over sluiced fly ash deposits, at the Facility. The analysis shall be based on the specific site characteristics, subsurface conditions, material properties and parameters existing at the raised Fly Ash Pond dike, as determined by field exploration and laboratory tests. The analysis shall be based on a design earthquake ground acceleration of at least 0.06g. Pseudo-static design methodologies may be used Existing field and laboratory data may be used to the extent that the data are representative of the conditions at the ash pond dike. A report of the analysis shall be prepared and at a minimum the report shall include:

(a) a description of the geotechnical properties used for each soil and ash layer used in the analysis including total and effective shear strength parameters;
(b) a description of the data collection and modeling methodologies utilized by AEP in the evaluation of seismic slope stability;
(c) an analysis of embankment internal stresses, including static pore pressures under expected seepage conditions;
(d) an analysis of embankment internal stresses, including static pore pressures during normal and maximum waste placement conditions;
(e) analyses of embankment stability shall consider both slope and base sliding conditions;
(f) analyses of slope stability shall include evaluation of critical full height and partial height potential failure planes;
(g) computed minimum safety factors during the design earthquake event for both slope and base sliding conditions;
(h) conclusions regarding seismic slope stability under design earthquake loading conditions of upper section of the Fly Ash Pond eastern dike at the Facility;
(i) recommendations for remedial action to enhance seismic stability of the upper section of the Fly Ash Pond eastern dike to acceptable safety margins, as may be required, depending on the results of the assessment;
(j) list of references;
(k) tables as needed to facilitate presentation of data;
(l) figures as needed for illustration purposes;
(m) an appendix containing summary descriptions of field and laboratory test procedures that may be used to develop additional soil and ash data as needed for the analysis;
(n) an appendix containing all test boring logs and other field data considered in the analysis, including existing data and additional data that may be obtained;
(o) an appendix containing all laboratory test data considered in the analysis, including existing data and additional data developed for the analysis;
(p) an appendix containing all stability analysis calculations; and
(q) certification of the analysis by a professional engineer registered in the state of West Virginia.

Enclosure 2

STATEMENT OF CERTIFICATION

I certify that the information contained in or accompanying this submission is true, accurate, and complete.

As to the identified portion(s) of this submission for which I cannot personally verify its truth and accuracy, I certify as the company official having supervisory responsibility for the person(s) who, acting under my direct instructions, made the verification, that this information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment.

By ______________________________
(Signature)

____
(Title)

____
(Date)

APPENDIX II

FIELD AND LABORATORY TEST DATA

DR. KALINSKI REPORT DATED MARCH 8, 2010 RELATED TO JANUARY 6 AND 7, 2010 GEOPHYSICAL TESTING AND LABORATORY DAMPING RATIO TESTING

March 8, 2010

Mr. Roger Cecil. P.E.
Geo/Environmental Associates
3502 Overlook Circle
Knoxville, TN 37909

RE: Vibration monitoring crosshole seismic testing, and resonant column testing at the AEP Sporn Power Plant, New Haven, West Virginia (revised report)

Dear Roger,

OVERVIEW

Vibration monitoring and crosshole seismic testing were performed on January 6-7, 2010 at the AEP Sporn Power Plant in New Haven, West Virginia. Vibration monitoring was performed at the same six locations that were used in November 2009, and crosshole seismic testing was performed at two of these locations. Laboratory free-free resonant column testing was also performed on undisturbed fly ash specimens to estimate the material damping of the fly ash. This letter report describes the methods used and results, and is accompanied by a CD containing the data.

VIBRATION MONITORING

Vibration monitoring was performed continuously for 30 hours from approximately 9:00 A.M. on January 6 until 3:00 P.M. on January 7 at six locations on the perimeter levees that contain the fly ash and bottom ash at the power plant. The locations are described as follows:

- Location A: outside toe of the bottom ash levee adjacent to the train tracks;
- Location B: outside crest of the bottom ash levee adjacent to the train tracks;
- Location C: outside toe of the fly ash levee adjacent to the train tracks;
- Location D: outside crest of the fly ash levee adjacent to the train tracks;
- Location E: outside crest of the fly ash levee adjacent to the Ohio River; and
- Location F: outside toe of the fly ash levee adjacent to the Ohio River.

These are the same locations that were used for vibration monitoring during the November 2009 survey.

Vibration monitoring was performed using six Blastmate III seismographs, which are manufactured by Instantel. The Blastmate III seismographs record four channels simultaneously during each event: one air wave channel with a microphone, and three ground wave channels using three geophones. The three geophones are oriented orthogonal to each other so that one geophone detects vertical particle motion, and the other two detect horizontal particle motion in two perpendicular directions. The two horizontal geophones are identified as longitudinal and transverse, with the longitudinal geophone oriented towards the vibration source, and the transverse oriented perpendicular to the longitudinal.

The geophones that accompany the Blastmate III have a damped resonant frequency of approximately 2.0 Hz and the data are sampled in the instrument at a rate of 1,024 samples per second. This allows vibrations to be recorded between the bandwidth of 2.0-250 Hz with minimal distortion. The vibrations imparted to the geophones are converted into voltage, and the voltage is converted to particle velocity using a calibration factor. To minimize wind and surface noise, the geophones are buried in sand a few inches below the ground surface and covered with a heavy weight such as a sand bag or water jug. The serial numbers of the seismographs used at each test location are as follows:

- Location A: Serial #BA11042;
- Location B: Serial #BA11291;
- Location C: Serial #BA10619;
- Location D: Serial #BA11821;
- Location E: Serial #BA11088; and
- Location F: Serial #BA11290.

Each instrument was calibrated according to ISO9001:2000 standards.

Vibration monitoring was performed on January 6-7, 2010 as indicated on the monitoring logs included in Appendix A of this report. During this period, four trains passed by the power plant:

- Train 1: January 6, 1:13 P.M.; approximately 95 seconds in duration;
- Train 2: January 7, 12:23 A.M.; approximately 132 seconds in duration;
- Train 3: January 7, 4:27 A.M.; approximately 120 seconds in duration; and
- Train 4: January 7, 12:05 P.M.; approximately 122 seconds in duration.

Trains 1 and 4 consisted of multiple (typically four) engines with mostly tank cars, and appeared to be traveling at a speed of around 25 mph. Trains 2 and 3 passed during the night and were not visually observed.

The vibration monitoring logs included in Appendix A indicate when the seismographs were actively monitoring and when vibration events were recorded, including the four trains. The monitoring logs indicate that additional events were also recorded. These additional events correspond to occasional testing of the seismographs by stomping on the ground next to the geophones. Details regarding these additional test events are not included herein.

For all logging, vibrations were only recorded when the vibration level exceeded 0.02 in./s. Below this level, vibrations were considered to be within the level of ambient noise. Peak particle velocities observed for each train and monitoring location are summarized in Table 1.

All of the vibration monitoring data are included in ASCII format in Appendix B on the attached CD. Given a sample rate of 1,024 samples/s, the vibration data should be plotted at a sample rate of 9.7656×10^{-4} s. Vibration data are presented in the ASCII files text in units of particle velocity in mm/s. Please note that the internal clocks on the six seismographs were set to the nearest minute, so the time stamps on the monitoring data may be slightly out of synch between seismographs.

Excel files containing particle acceleration are also included in Appendix B. Acceleration is defined a change in velocity per unit time, and was derived by calculating the difference in particle velocity between successive points and dividing the difference by the sample rate. For example, if the particle velocity for a given sample time is 0.349 mm/s, the particle velocity for the next sample time is 0.302 mm/s, and the sample rate is 1.019×10^{-4} s, then the particle acceleration is $(0.302 \text{ mm/s} - 0.349 \text{ mm/s})/9.77 \times 10^{-4} \text{ s} = -4.81 \times 10^{-1} \text{ mm/s}^2$, or -4.90×10^{-3} g.

CROSSHOLE SEISMIC TESTING

Crosshole seismic testing was performed at vibration monitoring Locations B (in bottom ash) and E (in fly ash). Crosshole seismic testing was performed using a three-hole array with one source hole and two receiver holes. The spacing at the ground surface was 10.0 ft, and an inclinometer survey was performed by Mr. Seth Frank to derive borehole spacing information for calculation of wave velocities. A mechanical wedge was used as a borehole seismic source, and BHG-2 borehole geophones were used as receivers. The BHG-2 geophones contain three geophones positioned in three orthogonal directions (one vertical and two horizontal). For crosshole seismic testing, the vertical geophone measures S-waves, while the horizontal geophones measure P-waves. All of the data were recorded using a Geometrics Geode multi-channel seismograph.

A set of typical crosshole data is shown in Fig. 1. For this record, the S-waves and P-waves are apparent on each trace. Although the vertical geophones are intended to record S-waves, there is some leakage of P-wave energy onto the records. Conversely, there is also leakage of S-wave energy onto the horizontally oriented geophones, which are primarily intended to record P-wave energy.

Spreadsheets including the details of crosshole seismic testing are included on the attached CD. Calculated wave velocities and values for Poisson's ratio are summarized in Tables 2 and 3, and the data are graphed in Figs. 2 and 3.

FREE-FREE RESONANT COLUMN TESTING

Free-free resonant column testing was performed on 2 fly ash specimens and one clay foundation specimen recovered from the site to calculate material damping. Each specimen was approximately 6.0 in. long and 3.0 in. in diameter. Resonant column testing is performed by suspending the specimens horizontally. Accelerometers are glued to the outer perimeter of one end to detect torsional motion, while a torsional excitation device is fixed to the other end. The specimens are encased in a latex membrane with end caps during testing, and a vacuum pressure of approximately 9.0 psi is applied to provide confinement to the specimens.

When the specimen is excited in torsion, it resonates at a frequency f_n that is calculated by performing spectral analysis of the free vibration record measured with the accelerometers. The auto power spectrum is calculated, which is a curve of accelerometer power versus frequency. The half-power bandwidth method is then used to estimate material damping. Given a resonant frequency f_n and spectral power of A, frequencies f_1 and f_2 are identified as the frequencies corresponding to a power of $0.5A$. Material damping is then estimated as:

$D = (f_2 - f_1)/(2 f_n)$.

Results are summarized in the table below.

Specimen description	Material damping (%)
FLY ASH: recovered from GA-1A-ST-7, depth = 48.5-51.0 ft	3.9
FLY ASH: recovered from GA-1A-ST-4, depth = 36.5-39.0 ft	5.1
FOUNDATION SOIL: recovered from GA-ST-2, depth = 59.0-61.5 ft	7.0

Please note that the material damping of 7.0% measured in the clay foundation soil specimen is higher than the typical range in material damping for clay specimens. Material damping of clay is typically around 2-4%. It was difficult to obtain a measurable signal in the clay specimen, which supports the observation that material damping in the clay is relatively high.

Thank you very much for providing me the opportunity to work with you on this project. Please do not hesitate to contact me if you have any questions or require any additional details or information.

Regards,

Michael E. Kalinski

Michael E. Kalinski, Ph.D.

Attachments: Tables 1-3
Figs. 1-3
Appendix A – vibration monitoring logs (on CD)
Appendix B -- vibration data (on CD)
Appendix C – crosshole seismic calculations (on CD)

Table 1. Peak particle velocities (PPVs) recorded for each train and location

Train	**Location**	**Tran. PPV (in./s)**	**Vert. PPV (in./s)**	**Long. PPV (in./s)**
1	A	0.007	0.035	0.016
	B	0.006	0.023	0.014
	C	0.044	0.042	0.047
	D	ND*	ND	ND
	E	ND	ND	ND
	F	ND	ND	ND
2	A	0.010	0.039	0.019
	B	0.007	0.024	0.010
	C	0.048	0.057	0.046
	D	ND	ND	ND
	E	ND	ND	ND
	F	ND	ND	ND
3	A	0.010	0.039	0.013
	B	ND	ND	ND
	C	0.055	0.054	0.053
	D	ND	ND	ND
	E	ND	ND	ND
	F	ND	ND	ND
4	A	0.009	0.039	0.016
	B	0.007	0.021	0.009
	C	0.043	0.049	0.047
	D	0.006	0.014	0.021
	E	ND	ND	ND
	F	ND	ND	ND

*ND = no vibrations detected above threshold level of 0.02 in./s

Table 2. Summary of results from crosshole seismic testing at Location B (bottom ash site)

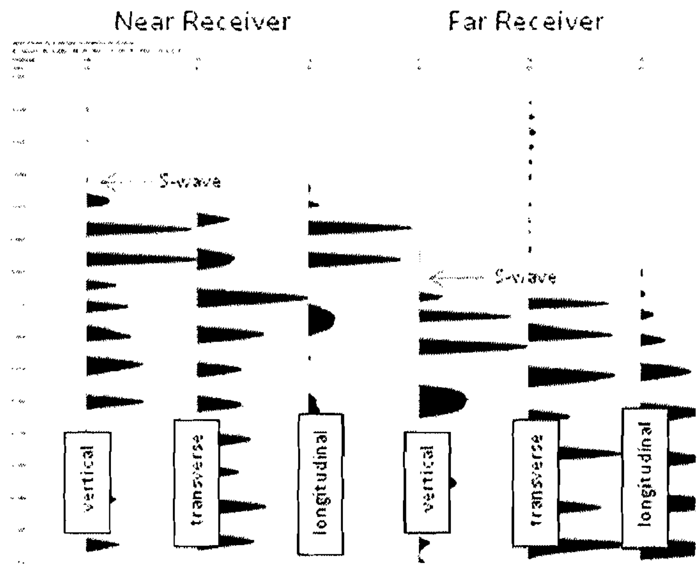
Depth (ft)	S-wave velocity (ft/s)	P-wave velocity (ft/s)	Poisson's ratio	Interpretation
10.0	814	?*	?	unsaturated fill
12.5	825	?	?	unsaturated fill
15.0	1061	?	?	unsaturated fill
17.5	1188	?	?	unsaturated fill
20.0	1501	?	?	unsaturated fill
22.5	1122	?	?	unsaturated fill
25.0	1741	3489	0.33	unsaturated fill
27.5	453	3917	0.49	saturated fly ash
30.0	500	5178	0.50	saturated fly ash
32.5	350	3854	0.50	saturated fly ash
35.0	?	5750	?	foundation soil
37.5	1468	5072	0.45	foundation soil
40.0	1505	6471	0.47	foundation soil
42.5	849	5638	0.49	foundation soil
45.0	1120	6414	0.48	foundation soil
47.5	1944	6400	0.45	foundation soil

*Could not be reliably identified on the data.

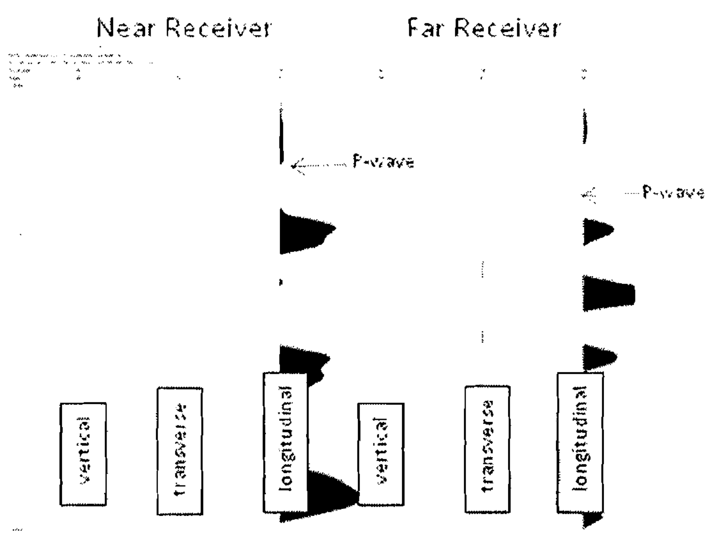
Table 3. Summary of results from crosshole seismic testing at Location E (fly ash site)

Depth (ft)	S-wave velocity (ft/s)	P-wave velocity (ft/s)	Poisson's ratio	Interpretation
10.0	1242	?*	?	unsaturated fill
15.0	1178	2195	0.30	unsaturated fill
17.5	690	2541	0.46	unsaturated fill
20.0	862	1930	0.38	unsaturated fill
22.5	963	1784	0.29	unsaturated fill
25.0	875	1718	0.33	unsaturated fill
27.5	1041	?	?	unsaturated fill
30.0	554	993	0.27	unsaturated fly ash
32.5	392	3963	0.50	saturated fly ash
35.0	364	5267	0.50	saturated fly ash
37.5	415	4740	0.50	saturated fly ash
40.0	321	4295	0.50	saturated fly ash
42.5	461	4282	0.49	saturated fly ash
45.0	470	4710	0.49	saturated fly ash
47.5	480	5894	0.50	saturated fly ash
50.0	516	5233	0.50	saturated fly ash
52.5	811	5233	0.49	saturated fly ash
55.0	403	3917	0.49	saturated fly ash
57.5	555	3942	0.49	saturated fly ash
60.0	527	5907	0.50	saturated fly ash
62.5	744	2069	0.43	foundation soil
65.0	771	2518	0.45	foundation soil
67.5	567	2389	0.47	foundation soil

*Could not be reliably identified on the data.



a. S-wave arrivals



b. P-wave arrivals (rescaled view of Fig. 1a)

Fig. 1. Typical records from crosshole seismic testing (recorded at Location E at a depth of 40.0 ft below the ground surface in fly ash).

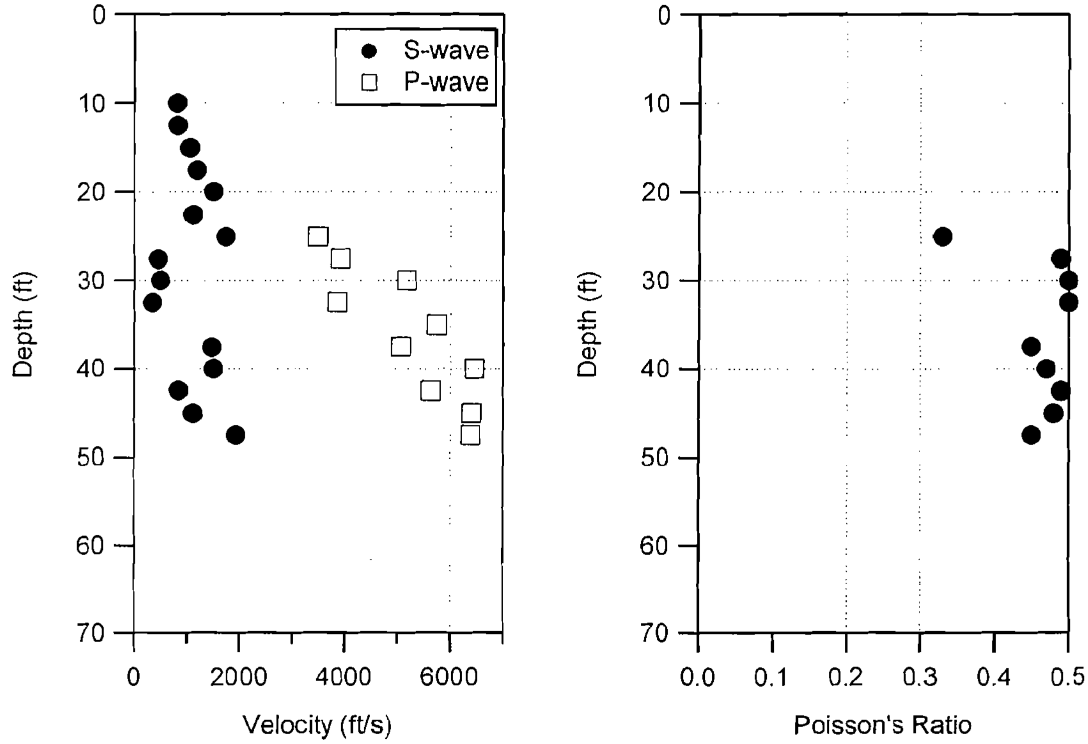


Fig. 2. Graph of wave velocities and Poisson's ratio from crosshole seismic testing at Location B (bottom ash site)

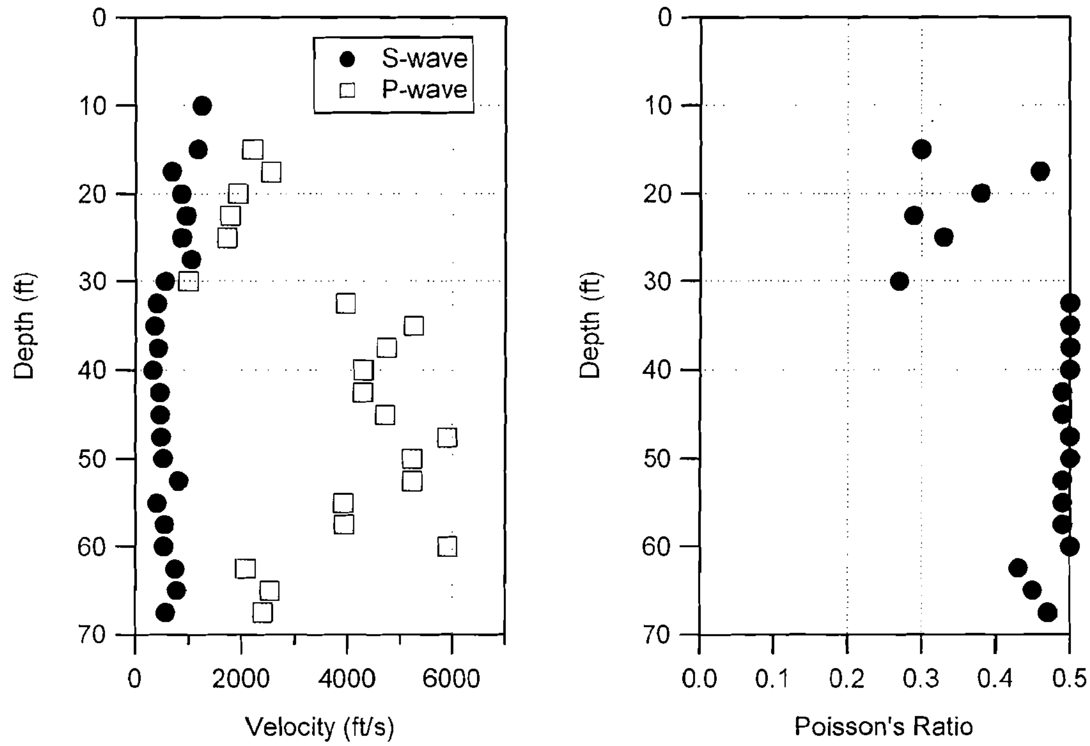


Fig. 3. Graph of wave velocities and Poissons ratios from crosshole seismic testing at Location E (fly ash site)

FIELD DATA FROM:
"PHILIP SPORN ELECTRIC GENERATING PLANT UNIT 5 ASH FACILITY – ENGINEERING REPORT"

PREPARED/COMPILED BY:
THE GEOTECHNICAL ENGINEERING SECTION OF AMERICAN ELECTRIC POWER SERVICE CORPORATION

DATED: JULY 1998

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
LOG OF BORING

JOB NUMBER 3966
COMPANY APPALACHIAN POWER COMPANY
PROJECT Sporn fly ash pond dikes
COORDINATES N 720,983.0 E 1,734,516.1
GROUND ELEVATION 619.0 SYSTEM STATE PLANE

BORING NO. 96-101 DATE SHEET 1 OF 2
BORING START 06/05/96 BORING FINISH 06/05/96
PIEZOMETER TYPE SS WELL TYPE
HGT. RISER ABOVE GROUND DIA
DEPTH TO TOP OF WELL SCREEN 24.4 BOTTOM 33.4
WELL DEVELOPMENT NO BACKFILL QUICK GROUT
FIELD PARTY MCR-REB RIG BK-81

WATER LEVEL	▽	▼	▽
TIME			
DATE			

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
1		0.0			0					No sample taken boring in road way		
2	SS	3.0	4.5	12-13-16	1.1				SM	BROWN SILTY GRAVELLY SAND Dry to moist, 1/2" max size, rounded, quartz.		
3	SS	5.0	6.5	7-9-9	1.2		5					
3	SS	8.5	10.0	3-4-5	1.2		10		SC	BROWN CLAYEY SAND Moist, fine grain with trace of gravel.		
4	SS	11.5	13.0	17-27-38	1.2				SM	BROWN SILTY GRAVELLY SAND Moist, fine grain, trace of gravel, quartz.		
5	SS	16.5	18.0	12-19-26	1.1		15					
							20					20.0 Top of seal.
6	SS	21.5	23.0	16-21-27	1.1				SW	BROWN GRAVELLY SAND Moist, trace of small gravel, quartz, rounded.		22.0 Top of sand.
							25					24.4 Top of screen.
7	SS	26.5	28.0	12-20-23	1.2				GP	BROWN SAND AND GRAVEL Moist to wet, quartz, rounded, 3/4" max size, some fines.		
							30					
8	SS	31.5	33.0	4-5-7	1.1				SM	BROWN SILTY SAND Moist, 100% fine grain.		
9	ST	33.5	35.5		1.6		35		CL	Push 2.0 Time 5 sec. PSI 800 Top of sample, BROWN SILTY SAND		34.0 Bottom of pipe. 34.4 Bottom of screen. 35.0 Bottom of sand.
10	SS	36.5	38.0	4-6-8	1.1					Bottom of sample, LIGHT GRAY CLAY Moist, low to medium plasticity.		
							40					
11	SS	41.5	43.0	4-5-6	1.1				SM	DARK GRAY SILTY SAND Wet, non to slight plasticity, with reddish brown quartz sand lens.		
12	ST	43.5	45.5		1.5		45		ML	PUSH 2.0 TIME 5 SEC		
13	SS	46.5	48.0	7-9-11	1.1				SP	PSI 800 Bottom of sample, Drillers identification fly ash I believe it is a light gray clay		

Continued Next Page

TYPE OF CASING USED

	NQ-2 ROCK CORE	
X	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER REB

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
LOG OF BORING

AEP

JOB NUMBER 3966

COMPANY APPALACHIAN POWER COMPANY — BORING NO. 96-101 — DATE ______ — SHEET 2 OF 2

PROJECT Sporn fly ash pond dikes — BORING START 06/05/96 — BORING FINISH 06/05/96

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										???????????????????????????????????? Top of sample, BROWN SILTY		
										BROWN GRAVELLY SAND Moist, 1/2" max size, rounded, quartz.		

AEPSPP-000607

AEPSPP003942

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
LOG OF BORING

AEP

JOB NUMBER 3966

COMPANY APPALACHIAN POWER COMPANY
PROJECT Sporn fly ash pond dikes
COORDINATES N 720,707.5 E 1,734,001.7
GROUND ELEVATION 619.6 SYSTEM STATE PLANE

BORING NO. 96-102 DATE ____ SHEET 1 OF 1
BORING START 06/05/96 BORING FINISH 06/05/96
PIEZOMETER TYPE ____ WELL TYPE ____
HGT. RISER ABOVE GROUND ____ DIA ____
DEPTH TO TOP OF WELL SCREEN ____ BOTTOM ____
WELL DEVELOPMENT ____ BACKFILL QUICK GROUT
FIELD PARTY MCR-REB RIG BK-81

WATER LEVEL	▽	▼	▼
TIME			
DATE			

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
1		0.0			0					NO SAMPLE TAKEN BORING IN ROAD AUGER CUTTINGS INDICATE BROWN SAND AND GRAVEL		Boring was grouted from grade to 48.2' with quick grout.
2	SS	3.0	4.5	12-16-19	1.1				SP	BROWN GRAVELLY SAND Moist, 1/2" max size, rounder, quartz with fines.		
3	SS	5.0	6.5	17-21-26	1.2		5					
4	SS	8.5	10.0	13-16-19	1.2		10					
5	SS	11.7	13.2	15-28-32	1.2		15					
6	SS	16.7	18.2	17-21-26	1.2		20					
7	SS	21.7	23.2	19-21-24	1.1		25			Sample moist to wet.		
8	SS	26.7	28.2	9-9-11	1.1		30		SM	DARK BROWN SANDY SILT Moist, non-plastic.		
9	SS	31.7	33.2	3-4-5	1.1				SC	BROWN SANDY CLAY Moist, low plasticity, with v-fine sand lens.		
10	ST	33.7	35.7		?		35			Time 5 sec. Push 2.0 PSI 1000		
11	SS	36.7	38.2	4-4-5	1.1		40		SM	BROWN SILTY SAND Moist, with very fine sand lens.		
12	SS	41.7	43.2	3-5-8	1.1		45		SP	BROWN GRAVELLY SAND Moist, 3/4" max size, rounded, quartz.		
13	SS	46.7	48.2	13-15-21	1.2							

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER REB

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER 3966

COMPANY APPALACHIAN POWER COMPANY

PROJECT Sporn fly ash pond dikes

COORDINATES N 719,785.3 E 1,734,133.3

GROUND ELEVATION 618.0 SYSTEM STATE PLANE

WATER LEVEL	∇	▼	∇
TIME			
DATE			

BORING NO. 96-103 DATE SHEET 1 OF 1

BORING START 06/04/96 BORING FINISH 06/04/96

PIEZOMETER TYPE WELL TYPE

HGT. RISER ABOVE GROUND DIA

DEPTH TO TOP OF WELL SCREEN BOTTOM

WELL DEVELOPMENT BACKFILL QUICK GROUT

FIELD PARTY MCR-REB RIG BK-81

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
1		0.0			0					NO SAMPLE TAKEN BORING LOCATED IN ROAD CUTTINGS INDICATE BROWN SAND AND GRAVEL		Boring grouted from grade to 48.1 w\ 60 gallons of quick grout.
2	SS	3.0	4.5	12-19-24	1.1				SP	DARK BROWN GRAVELLY SAND Moist, rounded, quartz, with fines, 3/4" max size.		
3	SS	5.0	6.5	14-17-19	1.2		5					
4	SS	8.5	10.0	17-21-25	1.1		10					
5	SS	11.6	13.1	19-25-28	1.1		15					
6	SS	16.6	18.1	12-19-25	1.2		20					
7	SS	21.6	23.1	5-14-21	1.1		25					
8	SS	26.6	28.1	11-17-28	1.2		30					
9	SS	31.6	33.1	8-9-10	1.1		35		CL	BROWN SILTY CLAY Moist, with fine grin sand lens, low plasticity.		
10	ST	36.6	38.6		1.6		40		SP	time 5 sec. Push 2.0 PSI 700 LIGHT BROWN SAND Fine grain.		
11	SS	41.6	43.1	4-5-6	1.1		45			BROWN SAND Moist, 100% fine grain, with fines.		
12	SS	46.6	48.1	6-6-5	?							

TYPE OF CASING USED		
X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER REB

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER 3966

COMPANY APPALACHIAN POWER COMPANY

PROJECT Sporn fly ash pond dikes

COORDINATES N 719,229.2 E 1,734,600.2

GROUND ELEVATION 618.7 SYSTEM STATE PLANE

BORING NO. 96-104 DATE ______ SHEET 1 OF 2

BORING START 06/04/96 BORING FINISH 06/04/96

PIEZOMETER TYPE SS WELL TYPE ______

HGT. RISER ABOVE GROUND ______ DIA ______

DEPTH TO TOP OF WELL SCREEN 24.1 BOTTOM 33.1

WELL DEVELOPMENT NO BACKFILL QUICK GROUT

FIELD PARTY MCR-REB RIG BK-81

WATER LEVEL	▽	▼	▽
TIME			
DATE			

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %
1	SS	0.0		2-4-8	1.1	
2	SS	3.0	4.5	9-14-18	1.2	
3	SS	5.0	6.5	73	1.1	
4	SS	8.5	10.0	9-18-25	1.2	
5	SS	11.7	13.2	19-26-31	1.2	
6	SS	16.7	18.2	18-21-26	1.2	
7	SS	21.7	23.2	17-21-25	1.2	
8	SS	26.7	28.2	4-6-8	1.1	
9	ST	31.7	33.7		1.6	
10	SS	36.7	38.2	3-3-5	1.2	
11	SS	41.7	43.2	4-4-7	1.1	
12	ST	46.7	48.7		1.5	

USCS	SOIL / ROCK IDENTIFICATION
CL	-
SP	DARK BROWN CLAY Moist, medium to high plasticity trace of sand.
GW	BROWN GRAVELLY SAND Dry, quartz, 1/2" max, rounded.
	DARK BROWN SAND AND GRAVEL Dry, quartz, 1/2" max, rounded. Same as above some fines, moist
SP	DARK BROWN GRAVELLY SAND Dry, 3/4" max, rounded, quartz.
SC	DARK BROWN CLAYEY SAND Moist, trace of gravel.
SP	LIGHT BROWN GRAVELLY SAND Dry, quartz, 3/4" max, rounded.
CL	LIGHT BROWN SILTY CLAY Moist, low to medium plasticity. PUSH 2.0 PSI 900 TIME 6 SEC. BROWN CLAYEY SAND Fine grain? LIGHT BROWN SILTY CLAY Moist, low to medium plasticity.
SM	LIGHT BROWN SILTY SAND Moist. v-fine grain 100%. PUSH 2.0 PSI 1200 TIME 6 SEC.

DRILLER'S NOTES:

20.4 Top seal.

22.5 Top of sand.

24.1 Top of screen.

33.1 Bottom of screen.

34.7 Bottom of sand.

TYPE OF CASING USED		
X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"

Continued Next Page

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER REB

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

AEP

JOB NUMBER 3966

COMPANY APPALACHIAN POWER COMPANY

BORING NO. 96-104 DATE ________ SHEET 2 OF 2

PROJECT Sporn fly ash pond dikes

BORING START 06/04/96 BORING FINISH 06/04/96

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										DARK BROWN SANDY CLAY Fine grain.		

AEPSPP-000611

AEPSPP003946

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
LOG OF BORING

JOB NUMBER 3966

COMPANY APPALACHIAN POWER COMPANY
PROJECT Sporn fly ash pond dikes
COORDINATES N 718,782.8 E 1,735,084.7
GROUND ELEVATION 619.3 SYSTEM STATE PLANE

WATER LEVEL	∇	▼	∇
TIME			
DATE			

BORING NO. 96-105 DATE ____ SHEET 1 OF 1
BORING START 06/03/96 BORING FINISH 06/03/96
PIEZOMETER TYPE ____ WELL TYPE ____
HGT. RISER ABOVE GROUND ____ DIA ____
DEPTH TO TOP OF WELL SCREEN ____ BOTTOM ____
WELL DEVELOPMENT ____ BACKFILL QUICK GROUT
FIELD PARTY MCR-REB RIG BK-81

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										No sample taken. Boring located in road bed. Auger cuttings sand and gravel.		Boring grouted from grade to 48.5' with 75 gallons of quick grout
1	SS	3.0	4.5	7-10-11	1.1				SW	BROWN SAND Dry, quartz, rounded with trace of gravel.		
2	SS	5.0	6.5	12-16-21	1.2		5			BROWN GRAVELLY SAND Dry quartz, rounded, 1/2" max size.		
3	SS	8.5	10.0	9-15-17	1.2					3/4" max size trace of fines.		
4	SS	11.5	13.0	9-16-19	1.1		10					
5	SS	16.5	18.0	9-14-17	1.2		15			Moist		
6	SS	21.5	23.0	7-9-14	1.1		20		SM	DARK BROWN SILTY SAND Moist, with trace of small gravel.		
7	SS	26.5	28.0	5-6-7	1.2		25		CL	BROWN SILTY CLAY Moist, low to medium plasticity.		
8	ST	31.5	33.5		1.7		30			PUSH 2.0 PSI 700 TIME 8 SEC.		
9	SS	36.5	38.0	3-3-5	1.1		35					
10	SS	41.5	43.0	4-4-5	1.2		40		SP SC	LIGHT BROWN CLAYEY SAND Moist, 100% v-fine grain.		
11	ST	46.5	48.0		1.8		45			TIME 5 SEC PSI 800 PUSH 2.0		

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER REB

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL ENGINEERING LABORATORY
LOG OF BORING

AEP

JOB NUMBER 3966
COMPANY APPALACHIAN POWER COMPANY
PROJECT Sporn fly ash pond dikes
COORDINATES N 719,271.8 E 1,735,858.4
GROUND ELEVATION 618.9 SYSTEM STATE PLANE

WATER LEVEL	∇ 60.2	▼	▼
TIME			
DATE	5-28-96		

BORING NO. 96-106 DATE ______ SHEET 1 OF 2
BORING START 05/28/96 BORING FINISH 05/28/96
PIEZOMETER TYPE ______ WELL TYPE ______
HGT. RISER ABOVE GROUND ______ DIA ______
DEPTH TO TOP OF WELL SCREEN ______ BOTTOM ______
WELL DEVELOPMENT ______ BACKFILL QUICK GROUT
FIELD PARTY MCR-REB RIG BK-81

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										NO SAMPLE TAKEN BORING IN ROAD BED.		
1	SS	3.0	4.5	15-17-21	1.1				GP	DARK BROWN SAND AND GRAVEL Moist, 1/2" max, rounded, quartz, some fines.		
2	SS	5.0	6.5	17-24-30	1.1		5			1" max size		
3	SS	8.5	10.0	13-17-20	1.2		10			1/2" max size		
4	SS	11.5	13.0	11-11-14	1.2							
5	SS	16.5	18.0	13-15-17	1.1		15			1/2" max size		
6	SS	21.5	23.0	6-8-10	1.2		20		SC	BROWN SANDY CLAY Dry, slight to low plasticity.		
7	SS	26.5	28.0	4-6-6	1.2		25			GRAY FLY ASH Dry.		
8	SS	31.5	33.0	1-1-1	1.2		30			Saturated		
9	SS	36.5	38.0	1-1-1	1.2		35					
10	SS	41.5	43.0	1-1-1	1.2		40					
11	SS	46.5	48.0	3-2-2	1.1		45					

TYPE OF CASING USED		
X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"

Continued Next Page

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER REB

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

AEP

JOB NUMBER 3966

COMPANY APPALACHIAN POWER COMPANY

PROJECT Sporn fly ash pond dikes

BORING NO. 96-106 DATE ______ SHEET 2 OF 2

BORING START 05/28/96 BORING FINISH 05/28/96

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
12	SS	51.5	53.0	2-2-2	1.2		55					
13	SS	56.5	58.0	3-4-4	1.2				CL	DARK GRAY SILTY CLAY Wet, low to medium plasticity, trace of organic material.		
14	ST	61.5	63.5		1.6		60			Time 7 sec. Push 2.0 PSI 600	∇	
15	SS	66.5	68.0	3-4-5	1.2		65			BROWN SILTY CLAY Trace of fine sand. BROWN CLAY Wet, medium to high plasticity.		Boring grouted from 68.0' to grade with 125 gallons quick grout.

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

AEP

JOB NUMBER 3966

COMPANY APPALACHIAN POWER COMPANY

PROJECT Sporn fly ash pond dikes

COORDINATES N 719,691.4 E 1,736,040.0

GROUND ELEVATION 618.8 SYSTEM STATE PLANE

BORING NO. 96-107 DATE ______ SHEET 1 OF 2

BORING START 05/29/96 BORING FINISH 05/29/96

PIEZOMETER TYPE ______ WELL TYPE ______

HGT. RISER ABOVE GROUND ______ DIA ______

DEPTH TO TOP OF WELL SCREEN ______ BOTTOM ______

WELL DEVELOPMENT ______ BACKFILL QUICK GROUT

FIELD PARTY MCR-REB RIG BK-81

WATER LEVEL	▽ 39.1	▼	▽
TIME			
DATE	5-29-96		

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										NO SAMPLE TAKEN BORING IN ROAD BED. AUGER CUTTINGS INDICATE BROWN SAND AND GRAVEL		Boring was grouted from 73.1 to grade w/approximately 100 gallons of quick grout.
1	SS	3.0	4.5	14-17-21	1.1				GP	BROWN SAND AND GRAVEL Moist, quartz, rounded, some fine 3/4' max size.		
2	SS	5.0	6.5	17-21-28	1.2		5					
3	SS	8.5	10.0	14-18-24	1.1					1/2" max size		
4	SS	11.6	13.1	13-16-21	1.2		10					
5	SS	16.6	18.1	5-8-10	1.1		15		ML	BROWN SILT Moist, non to v-slight plasticity.		
6	SS	21.6	23.1	8-8-11	1.2		20		SM	Attempted shelby tube lifted rig BROWN SILT SAND Moist, 100% v-fine grain.		
7	SS	26.6	28.1	4-5-9	1.2		25			GRAY FLY ASH Moist.		
8	SS	31.6	33.1	5-8-11	1.2		30			Saturated		
9	SS	36.6	38.1	1-1-1	1.1		35				▽	
10	SS	41.6	43.1	1-1-1	1.2		40					
11	SS	46.6	48.1	1-1-1	1.2		45					

Continued Next Page

TYPE OF CASING USED		
X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER REB

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER 3966

COMPANY APPALACHIAN POWER COMPANY | BORING NO. 96-107 | DATE ____ | SHEET 2 OF 2

PROJECT Sporn fly ash pond dikes | BORING START 05/29/96 | BORING FINISH 05/29/96

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
12	SS	51.6	53.1	2-1-1	1.2							
13	SS	56.6	58.1	0	1.3		55					Weight of 140# hammer.
14	SS	61.6	63.1	4-7-10	1.2		60		CL	DARK BROWN CLAY Moist. medium to high plasticity.		
15	ST	66.6	68.6		1.5		65			Push 2.0 Time 5 sec. PSI 600 BROWN CLAY		
16	SS	71.6	73.1	4-6-7	1.2		70					

AEPSPP-000616

AEPSPP003951

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

AEP

JOB NUMBER 3966

COMPANY APPALACHIAN POWER COMPANY

PROJECT Sporn fly ash pond dikes

COORDINATES N 719,761.8 E 1,736,125.4

GROUND ELEVATION 603.4 SYSTEM STATE PLANE

BORING NO. 96-108 DATE ______ SHEET 1 OF 2

BORING START 06/11/96 BORING FINISH 06/11/96

PIEZOMETER TYPE SS WELL TYPE ______

HGT. RISER ABOVE GROUND ______ DIA ______

DEPTH TO TOP OF WELL SCREEN 63.3 BOTTOM 72.3

WELL DEVELOPMENT NO BACKFILL QUICK GROUT

FIELD PARTY MCR-WEB RIG BK-81

WATER LEVEL	∇	▼	∇
TIME			
DATE			

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										No sample road base		
1	SS	3.0	4.5	11-15-16	1.2					BLACK SAND AND BOTTOM ASH Moist.		
3	SS	5.0	6.5	12-17-21	1.5		5					
4	SS	8.5	10.0	12-16-29	.9		10		SC	DARK BROWN CLAYEY SAND Moist, with fine sand lens.		
5	SS	11.6	13.1	9-18-22	1.2		15		SP	DARK BROWN GRAVELLY SAND Moist, quartz, some fine, 1/2" max size.		
6	SS	16.6	18.1	18-24-21	.8		20		SC	DARK BROWN CLAYEY SAND Moist, trace of small gravel and ash.		
7	SS	21.6	23.1	6-6-8	1.5		25		CL	LIGHT BROWN SILTY CLAY Moist, low plasticity.		
8	SS	26.6	28.1	4-4-4	1.0		30			BLACK BOTTOM ASH Saturated.		
9	SS	31.6	33.1	2-1-2	1.1		35			GRAY FLY ASH Saturated.		
10	SS	36.6	38.1	2-1-1	1.5		40					
11	SS	41.6	43.1	3-5-7	.8		45		CL	LIGHT GRAY CLAY Moist to wet, medium to high plasticity.		
12	ST	46.6	48.6		2.0					PUSH 2.0 TIME 7 SEC. PSI 1000		

Continued Next Page

TYPE OF CASING USED		
X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER REB

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER 3966

COMPANY APPALACHIAN POWER COMPANY — BORING NO. 96-108 — DATE ______ — SHEET 2 OF 2

PROJECT Sporn fly ash pond dikes — BORING START 06/11/96 — BORING FINISH 06/11/96

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
13	SS	51.6	53.1	2-2-3	?				CL	DARK GRAY SILTY CLAY Wet, low plasticity, trace of organic and sand.		
14	SS	56.6	58.1	2-2-3	1.5		55					57.0 Top of seal.
15	SS	61.6	63.1	3-4-5	1.5		60					60.6 Top of sand. 63.3 Top screen.
16	SS	66.6	68.1	4-4-5	1.5		65					
17	SS	71.6	73.1	4-5-6	1.5		70					72.3 Bottom of screen. 74.0 Bottom of sand.

AEPSPP-000618

AEPSPP003953

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER 3966

COMPANY APPALACHIAN POWER COMPANY

PROJECT Sporn fly ash pond dikes

COORDINATES N 720,227.5 E 1,735,579.0

GROUND ELEVATION 619.6 SYSTEM STATE PLANE

BORING NO. 96-109 DATE ______ SHEET 1 OF 2

BORING START 05/29/96 BORING FINISH 05/30/96

PIEZOMETER TYPE ______ WELL TYPE ______

HGT. RISER ABOVE GROUND ______ DIA ______

DEPTH TO TOP OF WELL SCREEN ______ BOTTOM ______

WELL DEVELOPMENT ______ BACKFILL QUICK GROUT

FIELD PARTY MCR-REB RIG BK-81

WATER LEVEL	▽ 20.5	▼	▼
TIME			
DATE	5-30-96		

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										NO SAMPLE TAKEN BORING LOCATED IN ROAD BASE. AUGER CUTTINGS INDICATE BROWN SAND AND GRAVEL		Boring grouted from 73.2 to grade with 150 gallons quick grout.
1	SS	3.0	4.5	13-19-24	1.2				GP	DARK BROWN SAND AND GRAVEL Moist, 1/2" max size, quartz, rounded, some fines.		
2	SS	5.0	6.5	15-18-21	1.1		5					
3	SS	8.5	10.0	15-18-21	1.2		10					
4	SS	11.7	13.2	12-13-14	1.0				SP	DARK BROWN SAND Moist, fine grain.		
							15					
5	SS	16.7	18.2	4-5-6	1.1				ML	BROWN SANDY SILT Moist, non plasticity.		
							20				▽	
6	SS	21.7	23.2	4-6-8	1.2							
							25					
7	ST	26.7	28.7		1.5					Time 10 sec PSI 1200 Push 2.0 By watching rig psi possible .4 to .5 of fly ash in bottom of tube.		
							30			GRAY FLY ASH Moist.		
8	SS (~~ST~~)	31.7	33.2	4-7-10	1.1							
							35					
9	SS	36.7	38.2	1-1-1	1.2					Saturated		
							40					
10	SS	41.7	43.2	1-1-1	1.2							
							45					
11	SS	46.7	48.2	1-1-3	?							

Continued Next Page

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER REB

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

AEP

JOB NUMBER 3966

COMPANY APPALACHIAN POWER COMPANY

BORING NO. 96-109 DATE ______ SHEET 2 OF 2

PROJECT Sporn fly ash pond dikes

BORING START 05/29/96 BORING FINISH 05/30/96

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
12	SS	51.7	66.7	1-1-2	1.2							
13	SS	56.7	58.2	1-1-4	1.2		55					
14	SS	61.7	63.2	4-6-8	?		60		CL	DARK BROWN CLAY Moist, medium to high plasticity.		
15	ST	66.7	68.7		1.7		65			Time 8 sec. Push 2.0 PSI 1000 Material same as sample no. 14		
16	SS	71.7	73.2	3-4-5	1.2		70					

AEPSPP-000620

AEPSPP003955

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

AEP

JOB NUMBER 3966

COMPANY APPALACHIAN POWER COMPANY

PROJECT Sporn fly ash pond dikes

COORDINATES N 720,277.1 E 1,735,665.6

GROUND ELEVATION 602.3 SYSTEM STATE PLANE

BORING NO. 96-110 DATE ______ SHEET 1 OF 2

BORING START 06/06/96 BORING FINISH 06/10/96

PIEZOMETER TYPE SS WELL TYPE ______

HGT. RISER ABOVE GROUND ______ DIA ______

DEPTH TO TOP OF WELL SCREEN 43.7 BOTTOM 52.7

WELL DEVELOPMENT NO BACKFILL QUICK GROUT

FIELD PARTY MCR-REB RIG BK-81

WATER LEVEL	DRY		
TIME			
DATE	6-10-96		

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										No sample taken, boring in road.		Grouted grade to 73.1' with approximately 80 gallons.
1	SS	3.0	4.5	13-18-24	1.1					DARK GRAY BOTTOM ASH Dry		
2	SS	5.0	6.5	10-11-14	1.2		5					
3	SS	8.5	10.0	5-7-9	1.1				GP	DARK BROWN SAND AND GRAVEL Dry, quartz, rounded, 3/4" max.		
4	SS	11.6	13.1	6-7-10	1.1		10					
							15					
5	SS	16.6	18.1	8-10-10	1.2				CL	BROWN CLAY Dry, low to medium plasticity with trace of v-fine sand.		
6	SS	18.6	20.1	9-11-12	1.2				SC	Attempted to push tube lifted drill, destroyed end of tube.		
7	SS	21.6	23.1	5-7-11	1.2		20			BROWN SANDY CLAY Moist, low to medium plasticity with v-fine grain sand lens.		
		23.6								Grading to more sand		
9	SS	26.6	28.1	5-7-11	1.2		25			Attempted to push tube, top hole broken in tube, pushed approximately 1' lifted rig. GRAYISH BROWN SILTY CLAY Moist, low to medium plasticity.		
10	SS	31.6	33 1	7-10-9	1.3		30		CL	Could not move or knock tube off to the side of lead auger, pulled augers grouted hole moved approximately three feet down stream to start new hole. No spt taken on new hole untill this point. SWL dry augers to 26.6'. Auger set all weekend at this point.		
11	SS	36.6	38 1		1.5		35		CL	REDDISH BROWN CLAY Dry to moist, medium to high plasticity.		
12	ST	38.6	40 6		2.0							39.1 Top of seal.
13	SS	41.6	43.1	3-5-7	1.5		40			MEDIUM GRAY CLAY Moist to dry, medium to high plasticity, with odor of organic. PUSH 2.0 PSI 1200 TIME 6 SEC.		41.7 Top of sand. 43.7 Top of screen.
14	SS	46.6	48.1	3-4-4	1.5		45			Top DARK BROWNISH GRAY SANDY CLAY Bottom BROWN SANDY CLAY DARK GRAY CLAY Moist to wet, medium to high plasticity, strong odor of organic.		

Continued Next Page

TYPE OF CASING USED		
X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER REB

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

AEP

JOB NUMBER 3966

COMPANY APPALACHIAN POWER COMPANY

PROJECT Sporn fly ash pond dikes

BORING NO. 96-110 DATE ______ SHEET 2 OF 2

BORING START 06/06/96 BORING FINISH 06/10/96

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
15	SS	51.6	53.1	3-3-5	1.5					GRAY BROWN CLAY Moist to wet, medium to high plasticity, odor of organic with v-fine grain sand lens, water on out side of spoon.		52.7 Bottom of screen. 53.3 Bottom of sand.
							55					
16	SS	56.6	58.1	3-4-4	1.5							
17	ST	58.6	60.6		2.0					PUSH 2.0 TIME 7 SEC. PSI 770		
							60					
18	SS	61.6	63.1	10	?					DARK GRAY SILTY CLAY DARK GRAY CLAY Moist to wet, medium to high plasticity, strong odor of organic material.		
							65					
19	SS	66.6	68.1	3-4-5	1.5							
							70					
20	SS	71.6	73.1	4-7-11	1.4							

AEPSPP-000622

Figure 8

DUTCH CONE PENETROMETER

Field Data Form

Date: 7-26-96

[Proje]ct: Sporn Plant Ash Dike

Test No.: 96101 DCR

[Lo]cation:

Tested by: Roush-Bowles

Remarks:

Test Procedure:

Rate of Feed: 2cm/sec or no more than 1 in/sec

Run test every 20 cm or approx. 8 inches

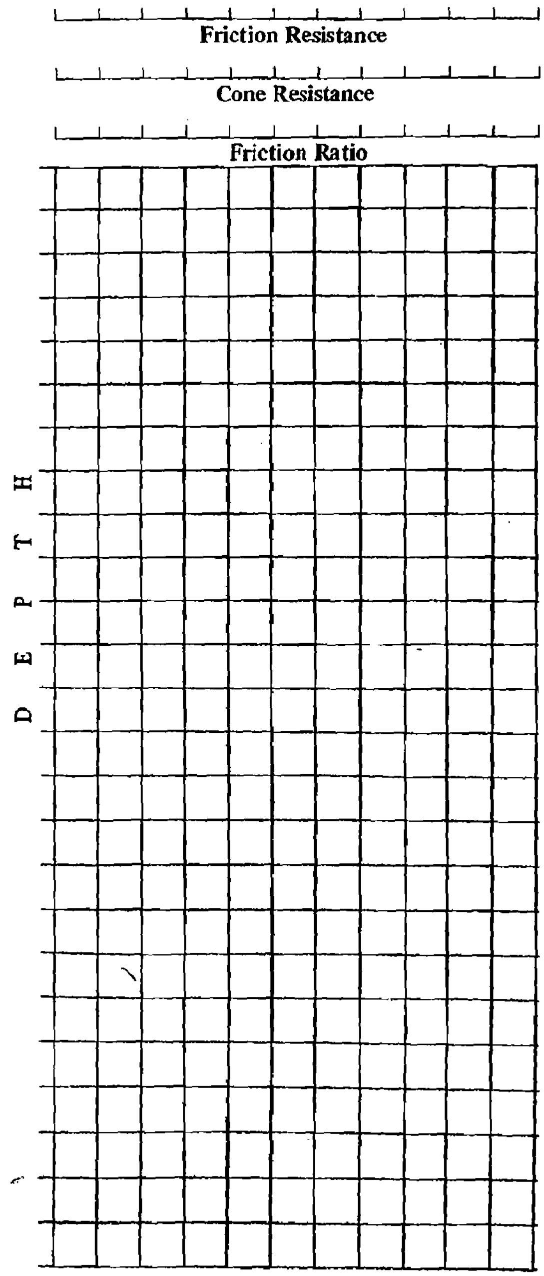
C = Cone F = Friction R = Resistance

CR = Cone Resistance LF = Local Friction

Weight of inner rod = 0.14 Kg/cm^2/rod length

Depth ①	C Kg/cm^2 ②	F + C Kg/cm^2 ③	F ③ − ② Kg/cm^2 ④	CR ② × 2 Kg/cm^2 ⑤	LF ④ × 0.133 Kg/cm^2 ⑥	Friction Ratio* ⑥ / ⑤ ⑦
35.1	5.6	12.3				
35.9	4.0					
36.7						
37.5	4.0	6.3				
38.3	6.6	10.6				
[illegible]1	5.0	8.3				
[illegible]9	4.3	9.3				
40.7	3.3	7.3				
41.5	4.6	7.6				
42.3	4.3	8.3				
43.1	4.3	7.3				
43.9	7.6	8.9				
44.7	8.0	14.0				
45.3	8.3	12.0				
46.3	15.3	28.0				
47.1		48.0				

Cone Lost



Note: The friction ratio is computed by dividing the local friction by the cone resistance measured 20 cm above the local friction during the previous test.

DUTCH CONE PENETROMETER

Field Data Form

Date: 7-30-96

[illegible]ct: Spown Plant

Test No.: B-96106 DCP

[illegible]cation: Fly Ash Dike

Tested by: Roush + Baukes Remarks:

Test Procedure:

Rate of Feed: 2cm/sec or no more than 1 in/sec

Run test every 20 cm or approx. 8 inches

C = Cone F = Friction R = Resistance

CR = Cone Resistance LF = Local Friction

Weight of inner rod = 0.14 Kg/cm²/rod length

Depth ①	C Kg/cm2 ②	F + C Kg/cm2 ③	F ③ − ② Kg/cm2 ④	CR ② × 2 Kg/cm2 ⑤	LF ④ × 0.133 Kg/cm2 ⑥	Friction Ratio* ⑥ / ⑤ ⑦
24.40	16.0	24.0				
25.15	16.0	30.0				
25.70	16.0	50.0				
26.35	10.0	12.0				
27.00	6.4	14.4				
[illegible]5	4.0	10.0				
[illegible].30	4.2	6.6				
28.95	4.8	7.2				
29.60	4.0	6.2				
30.25	3.2	5.6				
30.90	2.8	4.7				
31.55	3.6	5.8				
32.20	2.8	4.8				
32.85	2.0	4.4				
33.50	3.2	6.3				
34.15	3.2	6.4				
34.80	2.8	5.6				
35.45	2.7	4.9				
36.10	2.9	4.7				
36.75	2.8	5.2				
37.40	2.9	4.3				
38.05	3.2	4.8				
3[illegible]0	2.8	4.7				
[illegible]5	2.4	5.8				
40.00	4.0	6.4				

Friction Resistance

Cone Resistance

Friction Ratio

DEPTH

Note: The friction ratio is computed by dividing the local friction by the cone resistance measured 20 cm above the local friction during the previous test.

AEPSPP-000624

AEPSPP003959

Figure 8 2-3

DUTCH CONE PENETROMETER

Field Data Form

Date: 7-30-96

ect: ______ Test No. B-96106 DCP

Location: ______

Tested by: ______ Remarks: ______

Test Procedure:

Rate of Feed: 2cm/sec or no more than 1 in/sec

Run test every 20 cm or approx. 8 inches

C = Cone F = Friction R = Resistance

CR = Cone Resistance LF = Local Friction

Weight of inner rod = 0.14 Kg/cm^2/rod length

Depth ①	C Kg/cm2 ②	F + C Kg/cm2 ③	F ③ — ② Kg/cm2 ④	CR ② x 2 Kg/cm2 ⑤	LF ④ x 0.133 Kg/cm2 ⑥	Friction Ratio* ⑥ / ⑤ ⑦
40.65	2.9	5.4				
41.30	2.4	4.5				
41.95	3.2	5.3				
42.60	3.2	4.9				
43.25	2.8	5.1				
.90	2.9	4.3				
44.55	3.1	4.8				
45.20	4.8	7.2				
45.85	6.3	8.8				
46.50	5.2	7.6				
47.15	4.0	5.9				
47.80	5.2	7.6				
48.45	3.2	6.0				
49.10	2.0	4.8				
49.75	2.4	4.6				
50.40	5.2	6.6				
51.05	2.7	5.7				
51.70	3.6	6.7				
52.35	2.1	4.6				
53.00	2.9	5.2				
53.65	2.5	4.7				
54.30	2.9	6.8				
95	2.7	7.6				

Friction Resistance

Cone Resistance

Friction Ratio

DEPTH

Note: The friction ratio is computed by dividing the local friction by the cone resistance measured 20 cm above the local friction during the previous test.

AEPSPP-000625

AEPSPP003960

Figure 8 3-3

DUTCH CONE PENETROMETER
Field Data Form

Date: 7-30-96

[illegible]ect:

Test No.: B-96106 DCP

Location:

Tested by:

Remarks:

Test Procedure:
Rate of Feed: 2cm/sec or no more than 1 in/sec
Run test every 20 cm or approx. 8 inches

C = Cone   F = Friction   R = Resistance
CR = Cone Resistance   LF = Local Friction
Weight of inner rod = 0.14 Kg/cm^2/rod length

Depth ①	C Kg/cm2 ②	F + C Kg/cm2 ③	F ③ − ② Kg/cm2 ④	CR ② × 2 Kg/cm2 ⑤	LF ④ × 0.133 Kg/cm2 ⑥	Friction Ratio* ⑥ / ⑤ ⑦
55.60	3.2	4.8				
56.25	2.2	5.4				
56.90	2.1	4.0				
57.55	2.4	4.4				
58.20	3.2	5.5				
[illegible]85	2.3	5.2				
[illegible].50	2.4	4.3				
60.15	2.1	4.2				
60.80	1.9	3.4				
61.45	1.8	3.1				
62.10	1.2	2.8				
62.75	1.2	2.6				

Friction Resistance

Cone Resistance

Friction Ratio

DEPTH

Note: The friction ratio is computed by dividing the local friction by the cone resistance measured 20 cm above the local friction during the previous test.

Figure 8

DUTCH CONE PENETROMETER
Field Data Form

Date: 7-29-96

Project: Sporn Plant

Test No.: B-96107 DCP

Location: Fly Ash Dike

Tested by: Roush- Bawkes

Remarks:

Test Procedure:
Rate of Feed: 2cm/sec or no more than 1 in/sec
Run test every 20 cm or approx. 8 inches

C = Cone F = Friction R = Resistance
CR = Cone Resistance LF = Local Friction
Weight of inner rod = 0.14 Kg/cm^2/rod length

Depth ①	C Kg/cm^2 ②	F + C Kg/cm^2 ③	F ③ — ② Kg/cm^2 ④	CR ② × 2 Kg/cm^2 ⑤	LF ④ × 0.133 Kg/cm^2 ⑥	Friction Ratio* ⑥ / ⑤ ⑦
30.70	2.4	6.0				
31.35	2.8	6.0				
32.00	4.0	6.4				
32.65	2.4	4.5				
33.30	2.4	5.6				
[illegible]95	3.8	6.0				
34.60	3.7	6.4				
35.25	2.4	5.6				
35.90	2.5	4.7				
36.55	3.8	6.2				
37.20	3.8	6.0				
37.85	2.4	4.8				
38.50	3.9	5.6				
39.15	2.4	4.5				
39.80	1.6	2.8				
40.45	2.0	4.0				
41.10	2.3	4.5				
41.75	2.5	4.8				
42.40	2.4	4.4				
43.05	3.4	5.6				
43.70	3.8	5.6				
44.35	4.0	6.0				
[illegible]00	3.8	6.0				
[illegible].65	3.2	5.2				
46.30	2.4	3.2				

Friction Resistance

Cone Resistance

Friction Ratio

DEPTH

Note: The friction ratio is computed by dividing the local friction by the cone resistance measured 20 cm above the local friction during the previous test.

AEPSPP-000627

DUTCH CONE PENETROMETER

Field Data Form

Date: 7-29-96

Test No.: B-96107 DCP

Project:

Location:

Tested by: Remarks:

Test Procedure:

Rate of Feed: 2cm/sec or no more than 1 in/sec

Run test every 20 cm or approx. 8 inches

C = Cone F = Friction R = Resistance

CR = Cone Resistance LF = Local Friction

Weight of inner rod = 0.14 Kg/cm²/rod length

Depth ①	C Kg/cm² ②	F + C Kg/cm² ③	F ③ – ② Kg/cm² ④	CR ② × 2 Kg/cm² ⑤	LF ④ × 0.133 Kg/cm² ⑥	Friction Ratio* ⑥ / ⑤ ⑦
46.95	2.4	3.2				
47.60	2.2	4.5				
48.25	2.4	5.7				
48.90	3.8	5.6				
49.55	2.4	6.4				
50.20	2.0	6.0				
50.85	3.6	5.6				
51.50	2.4	5.8				
52.15	2.8	5.2				
52.80	4.0	5.9	Pulled	Rod	Raw	
53.45	2.0	3.6	augers	TO	49.0'	
54.10	0.0	5.2				
54.75	0.0	4.4				
55.40	2.0	4.2				
56.05	2.4	5.2				
56.70	0.0	5.2				
57.35	1.8	4.4				
58.65	0.0	6.4				
59.30	3.6	6.4				
59.95	2.4	5.6				
60.60	2.4	4.4				
61.25	2.0	4.0				
61.90	1.6	3.2				
62.55	1.6	2.4				
			Stopped Boring			

Friction Resistance

Cone Resistance

Friction Ratio

DEPTH

Note: The friction ratio is computed by dividing the local friction by the cone resistance measured 20 cm above the local friction during the previous test.

DUTCH CONE PENETROMETER

Field Data Form

Date: 7-30-96

[illegible]ct: Spann Plant

Test No.: 96109 DCP

[illegible]cation: Fly Ash Dike

Tested by: Roush + Brookes Remarks:

Test Procedure:

Rate of Feed: 2cm/sec or no more than 1 in/sec

Run test every 20 cm or approx. 8 inches

C = Cone F = Friction R = Resistance

CR = Cone Resistance LF = Local Friction

Weight of inner rod = 0.14 Kg/cm²/rod length

Depth ①	C Kg/cm² ②	F + C Kg/cm² ③	F ③ — ② Kg/cm² ④	CR ② x 2 Kg/cm² ⑤	LF ④ x 0.133 Kg/cm² ⑥	Friction Ratio* ⑥ / ⑤ ⑦
29.20	3.8	6.0				
29.85	4.0	7.6				
30.50	2.4	5.2				
31.15	9.6	10.4				
31.80	4.5	10.4				
[illegible]45	5.6	6.4				
[illegible]10	2.4	5.7				
33.75	3.2	5.2				
34.40	3.2	4.8				
35.05	3.9	5.9				
35.70	3.6	6.4				
36.35	3.2	5.6				
37.00	4.0	6.2				
37.65	3.2	5.7				
38.30	3.2	5.6				
38.95	4.0	6.4				
39.60	3.6	5.6				
40.25	2.4	5.2				
40.90	2.2	4.3				
41.55	2.5	4.4				
42.20	2.4	4.5				
42.85	2.2	5.6				
4[illegible]50	3.2	5.2				
[illegible]5	2.4	5.6				
44.80	4.0	8.0				

Friction Resistance

Cone Resistance

Friction Ratio

DEPTH

Note: The friction ratio is computed by dividing the local friction by the cone resistance measured 20 cm above the local friction during the previous test.

Figure 8 Page 2-3

DUTCH CONE PENETROMETER

Field Data Form

Date: ______

[illegible]ct: SpoRN Plant

Test No.: ______

[illegible]cation: ______

Tested by: ______ Remarks: ______

Test Procedure:

Rate of Feed: 2cm/sec or no more than 1 in/sec

Run test every 20 cm or approx. 8 inches

C = Cone F = Friction R = Resistance

CR = Cone Resistance LF = Local Friction

Weight of inner rod = 0.14 Kg/cm²/rod length

Depth ①	C Kg/cm2 ②	F + C Kg/cm2 ③	F ③ − ② Kg/cm2 ④	CR ② x 2 Kg/cm2 ⑤	LF ④ x 0.133 Kg/cm2 ⑥	Friction Ratio* ⑥ / ⑤ ⑦
45.45	2.8	4.4				
46.10	2.2	4.8				
46.75	2.8	4.9				
47.4	3.2	5.6				
48.05	2.4	5.6				
[illegible]70	2.0	4.9				
[illegible].35	2.0	4.4				
50.06	2.4	5.3				
50.65	2.0	4.8				
51.30	2.0	4.5				
51.95	2.4	5.2				
52.60	2.2	4.3				
53.25	1.9	4.0				
53.90	2.0	4.3				
54.55	1.9	4.8				
55.20	1.8	4.4				
55.85	1.6	4.0				
56.30	2.6	4.7				
57.15	1.9	4.8				
57.80	1.6	4.7				
58.45	2.8	5.2				
59.10	3.2	5.8				
5[illegible]75	3.3	64				
[illegible]0	3.6	6.0				
61.05	2.0	3.6				

Friction Resistance

Cone Resistance

Friction Ratio

DEPTH

Note: The friction ratio is computed by dividing the local friction by the cone resistance measured 20 cm above the local friction during the previous test.

AEPSPP-000630

AEPSPP003965

DUTCH CONE PENETROMETER

Field Data Form

Date: ______

...ct: Sporn Plant ______ Test No.: ______

...cation: ______

Tested by: ______ Remarks: ______

Test Procedure:
Rate of Feed: 2cm/sec or no more than 1 in/sec
Run test every 20 cm or approx. 8 inches

C = Cone F = Friction R = Resistance
CR = Cone Resistance LF = Local Friction
Weight of inner rod = 0.14 Kg/cm^2/rod length

Depth ①	C Kg/cm2 ②	F + C Kg/cm2 ③	F ③ − ② Kg/cm2 ④	CR ② × 2 Kg/cm2 ⑤	LF ④ × 0.133 Kg/cm2 ⑥	Friction Ratio* ⑥ / ⑤ ⑦
61.76	1.9	3.2				
62.35	1.2	2.3				
63.00	.9	1.4				

Friction Resistance

Cone Resistance

Friction Ratio

DEPTH

Note: The friction ratio is computed by dividing the local friction by the cone resistance measured 20 cm above the local friction during the previous test.

AEP CIVIL ENGINEERING LABORATORY
LOG OF BORING

JOB NUMBER 3015
COMPANY APPALACHIAN POWER COMPANY
PROJECT SPORN PLANT ASH HAUL ROAD
COORDINATES
GROUND ELEVATION SYSTEM

BORING NO. 9301 DATE SHEET 1 OF 2
BORING START 09/13/93 BORING FINISH 09/14/93
PIEZOMETER TYPE SS WELL TYPE
HGT. RISER ABOVE GROUND 2.5 DIA 1"
DEPTH TO TOP OF WELL SCREEN 3.5 BOTTOM 12.5
WELL DEVELOPMENT BACKFILL BENTONITE
FIELD PARTY MCR-TLS RIG BK-81

WATER LEVEL	DRY		
TIME			
DATE	9-9-93		

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	SOIL / ROCK IDENTIFICATION	DRILLER'S NOTES
1	SS	0.0	1.5	3-3-4	1.2			BROWN SILTY CLAY Dry.	Inside of augers dry untill hitting sand and gravel.
2	SS	1.5	3.0	5-15-15	.9			BROWN SANDY CLAY Moist, with some gravel.	3.0 Top of gravel.
3	SS	3.0	4.5	10-12-13	1.1			GRAY BOTTOM ASH Moist.	3.5 Top of screen.
~~4~~	~~SS~~	~~4.5~~	~~6.0~~	~~7-20-22~~	~~1.2~~		5		
5	SS	6.0	7.5	10-18-20	1.4				
6	SS	7.5	9.0	18-20-16	1.4				
7	SS	9.0	10.5	25-16-13	1.5		10	GRAY FLY ASH Moist.	
8	SS	10.5	12.0	1-11-10	1.4				
9	SS	12.0	13.5	13-12-13	1.3				12.5 Bottom of screen.
10	SS	13.5	15.0	14-11-5	1.4				13.0 Bottom of gravel and bottom of hole.
11	SS	15.0	16.5	5-4-2	1.3		15		
12	SS	16.5	18.0	1-1-1	1.5				
13	SS	18.0	19.5	0	1.5				
~~14~~	~~SS~~	~~19.5~~	~~21.0~~	~~1-1-4~~	~~1.5~~		20	BROWN SAND AND GRAVEL	
15	SS	21.0	22.5	8-7-8	1.5			GRAY FLY ASH	
16	SS	22.5	24.0	6-5-6	.8			BLACK BOTTOM ASH	
17	SS	24.0	25.5	7-10-10	1.2		25	BROWN SILTY CLAY Wet.	
18	ST	25.5	27.5		1.3			BLACK BOTTOM ASH Wet.	
19	SS	27.5	29.0	5-5-9	1.5			BROWN SILTY CLAY Moist.	
20	ST	29.0	31.0		1.7		30	BROWN SANDY CLAY Moist.	
21	SS	31.0	32.5	5-7-9	1.2			BROWN AND GRAY SILTY CLAY Mottled, moist	
22	ST	32.5	34.5		1.4			BROWN SILTY CLAY Moist.	
~~23~~	~~SS~~	~~34.5~~	~~36.0~~	~~6-7-9~~	~~1.5~~		35	BROWN AND GRAY SILTY CLAY Moist.	
24	ST	36.0	38.0		2.0			BROWN/GRAY CLAY	
25	SS	38.0	39.5	5-7-8	?			BROWN SILTY CLAY Moist.	
~~26~~	~~ST~~	~~39.5~~	~~41.5~~		~~2.0~~		40		
27	SS	41.5	43.0	4-5-5	?			BROWN SANDY CLAY Moist.	
28	ST	43.0	45.0		2.0			BROWN CLAYEY SAND Moist.	
29	SS	45.0	46.5	3-3-4	?		45		
30	ST	46.5	48.5		1.6			BROWN SAND AND GRAVEL Wet.	

Continued Next Page

TYPE OF CASING USED		
	NQ-2 ROCK CORE	
X	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL EN' 'IEERING LABOR' 'ORY

LOG OF BORING

AEP

JOB NUMBER 3015

COMPANY APPALACHIAN POWER COMPANY

BORING NO. SI-3 DATE ______ SHEET 1 OF 2

JECT SPORN PLANT ASH HAUL ROAD

BORING START 06/16/88 BORING FINISH 06/23/99

COORDINATES ______

PIEZOMETER TYPE ______ WELL TYPE ______

GROUND ELEVATION 600.3 SYSTEM ______

HGT. RISER ABOVE GROUND ______ DIA 6"

WATER LEVEL	∇ 28.0	▼ 49.0	∇
TIME		0710	
DATE	06/19/88	06/23/88	

DEPTH TO TOP OF WELL SCREEN ______ BOTTOM ______

WELL DEVELOPMENT ______ BACKFILL ______

FIELD PARTY MCR/TJH RIG B-61

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
1	SS	3.0	4.5	16-16-14	.83		5			BROWN SILTY SAND, moist, quartz, trace of small gravel		
2	SS	8.0	9.5	5-4-3	.17		10			LIMESTONE AND SAND		
3	SS	13.0	14.5	4-4-5	.5		15			SILTY SAND AND GRAVEL, wet to saturated, quartz, 1/2" max size, rounded		
4	SS	18.0	19.5	11-12-11	1.0		20			BROWN SANDY SILT, moist		
5	SS	23.0	24.5	5-6-8	1.0		25			BROWN SANDY SILT. moist		
6	SS	28.0	29.5	7-8-9	1.0		30			BROWN SANDY SILT,moist	∇	
7	SS	33.0	34.5	8-9-11	.83		35			BROWN CLAY, moist to wet, medium to low plasticity		
8	SS	38.0	39.5	7-8-10	1.0		40			GRAY ORGANIC SILT, moist		
9	SS	43.0	44.5	4-4-5	1.3		45			GRAY BROWN SILTY SAND,moist to wet w/ organic material		
10	ST	45.0	47.0		2.0							SHELBY TUBE PUSH 2.0'
11	ST	47.0	49.0		1.2						▼	REC 2.0' TIME 4 SEC

TYPE OF CASING USED		
	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"

Continued Next Page

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER ______

Tal... 11

AMERICAN ELECTRIC POWER SERVICE CORPORATION
AEP CIVIL EN NEERING LABOR ORY
LOG OF BORING

JOB NUMBER 3015
COMPANY APPALACHIAN POWER COMPANY
BORING NO. SI-3 DATE SHEET 2 OF 2
OJECT SPORN PLANT ASH HAUL ROAD
BORING START 06/16/88 BORING FINISH 06/23/99

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
												PSI 550 SHELBY TUBE PUSH 1.2' REC 1.2' TIME 7 SEC PSI 750
12	SS	53.0	54.5	34-50/.2	.5		55			BROWN SILTY SAND AND GRAVEL, saturated, 3/4" max. size, rounded, quartz		
13	SS	58.0	59.5	22-26-29	.67		60			BROWN SILTY SAND AND GRAVEL, saturated, 3/4" max. size, rounded, quartz		
14	SS	63.0	64.5	24-24-29	.83		65			BROWN SAND AND GRAVEL saturated, 1/2" max size, rounded, quartz		
15	SS	68.0	69.5	19-14-10	.25		70			DARK BROWN SAND AND GRAVEL, saturated, 3/4" max. size, rounded, quartz, some fines		
16	SS	73.0	74.5	22-19-10	.67		75			BROWN SILTY SAND, saturated, w/ some 1" max. size quartz		
17	SS	78.0	79.5	8-8-9	.5		80			BROWN SAND, saturated, quartz, trace of fines		
18	SS	83.0	84.5	12-12-15	.25		85			BROWN SAND, saturated, quartz, trace of fines		
19	SS	88.0	89.5	14-17-17	.75		90			BROWN SAND saturated, quartz, trace of fines		
20	SS	93.0	94.5	12-19-16	1.2		95			BROWN SILTY SAND AND GRAVEL, saturated, 1" max. size, quartz		
							100			GRAY SANDSTONE Auger Refusal 95.2' Set HW casing at 95' Used 3 7/8" roller bit to cut gray sandstone to 101.7' Cut rock to 99' Casing not on rock, Set casing at 96' Cut rock to 101.7' Void in sandstone at 99.2' and 100.1', both voids approx .3 to .4' Lost water 99,2 Tip of slope indicator at 101.7' Indicator casing installed in 10' lengths		

AEPSPP-000634

AEPSPP003969

FIELD DATA FROM:
"PHILIP SPORN POWER PLANT – STABILITY ANALYSIS"

PREPARED/COMPILED BY:
THE GEOTECHNICAL ENGINEERING SECTION OF AMERICAN ELECTRIC POWER SERVICE CORPORATION

DATED: MARCH 2009

SWF [Sporn Liquefaction Assessment_Response 1a-1r_7-23-10]

GEOTECHNICAL DATA COLLECTION REPORT

AEP SPORN FLY ASH AND BOTTOM ASH POND COMPLEX
NEW HAVEN, WEST VIRGINIA

HCN/TERRACON PROJECT NO. N2095019
March 3, 2009

Prepared For:

AMERICAN ELECTRIC POWER

Prepared by:

H.C. NUTTING
A Terracon Company
Charleston, West Virginia

H. C. NUTTING
A Terracon COMPANY
912 Morris Street
Charleston, West Virginia 25301
304-344-0821 Fax:304-342-4711

March 3, 2009

HCN/Terracon Project No. N2095019

Mr. Tim Howdyshell
American Electric Power
1 Riverside Plaza – 22nd Floor
Columbus, OH 43215

Re: Geotechnical Data Collection Report
AEP Sporn Fly Ash and Bottom Ash Pond Complex
New Haven, West Virginia

Dear Mr. Howdyshell:

H. C. Nutting Company (HCN), a Terracon company is pleased to present our geotechnical data collection report for the geotechnical services associated with the maintenance of the American Electric Power (AEP) Sporn Fly Ash and Bottom Ash Pond Complex in New Haven, West Virginia. This work was performed in general accordance with our proposal dated February 9, 2009 and AEP Letter of Authorization dated February 10, 2009.

SCOPE OF WORK

HCN's scope of work for this project included performing a total of five (5) test borings, installation of observation wells at all 5 boring locations, inspection of drilling activities, preparation of boring logs based on visual classification, and preparation of this report.

FIELD EXPLORATION

Test Borings

A total of five (5) Standard Penetration Test (SPT) borings were drilled for this project. The test borings were selected and staked in the field by AEP and HCN personnel and later surveyed in the field by AEP surveyor (to be provided).

The test borings were performed utilizing a drill rig mounted on an All-Terrain Vehicle. The field operations were performed between February 16, 2009 through February 23, 2009. Boreholes were advanced and stabilized using hollow-stem augers. The drilling activities were performed under the supervision of HCN personnel.

Sampling was accomplished using the Standard Penetration Test (ASTM D 1586) and Shelby tube (ASTM D 1587) methods. Split-spoon samples were obtained at 2.5 ft. intervals. Shelby tube samples were collected at within cohesive soils. The borings were completed at depths of 50 feet below the existing ground surface.

After completion of drilling activities, all of the five test borings were converted into observation wells. All wells were constructed from 1.92-inch OD (1.5-inch ID) threaded PVC with #10 slot screen and 5-foot solid PVC section at the top. The PVC casing was constructed to just below the existing ground surface and protected with a "Global HRB 141412-F H20" locking steel protective cover. The well pad was then constructed around the observation well with approximate dimensions of 3 feet by 3 feet and a minimum of 8 inch thickness.

Each well was developed using a surge block and evacuated until the discharge water stabilized. All development data and estimated purge volumes were recorded and are shown on the attached well development logs.

On the following table we have indicated the beginning and ending depths of the screening sections.

Observation Well Screen Depths

Boring	Screening Section	
	Beginning Depth (feet)	Ending Depth (feet)
PZ-09-01	6	50.3
PZ-09-02	5.5	35
PZ-09-03	6	50.4
PZ-09-04	5.5	49.8
PZ-09-05	5.2	50.2

The observation well logs are included with this report.

CLOSING

We appreciate the opportunity of working with you on this project. Please contact us concerning any questions that may arise during review of the report, or if you require additional information as you proceed into the final design and construction stage of this project.

Thank you for your consideration.

Respectfully submitted,
H. C. NUTTING COMPANY

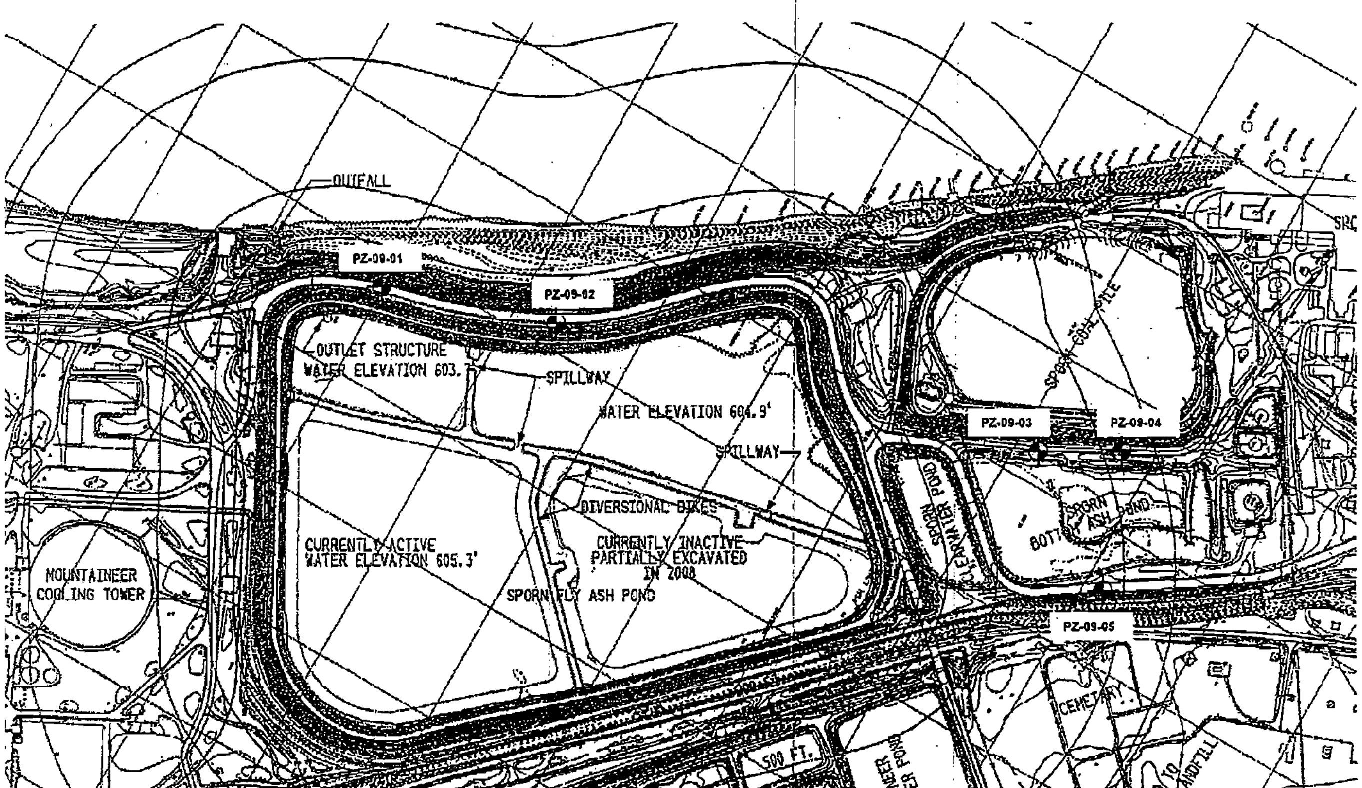
Lewis E. Eplin
Staff Geologist

YOGESH S. REGE REGISTERED 16606 STATE OF WEST VIRGINIA PROFESSIONAL ENGINEER

Yogesh S. Rege, P.E.
Department Manager
Geotechnical Services

APPENDIX

FIGURE 1: BORING LOCATION DIAGRAM
LOG OF TEST BORINGS
WELL DEVELOPMENT LOGS
OBSERVATION WELL LOGS
GENERAL NOTES
UNIFIED SOIL CLASSIFICATION SYSTEM




Approximate Boring Location

Project Mngr: YSR	Project No. N2095019
Drawn By: YSR	Scale: NTS
Checked By: YSR	File No. N2095019
Approved By:	Date: 2/23/2009

Terracon
Consulting Engineers and Scientists
Charleston, West Virginia

Boring Location Diagram

Sporn Fly Ash and Bottom Ash Pond Complex
New Haven, West Virginia
American Electric Power

FIG. No. 1

LOG OF BORING NO. PZ-09-01

CLIENT: American Electric Power

SITE: Philip Sporn Power Plant, New Haven, West Virginia

PROJECT: Sporn Fly Ash and Bottom Ash Pond Complex

Boring Location: 721043.509, 1735345.011

Approx. Surface Elev.: 600.817 ft

Depth (ft)	DESCRIPTION	Elev. (ft)	DEPTH, ft.	USCS SYMBOL	SAMPLES: NUMBER	TYPE	RECOVERY, in.	SPT - N** BLOWS / ft.	TESTS: WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, psf	
0.5	**ASPHALT**	600.5										
1	**FILL**, stabilized and compacted bottom ash	600		SM	1	SS	18	24				
	FILL, silty sand with bottom ash, trace gravel, gray, medium dense, dry to moist - Geogrid observed at 4'			SM	2	SS	18	17				
			5	SM	3	SS	18	16				
8.5		592.5										
	FILL, silty sand with bottom ash, gray to dark gray, medium dense, moist			SM	4	SS	18	14				
			10	SM	5	SS	18	12				
12		589										
	FILL, silty sand with gravel, light brown, medium dense, moist											
14		587		CL	6	SS	12	16			9000*	
	FILL, lean clay with sand, light brown, stiff, moist		15	CL	7	SS	12	10			4000*	
18.5		582.5										
	FILL, silty sand with gravel, dark brown, loose, moist			SM	8	SS	18	14				
21		580	20									
	FILL, bottom ash with coal fragments, black, medium dense, wet				9	SS	18	18				
23.5		577.5										
	LEAN CLAY with SAND light brown, stiff, moist			CL	10	SS	18	19			7000*	
			25	CL	11	ST	24					800 psi/24 sec
28.5		572.5										
	SANDY LEAN CLAY, brown to gray, stiff, moist			CL	12	SS	18	20			7000*	
			30	CL	13	SS	18	16			6500*	

Continued Next Page

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer
**CME 140H SPT automatic hammer

WATER LEVEL OBSERVATIONS, ft			
WL	21	WD 18.1	4 hr
WL	18	48 hr	
WL			

Terracon

BORING STARTED	2-20-09
BORING COMPLETED	2-21-09
RIG	Track
FOREMAN	
LOGGED	LE
JOB #	N2095019

REVISED BORING LOGS SPORN BOTTOM ASH POND COMPLEX.GPJ TERRACON.GDT 3/3/09

LOG OF BORING NO. PZ-09-01

CLIENT
American Electric Power

SITE **Philip Sporn Power Plant**
New Haven, West Virginia

PROJECT
Sporn Fly Ash and Bottom Ash Pond Complex

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY, in.	SAMPLES: SPT - N** BLOWS / ft.	TESTS: WATER CONTENT, %	TESTS: DRY UNIT WT pcf	TESTS: UNCONFINED STRENGTH, psf
	SANDY LEAN CLAY, brown to gray, stiff, moist		CL	14	SS	18	18			6500*
		35								
			CL	15	SS	18	10			4500*
			CL	16	SS	18	18			4000*
		40								
			CL	17	SS	18	14			3500*
			CL	18	SS	18	18			5000*
		45								
	47 — 554		CL	19	SS	18	13			3000*
	CLAYEY SAND, brown, dense, very moist, fine grained sand - with gravel at 49'		SC	20	SS	18	47			
	50 — 551	50								
	BORING COMPLETED									

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer
**CME 140H SPT automatic hammer

WATER LEVEL OBSERVATIONS, ft				
WL	∇ 21	WD	▼ 18.1	4 hr
WL	▼ 18	48 hr	▼	
WL				

Terracon

BORING STARTED	2-20-09
BORING COMPLETED	2-21-09
RIG Track	FOREMAN
LOGGED LE	JOB # N2095019

LOG OF BORING NO. PZ-09-02

CLIENT: American Electric Power

SITE: Philip Sporn Power Plant, New Haven, West Virginia

PROJECT: Sporn Fly Ash and Bottom Ash Pond Complex

Boring Location: 720306.293, 1735648.836

Approx. Surface Elev.: 601.345 ft

Layer depth / elev.	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES: NUMBER	TYPE	RECOVERY, in.	SPT - N** BLOWS / ft.	TESTS: WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, psf	
0.5 / 601	**ASPHALT**										
2 / 599.5	**FILL**, stabilized and compacted bottom ash			1	SS	12	52				
	FILL, silty sand with bottom ash and gravel, dark gray to brown, very dense, moist		SM	2	SS	18	65				
7 / 594.5		5	SM	3	SS	18	51				
	FILL, silty sand with gravel, light brown, dense, moist		SM	4	SS	18	36				
		10	SM	5	SS	18	47				
			SM	6	SS	18	45				
16 / 585.5		15									
	FILL, silty sand, light brown, very dense, dry to moist, fine grained		SM	7	SS	18	37			9000*	
			SM	8	ST	12					1000 psi/24 sec
		20	SM	9	SS	18	33			9000*	
23.5 / 578											
	FILL, silty sand, light brown, dense, moist, fine grained		SM	10	SS	18	38				
26 / 575.5		25									
	FILL, bottom ash with coal fragments, black, medium dense, wet			11	SS	18	21				
28.5 / 573											
	LEAN CLAY, trace to with sand, gray to light brown, very stiff to stiff, moist - Trace organics (roots) at 28.5 - 29'		CL	12	SS	18	16			8000*	
		30	CL	13	ST	24					1200 psi/30 sec

Continued Next Page

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer
**CME 140H SPT automatic hammer

WATER LEVEL OBSERVATIONS, ft				
WL	∇ 26	WD ▼ 16	24 hr	
WL	∇ 21.1	72 hr	∇	
WL				

Terracon

BORING STARTED	2-19-09
BORING COMPLETED	2-20-09
RIG Track	FOREMAN
LOGGED LE	JOB # N2095019

REVISED BORING LOGS SPORN BOTTOM ASH POND COMPLEX.GPJ TERRACON.GDT 3/3/09

LOG OF BORING NO. PZ-09-02

CLIENT
American Electric Power

SITE
Philip Sporn Power Plant
New Haven, West Virginia

PROJECT
Sporn Fly Ash and Bottom Ash Pond Complex

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY, in.	SAMPLES: SPT - N** BLOWS / ft.	TESTS: WATER CONTENT, %	TESTS: DRY UNIT WT pcf	TESTS: UNCONFINED STRENGTH, psf	
	LEAN CLAY, trace to with sand, gray to light brown, very stiff to stiff, moist		CL	14	SS	18	34			8000*	
		35									
			CL	15	SS	12	19			3000*	
			CL	16	SS	18	17			8000*	
		40									
			CL	17	SS	18	24			7000*	
			CL	18	SS	18	23			4000*	
		45									
			CL	19	SS	18	12			2500*	
			CL	20	SS	18	13			3000*	
	50 551.5	50									
	BORING COMPLETED										

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer
**CME 140H SPT automatic hammer

WATER LEVEL OBSERVATIONS, ft				
WL	▽ 26	WD	▼ 16	24 hr
WL	▼ 21.1	72 hr	▼	
WL				

Terracon

BORING STARTED			2-19-09
BORING COMPLETED			2-20-09
RIG	Track	FOREMAN	
LOGGED	LE	JOB #	N2095019

REVISED BORING LOGS SPORN BOTTOM ASH POND COMPLEX.GPJ TERRACON.GDT 3/3/09

LOG OF BORING NO. PZ-09-03

CLIENT: American Electric Power

SITE: Philip Sporn Power Plant, New Haven, West Virginia

PROJECT: Sporn Fly Ash and Bottom Ash Pond Complex

Boring Location: 718396.378, 1736131.654

Approx. Surface Elev.: 596.521 ft

Depth / Elev.	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	NUMBER	TYPE	RECOVERY, in.	SPT - N** BLOWS / ft.	WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, psf	
	FILL, silty sand with gravel, yellowish brown to dark brown, medium dense to dense, moist, fine to coarse grained sand, rounded gravel		SM	1	SS	14	30				
			SM	2	SS	18	29				
		5	SM	3	SS	18	45				
11 / 585.5		10	SM	4	SS	14	70				
13.5 / 583	**FILL**, silty sand with gravel, yellowish brown to dark brown, medium dense, moist, fine to coarse grained sand, rounded gravel		SM	5	SS	18	22				
	FILL, sandy lean clay, light brown to gray, medium stiff, very moist, fine grained sand		CL	6	SS	18	8				
18 / 578.5	▼	15	CL	7	ST	21.5					800 psi/30 sec
	FILL, lean clay with sand, brown and gray mottled, very stiff, moist, fine grained sand		CL	8	SS	18	20			9000*	
23.5 / 573	▽	20	CL	9	SS	18	24			9000*	
	FILL, coal and bottom ash, black, medium dense, wet, sand to gravel size particles		SM	10	SS	10	15				
28.5 / 568		25	SM	11	SS	14	12				
31 / 565.5	**FILL**, coal and bottom ash, black to dark gray, loose, wet, fine sand to silt size particles with gravel size coal fragments		SM	12	SS	18	4				
		30	SM	13	SS	18	6				

Continued Next Page

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer
**CME 140H SPT automatic hammer

WATER LEVEL OBSERVATIONS, ft			
WL	▽ 23	WD ▼ 16.8	24 hr
WL	▽	▽	
WL			

Terracon

BORING STARTED			2-17-09
BORING COMPLETED			2-18-09
RIG	Track	FOREMAN	
LOGGED	LE	JOB #	N2095019

REVISED BORING LOGS SPORN BOTTOM ASH POND COMPLEX.GPJ TERRACON.GDT 3/3/09

AEPSPP-000102

AEPSPP003981

LOG OF BORING NO. PZ-09-03

CLIENT: American Electric Power

SITE: Philip Sporn Power Plant, New Haven, West Virginia

PROJECT: Sporn Fly Ash and Bottom Ash Pond Complex

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY, in.	SAMPLES: SPT - N** BLOWS / ft.	TESTS: WATER CONTENT, %	TESTS: DRY UNIT WT pcf	TESTS: UNCONFINED STRENGTH, psf	TESTS
	FILL, coal and bottom ash, black to dark gray, loose to very loose, wet, fine sand to silt size particles		SM	14	SS	12	5				
		35									
			SM	15	SS	18	4				
			SM	16	SS	18	3				
		40									
			SM	17	SS	6	4				
	43.5 — 553										
	SANDY LEAN CLAY, dark gray, stiff to very soft, moist to wet, fine grained sand		CL	18	SS	18	9			500*	
		45									
			CL	19	ST	22					800 psi/15 sec
			CL	20	SS	18	W.H.			500*	
	50 — 546.5	50									
	BORING COMPLETED										

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer
**CME 140H SPT automatic hammer

WATER LEVEL OBSERVATIONS, ft				BORING STARTED	2-17-09
WL	∇ 23	WD ▼ 16.8	24 hr	BORING COMPLETED	2-18-09
WL	▼	▼		RIG Track	FOREMAN
WL				LOGGED LE	JOB # N2095019

Terracon

REVISED BORING LOGS SPORN BOTTOM ASH POND COMPLEX.GPJ TERRACON.GDT 3/3/09

LOG OF BORING NO. PZ-09-04

CLIENT: American Electric Power

SITE: Philip Sporn Power Plant, New Haven, West Virginia

PROJECT: Sporn Fly Ash and Bottom Ash Pond Complex

Boring Location: 718148.27, 1736259.447

Approx. Surface Elev.: 593.692 ft

DESCRIPTION	Elev.	DEPTH, ft.	USCS SYMBOL	NUMBER	TYPE	RECOVERY, in.	SPT - N** BLOWS / ft.	WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, psf	
FILL, silty sand with gravel, gray, medium dense, moist, medium to coarse grained sand			SM	1	SS	17	27				
3.5	590										
FILL, silty sand, trace gravel and clay, light brown, dense to medium dense, moist			SM	2	SS	18	43				
		5	SM	3	SS	18	28				
8	585.5										
FILL, lean clay, light brown			CL	4	ST	20					800 psi/34 sec
		10									
11	582.5										
FILL, well graded sand with gravel, light brown, medium dense, moist, coarse to fine grained sand, rounded gravel			SW	5	SS	18	21				
▼			SW	6	SS	12	23				
		15	SW	7	SS	14	26				
18.5	575										
FILL, silty sand with gravel, trace clay, dark brown to gray, dense, very moist, coarse to fine grained sand, rounded gravel			SM	8	SS	18	30				
21	572.5	20									
FILL, well graded gravel with sand, brown, dense to medium dense, wet, rounded gravel ∇			GW	9	SS	18	35				
			GW	10	SS	18	16				
		25	GW	11	SS	18	10				
27	566.5										
FILL, bottom ash, gray to black, medium dense to very loose, wet, fine sand to silt size particles			SP	12	SS	18	9				
		30	SP	13	SS	18	6				

Continued Next Page

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer
**CME 140H SPT automatic hammer

WATER LEVEL OBSERVATIONS, ft			
WL	∇ 23	WD ▼ 14.5	24 hr
WL	▼ -	∇	
WL			

Terracon

BORING STARTED	2-18-09
BORING COMPLETED	2-19-09
RIG Track	FOREMAN
LOGGED LE	JOB # N2095019

REVISED BORING LOGS SPORN BOTTOM ASH POND COMPLEX.GPJ TERRACON.GDT 3/3/09

LOG OF BORING NO. PZ-09-04

CLIENT American Electric Power	
SITE Philip Sporn Power Plant, New Haven, West Virginia	PROJECT Sporn Fly Ash and Bottom Ash Pond Complex

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES: NUMBER	TYPE	RECOVERY, in.	SPT - N** BLOWS / ft.	TESTS: WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, psf	
	FILL, bottom ash, gray to black, medium dense to very loose, wet, fine sand to silt size particles		SP	14	SS	18	9				
		35									
			SP	15	SS	18	11				
			SP	16	SS	18	WOT				
	41 552.5	40									
	LEAN CLAY, dark gray, stiff, very moist to wet, high silt content		CL	17	SS	18	9				
			CL	18	ST						800 psi/15 sec
		45									
			CL	19	SS	18	9				
			CL	20	SS	18	10				
	50 543.5	50									
	BORING COMPLETED										

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer
**CME 140H SPT automatic hammer

WATER LEVEL OBSERVATIONS, ft			
WL	∇ 23	WD ▼ 14.5	24 hr
WL	∇	▼	
WL			

Terracon

BORING STARTED	2-18-09		
BORING COMPLETED	2-19-09		
RIG	Track	FOREMAN	
LOGGED	LE	JOB #	N2095019

REVISED BORING LOGS SPORN BOTTOM ASH POND COMPLEX.GPJ TERRACON.GDT 3/3/09

LOG OF BORING NO. PZ-09-05

CLIENT: American Electric Power	
SITE: Philip Sporn Power Plant, New Haven, West Virginia	PROJECT: Sporn Fly Ash and Bottom Ash Pond Complex

Boring Location: 717959.368, 1735750.984

Approx. Surface Elev.: 593.453 ft

Depth (ft)	DESCRIPTION	Elev.
0.5	**ASPHALT**	593
1.4	**FILL**, stabilized and compacted bottom ash	592
2.5	**FILL**, silty sand with gravel, yellowish brown and gray, dense, dry to moist	591
6.5	**FILL**, silty sand with bottom ash, trace gravel, dark brown to black, medium dense, moist	587
9.5	**FILL**, silty sand with gravel, trace bottom ash and coal, yellowish brown, dense, moist, fine to coarse grained sand. Trace clay at 8.5'	584
11	**FILL**, silty sand with gravel, brown, dense, moist, fine to coarse grained sand	582.5
26	**FILL**, silty sand with bottom ash and gravel, reddish brown to black, dense to medium dense, moist to wet, fine to coarse grained sand, cobbles present. Clay seam at 17'	567.5
	FILL, silty sand with bottom ash, trace gravel, dark gray to black, loose to very loose, wet, fine grained sand, silt size particles	

Continued Next Page

USCS SYMBOL	NUMBER	TYPE	RECOVERY, in.	SPT - N** BLOWS / ft.	WATER CONTENT, %	DRY UNIT WT pcf	UNCONFINED STRENGTH, psf
SM	1	SS	15	47			
SM	2	SS	18	25			
SM	3	SS	18	46			
CL	4	SS	17	43			
SM	5	SS	17	50/5			
SM	6	SS	2	50/2			
SM	7	SS	18	32			
SM	8	SS	18	15			
SM	9	SS	18	22			
SM	10	SS	18	12			
SM	11	SS	18	6			
SM	12	SS	18	8			
SM	13	SS	18	3			

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer
**CME 140H SPT automatic hammer

WATER LEVEL OBSERVATIONS, ft				
WL	15	WD	20	AB
WL	29.8	20 hr		
WL				

Terracon

BORING STARTED	2-16-09		
BORING COMPLETED	2-16-09		
RIG	Track	FOREMAN	
LOGGED	LE	JOB #	N2095019

REVISED BORING LOGS. SPORN BOTTOM ASH POND COMPLEX.GPJ TERRACON.GDT 3/3/09

LOG OF BORING NO. PZ-09-05

CLIENT American Electric Power	
SITE Philip Sporn Power Plant New Haven, West Virginia	PROJECT Sporn Fly Ash and Bottom Ash Pond Complex

GRAPHIC LOG	DESCRIPTION	DEPTH, ft.	USCS SYMBOL	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY, in.	SAMPLES: SPT - N** BLOWS / ft.	TESTS: WATER CONTENT, %	TESTS: DRY UNIT WT pcf	TESTS: UNCONFINED STRENGTH, psf	TESTS
	34.5 — 559		SM	14	SS	18	2				
	LEAN CLAY with SAND, light brown and gray mottled to brown and gray mottled, soft to stiff, wet to very moist	35									
			CL	15	SS	18	14			2000*	
	Sand content increase with depth		CL	16	ST	17.5					800 psi/10 sec
		40									
			CL	17	SS	6	6			500*	
			CL	18	SS	18	14				
	45 — 548.5	45									
	CLAYEY SAND, reddish brown and gray mottled, medium dense to loose, very moist to wet, fine grained sand		SC	19	SS	18	8				
			SC	20	SS	18	8				
	50 — 543.5	50									
	BORING COMPLETED										

The stratification lines represent the approximate boundary lines between soil and rock types: in-situ, the transition may be gradual.

*Calibrated Hand Penetrometer
**CME 140H SPT automatic hammer

WATER LEVEL OBSERVATIONS, ft					BORING STARTED		2-16-09
WL	▽ 15	WD	▼ 20	AB	BORING COMPLETED		2-16-09
WL	▽ 29.8	20 hr	▼		RIG	Track	FOREMAN
WL					LOGGED	LE	JOB # N2095019

Terracon

REVISED BORING LOGS SPORN BOTTOM ASH POND COMPLEX.GPJ TERRACON.GDT 3/3/09

Well Development Log

H. C. NUTTING
A Terracon COMPANY
790 Morrison Road • Columbus, OH 43230 • (614) 863-3113

JOB N2095019
SHEET NO. 1 OF 1
CALCULATED BY JCE DATE 2/21/09
CHECKED BY – DATE –
SCALE NTS

American Electric Power

Sporn Plant

Date Well Installed: Feb. 21, 2009

PZ-09-01

▼ Initial GW Elev. Prior to Well Development 18.1' B.G.S.

Grd. Surface / Top of Vault 0.0' B.G.S.
Well Vault – Top of Well Riser 1.06' B.G.S. (12 3/4")

*** Well Volume ***
- 1 1/2" ID Screen & Riser 0.09 gals/L.F.
- 32.2' x 0.09 = 2.9 gals.

Min. development volume 3 x 2.9 gals = 8.7 gals.

2/21/09

- 6^15 pm Initial H_2O Rdg – Water @ 18.1' BGS
- Surge well w/ 3' long by 1" Ø PVC Surge Block
- 6^20 Initiate Pumping – No Sediment Noted
- 6^20 – 6^35 pm Pump 15± gals Dark brown heavily silted H_2O w/ fine sand – Well Depleted –
- * 6^35 – 6^45 pm Pump 10± gals Brown heavily silted H_2O w/ fine sand while adding 20± gals potable H_2O to top of well
- 6^45 – 6^50 pm Pump 5± gals Brown moderately to slightly silty H_2O w/ some fine sand
  - → 6^50 – 7^00 pm Allow well to recharge
- 7^00 – 7^10 pm Pump 10± gals. Brown moderately silty H_2O w/ some fine sand
  - → 7^10 – 7^35 pm Allow well to recharge
  - ▼ 7^35 pm H_2O Rdg – Water @ 22.5' BGS
- 7^40 – 7^55 pm Pump 10± gals Brown moderately to slightly silty H_2O w/ some to trace fine sand. Well nearly depleted.

Well Development Complete 8^00 pm

2/23/09

▼ 1^45 pm H_2O @ 18.0' BGS.

- 20± gals potable H_2O added to well during development.
- 50± gals H_2O pumped from well during development.

▼ H_2O Rdg 2/26/09 11^30 am 18.0' BGS

– Bottom of Well 50.3' B.G.S.

AEPSPP-000108

AEPSPP003987

Well Development Log

H. C. NUTTING
A Terracon COMPANY
790 Morrison Road • Columbus, OH 43230 • (614) 863-3113

JOB N2095019
SHEET NO. 1 OF 1
CALCULATED BY JCE DATE 2/21/09
CHECKED BY — DATE —
SCALE NTS

American Electric Power

Sporn Plant

Date Well Installed: Feb. 20, 2009

PZ-09-02

▼ Initial GW Elev. Prior to Well Development 16.0' B.G.S.

Grd. Surface/Top of Vault 0.0' B.G.S.
Well Vault - Top of Well Riser 0.44' B.G.S. (5¼")

2/21/09

- 4:35 PM Initial H2O Rdg 16.0' BGS
Sediment noted in Bottom of Well
- Well surged w/ 3' long by 1" ø PVC surge block
- 4:45 PM Initiate pumping
4:45-5:00 pm Pumped 15± gals of Dark Brown heavily silted H2O w/ fine sand
- Well depleted - Recharge for 5 mins.

* 5:05-5:15 pm Pumped 10± gals Brown heavily silted H2O w/ fine sand while adding 15± gals potable H2O to top of well
- 5:15-5:25 pm Pump 10± Brown moderately silty then back to heavily silted H2O w/ fine sand - Well depleted.
* 5:25 to 5:30 pm Pump 5± gals Br. heavily silted H2O while adding 5± gals potable H2O to top of well.
* 5:30 to 5:35 pm Add 10± gals potable H2O to top of well.
- 5:35-5:45 pm Pump 10± gals Brown moderately to slightly silty H2O w/ some fine sand - Suspend Pumping
▼ 5:45 pm H2O @ 18.8' BGS
▼ 5:50 pm H2O @ 18.0' BGS
▼ 6:05 pm H2O @ 17.2' BGS
Development Complete

2/23/09
▼ 2:30 pm H2O @ 21.2' BGS

▼ H2O Rdg 2/25/09 12:50 pm 22.3' BGS

— Bottom of Well 34.7' B.G.S.

* Well Volume *
- 1½" ID Screen & Riser 0.09 gals/L.F.
- 18.7' x 0.09 = 1.7 gals.
Min. development volume
3 x 1.7 gals = 5.1 gals.

30± gals H2O Added to well during development

50± Total gals H2O Pumped from well during development.

Well Development Log

H. C. NUTTING
A Terracon COMPANY
790 Morrison Road • Columbus, OH 43230 • (614) 863-3113

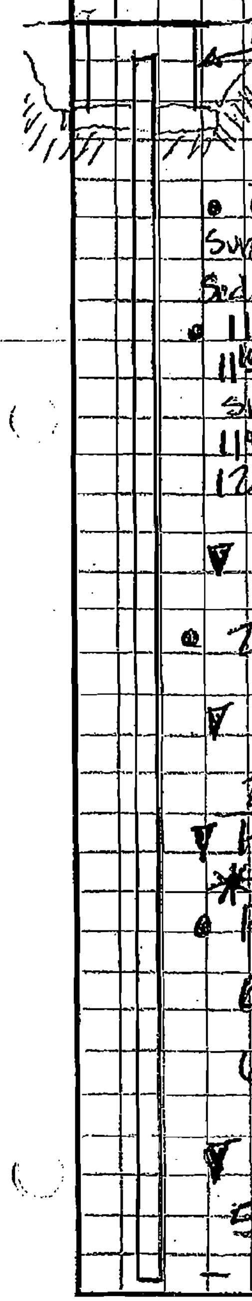
JOB N2095019
SHEET NO. 1 OF 1
CALCULATED BY JCE DATE 2/19/09
CHECKED BY — DATE 2/20/09
SCALE NTS

American Electric Power

Sporn Plant — Date Well Installed: Feb. 18, 2009

PZ-09-03

▼ Initial GW Elev. Prior to Well Development 16.8' B.G.S.



Grd. Surface/Top of Vault 0.0' B.G.S.
Well Vault — Top of Well Riser 1.14' B.G.S. (13 5/8")

2/19/09

- 9⁰⁰ Am Initial H2O Rdg - water @ 16.8' BGS
  Surge well w/ 3' long PVC 1" Ø Surge Blade
  Sediment in well to 47.6' ± B.G.S.
- 11⁰⁰ Am Initiate pumping set up
  11¹⁰ - 11³⁰ Am Pump 15± gals Gray heavily silted H2O w/ fine sand + Agitate well
  11⁴⁵ - 12⁰⁰ pm Pump 15± gals Gray heavily silted H2O w/ fine sand
  12⁰⁰ pm - 12⁴⁵ pm Pump 45± gals Gray heavily to moderately silty H2O w/ fine sand - Sand content diminishing
- ▼ H2O reading 2⁰⁰ pm after allowing well to settle 17.0' ± BGS
- 2⁰⁰ - 2²⁰ pm Pump 20± gals Gray heavy to moderately silty H2O w/ fine sand
- ▼ H2O Rdg 2²⁵ pm 16.9' ± BGS Suspend development

*** Well Volume ***

- 1 1/2" ID Screen & Riser 0.09 gals/L.F.
- 34.2' x 0.09 = 3.1 gals.
  Min. development volume 3 x 3.1 = 9.3 gals.

2/20/09

- ▼ H2O Rdg 5³⁰ pm 16.9' ± BGS Sediment in well to 48.0' ±
- * Jetted well to suspend sediment w/ 5 to 10 gals potable H2O
- Resume pumping - All sediment in suspension
  5⁴⁰ - 6⁰⁰ pm Pump 20± gals Heavily silted H2O w/ fine sand
  6⁰⁰ - 6³⁰ pm Pump 30 gals Gray heavily then moderately silty H2O w/ fine sand - Sand content diminishing
  6³⁰ - 6⁴⁵ pm Pump 15± gals Gray moderately to slightly silty H2O w/ some fine sand
- ▼ H2O level @ completion 6⁵⁰ pm 17.0' ± B.G.S.

5 to 10 gals H2O added to well during jetting / 160± total gals H2O pumped during development

— Bottom of Well 50.4' B.G.S.

Complete 6⁵⁰ pm 2/20/09

AEPSPP-000110

AEPSPP003989

Well Development Log

HCN H. C. NUTTING
A Terracon COMPANY
790 Morrison Road • Columbus, OH 43230 • (614) 863-3113

JOB N2095019
SHEET NO. 1 OF 1
CALCULATED BY JCE DATE 2/21/09
CHECKED BY – DATE –
SCALE NTS

American Electric Power

Sporn Plant — Date Well Installed: Feb. 19, 2009

PZ-09-04

▼ Initial GW Elev. Prior to Well Development 14.1 ' B.G.S.

Grd. Surface / Top of Vault 0.0' B.G.S.
Well Vault — Top of Well Riser 0.59' B.G.S. (7 1/8")

2/21/09

- 2:50 pm Initial H2O Rdg. Water @ 14.1 BGS
  Surge Well w/ 3' long by 1" Ø PVC Surge block
- 2:55 pm Initiate Pumping
- 2:55–3:05 pm Pumped 10 gals. Dark Gray very heavily silted H2O w/ fine sand
- 3:05–3:25 pm Pumped 25± gals Gray heavily silted H2O w/ fine sand
- 3:25 pm – 3:40 pm Pumped 20± gals Gray to Lt. gray moderately silty H2O w/ some fine sand
- 3:40–4:05 pm Pumped 25± gals Lt. gray moderately to slightly silty H2O w/ some fine sand
- 4:05 – 4:15 pm Pumped 10± gals Lt. gray slightly silty H2O w/ some fine sand

✱ Well Volume ✱
1 1/2" ID Screen & Riser
0.09 gals/L.F.
35.7' x 0.09 = 3.2 gals.
Min. development volume
3 x 3.21 gals = 9.6 gals.

▼ H2O Rdg 4:25 pm Water @ 14.5' BGS

90± Total gals. H2O pumped from well during development

Development complete 4:25 pm

— Bottom of Well 49.8 ' B.G.S.

Well Development Log

H. C. NUTTING
A Terracon COMPANY
790 Morrison Road • Columbus, OH 43230 • (614) 863-3113

JOB N2095019
SHEET NO. 1 OF 1
CALCULATED BY JCE DATE 2/20/09
CHECKED BY — DATE —
SCALE NTS

American Electric Power

Sporn Plant — Date Well Installed: Feb. 17, 2009

PZ-09-05

▼ Initial GW Elev. Prior to Well Development 15.7' B.G.S.

Well Vault — Grd. Surface/Top of Vault 0.0' B.G.S.
— Top of Well Riser 0.2' B.G.S. (2½")

2/20/09
- 2:30 pm Initial H2O Rdg - water @ 15.7' BGS
Surge well w/ 3' long PVC 1" Ø surge block
- 2:35 pm Initiate Pumping
  2:35 - 3:00 pm Pump 20 gals Brown/Grey heavily silted H2O w/ fine sand
- ► Sediment in well to 46.5'± BGS

* Well Volume *
- 1½" ID Screen & Riser 0.09 gals/L.F.
- 34.5' x 0.09 = 3.1 gals.
Min. development volume
3 x 3.1 = 9.3 gals.

* Jetted well w/ 5 to 10 gallons potable H2O to suspend sediment
- Resume Pumping
  3:25 pm - 3:40 pm Pumped 15± gallons Brown/grey heavily silted H2O w/ fine sand
  3:40 pm - 4:00 pm Pumped 20± gallons Brown to light brown moderately silty H2O w/ some fine sand
  4:00 pm - 4:20 pm Pumped 20± gallons light brown moderately to slightly silty H2O w/ trace fine sand
  4:20 pm - 4:35 pm Pumped 15± gallons light brown slightly silty H2O w/ trace fine sand

▼ H2O level immediately after pumping 15.9' B.G.S.

► 5 to 10 gallons H2O added to well during jetting.

90± gals. Total H2O Pumped from Well during development

(2/20/09 4:40 pm Development Complete)

— Bottom of Well 50.2' B.G.S.

TERRACON PROJECT NO. N2095019

PROJECT SPORN FLY ASH AND BOTTOM ASH POND COMPLEX

SUMMARY ELEVATIONS
(FT. NGVD)

COORDINATES 721044.45 N/1735346.82 E (NAD 27)(NGVD29 WV N)

DATE INSTALLED 02/21/09

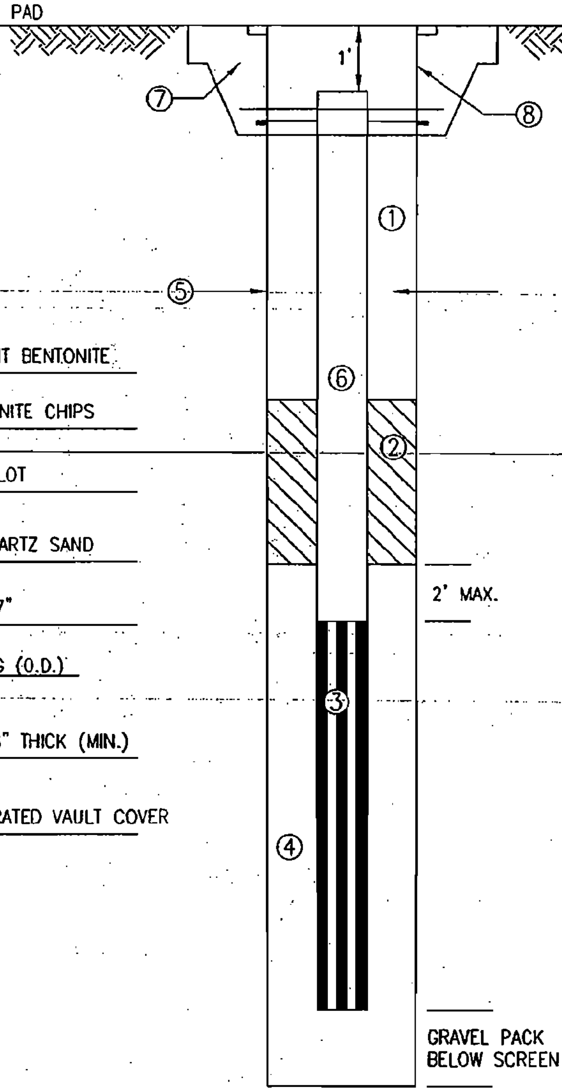
PIEZOMETER NO. PZ-09-01

REF. DATUM PT.:
TOP OF PROTECTIVE
VAULT/GROUND SURFACE

REF. DATUM PT. ________

GROUND SURFACE/TOP OF PAD

GRADE 0' (600.82')



DEPTH (ELEV.)

TOP OF BENTONITE SEAL 4.0' (596.82')

TOP OF GRAVEL PACK 5.0' (595.82')

TOP OF SCREEN 6.0' (594.82')

BOTTOM OF SCREEN 50.3' (550.52')

BOTTOM OF BLANK SEC. N/A

BOTTOM OF GRAVEL PACK 51.0' (549.82')

BOTTOM OF BOREHOLE 51.0' (549.82')

1 GROUT SEAL MATERIAL: CEMENT BENTONITE

2 BENTONITE SEAL MATERIAL: BENTONITE CHIPS

3 SCREEN SIZE: 0.010" SLOT

4 GRAVEL PACK MATERIAL: #5 QUARTZ SAND

5 BOREHOLE DIAMETER 6" MIN. 7"

6 1.92" DIA. PVC CASING (O.D.)

7 CONCRETE PAD DIMENSIONS: 3'x3'x8" THICK (MIN.)

8 PROTECTIVE STEEL H2 RATED VAULT COVER

NOTE: DEPTHS OF MATERIALS ARE TAKEN FROM TOP OF VAULT/GROUND SURFACE

SCALE: NTS

GEOTECHNICAL ENGINEERING SECTION CIVIL DESIGN STANDARD		REVISION 0		OBSERVATION WELL	
APP'D.	DR.	C.K.	DATE		
AMERICAN ELECTRIC POWER SERVICE CORP.				CDS-04A	SH.

AMERICAN ELECTRIC POWER
SPORN FLY ASH AND BOTTOM ASH POND COMPLEX

GEOLOGIST/ENGINEER:
LEWIS EPLIN H.C. NUTTING CO.

TERRACON PROJECT NO. N2095019

PROJECT SPORN FLY ASH AND BOTTOM ASH POND COMPLEX

SUMMARY ELEVATIONS
(FT. NGVD)

COORDINATES 720305.06 N/1735649.89 E (NAD 27)(NGVD29 WV N)

DATE INSTALLED 02/20/09

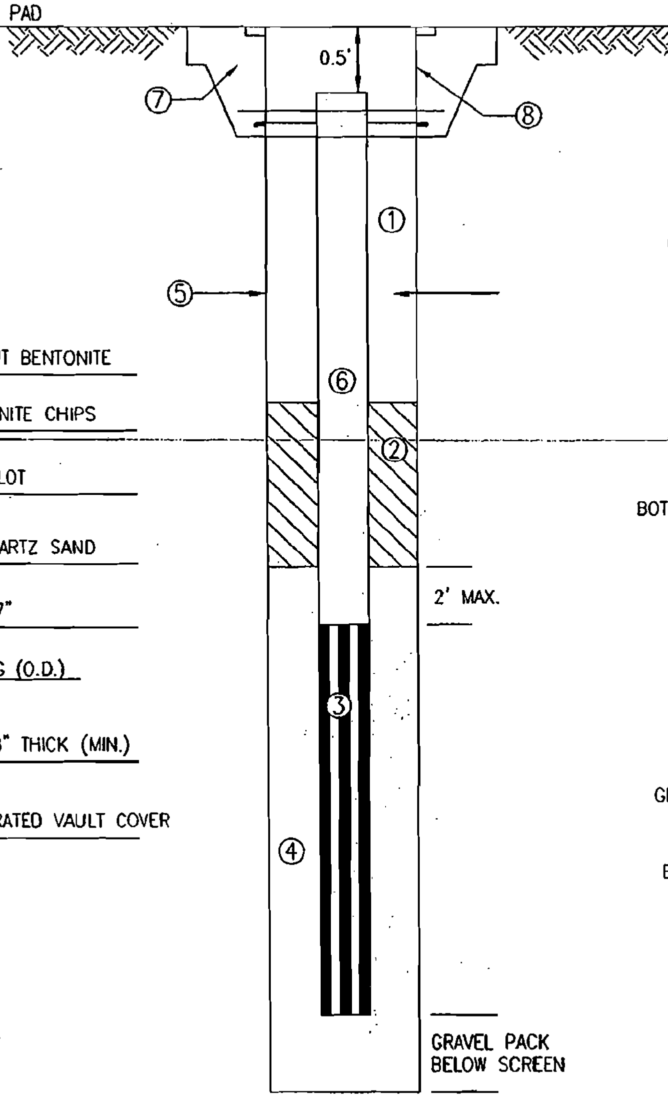
PIEZOMETER NO. PZ-09-02

REF. DATUM PT.:
TOP OF PROTECTIVE
VAULT/GROUND SURFACE

REF. DATUM PT. ________

GROUND SURFACE/TOP OF PAD

GRADE 0' (601.35')



DEPTH (ELEV.)

TOP OF BENTONITE SEAL 2.0' (599.35')

TOP OF GRAVEL PACK 3.5' (597.85')

TOP OF SCREEN 5.5' (595.85')

BOTTOM OF SCREEN 35.0' (566.35')

BOTTOM OF BLANK SEC. N/A

BOTTOM OF GRAVEL PACK 36.0' (565.35')

BOTTOM OF BOREHOLE 50.0' (551.35')

GROUTED 36.0' TO 50.0'

1 GROUT SEAL MATERIAL: CEMENT BENTONITE

2 BENTONITE SEAL MATERIAL: BENTONITE CHIPS

3 SCREEN SIZE: 0.010" SLOT

4 GRAVEL PACK MATERIAL: #5 QUARTZ SAND

5 BOREHOLE DIAMETER 6" MIN. 7"

6 1.92" DIA. PVC CASING (O.D.)

7 CONCRETE PAD DIMENSIONS: 3'x3'x8" THICK (MIN.)

8 PROTECTIVE STEEL H2 RATED VAULT COVER

NOTE: DEPTHS OF MATERIALS ARE TAKEN FROM TOP OF VAULT/GROUND SURFACE

SCALE: NTS

GEOTECHNICAL ENGINEERING SECTION CIVIL DESIGN STANDARD		REVISION 0		OBSERVATION WELL	
APP'D.	DR.	C.K.	DATE		
AMERICAN ELECTRIC POWER SERVICE CORP.				CDS-04A	SH.

AMERICAN ELECTRIC POWER
SPORN FLY ASH AND BOTTOM ASH POND COMPLEX

GEOLOGIST/ENGINEER:
LEWIS EPLIN H.C. NUTTING CO.

AEPSPP-000114

AEPSPP003993

TERRACON PROJECT NO. N2095019

PROJECT SPORN FLY ASH AND BOTTOM ASH POND COMPLEX

SUMMARY ELEVATIONS
(FT. NGVD)

COORDINATES 718399.12 N/1736131.92 E (NAD 27)(NGVD29 WV N)

DATE INSTALLED 02/18/09

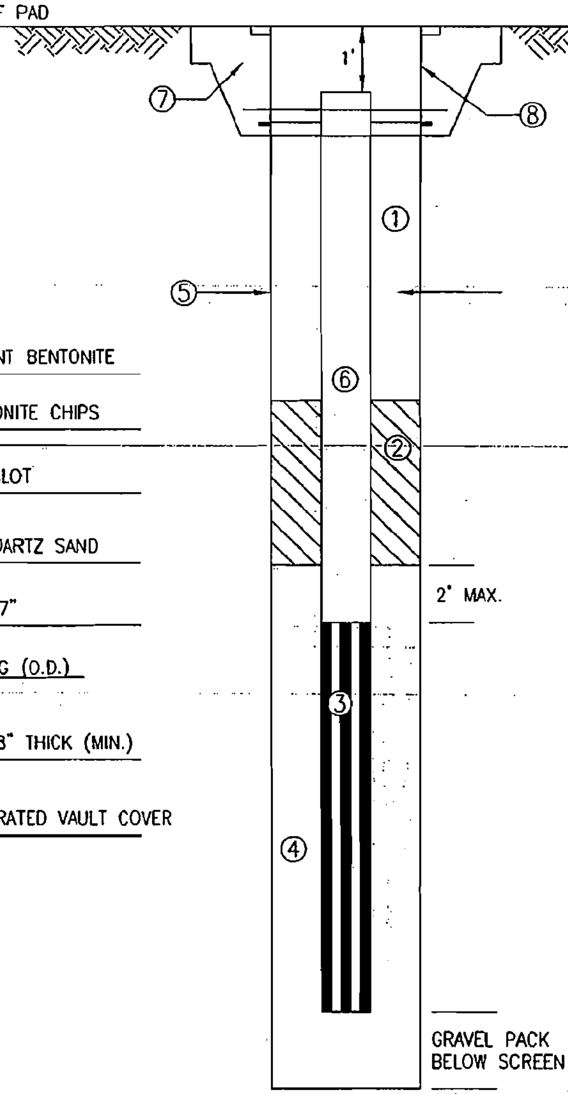
PIEZOMETER NO. PZ-09-03

REF. DATUM PT.:
TOP OF PROTECTIVE
VAULT/GROUND SURFACE

REF. DATUM PT. ________

GROUND SURFACE/TOP OF PAD

GRADE 0' (596.52')



DEPTH (ELEV.)

TOP OF BENTONITE SEAL 4.0' (592.52')

TOP OF GRAVEL PACK 5.0' (591.52')

TOP OF SCREEN 6.0' (590.52')

BOTTOM OF SCREEN 50.4' (546.12')

BOTTOM OF BLANK SEC. N/A

BOTTOM OF GRAVEL PACK 51.0' (545.52')

BOTTOM OF BOREHOLE 51.0' (545.52')

1 GROUT SEAL MATERIAL: CEMENT BENTONITE
2 BENTONITE SEAL MATERIAL: BENTONITE CHIPS
3 SCREEN SIZE: 0.010" SLOT
4 GRAVEL PACK MATERIAL: #5 QUARTZ SAND
5 BOREHOLE DIAMETER 6" MIN. 7"
6 1.92" DIA. PVC CASING (O.D.)
7 CONCRETE PAD DIMENSIONS: 3'x3'x8" THICK (MIN.)
8 PROTECTIVE STEEL H2 RATED VAULT COVER

NOTE: DEPTHS OF MATERIALS ARE TAKEN FROM TOP OF VAULT/GROUND SURFACE

SCALE: NTS

GEOTECHNICAL ENGINEERING SECTION CIVIL DESIGN STANDARD		REVISION 0		OBSERVATION WELL
APP'D.	DR.	C.K.	DATE	
AMERICAN ELECTRIC POWER SERVICE CORP.				CDS-04A SH.

AMERICAN ELECTRIC POWER
SPORN FLY ASH AND BOTTOM ASH POND COMPLEX

GEOLOGIST/ENGINEER:
LEWIS EPLIN H.C. NUTTING CO.

TERRACON PROJECT NO. N2095019

PROJECT SPORN FLY ASH AND BOTTOM ASH POND COMPLEX

COORDINATES 718150.72 N/1736258.64 E (NAD 27)(NGVD29 WV N)

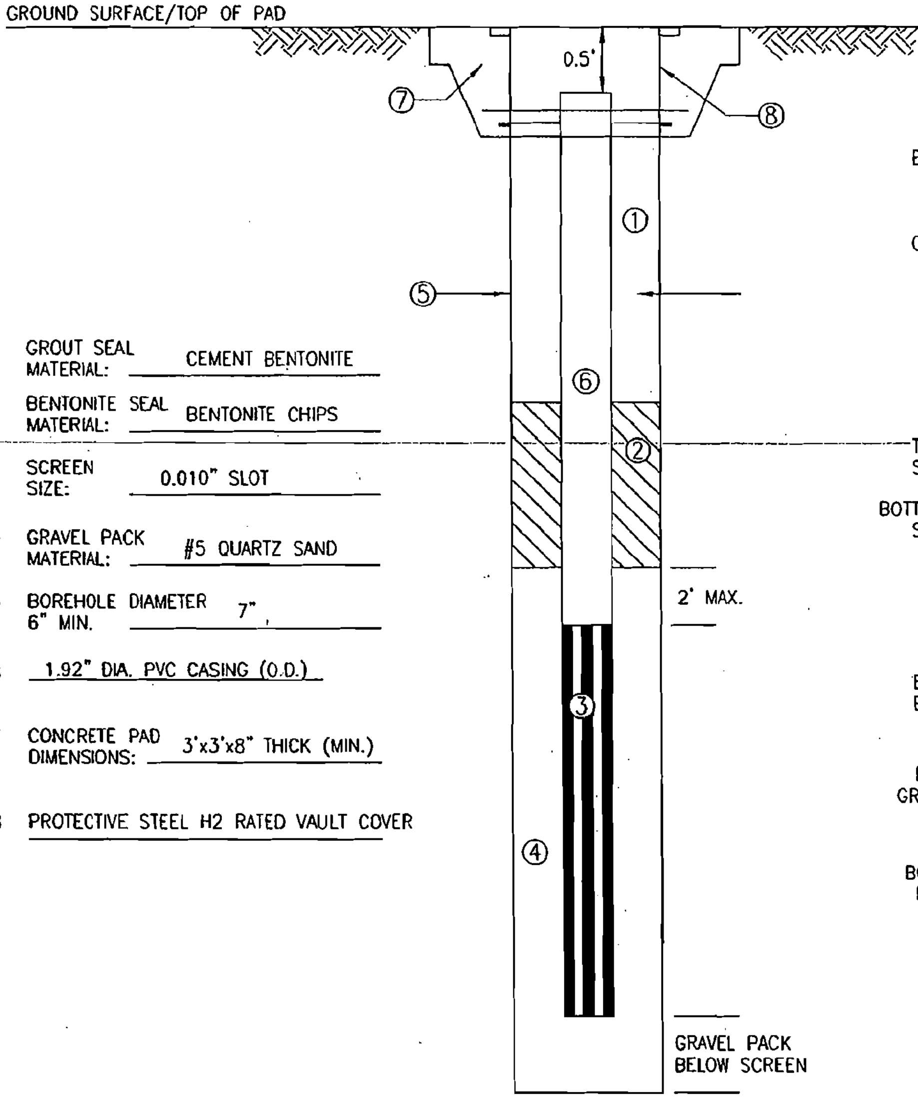
DATE INSTALLED 02/19/09

SUMMARY ELEVATIONS (FT. NGVD)

PIEZOMETER NO. PZ-09-04

REF. DATUM PT.

REF. DATUM PT.: TOP OF PROTECTIVE VAULT/GROUND SURFACE



GRADE 0' (593.69')

DEPTH (ELEV.)

TOP OF BENTONITE SEAL 3.5' (590.19')

TOP OF GRAVEL PACK 4.5' (589.19')

TOP OF SCREEN 5.5' (588.19')

BOTTOM OF SCREEN 49.8' (543.89')

BOTTOM OF BLANK SEC. N/A

BOTTOM OF GRAVEL PACK 51.0' (542.69')

BOTTOM OF BOREHOLE 51.0' (542.69')

1. GROUT SEAL MATERIAL: CEMENT BENTONITE
2. BENTONITE SEAL MATERIAL: BENTONITE CHIPS
3. SCREEN SIZE: 0.010" SLOT
4. GRAVEL PACK MATERIAL: #5 QUARTZ SAND
5. BOREHOLE DIAMETER 6" MIN. 7"
6. 1.92" DIA. PVC CASING (O.D.)
7. CONCRETE PAD DIMENSIONS: 3'x3'x8" THICK (MIN.)
8. PROTECTIVE STEEL H2 RATED VAULT COVER

NOTE: DEPTHS OF MATERIALS ARE TAKEN FROM TOP OF VAULT/GROUND SURFACE

SCALE: NTS

GEOTECHNICAL ENGINEERING SECTION CIVIL DESIGN STANDARD		REVISION 0		OBSERVATION WELL
APP'D.	DR.	C.K.	DATE	
AMERICAN ELECTRIC POWER SERVICE CORP.				CDS-04A	SH.

AMERICAN ELECTRIC POWER
SPORN FLY ASH AND BOTTOM ASH POND COMPLEX

GEOLOGIST/ENGINEER:
LEWIS EPLIN H.C. NUTTING CO.

TERRACON PROJECT NO. N2095019

PROJECT SPORN FLY ASH AND BOTTOM ASH POND COMPLEX

SUMMARY ELEVATIONS (FT. NGVD)

COORDINATES 717961.56 N/1735749.39 E (NAD 27)(NGVD29 WV N)

DATE INSTALLED 02/17/09

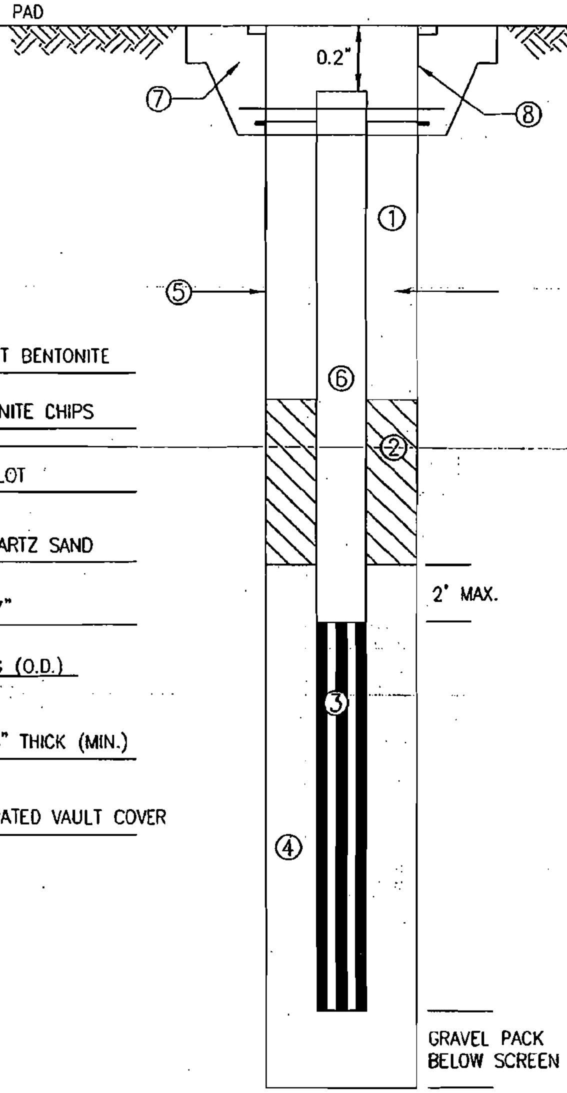
PIEZOMETER NO. PZ-09-05

REF. DATUM PT.: TOP OF PROTECTIVE VAULT/GROUND SURFACE

REF. DATUM PT. ______

GROUND SURFACE/TOP OF PAD

GRADE 0' (593.45')



DEPTH (ELEV.)

TOP OF BENTONITE SEAL	3.2' (590.25')
TOP OF GRAVEL PACK	4.2' (589.25')
TOP OF SCREEN	5.2' (588.25')
BOTTOM OF SCREEN	50.2' (543.25')
BOTTOM OF BLANK SEC.	N/A
BOTTOM OF GRAVEL PACK	51.0' (542.45')
BOTTOM OF BOREHOLE	51.0' (542.45')

1. GROUT SEAL MATERIAL: CEMENT BENTONITE
2. BENTONITE SEAL MATERIAL: BENTONITE CHIPS
3. SCREEN SIZE: 0.010" SLOT
4. GRAVEL PACK MATERIAL: #5 QUARTZ SAND
5. BOREHOLE DIAMETER 6" MIN. 7"
6. 1.92" DIA. PVC CASING (O.D.)
7. CONCRETE PAD DIMENSIONS: 3'x3'x8" THICK (MIN.)
8. PROTECTIVE STEEL H2 RATED VAULT COVER

NOTE: DEPTHS OF MATERIALS ARE TAKEN FROM TOP OF VAULT/GROUND SURFACE

SCALE: NTS

GEOTECHNICAL ENGINEERING SECTION CIVIL DESIGN STANDARD		REVISION 0	OBSERVATION WELL
APP'D.	DR.	C.K. / DATE	
AMERICAN ELECTRIC POWER SERVICE CORP.		CDS-04A	SH.

AMERICAN ELECTRIC POWER
SPORN FLY ASH AND BOTTOM ASH POND COMPLEX

GEOLOGIST/ENGINEER:
LEWIS EPLIN H.C. NUTTING CO.

GENERAL NOTES

DRILLING & SAMPLING SYMBOLS:

SS:	Split Spoon - 1-3/8" I.D., 2" O.D., unless otherwise noted	HS:	Hollow Stem Auger
ST:	Thin-Walled Tube - 2" O.D., unless otherwise noted	PA:	Power Auger
RS:	Ring Sampler - 2.42" I.D., 3" O.D., unless otherwise noted	HA:	Hand Auger
DB:	Diamond Bit Coring - 4", N, B	RB:	Rock Bit
BS:	Bulk Sample or Auger Sample	WB:	Wash Boring or Mud Rotary

The number of blows required to advance a standard 2-inch O.D. split-spoon sampler (SS) the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches is considered the "Standard Penetration" or "N-value".

WATER LEVEL MEASUREMENT SYMBOLS:

WL:	Water Level	WS:	While Sampling	N/E:	Not Encountered
WCI:	Wet Cave in	WD:	While Drilling		
DCI:	Dry Cave in	BCR:	Before Casing Removal		
AB:	After Boring	ACR:	After Casing Removal		

Water levels indicated on the boring logs are the levels measured in the borings at the times indicated. Groundwater levels at other times and other locations across the site could vary. In pervious soils, the indicated levels may reflect the location of groundwater. In low permeability soils, the accurate determination of groundwater levels may not be possible with only short-term observations.

DESCRIPTIVE SOIL CLASSIFICATION: Soil classification is based on the Unified Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf	Standard Penetration or N-value (SS) Blows/Ft.	Consistency
< 500	0 - 1	Very Soft
500 – 1,000	2 - 4	Soft
1,000 – 2,000	4 - 8	Medium Stiff
2,000 – 4,000	8 - 15	Stiff
4,000 – 8,000	15 - 30	Very Stiff
8,000+	> 30	Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS

Standard Penetration or N-value (SS) Blows/Ft.	Relative Density
0 – 3	Very Loose
4 – 9	Loose
10 – 29	Medium Dense
30 – 49	Dense
> 50	Very Dense

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 – 29
Modifier	> 30

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 – 12
Modifiers	> 12

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300mm)
Cobbles	12 in. to 3 in. (300mm to 75 mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm)
Silt or Clay	Passing #200 Sieve (0.075mm)

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1-10
Medium	11-30
High	> 30

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UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: Group Name[B]
Coarse Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]	GW	Well-graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]	GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]	SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$[E]	SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines Classify as CL or CH	SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	$PI > 7$ and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			$PI < 4$ or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OL	Organic clay[K,L,M,N]
					Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic Silt[K,L,M]
		organic	Liquid limit - oven dried / Liquid limit - not dried < 0.75	OH	Organic clay[K,L,M,P]
					Organic silt[K,L,M,Q]
Highly organic soils		Primarily organic matter, dark in color, and organic odor		PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

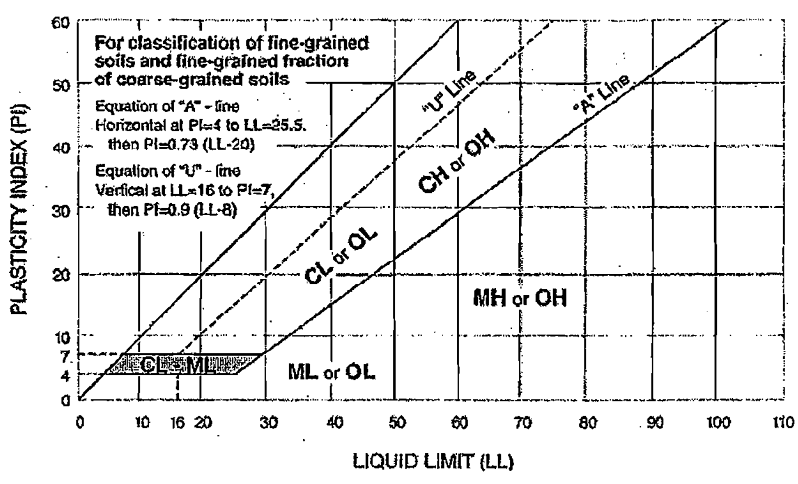
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] $PI \geq 4$ and plots on or above "A" line.

[O] $PI < 4$ or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



Terracon

Form 111—6/98

FIELD DATA COLLECTED BY:
GEO/ENVIRONMENTAL ASSOCIATES, INC.

DATED: DECEMBER 2009 & JANUARY 2010

Geo/Environmental Associates, Inc.

Boring No. GA-1A

PROJECT: AEP Philip Sporn	PROJECT NO: 09-387
Start Date: 12-10-09	Drilling Contractor: Horn and Associates
Finish Date: 12-10-09	Driller: Tom Leininger
Logged By: Seth Frank	Helper: Robert, George
Location: FAP – East Dike section K-K	Drill Type: Diedrich D120 Truck Mounted
Ground Elevation: 619.13' NGVD29	AEP Contacts: Mark King and Ginger MacKnight
Notes: woven fabric approx 0.5' bgs	Thickness of Soil:
NAD27 Coordinates Provided by AEP	Depth Drilled In Rock:
N 719696.84 E 1736037.33	Total Depth of Boring: 69.0'

DEPTH (FEET)		SAMPLE NOS., & SPLIT SPOON RECOVERY	SOIL/BEDROCK DESCRIPTION	BLOW COUNTS AND COMMENTS
FROM	TO			
2.0	2.5	S-1 / 0.4'	Sand, gravel, brown, very dense, damp	50 / 0.5'
4.0	4.6	S-2 / 0.5'	Sand, gravel, brown, very dense, damp	35-50 / 0.1'
6.5	7.0	S-3 / 0.4'	Sand, gravel, brown, very dense, damp	50 / 0.5'
9.0	10.5	S-4 / 0.4'	Sand, gravel, brown, very dense, damp	33-37-31
11.5	13.0	S-5 / 1.4'	Sand, gravel, brown, very dense, damp	35-36-29
14.0	14.5	S-6 / 0.4'	Sand, gravel, brown, very dense, damp	50 / 0.5'
16.5	18.0	S-7 / 1.5'	Sand, clay, brown, medium dense, damp	17-17-13
19.0	20.5	S-8 / 1.5'	Sand, clay, brown, medium dense, damp	20-12-11
20.5	22.0	S-9 / 1.3'	Sand, clay, brown, medium dense, damp	11-14-15
22.0	23.5	S-10 / 1.5'	0 -1.1' Sand, clay, brown / 1.1-1.5' Bottom Ash, sand, black, dense, damp	23-26-20
23.5	25.0	S-11 / 1.5'	Sand, bottom ash streaks, clay, brown streaked black, dense, damp	17-20-17
25.0	26.5	S-12 / 1.5'	Bottom Ash, fly ash, grey-black, dense, moist (approximate start of fly ash)	17-16-16

Geo/Environmental Associates, Inc.

Project Name/ Job Number: 09-387

Boring Log No.: GA-1A

DEPTH (FEET)		SAMPLE NO., SAMPLE INTERVAL & SPLIT SPOON RECOVERY	SOIL/BEDROCK DESCRIPTION	BLOW COUNTS AND COMMENTS
FROM	TO			
26.5	27.2	ST-1 / 0.7'	Fly Ash, bottom ash, grayish black, wet	W/L ≈ 27' bgs
28.5	31.0	ST-2 / 2.66'	Fly Ash, gray, wet	
31.0	32.5	S-13 / 1.5'	Fly Ash, gray, loose, wet	3-2-3
32.5	35.0	ST-3 / 2.50'	Fly Ash, gray, wet	
35.0	36.5	S-14 / 1.5'	Fly Ash, gray, loose wet	3-3-3
36.5	39.0	ST-4 / 2.60'	Fly Ash, gray, wet	
39.0	40.5	S-15 / 1.5'	Fly Ash, gray, loose, wet	2-3-2
40.5	43.0	ST-5 / 2.55'	Fly Ash, gray, wet	
43.0	44.5	S-16 / 1.5'	Fly Ash, gray, loose, wet	1-3-3
44.5	47.0	ST-6 / 2.55'	Fly Ash, gray, wet	
47.0	48.5	S-17 / 1.5'	Fly Ash, gray, loose, wet	5-4-4
48.5	51.0	ST-7 / 2.41'	Fly Ash, gray, wet	
51.0	52.5	S-18 / 1.5'	Fly Ash, gray, loose, wet	7-2-4
52.5	55.0	ST-8 / 2.55'	Fly Ash, gray, wet	
55.0	56.5	S-19 / 1.5'	Fly Ash, gray, loose, wet	1-3-4
56.5	59.0	ST-9 / 2.37'	Fly Ash, gray, wet	
59.0	60.5	S-20 / 1.5'	0-1.0' Fly Ash, clay, gray 1.0-1.5' Clay, silt, brown, stiff, wet (approximate end of fly ash)	3-4-8
60.5	63.0	ST-10 / 2.49'	Clay, silt, brown	
69.0	70.5	S-21 / 1.5'	Silt, clay, brown, very stiff, moist-wet	6-8-8
			Set Inclinometer at ≈ 69' bgs. Back fill with grout mix: approx 1 unit pcc, 1 unit bentonite, 6.25 units water by weight.	

Geo/Environmental Associates, Inc.	Boring No. GA-1B Page 1 Of 1
PROJECT: AEP Philip Sporn	**PROJECT NO: 09-387**
Start Date: 12-11-09	Drilling Contractor: Horn and Associates
Finish Date: 12-14-09	Driller: Tom Leininger
Logged By: Seth Frank	Helper: Robert, George, Jared
Location: FAP – East Dike section K-K	Drill Type: Diedrich D120 Truck Mounted
Ground Elevation: 619.04' NGVD29	AEP Contacts: Mark King and Ginger MacKnight
Notes: woven fabric approx 0.5' bgs	Thickness of Soil:
NAD27 Coordinates Provided by AEP	Depth Drilled In Rock:
N 719704.38 E 1736031.96	Total Depth of Boring: 69.0'

DEPTH (FEET)		SAMPLE NOS., & SPLIT SPOON RECOVERY	SOIL/BEDROCK DESCRIPTION	BLOW COUNTS AND COMMENTS
FROM	TO			
9.0	10.5	S-1 / 1.2'	Sand, gravel, brown, very dense, damp	32-37-35
19.0	20.5	S-2 / 1.5'	Sand, clay, brown – mottled black, medium dense, damp	12-7-9
29.0	30.5	S-3 / 1.5'	Fly Ash, gray, loose, wet	5-4-5
39.0	40.5	S-4 / 1.5'	Fly Ash, gray, very loose, wet	0-1-0
49.0	50.5	S-5 / 1.5'	Fly Ash, gray, loose, wet	2-3-5
59.0	60.5	S-6 / 1.5'	0-1.0 Fly Ash, gray, very loose, wet 1.0-1.5 Clay, silty, brown, soft, damp-moist	0-0-3
69.0	70.5	S-7 / 1.5'	Clay, silty, brown, very stiff, damp-moist	9-10-10
			Set Inclinometer at ≈ 69' bgs. Back fill with grout mix: approx 1 unit pcc, 1 unit bentonite, 6.25 units water by weight.	

Geo/Environmental Associates, Inc.

Boring No. GA-1C

Page 1 Of 1

PROJECT: AEP Philip Sporn	**PROJECT NO: 09-387**
Start Date: 12-16-09	Drilling Contractor: Horn and Associates
Finish Date: 12-16-09	Driller: Tom Leininger
Logged By: Seth Frank	Helper: Robert, George, Jared
Location: FAP – East Dike section K-K	Drill Type: Diedrich D120 Truck Mounted
Ground Elevation: 619.03' NGVD29	AEP Contacts: Mark King and Ginger MacKnight
Notes: woven fabric approx 0.5' bgs	Thickness of Soil:
NAD27 Coordinates Provided by AEP	Depth Drilled In Rock:
N 719712.67 E 1736026.24	Total Depth of Boring: 79.0'

DEPTH (FEET)		SAMPLE NOS., & SPLIT SPOON RECOVERY	SOIL/BEDROCK DESCRIPTION	BLOW COUNTS AND COMMENTS
FROM	TO			
9.0	10.5	S-1 / 1.4'	Sand, gravel, brown, very dense, damp	29-30-31
19.0	20.5	S-2 / 1.5'	Sand, clay, brown streaked black, medium dense, damp-moist	9-11-7
29.0	30.5	S-3 / 1.5'	Fly Ash, grayish black, medium dense, wet	9-8-7
35.0		Vain Shear 1	30 lb-ft / 60° 10 lb-ft / 360°	
39.0	41.5	ST-1 / 0.98'	Fly Ash, grey, wet	
42.5		Vane Shear 2	100 lb-ft / 90° 60 lb-ft / 360°	
50.0'		Vane Shear 3	40 lb-ft / 60° 20 lb-ft / 360°	
59.0	60.5	S-4 / 1.5'	Fly Ash, clay, organic material, silty, brownish black, soft, moist-wet	1-1-3
69.0	71.5	ST-2 / 2.58'	Clay, silty, sandy, brown, moist-wet	
79.0	80.5	S-5 / 1.5'	Clay, silty, brown, stiff, wet	5-8-7 1.75 tsf
			Set Inclinometer at ≈ 79' bgs. Back fill with grout mix: approx 1 unit pcc, 1 unit bentonite, 6.25 units water by weight.	

Geo/Environmental Associates, Inc.

Boring No. GA-1D

PROJECT: AEP Philip Sporn

PROJECT NO: 09-387

Start Date: 12-16-09

Finish Date: 12-17-09

Logged By: Seth Frank

Location: FAP – East Dike section K-K

Ground Elevation: 619.21' NGVD29

Drilling Contractor: Horn and Associates

Driller: Tom Leininger

Helper: Robert, George, Jared

Drill Type: Diedrich D120 Truck Mounted

AEP Contacts: Mark King and Ginger MacKnight

Notes: woven fabric approx 0.5' bgs

NAD27 Coordinates Provided by AEP

N 719729.38 E 1736015.38

Thickness of Soil:

Depth Drilled In Rock:

Total Depth of Boring: 59.0'

DEPTH (FEET)		SAMPLE NOS., & SPLIT SPOON RECOVERY	SOIL/BEDROCK DESCRIPTION	BLOW COUNTS AND COMMENTS
FROM	TO			
9.0	9.4	S-1 / 0.3'	Sand, gravel, brown, very dense, damp	50 / 0.4'
19.0	20.5	S-2 / 1.4'	Sand, clay, brown streaked black, medium dense, damp-moist	21-14-12
29.0	30.5	ST-1 / 1.17'	Fly Ash, gray, wet	
32.5		Vane Shear 1	10 lb-ft / 60° 10 lb-ft / 360°	
39.0	41.5	ST-2 / 2.48'	Fly Ash, gray, wet	
42.5		Vane Shear 2	30 lb-ft / 60° 20 lb-ft / 360°	
50.5'		Vane Shear 3	30 lb-ft / 60° 20 lb-ft / 360°	
59.0	61.5	ST-3 / 2.36'	Fly Ash, clay, grayish black	

Geo/Environmental Associates, Inc. Project Name/ Job Number: 09-387

Boring Log No.: GA-1D

Page 2 of 2

DEPTH (FEET)		SAMPLE NO., SAMPLE INTERVAL & SPLIT SPOON RECOVERY	SOIL/BEDROCK DESCRIPTION	BLOW COUNTS AND COMMENTS
FROM	TO			
			Set Piezometer at approximately 60' bgs	
0	0.5		Flush Mount Piezometer Cover	
0.5	23.0		Grout	
23.0	25.0		Bentonite	
25.0	60.0		Prepak Screen Backfilled With Sand	
60.0	61.5		Bentonite mix	
			Water Elevation December 17, 2009: 25.2' bgs	
			Water Elevation January 8, 2010: 25.6' bgs	

Geo/Environmental Associates, Inc.	Boring No. GA-2 Page 1 Of 2

PROJECT: AEP Philip Sporn	PROJECT NO: 09-387
Start Date: 12-17-09	Drilling Contractor: Horn and Associates
Finish Date: 12-18-09	Driller: Tom Leininger
Logged By: Seth Frank	Helper: Robert, George, Jared
Location: FAP – East Dike section M-M	Drill Type: Diedrich D120 Truck Mounted
Ground Elevation: 619.76' NGVD29	AEP Contacts: Mark King and Ginger MacKnight
Notes: woven fabric approx 0.5' bgs	Thickness of Soil:
NAD27 Coordinates Provided by AEP	Depth Drilled In Rock:
N 721075.13 E 1735262.04	Total Depth of Boring: 69.0'

DEPTH (FEET)		SAMPLE NOS., & SPLIT SPOON RECOVERY	SOIL/BEDROCK DESCRIPTION	BLOW COUNTS AND COMMENTS
FROM	TO			
4.0	4.5	S-1 / 0.3'	Sand, gravel, brown, very dense, damp	50 / 0.5'
9.0	9.8	S-2 / 0.5'	Sand, gravel, brown, very dense, damp-moist	35-50 / 0.3'
14.0	14.8	S-3 / 0.6'	Sand, gravel, clay, brown, very dense, damp-moist	29-50 / 0.3'
19.0	20.5	S-4 / 1.4'	Sand, brown, dense, damp	27-22-18
24.0	25.5	S-5 / 1.5'	Sand, bottom ash, black, dense, damp	22-18-14
29.0	30.5	S-6 / 1.5'	Fly Ash, gray, loose, moist-wet	2-4-5
34.0	35.5	S-7 / 1.5'	Fly Ash, gray, very loose, wet	2-1-2
39.0	41.5	ST-1 / 1.10'	Fly Ash, gray, wet	
44.0	45.5	S-8 / 1.5'	Fly Ash, gray, very loose, wet	1-0-2
49.0	50.5	S-9 / 1.5'	Fly Ash, gray, very loose, wet	1-0-0
54.0	55.5	S-10 / 1.5'	Fly Ash, gray, very loose, wet	0-0-0
59.0	61.5	ST-2 / 2.50'	Fly Ash at top of sample – Transition to Silt, clay, sand, brown, moist	

Geo/Environmental Associates, Inc.

Project Name/ Job Number: 09-387

Boring Log No.: GA-2

DEPTH (FEET)		SAMPLE NO., SAMPLE INTERVAL & SPLIT SPOON RECOVERY	SOIL/BEDROCK DESCRIPTION	BLOW COUNTS AND COMMENTS
FROM	TO			
64.0	65.5	S-11 / 1.5'	Sand, clay, brown, medium dense, moist	6-9-8
69.0	71.5	ST-3 / 1.70'	Sand, clay, brown, some gravel at bottom of tube	
			Backfill hole with grout mix	

Geo/Environmental Associates, Inc.

Boring No. GA-3

Page 1 Of 2

PROJECT: AEP Philip Sporn	**PROJECT NO: 09-387**
Start Date: 12-17-09	Drilling Contractor: Horn and Associates
Finish Date: 12-17-09	Driller: Tom Leininger
Logged By: Seth Frank	Helper: Robert, George, Jared
Location: FAP – East Dike section L-L	Drill Type: Diedrich D120 Truck Mounted
Ground Elevation: 619.83' NGVD29	AEP Contacts: Mark King and Ginger MacKnight
Notes: woven fabric approx 0.5' bgs	Thickness of Soil:
NAD27 Coordinates Provided by AEP	Depth Drilled In Rock:
N 720258.79 E 1735560.40	Total Depth of Boring: 79.0'

DEPTH (FEET)		SAMPLE NOS., & SPLIT SPOON RECOVERY	SOIL/BEDROCK DESCRIPTION	BLOW COUNTS AND COMMENTS
FROM	TO			
4.0	4.5	S-1 / 0.4'	Sand, gravel, dark brown, very dense, damp	50 / 0.5'
9.0	10.5	S-2 / 1.1'	Sand, gravel, brown, dense, moist	37-31-17
14.0	15.5	S-3 / 1.4'	Sand, clay, brown, dense, damp	23-24-12
19.0	20.5	S-4 / 1.5'	Clay, sand, silt, brown, very stiff, moist-wet	14-13-12 2.5 tsf
24.0	25.5	S-5 / 1.5'	Clay, sand, silt, brown, hard, wet	22-18-14 2.25 tsf
29.0	31.5	ST-1 / 1.51'	Fly Ash, gray	
34.0	35.5	S-6 / 1.5'	Fly Ash, gray, medium dense, wet	6-7-8
39.0	41.5	S-7 / 1.5'	Fly Ash, gray, very loose, wet	3-0-1
44.0	45.5	S-8 / 1.5'	Fly Ash, gray, loose, wet	0-2-3
49.0	51.5	ST-2 / 2.34'	Fly Ash, gray	
54.0	55.5	S-9 / 1.5'	Fly Ash, gray, loose, wet	5-5-5
59.0	60.5	S-10 / 1.5'	0.0-0.1' Ash, clay, gray 0.1-1.5' Clay, silty, sandy, brown, very stiff, moist-wet	7-10-14

Geo/Environmental Associates, Inc.

Project Name/ Job Number: 09-387

Boring Log No.: GA-3

Page 2 **of** 2

DEPTH (FEET) FROM	DEPTH (FEET) TO	SAMPLE NO., SAMPLE INTERVAL & SPLIT SPOON RECOVERY	SOIL/BEDROCK DESCRIPTION	BLOW COUNTS AND COMMENTS
64.0	65.5	S-11 / 1.5'	Clay, silt, sand, brown, very stiff, moist	8-9-13
69.0	70.5	S-12 / 1.5'	Clay, silt, reddish brown, very stiff, moist	8-9-9
74.0	75.5	S-13 / 1.5'	Clay, sand, silt, brown, soft, moist-wet	0-2-2
79.0	81.5	ST-3 / 2.27'	Clay, sand, silt, brown	
			Backfill hole with grout mix	

Geo/Environmental Associates, Inc.

GA-1A, 1B, & 1C Inclinometer Survey

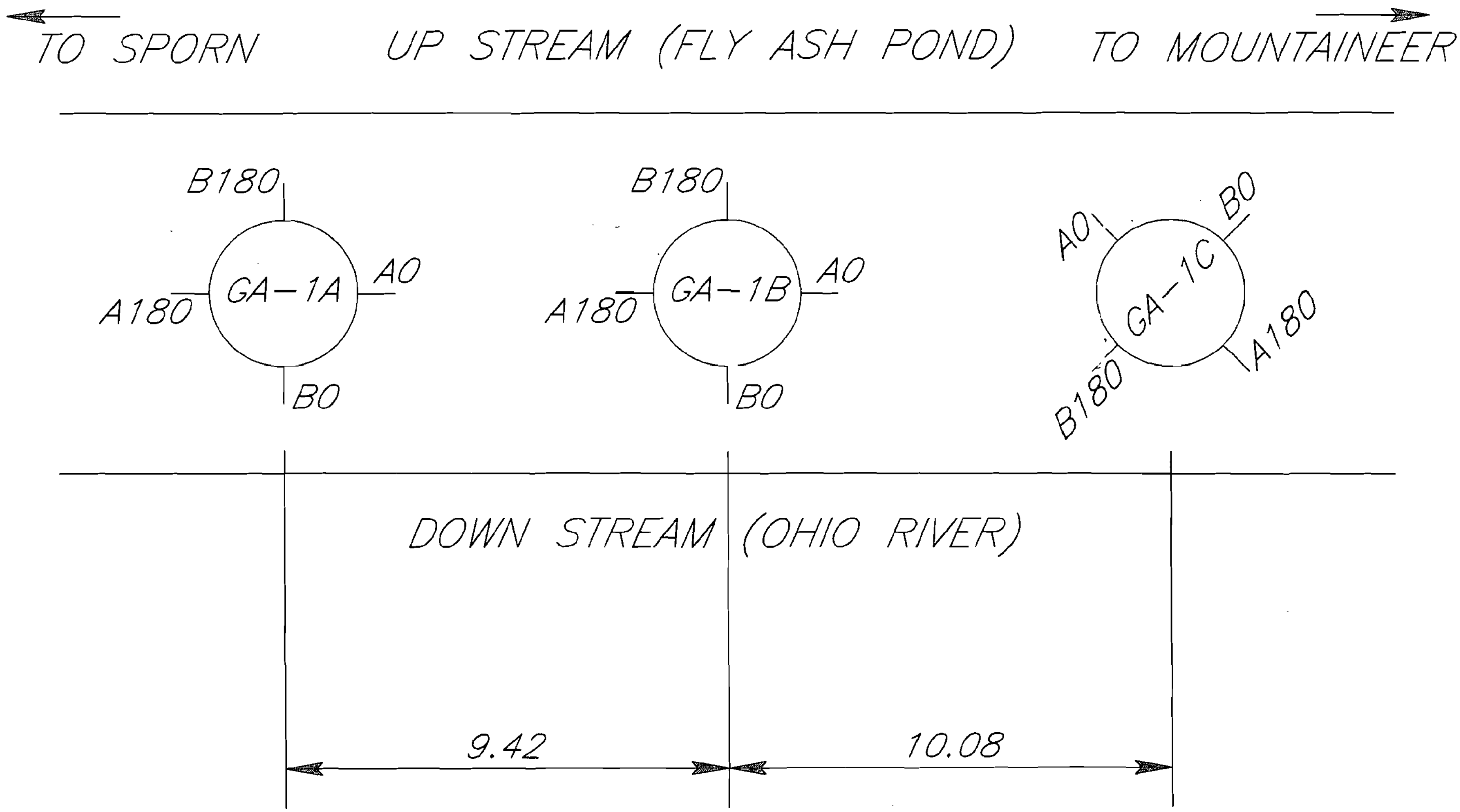
Project: Fly Ash Pond East Dike Cross Borehole Seismic
GA Job No.: 09-387
Title: Down Hole Inclinometer Survey
Performed By: SWF
Location: N 38.97292 W 081.92823
Date: January 6-7, 2010

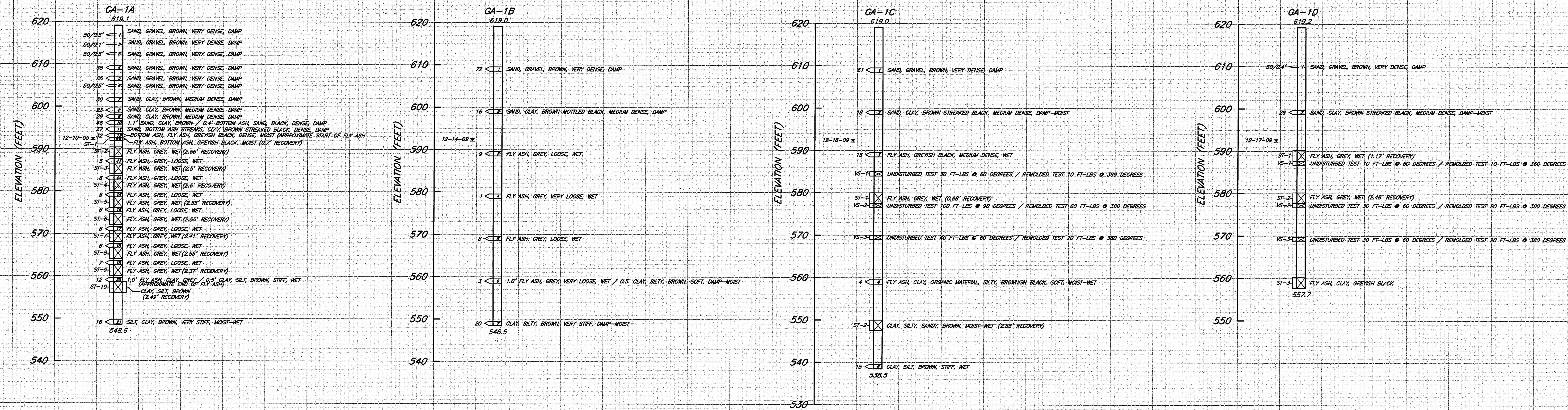
	GA-1A	←Distance (ft)→	GA-1B	←Distance (ft)→	*GA-1C		
Depth (feet)	A-Axis Cumulative Deviation (inches)	Based on Top of Pipe Distance = 9.42'	A-Axis Cumulative Deviation (inches)	Based on Top of Pipe Distance = 10.08'	A-Axis Cumulative Deviation (inches)	B-Axis Cumulative Deviation (inches)	Combined A&B Axis Deviation (inches)
2.5	-0.91	9.51	0.22	10.02	0.27	-0.48	-0.53
4.5	-1.81	9.60	0.38	9.96	0.57	-0.98	-1.10
6.5	-2.59	9.67	0.42	9.91	0.88	-1.44	-1.64
8.5	-3.19	9.71	0.29	9.87	1.22	-1.88	-2.19
10.5	-3.57	9.71	-0.14	9.87	1.50	-2.27	-2.66
12.5	-3.95	9.69	-0.71	9.88	1.80	-2.64	-3.14
14.5	-4.40	9.68	-1.27	9.88	2.12	-2.99	-3.62
16.5	-4.92	9.68	-1.83	9.89	2.45	-3.34	-4.09
18.5	-5.49	9.68	-2.40	9.90	2.82	-3.67	-4.59
20.5	-6.03	9.67	-3.08	9.91	3.20	-3.98	-5.08
22.5	-6.58	9.65	-3.79	9.93	3.62	-4.30	-5.60
24.5	-7.17	9.64	-4.57	9.96	3.96	-4.61	-6.06
26.5	-7.75	9.62	-5.34	9.99	4.25	-4.91	-6.47
28.5	-8.14	9.59	-6.04	10.01	4.59	-5.14	-6.89
30.5	-8.41	9.55	-6.87	10.05	4.89	-5.40	-7.27
32.5	-8.74	9.51	-7.70	10.07	5.22	-5.76	-7.77
34.5	-9.22	9.48	-8.45	10.09	5.56	-6.20	-8.31
36.5	-9.82	9.48	-9.11	10.10	5.83	-6.65	-8.83
38.5	-10.46	9.48	-9.78	10.12	6.09	-7.10	-9.33
40.5	-10.91	9.45	-10.55	10.14	6.33	-7.50	-9.78
42.5	-11.35	9.42	-11.29	10.17	6.67	-7.85	-10.27
44.5	-11.93	9.42	-11.99	10.18	7.15	-8.16	-10.82
46.5	-12.64	9.43	-12.57	10.18	7.71	-8.45	-11.43
48.5	-13.35	9.43	-13.18	10.17	8.31	-8.77	-12.07
50.5	-13.91	9.42	-13.95	10.19	8.81	-9.12	-12.67
52.5	-14.41	9.42	-14.37	10.17	9.28	-9.52	-13.30
54.5	-14.94	9.44	-14.67	10.14	9.72	-9.97	-13.93
56.5	-15.55	9.45	-15.17	10.14	10.09	-10.42	-14.50
58.5	-16.20	9.48	-15.50	10.12	10.39	-10.80	-14.98
60.5	-16.82	9.51	-15.72	10.12	10.46	-11.08	-15.23
62.5	-17.42	9.54	-15.96	10.11	10.63	-11.37	-15.56
64.5	-17.98	9.57	-16.23	10.09	11.05	-11.76	-16.12
66.5	-18.46	9.58	-16.53	10.05	11.62	-12.25	-16.87
68.5					12.19	-12.78	-17.66
70.5					12.57	-13.31	-18.30
72.5					12.98	-13.82	-18.95
74.5					13.46	-14.34	-19.66
76.5					14.01	-14.89	-20.43

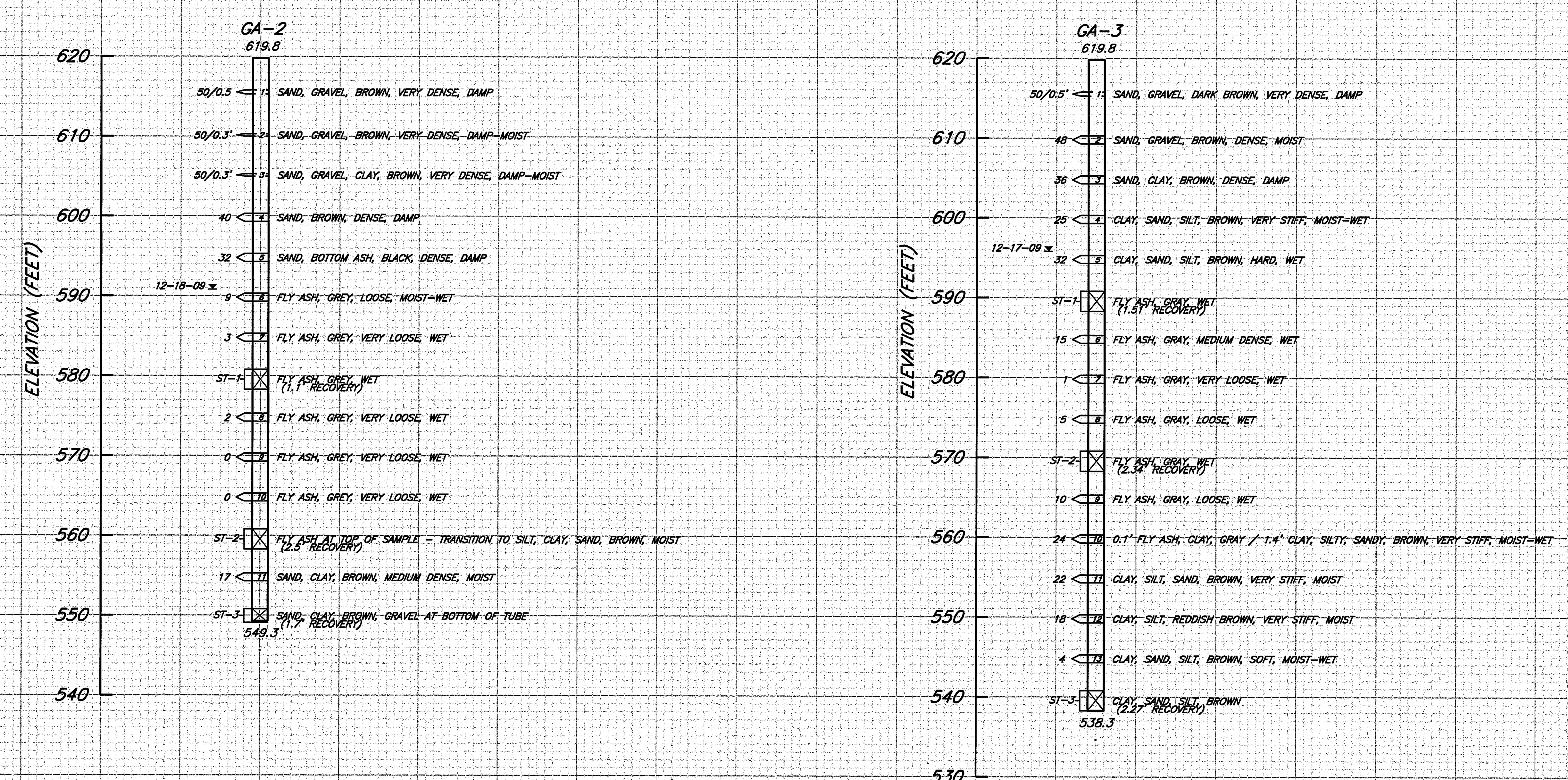
* Inclinometer Casing in GA-1C was oriented approximately 45° off the target direction.

PHILIP SPORN FLY ASH POND EAST DIKE
BOREHOLES: GA–1A, 1B, AND 1C
APPROXIMATE TOP OF PIPE ORIENTATION

(NOT TO SCALE)







LEGEND

SAMPLED HOLE

1 — HOLE NUMBER
100.0 — SURFACE ELEVATION
5 — DRIVE-SAMPLE #1 WITH "N" VALUE (AS PER A.S.T.M. D1586) UNLESS OTHERWISE NOTED
1-1-93 — WATER FIRST ENCOUNTERED DURING DRILLING
1-1-93 — WATER LEVEL AT COMPLETION OF DRILLING
1-1-93 — WATER LEVEL ON DATE SHOWN
APPROX CHANGE IN TYPE OF MATERIAL
ST-1 — UNDISTURBED SAMPLE #1
75.0 — BOTTOM ELEVATION OF HOLE
REF — REFUSAL OF AUGERS OR SAMPLE TUBE
NO REF — NO REFUSAL OF AUGERS OR SAMPLE TUBE
DRY — DRY UPON COMPLETION

NOTE: THE SYMBOL I INDICATES INITIAL WATER LEVEL MEASUREMENT.

ABBREVIATIONS

ABUND —ABUNDANT
APPROX—APPROXIMATE
ARG —ARGILLACEOUS
ASPH —ASPHALT
AX —CORE DRILL SIZE
BD/S —BAND/S
BL —BLUE
BLDR/S —BOULDER/S
BLK —BLACK
BLSH —BLUISH
BP/S —BEDDING PLANE/S
BR —BROWN
BRECC —BRECCIATED
BRK/S —BRICK/S
BRNSH —BROWNISH
BX/BQ —CORE DRILL SIZE
C —COARSE
CALC —CALCAREOUS
CAV/Y —CAVITY/CAVITIES
CBLS —COBBLES
CEM —CEMENT/CEMENTED
CHT/Y —CHERT/CHERTY
CL/Y —CLAY/CLAYEY
CNDS —CINDERS
CONC —CONCRETE
CS —CRUSHED STONE
CSG —CASING
D —DENSE/DENSELY
DEB —DEBRIS
DEC —DECOMPOSED
DF/S —DIAGONAL FRACTURE/S
DISPL —DISPLACEMENT
DK —DARK
DLLG —DRILLING
DO —DITTO
DOL —DOLOMITE
DWR —DRILL WATER RETAINED
ELEV —ELEVATION
EST —ESTIMATED
F —FINE/FINELY
FE —FERROUS
FM —FORMATION
FOSS —FOSSILIFEROUS
FRAC/S —FRACTURE/S
FRAG/S —FRAGMENT/S
GD —GROUND
GPM —GALLONS PER MINUTE
GR —GRAY
GRN —GREEN
GRND —GRAINED
GRNSH —GREENISH
GRSH —GRAYISH
GVL/Y —GRAVEL/LY
GYP —GYPSUM
HD —HARD
HYCB —HONEYCOMBED
I —INITIAL WATER LEVEL DURING DRILLING
JTD —JOINTED
KSF —KIPS PER SQUARE FOOT
LAM —LAMINATED
LDW —LOST DRILL WATER
LEA —LEACHED
LG —LARGE
LGT —LIGHT
LL —LIQUID LIMIT
LS —LIMESTONE
LSE —LOOSE
LTL —LITTLE
LYS —LAYERS
LZ —LENSES
M —MEDIUM
MATL —MATERIAL
MAX —MAXIMUM
MIC —MICACEOUS
MIN —MINIMUM
MINL —MINERAL
MOD —MODERATELY
MOTT —MOTTLED
NX —CORE DRILL SIZE
NODS —NODULES
NUM —NUMEROUS
OCC —OCCASIONAL/OCCASIONALLY
ORG —ORGANIC
OSBP/S —OPEN,STAINED BEDDING PLANE/S
OSDF/S —OPEN,STAINED DIAGONAL FRACTURE/S
OSLBP/S —OPEN,STAINED,LEACHED BEDDING PLANE/S
OSLVF/S —OPEN,STAINED,LEACHED VERTICAL FRACTURE/S
OSVF/S —OPEN,STAINED VERTICAL FRACTURE/S
OVB —OVERBURDEN
PF —PARTLY FILLED
PHOS —PHOSPHATIC
PI —PLASTICITY INDEX
POSS —POSSIBLE/POSSIBLY
PL —PLASTIC LIMIT
PP —POCKET PENETROMETER (TSF)
PROB —PROBABLE/PROBABLY
PROJ —PROJECTED
PTG —PARTING
PTLY —PARTLY
PTTD —PITTED
PZ —PIEZOMETER
RDSH —REDDISH
RECY —RECOVERY
REF —REFUSAL
RK —ROCK
RTN —ROTTEN
RTS —ROOTS
SAT —SATURATED
SCATT —SCATTERED
SD/Y —SAND/Y
SVRLY —SEVERELY
SEV —SEVERAL
SH/Y —SHALE/Y
SL —SLIGHTLY
SLSD —SLICKENSIDED
SLST —SILTSTONE
SM —SOME
SML —SMALL
SOFN —SOFTENED
SOLN —SOLUTION
SPLE —SAMPLE
SS —SANDSTONE
ST —STAINED
STA —STATION
STKS —STREAKS
STRAT —STRATIFIED
SURF —SURFACE
T —TAN
TOR —TOP OF ROCK
TR/S —TRACE/TRACES
TSF —TONS PER SQUARE FOOT
USC —UNIFIED SOIL CLASSIFICATION
V —VERY
VAR —VARIABLE/VARIABLY
VEG —VEGETATION
VF/S —VERTICAL FRACTURE/S
W —% NATURAL MOISTURE CONTENT
w/ —WITH
WB —WASHBOARD
WD —WOOD
WEA —WEATHERED
WHT —WHITE
WT —WEIGHT
WTR —WATER
XCPT —EXCEPT
XLN —CRYSTALLINE
YEL —YELLOW
YELSH —YELLOWISH
ZN/S —ZONE/S
$\gamma\delta$ —DRY UNIT WEIGHT IN PCF
qu —UNCONFINED COMPRESSIVE STRENGTH IN KSF

ROGER W. CE... REGISTERED 14367 STATE OF WEST VIRGINIA PROFESSIONAL ENGINEER
7/23/10

THESE DRAWINGS ARE PART OF A SET OF DESIGN DOCUMENTS WHICH ALSO CONTAINS A WRITTEN TEXT. THAT TEXT EXPLAINS SOME OF THE DETAILS SHOWN HEREIN AND THEREFORE THESE DRAWINGS SHOULD ONLY BE USED IN CONJUNCTION WITH THE TEXT.

DATE	REVISIONS	BY

BOREHOLE LOGS

FLY ASH DISPOSAL FACILITY
PHILIP SPORN PLANT

NEW HAVEN, WEST VIRGINIA

SCALE: AS SHOWN | DR SWF | CHK RWC | REV RWC

PREPARED FOR:

AMERICAN ELECTRIC POWER

PREPARED BY:

GA Geo/Environmental Associates, Inc.
3602 OVERLOOK CIRCLE • KNOXVILLE, TENNESSEE 37909 • (865) 584-0344

PROJ: 09-387 | DATE: 7-23-10 | SHEET 1 OF 1

LABORATORY DATA FROM:
"PHILIP SPORN ELECTRIC GENERATING PLANT UNIT 5 ASH FACILITY – ENGINEERING REPORT"

PREPARED/COMPILED BY:
THE GEOTECHNICAL ENGINEERING SECTION OF AMERICAN ELECTRIC POWER SERVICE CORPORATION

DATED: JULY 1998

H. C. NUTTING COMPANY
EMPLOYEE OWNED
GEOTECHNICAL, ENVIRONMENTAL AND TESTING ENGINEERS
SINCE 1921

CORPORATE CENTER
4120 AIRPORT ROAD
CINCINNATI, OHIO 45226
(513) 321-5816
FAX (513) 321-0294

Order No. 90979.030

December 19, 1996

Mr. J.P. Amaya
American Electric Power Corporation
1 Riverside Plaza
Columbus, OH 45315

Re: **Laboratory Tests**
Project: **Sporn Plt-Bott. Ash Pond**
Certification-C-9117
LOA-002-96

Dear Mr. Amaya:

Submitted herewith is our report covering the results of seventeen (17) consolidated undrained triaxial tests with pore pressure measurements, seven (7) mechanical sieve and hydrometer and (7) Atterberg Limits. Tests were performed per your request by letter dated November 22, 1996. All samples were obtained and shipped to our laboratory from the referenced project by your representative. Cost for these tests were as outlined per Contract No. C-9117.

Should any discussion be required concerning this report, please feel free contact the undersigned. The H.C. Nutting Company **thanks** American Electric Power for allowing them this opportunity to be of service.

Respectfully submitted,

H.C. NUTTING COMPANY

Robert L. House,
Vice President/Lab. Director

H.C. Nutting Company
4120 Airport Road
Cincinnati, Ohio 45226

12/19/69smo

American Electric Power
Sporn Plt-Bott. Ash Pond Certification LOA-002-96
New Haven, WV
HCN W.O. #90979.030

TABLE I

CLASSIFICATION TEST DATA

Lab No.	Boring No.	Sample No.	Depth (Ft.)	Mechanical Analysis % Gravel	% Sand	% Silt	% Clay	Atterberg Limits Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	U.S.C.S Classification
8563	96-101	ST-10	---	0	18	58	24	27	20	7	CL-ML
8564	96-104	ST-9	31.7-33.7	16	46	26	12	NP	NP	NP	SM
8565	96-106	ST-15	61.5-63.5	0	7	58	35	38	24	14	CL
8566	96-107	ST-16	66.6-68.6	0	16	52	32	43	26	17	CL
8567	96-108	ST-10	41.6-43.6	0	7	52	42	44	30	14	ML
8568	96-109	ST-8	26.7-28.7	0	54	43	3	NP	NP	NP	SM
8569	96-110	ST-18	58.6-60.6	0	19	50	31	39	27	12	ML

H.C. NUTTING COMPANY

Robert L. House

Robert L. House,
Vice President/Lab. Director

AEPSPP-000637

H.C. Nutting Company
4120 Airport Road
Cincinnati, Ohio 45226

12/19/96smo

American Electric Power
Sporn Plt-Bott. Ash Pond Certification LOA-002-96
New Haven, WV
HCN W.O. # 90979.030

TABLE II
TABULATION OF UNDISTURBED TEST DATA

PAGE 1 OF 2

Boring No.	Sample No.	Depth (Ft.)	Triaxial Compressive Strength (TSF)	Confining Pressure P.S.I.	Failure Strain (%)	Dry Density (Lbs./Cu. Ft.)	Water Content (%)	Lab No.
96-101	ST-10	---	4.31	14	13.4	106.5	18.5	8563
			5.69	28	15.9	113.5	16.8	"
			9.15	56	21.8	114.3	15.4	"
96-104	ST-9	31.7-33.7	3.67	14	23.4	119.4	8.2	8564
			3.22	28	24.6	113.3	9.2	"
			---	56	---	---	9.9	"
96-106	ST-15	61.5-63.5	2.17	21	17.5	97.1	26.5	8565
			3.69	42	15.8	98.1	26.5	"
			3.64	84	20.4	99.1	26.5	"
96-107	ST-16	66.6-68.6	2.18	21	15.7	98.3	26.0	8566
			3.40	42	11.7	97.2	27.4	"
			5.83	84	12.1	96.5	28.4	"

H.C. NUTTING COMPAN

Robert L. House,
Vice President/Lab. Director

AEPSPP-000638

H.C. Nutting Company
4120 Airport Road
Cincinnati, Ohio 45226

12/19/96smo

American Electric Power
Sporn Plt-Bott. Ash Pond Certification LOA-002-96
New Haven, WV
HCN W.O. # 90979.030

TABLE II
TABULATION OF UNDISTURBED TEST DATA

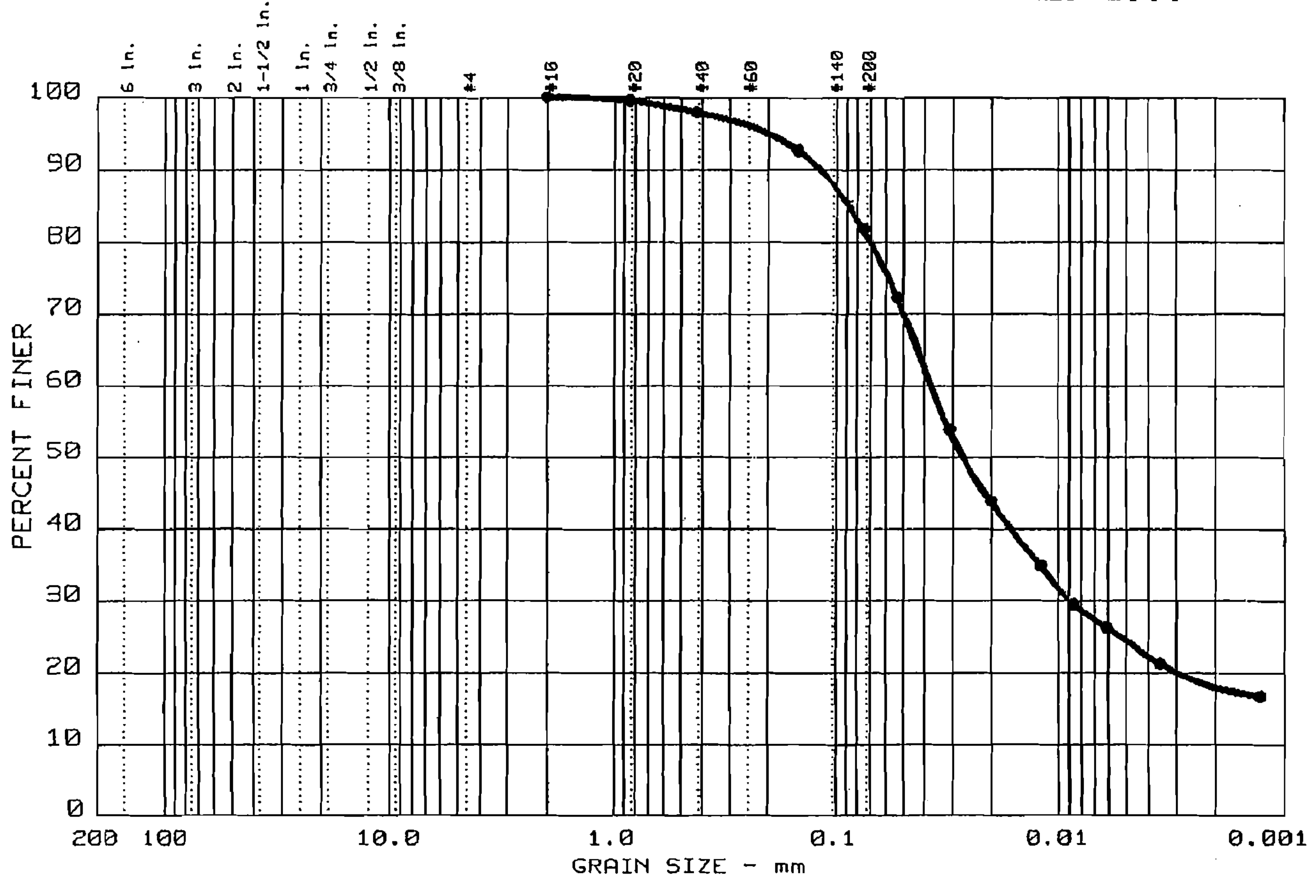
Boring No.	Sample No.	Depth (Ft.)	Triaxial Compressive Strength (TSF)	Confining Pressure P.S.I.	Failure Strain (%)	Dry Density (Lbs./Cu. Ft.)	Water Content (%)	Lab No.
96-108	ST-10	41.6-43.6	1.77	14	7.4	88.1	34.6	8567
			2.25	28	12.8	85.1	38.4	"
			3.82	56	15.8	84.7	36.9	"
96-109	ST-8	26.7-28.7	UNIT WT.	---	---	74.3	4.1	8568
96-110	ST-18	58.6-60.6	2.55	21	6.3	94.3	28.9	8569
			2.70	42	9.3	93.9	28.8	"
			5.22	84	5.7	94.5	27.5	"

H.C. NUTTING COMPAN

Robert L. House,
Vice President/Lab. Director

AEPSPP-000639

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	18.3	57.3	24.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	27	7	0.09	0.04	0.03	0.009				

MATERIAL DESCRIPTION	USCS	AASHTO
● SILTY CLAY WITH SAND	CL-ML	

Project No.: 90979.030
Project: Sporn Plt-Bott.Ash Pond Certification LOI-002-96*
● Location: Boring:96-101 Sample:ST-10

*New Haven, WV

Date: 12/13/95

Remarks:

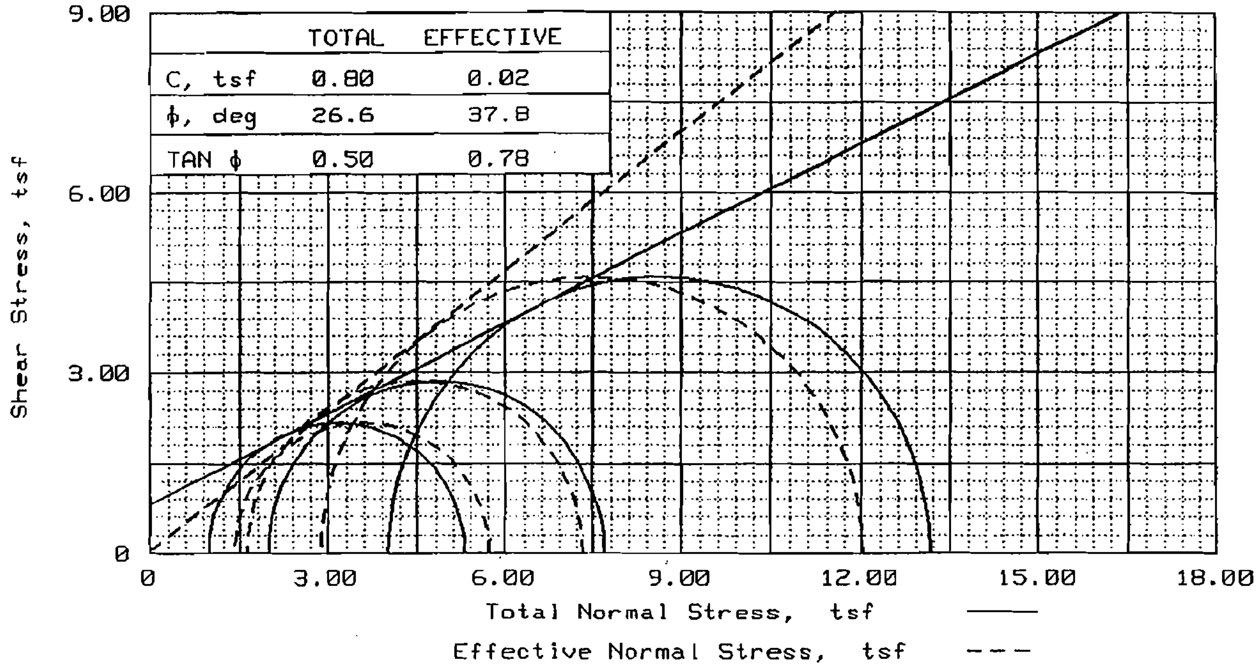
Client: American Electric Power

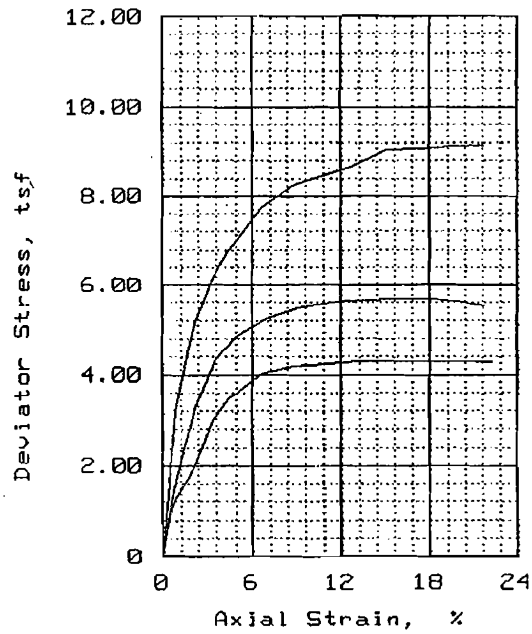
Lab No. 8563

GRAIN SIZE DISTRIBUTION TEST REPORT

H. C. NUTTING COMPANY

Figure No. ______





SAMPLE NO.		1	2	3
INITIAL	WATER CONTENT, %	18.5	16.8	15.4
	DRY DENSITY, pcf	106.5	113.5	114.3
	SATURATION, %	100.0	100.0	100.0
	VOID RATIO	0.594	0.496	0.485
	DIAMETER, in	2.84	2.85	2.85
	HEIGHT, in	4.54	4.52	4.62
AT TEST	WATER CONTENT, %	22.5	18.2	16.3
	DIAMETER, in	2.81	2.82	2.78
	HEIGHT, in	4.49	4.47	4.50
Strain rate, %/min		0.001	0.001	0.001
BACK PRESSURE, tsf		2.88	2.88	2.88
CELL PRESSURE, tsf		3.89	4.90	6.91
FAILURE STRESS, tsf		4.31	5.69	9.15
PORE PRESSURE, tsf		2.46	3.25	4.02
ULTIMATE STRESS, tsf				
PORE PRESSURE, tsf				
$\bar{\sigma}_1$ FAILURE, tsf		5.74	7.34	12.04
$\bar{\sigma}_3$ FAILURE, tsf		1.49	1.65	2.89

TYPE OF TEST:
CU with pore pressures
SAMPLE TYPE:
DESCRIPTION: BR & GR SILTY CLAY WITH SAND
LL= 27 PL= 20 PI= 7.0
SPECIFIC GRAVITY=
REMARKS: Lab No. 8563

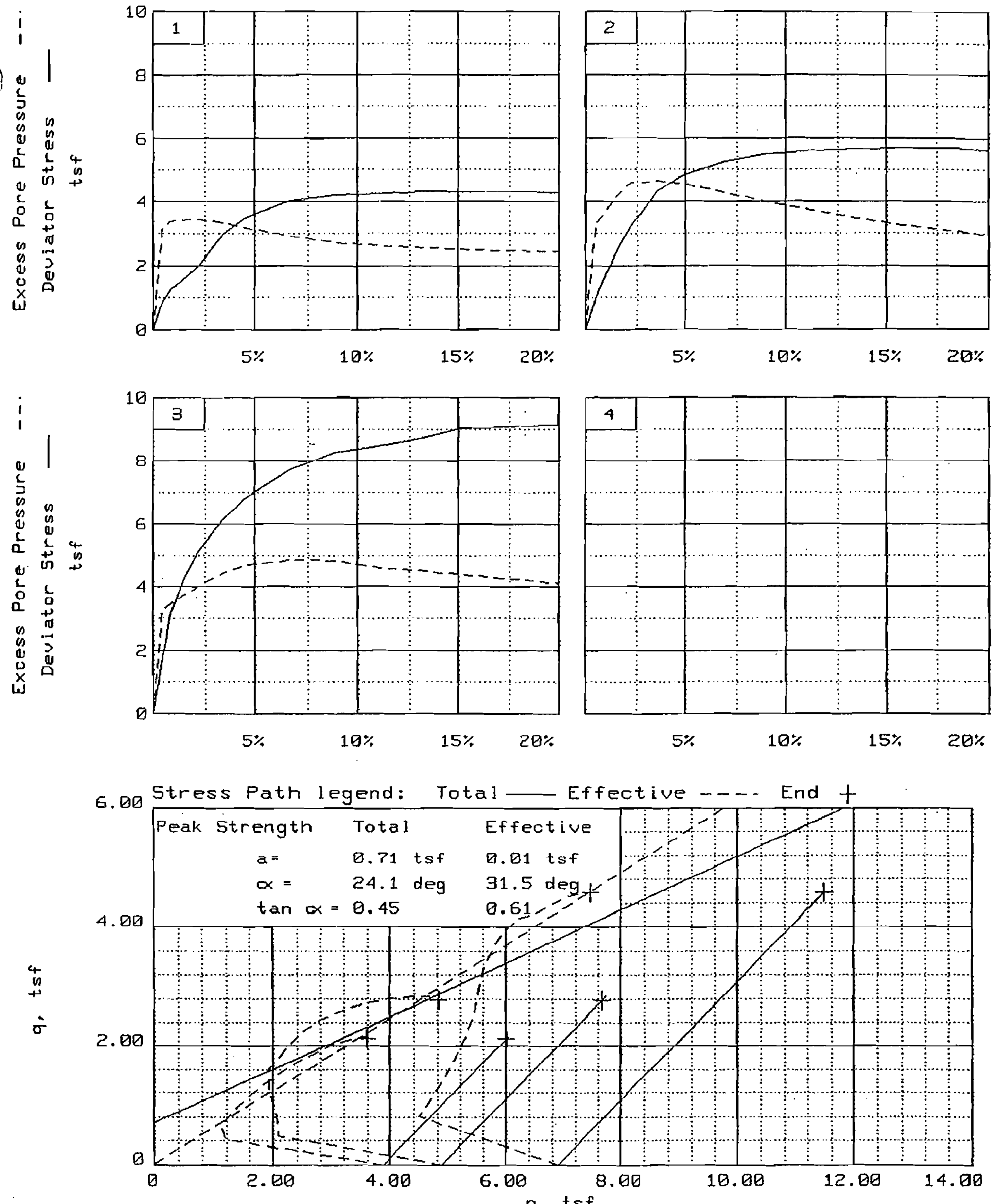
FIG. NO.

CLIENT: American Electric Power

PROJECT: Sporn Plt-Bott.Ash Pond
Certification LOA-002-96, New Haven, WV
SAMPLE LOCATION: Boring:96-101
Sample:ST-10
PROJ. NO.: 90979.030 DATE: 12/13/96

TRIAXIAL SHEAR TEST REPORT

H. C. NUTTING COMPANY



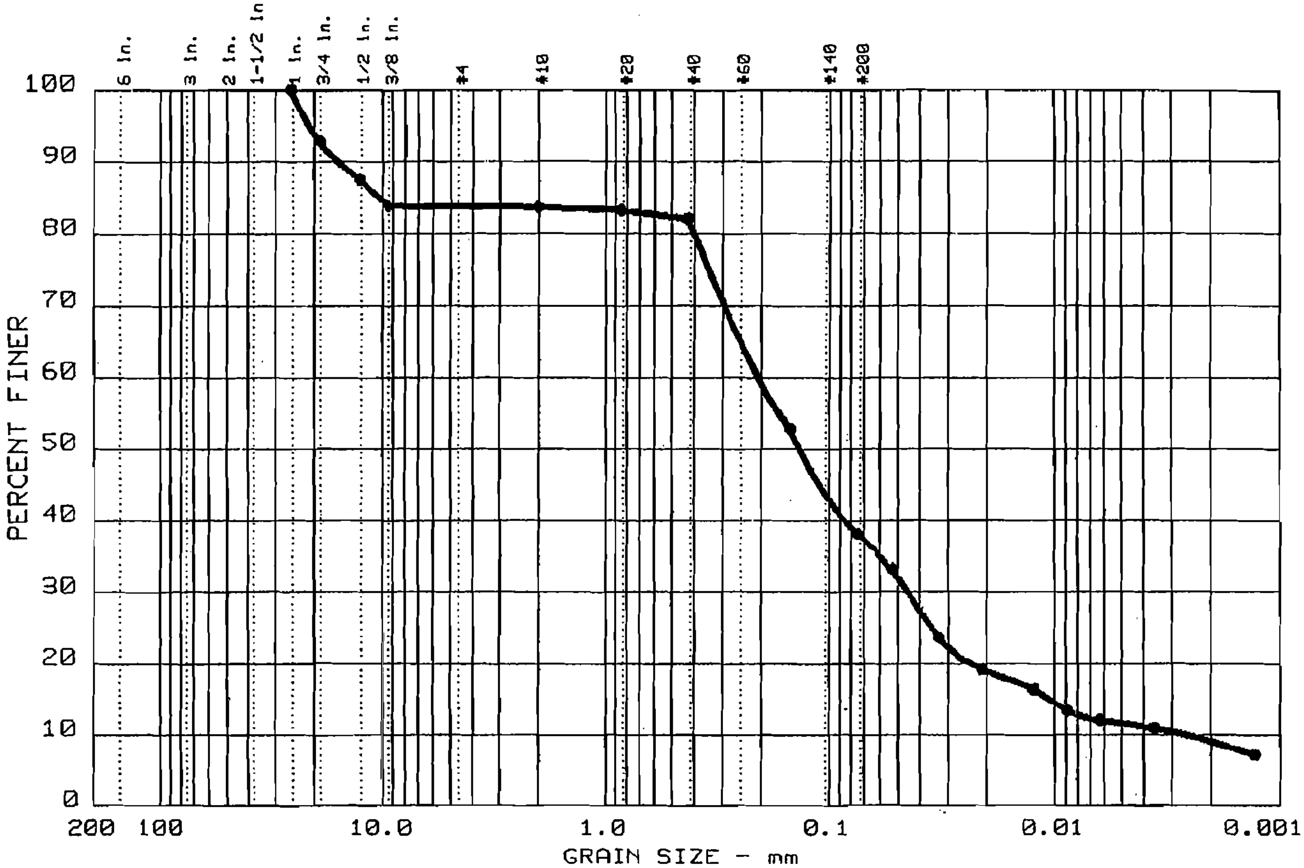
Client: American Electric Power

Project: Sporn Plt-Bott.Ash Pond Certification LOA-002-96, New Haven, WV

Location: Boring:96-101 Sample:ST-10

File: 8563 Project No.: 90979.030 Page 2/2 Fig. No. ____

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	16.2	45.7	26.4	11.7

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	NP	NP	10.35	0.20	0.14	0.045	0.0106	0.0025	3.92	80.6

MATERIAL DESCRIPTION	USCS	AASHTO
● SILTY SAND WITH GRAVEL	SM	

Project No.: 90979.030
Project: Sporn Plt-Bott. Ash Pond Certification LOA-002-96
● Location: Boring:96-104 Depth:31.7-33.7' *
*New Haven, WV

Date: 12/13/95

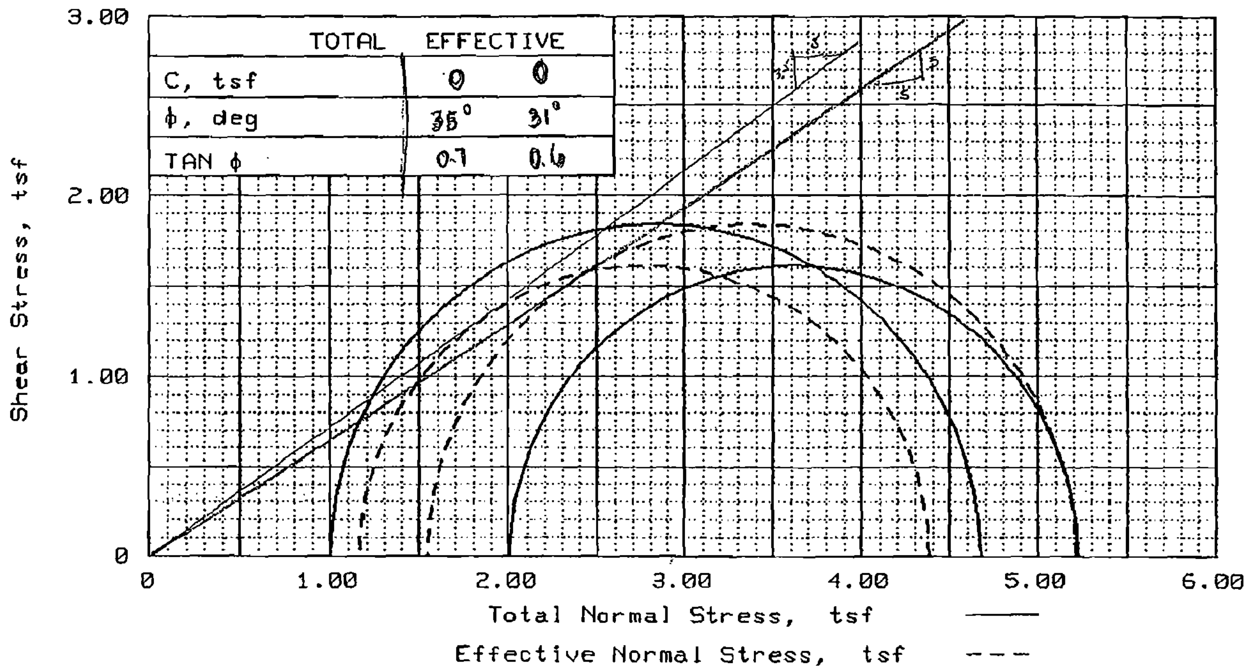
GRAIN SIZE DISTRIBUTION TEST REPORT
H. C. NUTTING COMPANY

Remarks:
Client: American Electric Power

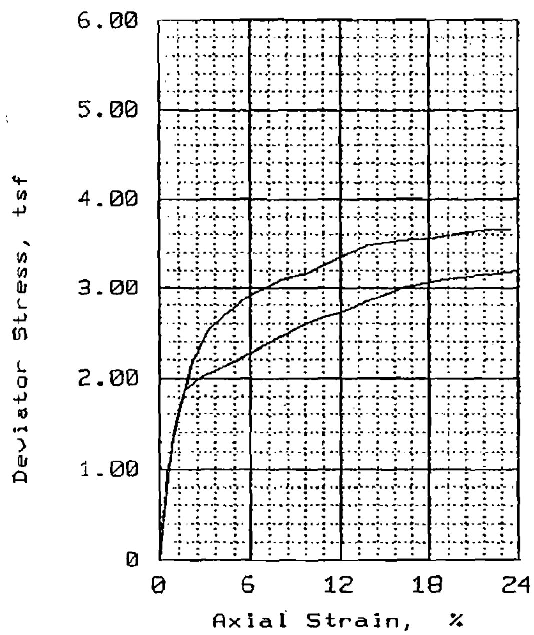
* Sample:ST-9

Lab No. 8564

Figure No. ______



	TOTAL	EFFECTIVE
C, tsf	0	0
ϕ, deg	35°	31°
TAN ϕ	0.7	0.6



	SAMPLE NO.	1	2
INITIAL	WATER CONTENT, %	8.2	9.2
	DRY DENSITY, pcf	119.4	113.3
	SATURATION, %	100.0	100.0
	VOID RATIO	0.401	0.477
	DIAMETER, in	2.85	2.81
	HEIGHT, in	4.91	4.40
AT TEST	WATER CONTENT, %	13.5	14.2
	DIAMETER, in	2.77	2.75
	HEIGHT, in	4.78	4.31
	Strain rate, %/min	0.001	0.001
	BACK PRESSURE, tsf	2.88	2.88
	CELL PRESSURE, tsf	3.89	4.90
	FAILURE STRESS, tsf	3.67	3.22
	PORE PRESSURE, tsf	2.34	3.72
	ULTIMATE STRESS, tsf		
	PORE PRESSURE, tsf		
	$\bar{\sigma}_1$ FAILURE, tsf	5.22	4.39
	$\bar{\sigma}_3$ FAILURE, tsf	1.55	1.17

TYPE OF TEST:
CU with pore pressures
SAMPLE TYPE:
DESCRIPTION: BR SILTY SAND WITH GRAVEL
LL= NP PL= NP PI= NP
SPECIFIC GRAVITY=
REMARKS: Lab No. 8564

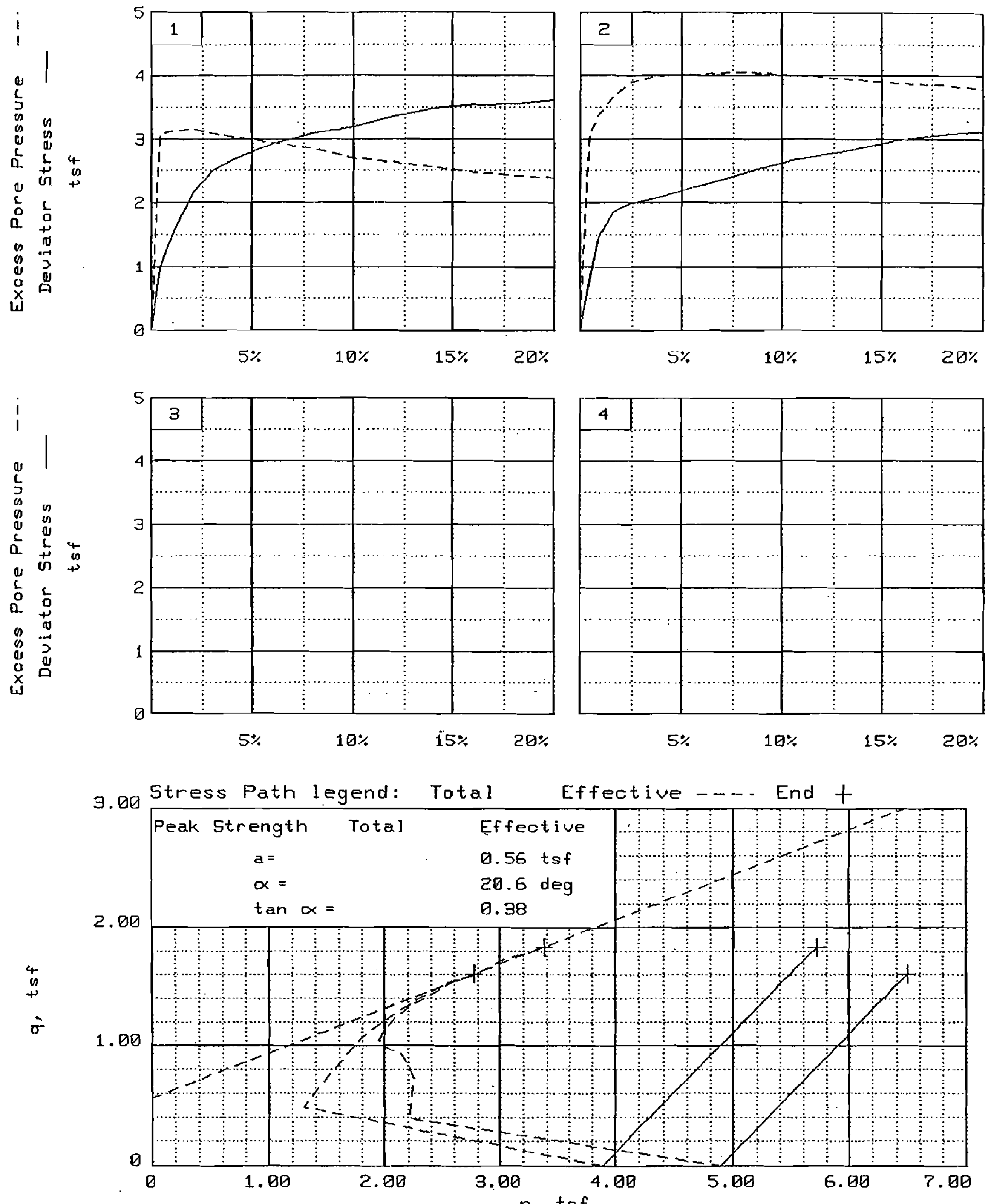
FIG. NO.

CLIENT: American Electric Power

PROJECT: Sporn Plt-Bott.Ash Pond
Certification LOA-002-96, New Haven, WV
SAMPLE LOCATION: Boring:96-104
Depth:31.7-33.7' Sample:ST-9
PROJ. NO.: 90979.030 DATE: 12/13/96

TRIAXIAL SHEAR TEST REPORT

H. C. NUTTING COMPANY



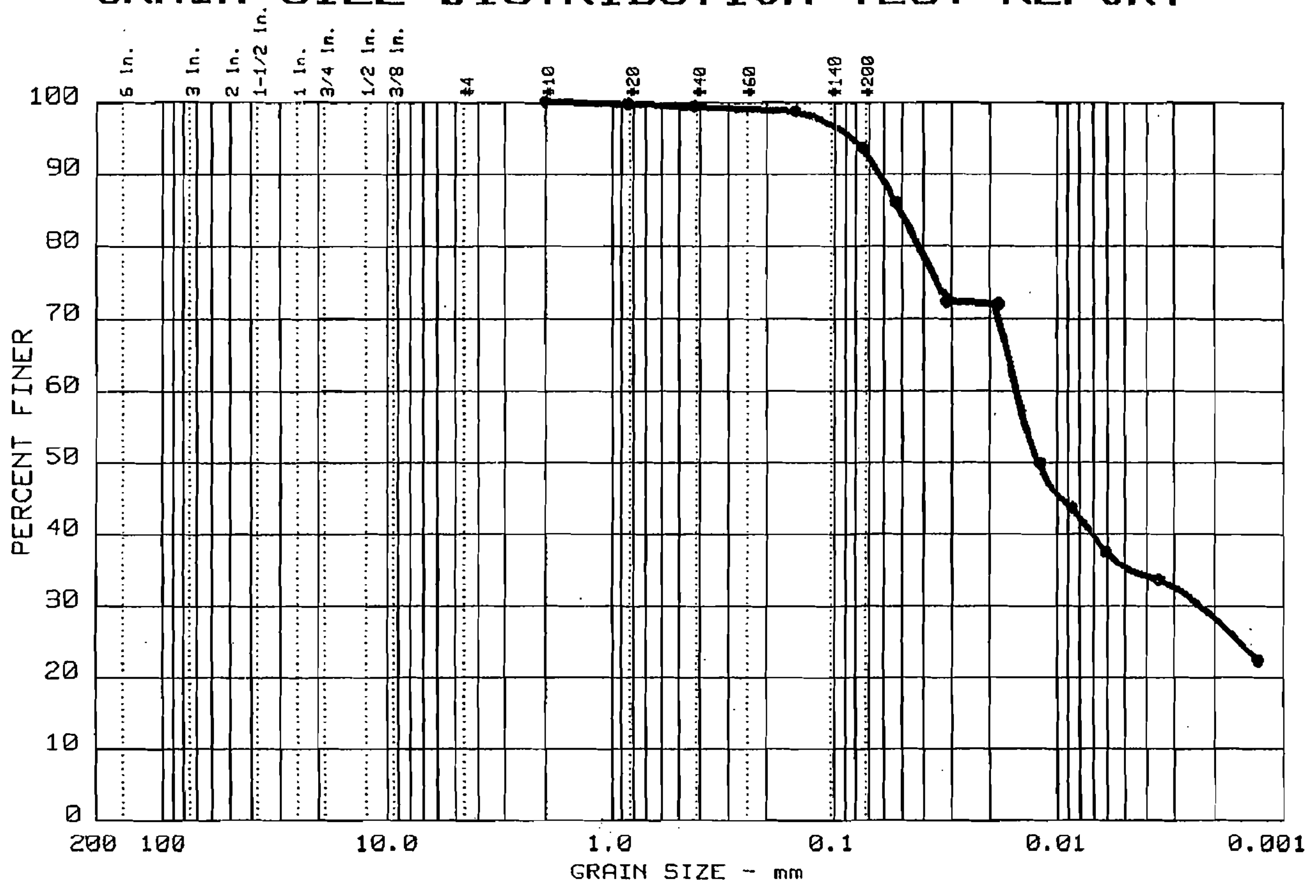
Client: American Electric Power

Project: Sporn Plt-Bott.Ash Pond Certification LOA-002-96, New Haven, WV

Location: Boring:96-104 Depth:31.7-33.7' Sample:ST-9

File: 8564 Project No.: 90979.030 Page 2/2 Fig. No. ____

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	6.5	58.2	35.3

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	38	14	0.05	0.02	0.01	0.002				

MATERIAL DESCRIPTION	USCS	AASHTO
● LEAN CLAY	CL	

Project No.: 90979.030
Project: Sporn Plt-Bott.Ash Pond Certification LOA-002-96*
● Location: Boring:96-106 Depth:61.5-63.5' *
*New Haven, WV

Date: 12/13/95

GRAIN SIZE DISTRIBUTION TEST REPORT

H. C. NUTTING COMPANY

Remarks:

Client: American Electric Power

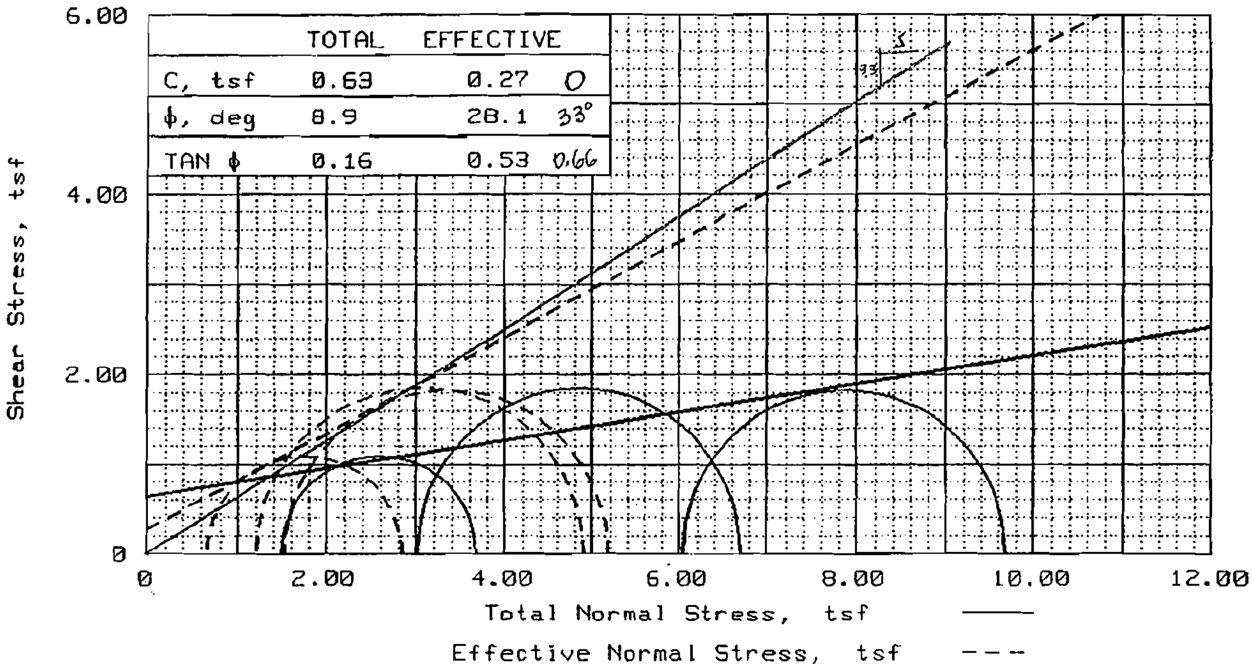
* Sample:ST-15

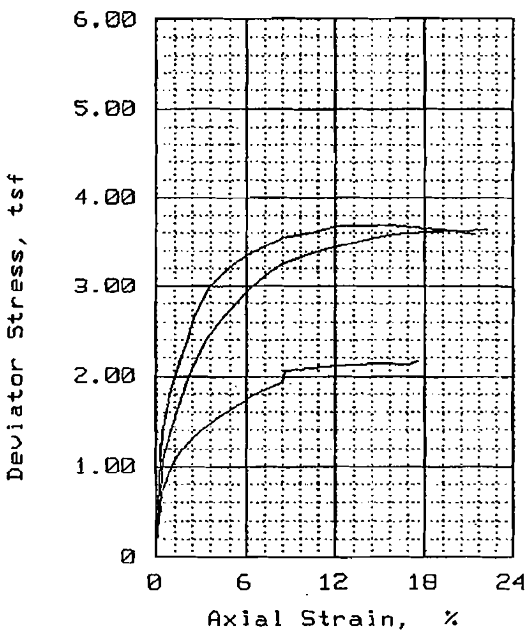
Lab No. 8565

Figure No. ______

AEPSPP-000646

AEPSPP004024





SAMPLE NO.		1	2	3
INITIAL	WATER CONTENT, %	26.5	26.5	26.5
	DRY DENSITY, pcf	97.1	98.1	99.1
	SATURATION, %	96.4	98.7	100.0
	VOID RATIO	0.749	0.730	0.713
	DIAMETER, in	2.78	2.83	2.84
	HEIGHT, in	5.25	5.37	5.16
AT TEST	WATER CONTENT, %	26.7	24.7	25.0
	DIAMETER, in	2.73	2.77	2.77
	HEIGHT, in	5.16	5.26	5.04
Strain rate, %/min		0.001	0.001	0.001
BACK PRESSURE, tsf		2.88	2.88	2.88
CELL PRESSURE, tsf		4.39	5.90	8.93
FAILURE STRESS, tsf		2.17	3.69	3.64
PORE PRESSURE, tsf		3.72	4.67	7.38
ULTIMATE STRESS, tsf				
PORE PRESSURE, tsf				
$\bar{\sigma}_1$ FAILURE, tsf		2.85	4.92	5.19
$\bar{\sigma}_3$ FAILURE, tsf		0.68	1.23	1.55

TYPE OF TEST:
CU with pore pressures
SAMPLE TYPE:
DESCRIPTION: Br LEAN CLAY

LL= 38 PL= 24 PI= 14.0
SPECIFIC GRAVITY=
REMARKS: Lab No. 8565

FIG. NO.

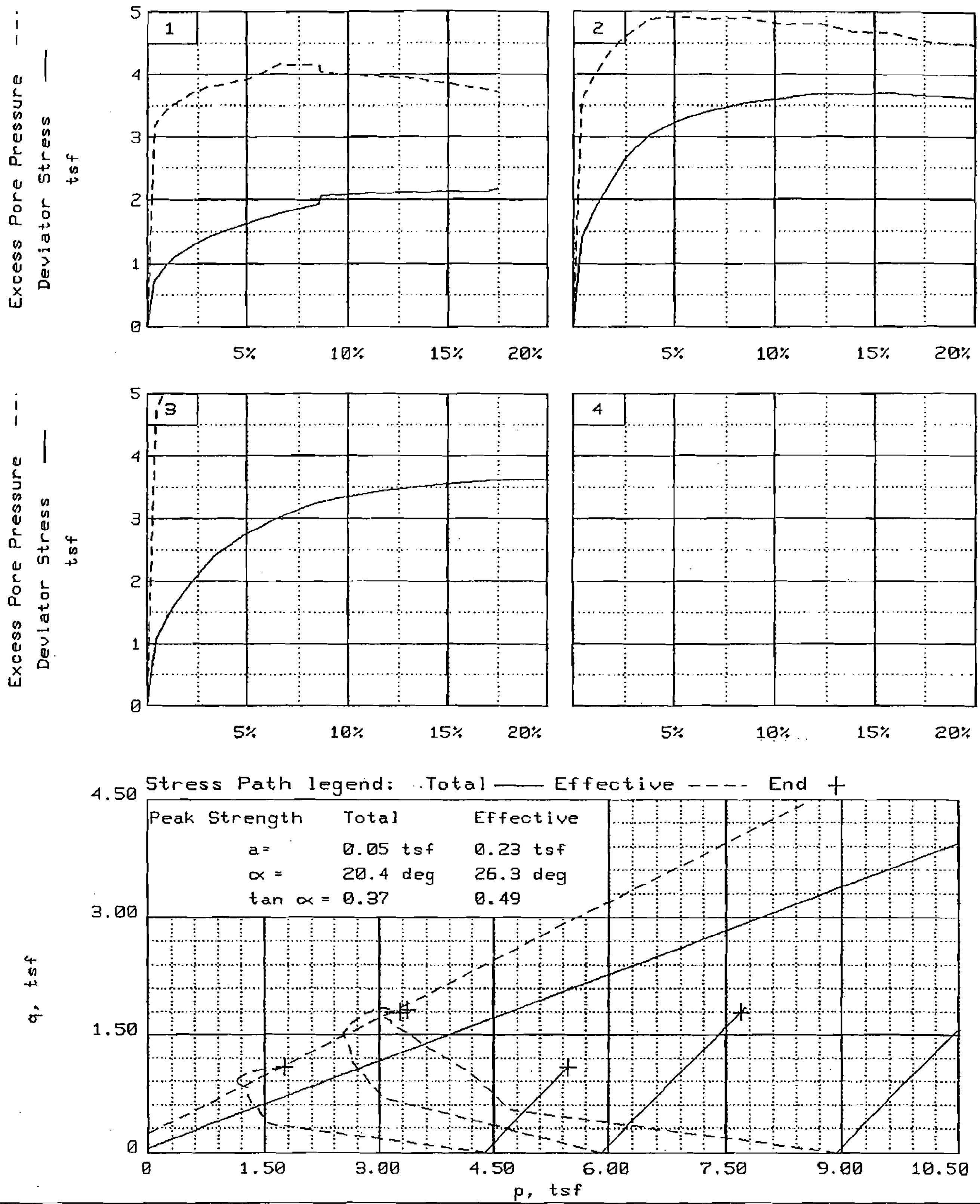
CLIENT: American Electric Power

PROJECT: Sporn Plt-Bott.Ash Pond
Certification LOA-002-96, New Haven, WV
SAMPLE LOCATION: Boring:96-106
Depth:61.5-63.5' Sample:ST-15

PROJ. NO.: 90979.030 DATE: 12/13/96

TRIAXIAL SHEAR TEST REPORT

H. C. NUTTING COMPANY



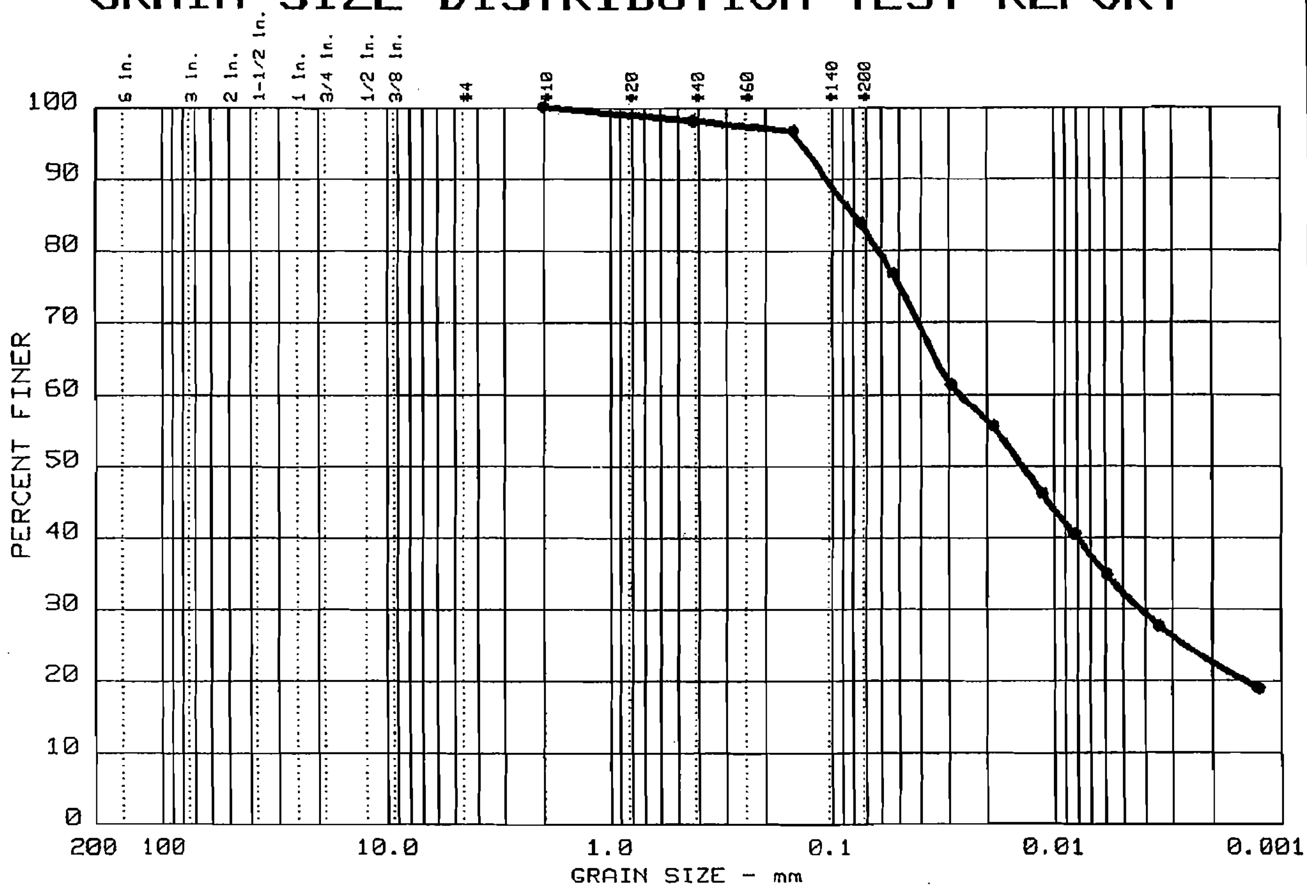
Client: American Electric Power

Project: Sporn Plt-Bott.Ash Pond Certification LOA-002-96, New Haven, WV

Location: Boring:96-106 Depth:61.5-63.5' Sample:ST-15

File: 8565 Project No.: 90979.030 Page 2/2 Fig. No. ____

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	16.1	51.5	32.4

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	43	17	0.08	0.03	0.01	0.004				

MATERIAL DESCRIPTION	USCS	AASHTO
● CLAY WITH SAND	CL	

Project No.: 90979.030

Project: Sporn Plt-~~Bott~~ Fly.Ash Pond Certification LOA-002-96*

● Location: Boring:96-107 Depth:66.6-68.6' *

*New Haven, WV

Date: 12/13/95

GRAIN SIZE DISTRIBUTION TEST REPORT

H. C. NUTTING COMPANY

Remarks:

Client: American Electric Power

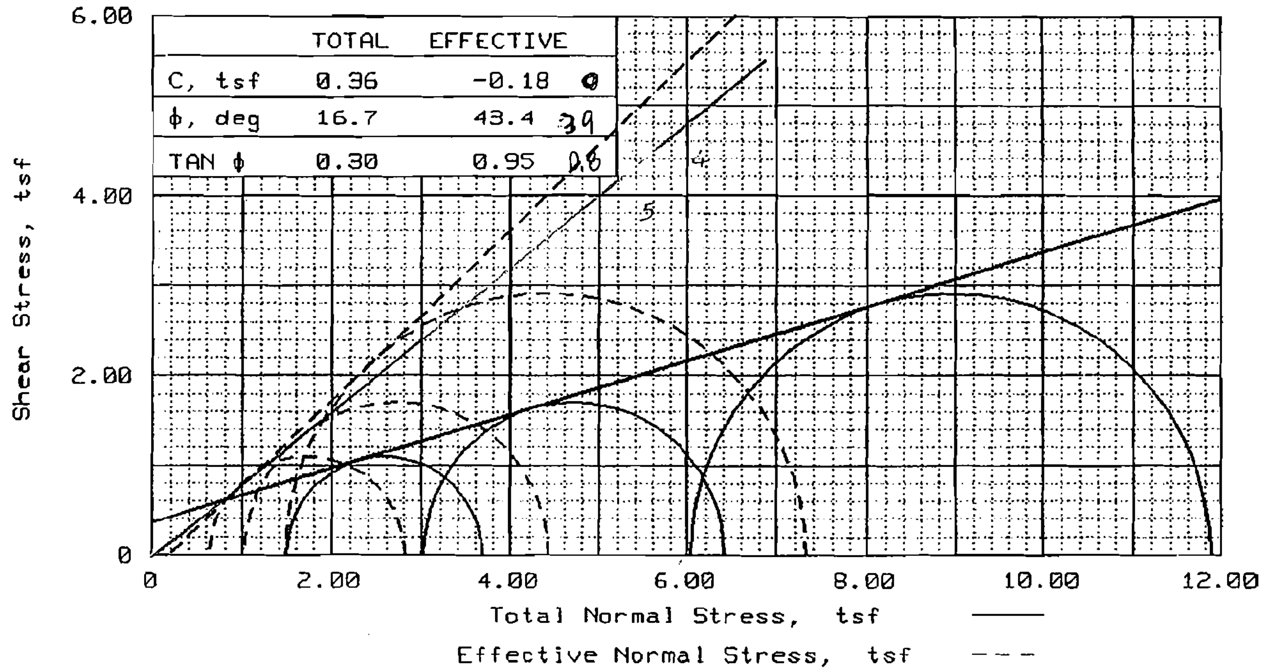
* Sample:ST-16

Lab No. 8566

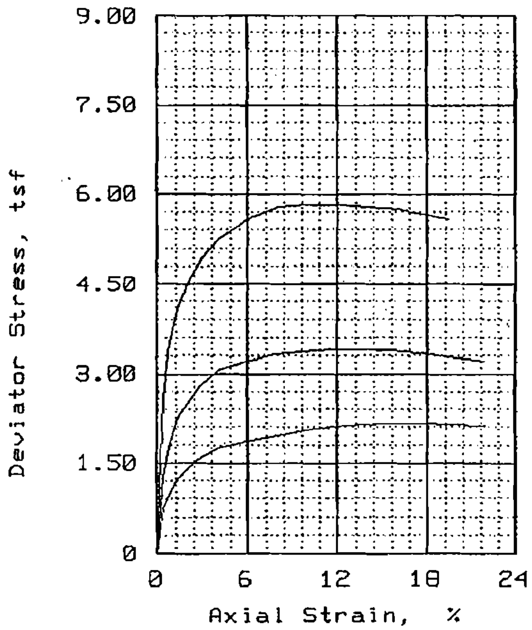
Figure No. ______

AEPSPP-000649

AEPSPP004027



	TOTAL	EFFECTIVE
C, tsf	0.36	-0.18 0
ϕ, deg	16.7	43.4 39
TAN ϕ	0.30	0.95 0.8



	SAMPLE NO.	1	2	3
INITIAL	WATER CONTENT, %	26.0	27.4	28.4
	DRY DENSITY, pcf	98.3	97.2	96.5
	SATURATION, %	95.8	98.4	100.0
	VOID RATIO	0.747	0.767	0.778
	DIAMETER, in	2.83	2.85	2.84
	HEIGHT, in	5.20	5.21	5.16
AT TEST	WATER CONTENT, %	26.6	25.6	23.6
	DIAMETER, in	2.78	2.81	2.73
	HEIGHT, in	5.11	5.13	4.96
	Strain rate, %/min	0.001	0.001	0.001
	BACK PRESSURE, tsf	2.88	2.88	2.88
	CELL PRESSURE, tsf	4.39	5.90	8.93
	FAILURE STRESS, tsf	2.18	3.40	5.83
	PORE PRESSURE, tsf	3.74	4.87	7.43
	ULTIMATE STRESS, tsf			
	PORE PRESSURE, tsf			
	$\bar{\sigma}_1$ FAILURE, tsf	2.82	4.43	7.33
	$\bar{\sigma}_3$ FAILURE, tsf	0.65	1.04	1.5

TYPE OF TEST:
CU with pore pressures

SAMPLE TYPE:

DESCRIPTION: Br CLAY WITH SAND

LL= 43 PL= 17 PI= 26.0

SPECIFIC GRAVITY=

REMARKS: Lab No. 8566

FIG. NO.

CLIENT: American Electric Power

PROJECT: Sporn Plt-~~Bott~~ Fly.Ash Pond
Certification LOA-002-96, New Haven, WV

SAMPLE LOCATION: Boring:96-107
Depth:66.6-68.6' Sample:ST-16

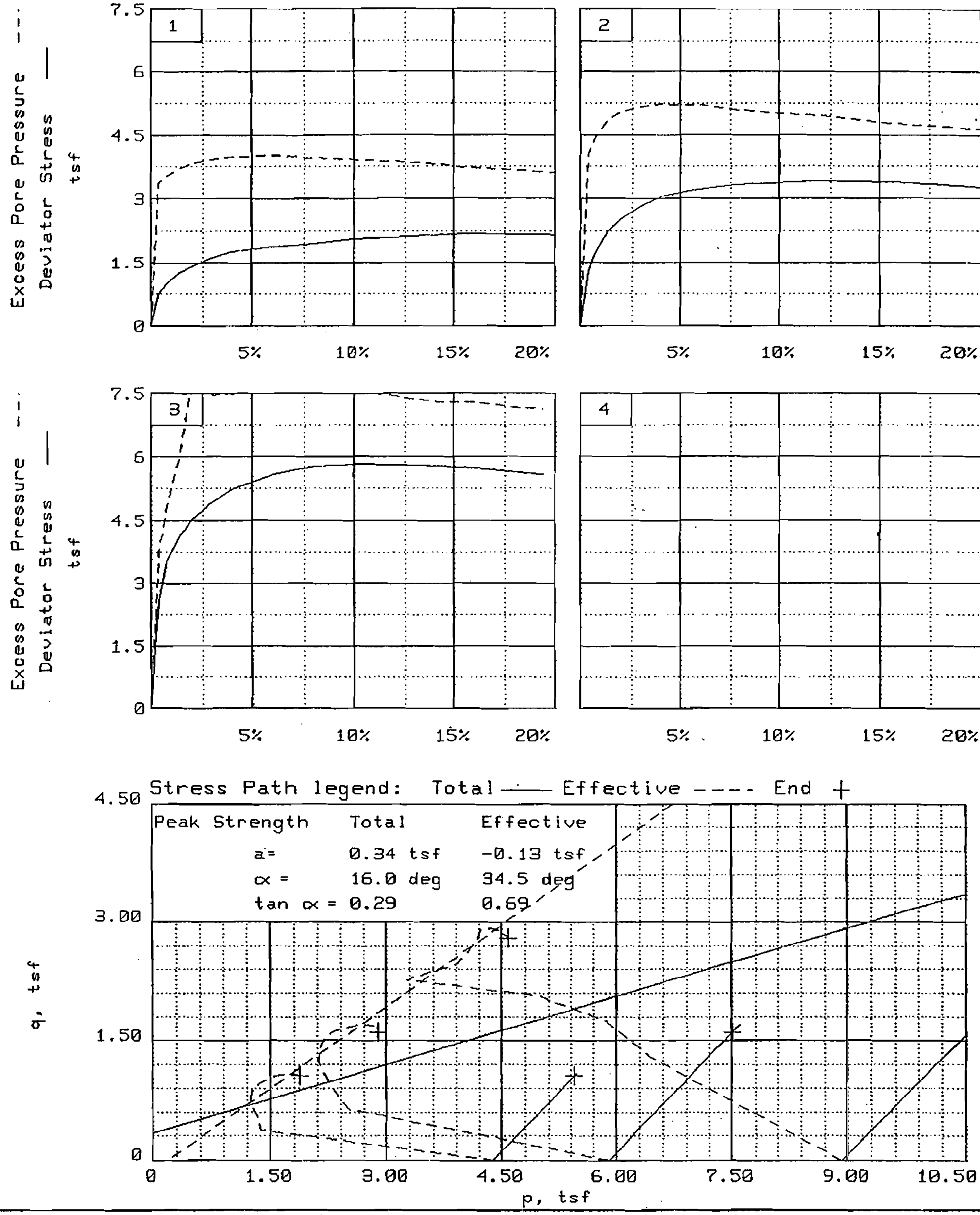
PROJ. NO.: 90979.030 DATE: 12/13/96

TRIAXIAL SHEAR TEST REPORT

H. C. NUTTING COMPANY

AEPSPP-000650

AEPSPP004028



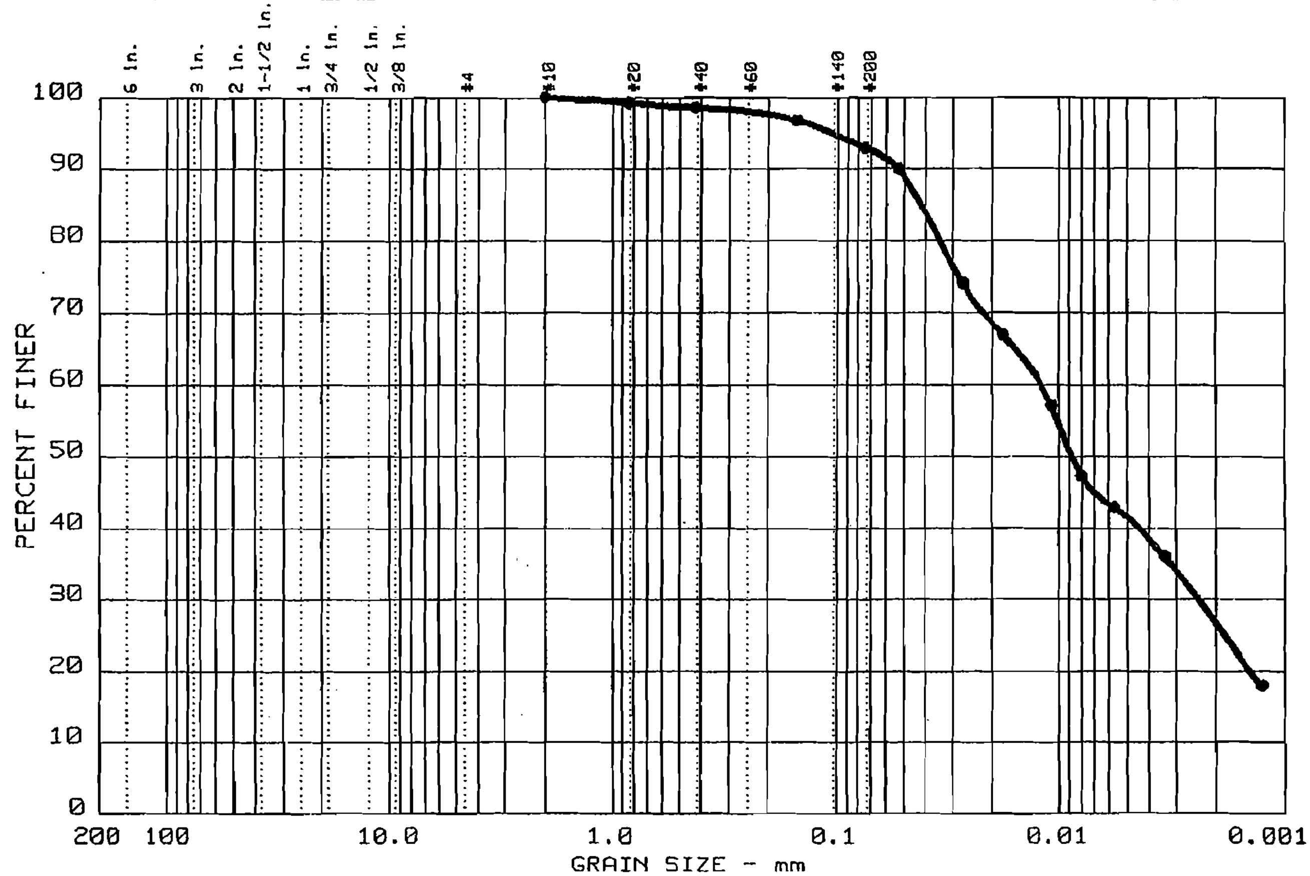
Client: American Electric Power

Project: Sporn Plt-Bott.Ash Pont Certification LOA-002-96, New Haven, WV

Location: Boring:96-107 Depth:66.6-68.6' Sample:ST-16

File: 8566 Project No.: 90979.030 Page 2/2 Fig. No. _____

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75 mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	7.2	51.3	41.5

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	44	14	0.04	0.01	0.01	0.002				

MATERIAL DESCRIPTION	USCS	AASHTO
● SILT	ML	

Project No.: 90979.030
Project: Sporn Plt-~~Bot~~ Fly.Ash Pond Certification LOA-002-96*
● Location: Boring:96-108 Depth:41.6-43.6' *
* New Haven, WV

Date: 12/16/95

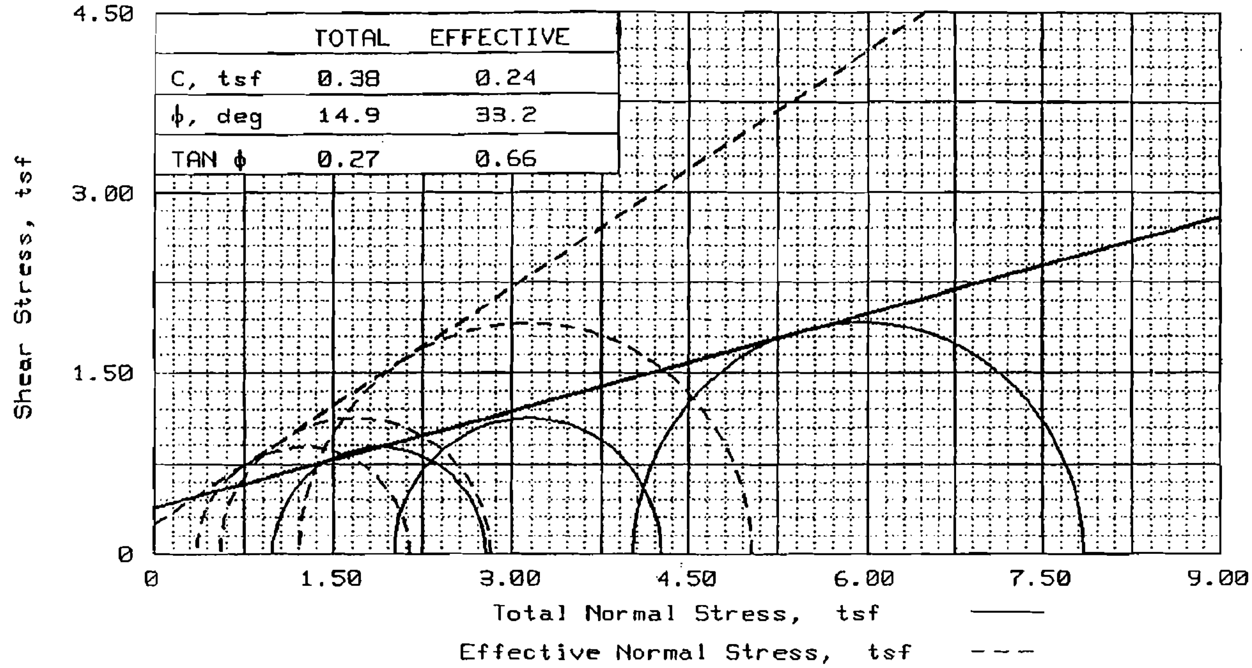
GRAIN SIZE DISTRIBUTION TEST REPORT
H. C. NUTTING COMPANY

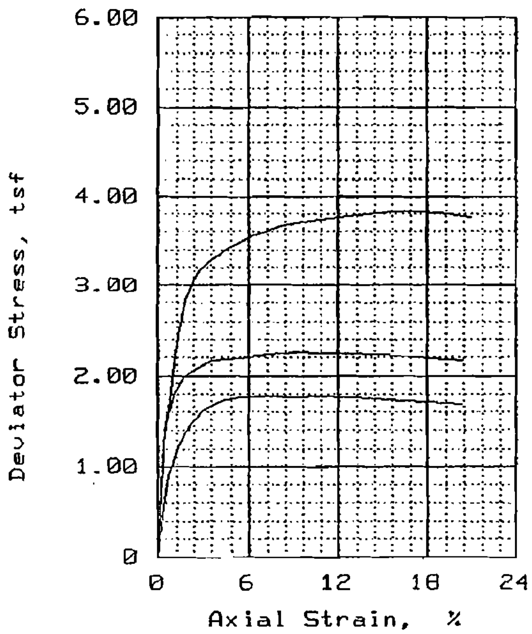
Remarks:
Client: American Electric Power

* Sample:ST-10
Lab No. 8567

Figure No. ______

	TOTAL	EFFECTIVE
C, tsf	0.38	0.24
ϕ, deg	14.9	33.2
TAN ϕ	0.27	0.66





SAMPLE NO.		1	2	3
INITIAL	WATER CONTENT, %	34.6	38.4	36.9
	DRY DENSITY, pcf	88.1	85.1	84.7
	SATURATION, %	100.0	100.0	100.0
	VOID RATIO	0.913	0.980	0.990
	DIAMETER, in	2.83	2.84	2.84
	HEIGHT, in	5.56	5.56	5.56
AT TEST	WATER CONTENT, %	34.5	33.9	32.9
	DIAMETER, in	2.81	2.80	2.75
	HEIGHT, in	5.52	5.49	5.38
Strain rate, %/min		0.001	0.001	0.001
BACK PRESSURE, tsf		2.88	2.88	2.88
CELL PRESSURE, tsf		3.89	4.90	6.91
FAILURE STRESS, tsf		1.77	2.25	3.82
PORE PRESSURE, tsf		3.51	4.33	5.70
ULTIMATE STRESS, tsf				
PORE PRESSURE, tsf				
$\bar{\sigma}_1$ FAILURE, tsf		2.14	2.81	5.04
$\bar{\sigma}_3$ FAILURE, tsf		0.37	0.56	1.22

TYPE OF TEST:
CU with pore pressures
SAMPLE TYPE:
DESCRIPTION: ~~SILT~~ ClAy

LL= 44 PL= 14 PI= 30.0

SPECIFIC GRAVITY= 0

REMARKS: Lab No. 8567

FIG. NO.

CLIENT: American Electric Power

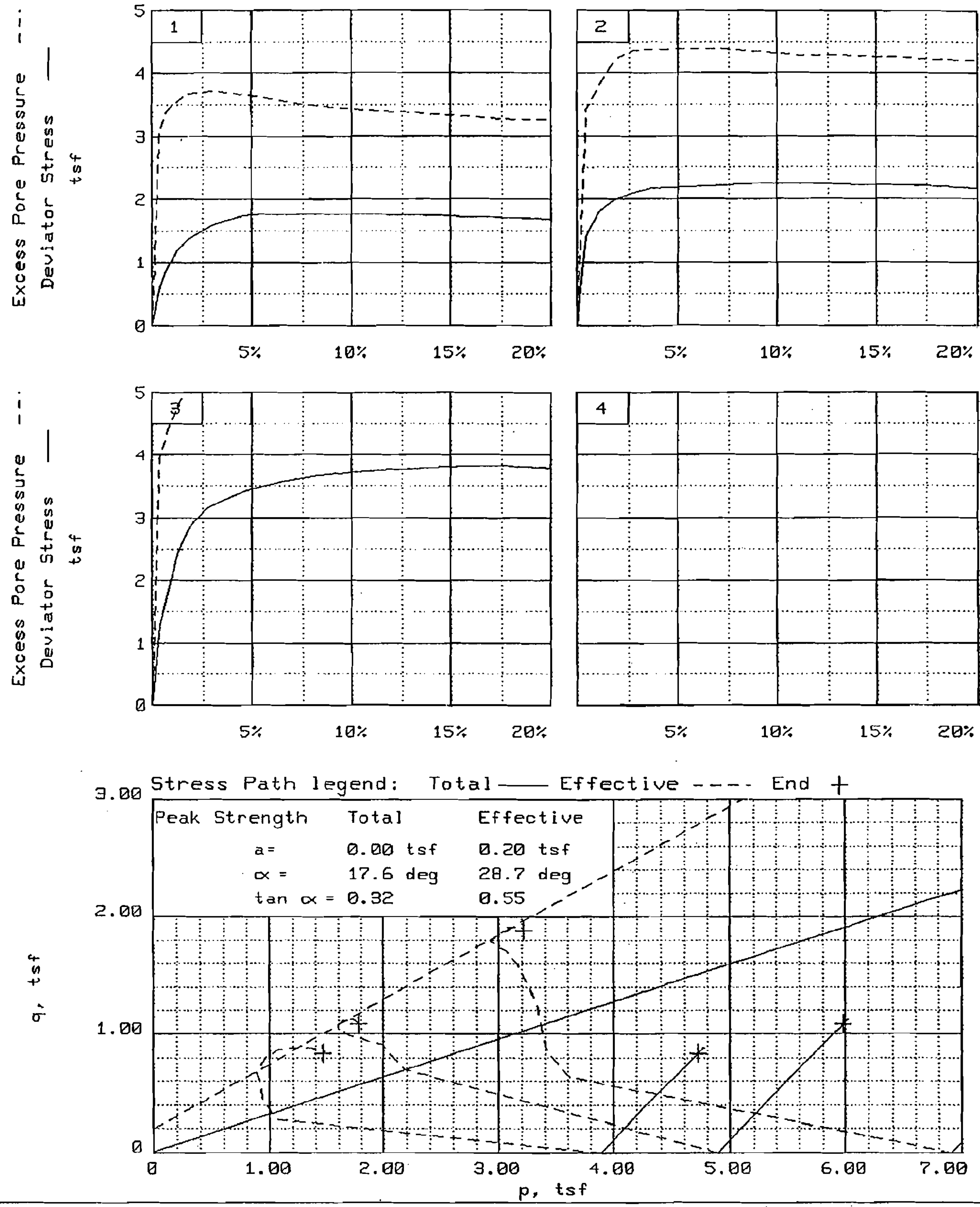
PROJECT: Sporn Plt- ~~Bott~~ Fly. Ash Pond
Certification LOA-002-96

SAMPLE LOCATION: Boring:96-108
Depth:41.6-43.6' Sample:ST-10

PROJ. NO.: 90979.030 DATE: 12/16/96

TRIAXIAL SHEAR TEST REPORT

H. C. NUTTING COMPANY



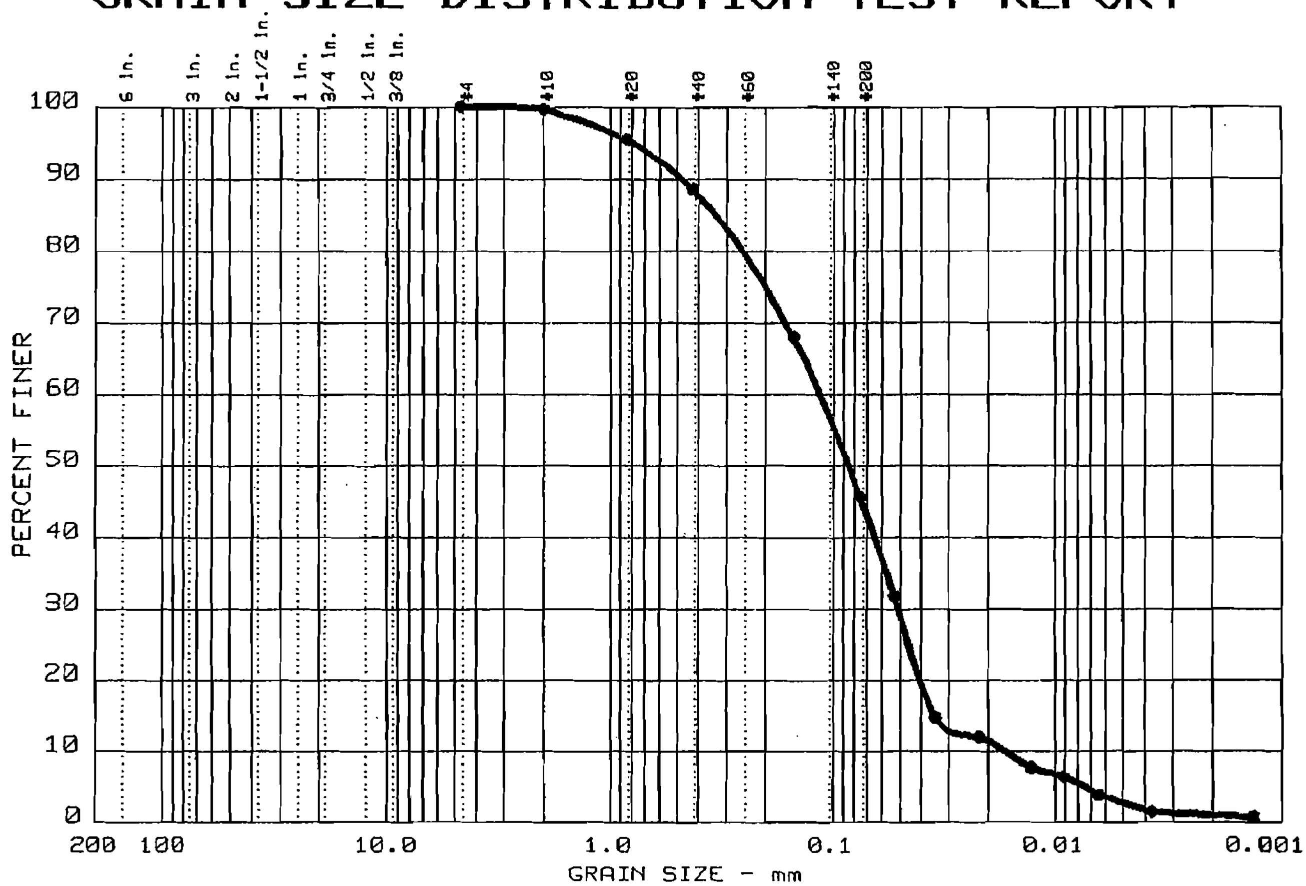
Client: American Electric Power

Project: Sporn Plt-Bott. Ash Pond Certification LOA-002-96

Location: Boring:96-108 Depth:41.6-43.6' Sample:ST-10

File: 8567 Project No.: 90979.030 Page 2/2 Fig. No. ____

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	54.3	43.0	2.7

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	NP	NP	0.33	0.11	0.08	0.051	0.0347	0.0168	1.34	6.8

MATERIAL DESCRIPTION	USCS	AASHTO
● SILTY SAND (Fly Ash)	SM	

Project No.: 90979.030
Project: Sporn Plt-~~Bott~~ Fly Ash Pond Certification LOA-002-96*
● Location: Boring:96-109 Depth:26.7-28.7' *
* New Haven, WV

Date: 12/16/95

GRAIN SIZE DISTRIBUTION TEST REPORT
H. C. NUTTING COMPANY

Remarks:

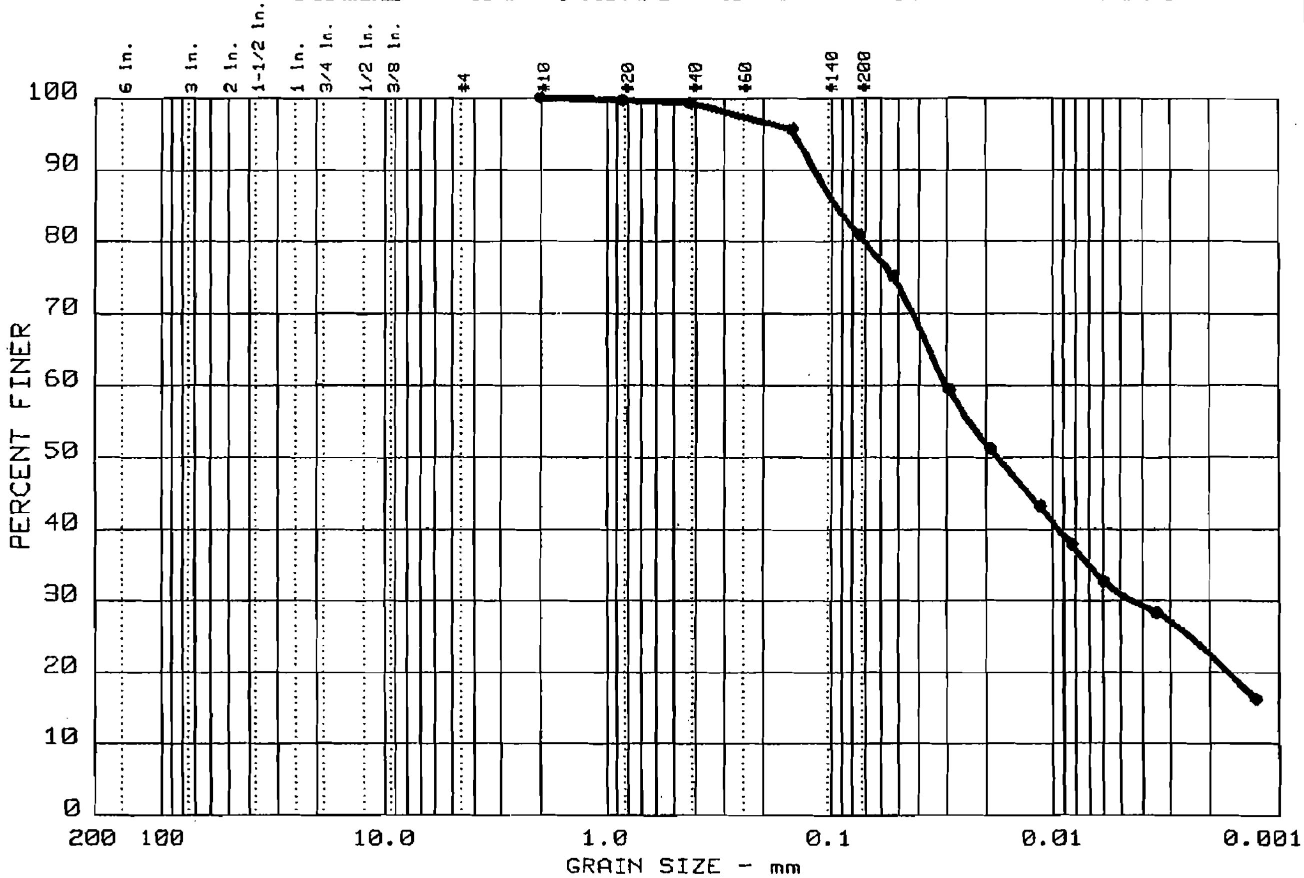
Client: American Electric Power

* Sample:ST-8

Lab No. 8568

Figure No. ______

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	0.0	19.0	50.3	30.7

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●	39	12	0.10	0.03	0.02	0.005				

MATERIAL DESCRIPTION	USCS	AASHTO
● SILT WITH SAND	ML	

Project No.: 90979.030

Project: Sporn Plt-~~Bott~~Fly.Ash Pond Certification LOA-002-96*

● Location: Boring:96-110 Depth:58.6-60.6' *

* New Haven, WV

Date: 12/16/95

Remarks:

Client: American Electric Power

* Sample:ST-18

Lab No. 8569

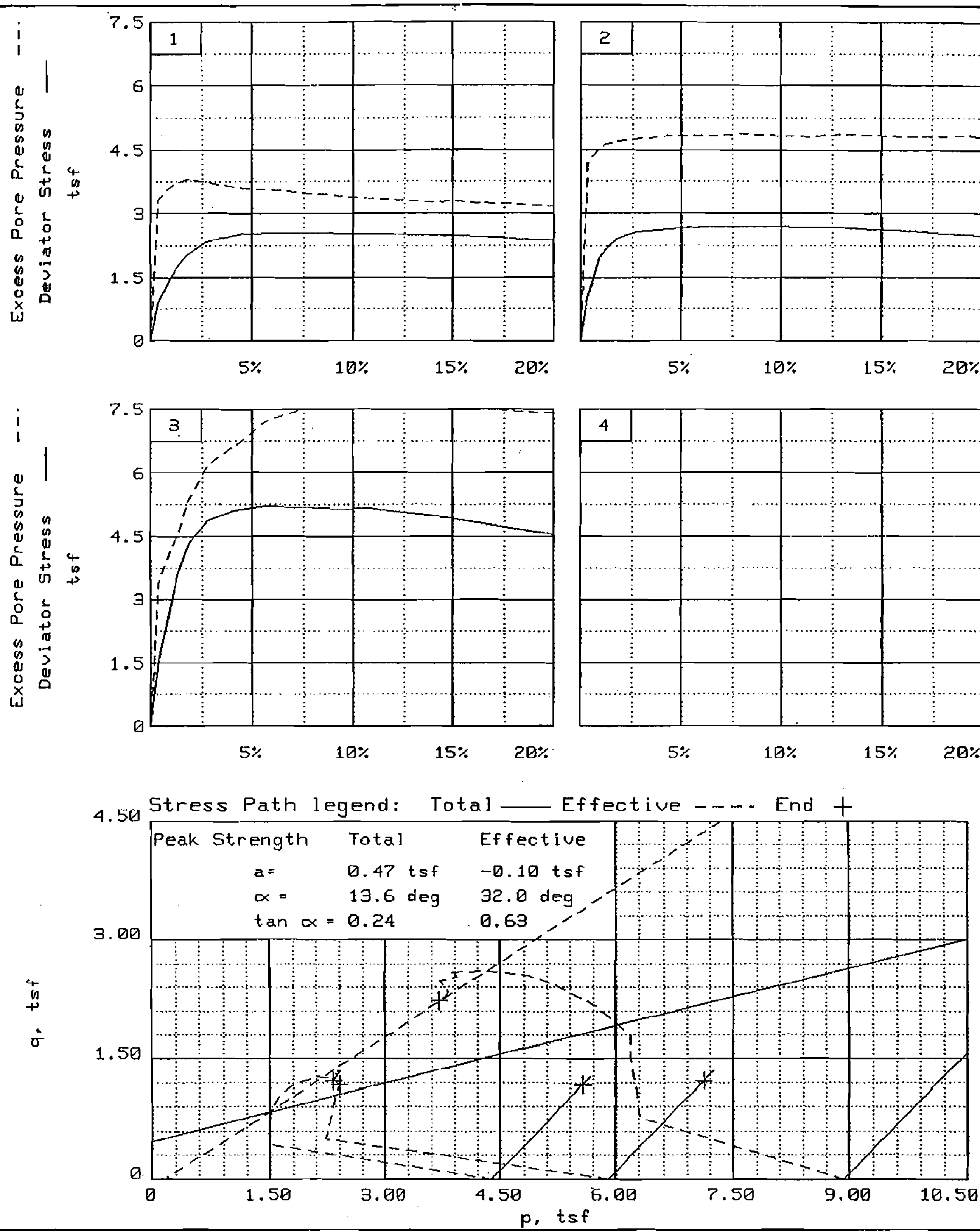
GRAIN SIZE DISTRIBUTION TEST REPORT

H. C. NUTTING COMPANY

Figure No. ______

AEPSPP-000656

AEPSPP004034



Client: American Electric Power

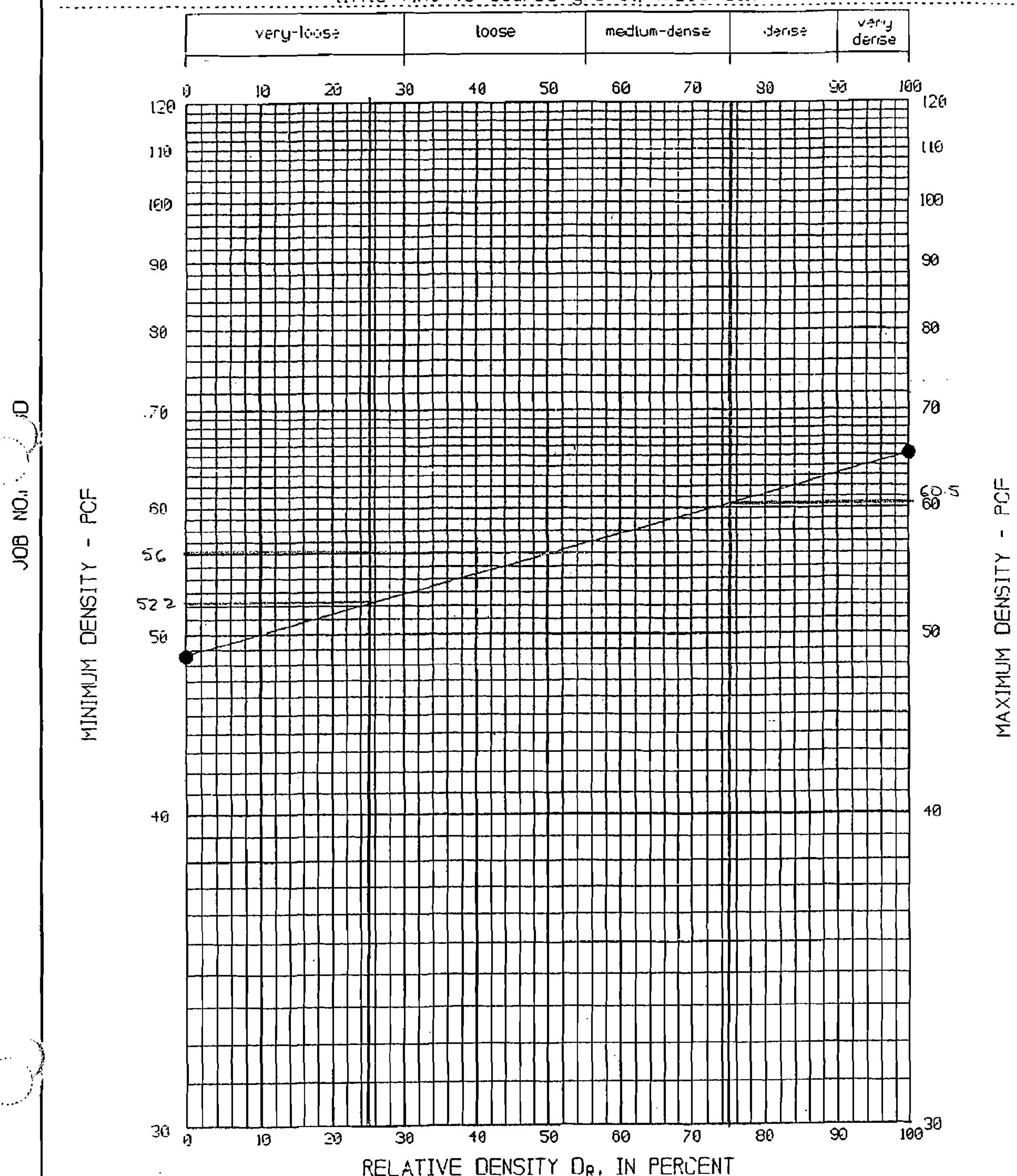
Project: Sporn Plt-Bott. Ash Pond Certification LOA-002-96, New Haven, WV

Location: Boring:96-110 Depth:58.6-60.6' Sample:St-18

File: 8569 Project No.: 09079.030 Page 2/2 Fig. No. _____

RELATIVE DENSITY - MAX/MIN METHOD

Project : Sporn Fly Ash Pond Dike Remediation
Location : New Haven, West Virginia
Sample : Bucket
Material : Bottom Ash : Dark-gray and gray fine to coarse sand, little fine to coarse gravel, trace silt.



AEPSPP-000658

AEPSPP004036

SUMMARY OF MATERIAL PROPERTIES

PROJECT: SPORN PLANT - FLY ASH POND DIKES
NUMBER:

Borehole or Excav No.	Depth ft.	ASTM Description	ASTM Classif-ication	Soil Type	Maximum Dry Density pcf	Optimum Moisture %	Liquid Limit %	Plastic Limit %	Gravel %	Sand %	<#200 Sieve %	<.002 mm %	Specific Gravity	Prmblty cm/sec	Natural Moisture %
96-101	5.0	SILTY SAND with GRAVEL	SM				NP	NP	29.9	51.2	18.9				6.5
96-101	8.5	SILTY SAND with GRAVEL	SM				NP	NP	17.6	44.1	38.3				10.0
96-101	16.5	SILTY SAND with GRAVEL	SM				NP	NP	24.7	57.3	18.0				4.2
96-101	21.5	POORLY GRADED SAND with SILT and GRAVEL	SP-SM				NP	NP	43.2	49.1	7.7				2.6
96-101	26.5	POORLY GRADED SAND with SILT and GRAVEL	SP-SM				NP	NP	35.5	52.3	12.2				6.8
96-101	31.5	[redacted] Silty clay w/sand	(CL-ML)	SEE TRIAXIAL TESTING BY [illegible]			NP	NP	0.4	48.7	50.9				10.8
96-101	36.5	LEAN CLAY	CL				26.6	16.3	0.0	10.7	89.3				17.0
96-102	8.5	SILTY SAND with GRAVEL	SM				NP	NP	31.3	49.7	19.0				6.5
96-102	16.7	POORLY GRADED GRAVEL with SILT and SAND	GP-GM				NP	NP	50.2	42.9	6.9				2.8
96-102	26.7	SANDY SILT	ML				NP	NP	1.7	37.1	61.2				11.8
96-102	31.7	LEAN CLAY with SAND	CL				27.7	18.4	0.0	24.2	75.8				18.4
96-102	36.7	SANDY LEAN CLAY	CL				23.8	16.2	0.0	47.3	52.7				15.6
96-102	41.7	POORLY GRADED SAND with SILT and GRAVEL	SP-SM				NP	NP	38.3	52.5	9.2				5.3
96-103	21.6	POORLY GRADED SAND with SILT and GRAVEL	SP-SM				NP	NP	40.0	51.0	9.0				4.7
96-103	31.6	LEAN CLAY with SAND	CL				28.6	18.8	0.0	26.6	73.4				14.5
96-103	41.6	SILTY SAND	SM				NP	NP	0.0	53.7	46.3				11.4
96-104	3.0	POORLY GRADED SAND with SILT and GRAVEL	SP-SM				NP	NP	41.5	53.6	4.9				1.1
96-104	8.5	POORLY GRADED SAND with SILT and GRAVEL	SP-SM				NP	NP	30.8	57.5	11.7				1.0
96-104	11.7	POORLY GRADED SAND with SILT and GRAVEL	SP-SM				NP	NP	41.7	48.5	9.8				1.2
96-104	16.7	SILTY SAND with GRAVEL	SM				NP	NP	19.4	64.7	15.9				4.0
96-104	21.7	SILTY SAND with GRAVEL	SM				NP	NP	34.4	47.5	18.1				2.9
96-104	36.7	LEAN CLAY with SAND	CL				27.2	19.0	0.0	22.8	77.2				18.9
96-104	41.7	SANDY SILT	ML				NP	NP	0.0	35.3	64.7				8.1
96-105	3.0	POORLY GRADED SAND with SILT and GRAVEL	SP-SM				NP	NP	40.2	53.9	5.9				1.6
96-105	16.5	POORLY GRADED SAND with SILT and GRAVEL	SP-SM				NP	NP	42.7	48.8	8.5				3.1
96-105	21.5	SILTY SAND with GRAVEL	SM				NP	NP	19.0	61.9	19.1				6.7
96-105	26.5	LEAN CLAY with SAND	CL				27.4	17.7	0.0	26.6	73.4				13.3
96-105	36.5	LEAN CLAY	CL				28.8	18.7	0.0	4.4	95.6				22.1
96-105	41.5	SILTY SAND	SM				NP	NP	0.0	51.2	48.8				11.9
96-106	11.5	SILTY SAND with GRAVEL	SM				NP	NP	19.1	59.8	21.1				5.5
96-106	21.5	SANDY LEAN CLAY	CL				26.1	17.5	0.0	33.4	66.6				11.1
96-106	31.5	SILT	ML				NP	NP	0.0	11.1	88.9		2.29		42.6

AEP Civil Engineering Laboratory, Groveport, Ohio

SUMMARY OF MATERIAL PROPERTIES

PROJECT: SPORN PLANT - FLY ASH POND DIKES

NUMBER:

Borehole or Excav No.	Depth ft.	ASTM Description	ASTM Classif-ication	Soil Type	Maximum Dry Density pcf	Optimum Moisture %	Liquid Limit %	Plastic Limit %	Gravel %	Sand %	<#200 Sieve %	<.002 mm %	Specific Gravity	Prmblty cm/sec	Natural Moisture %
96-106	51.5	SILT with SAND	ML				NP	NP	0.0	15.2	84.8		2.42		35.7
96-106	56.5	LEAN CLAY	CL				43.6	25.6	0.0	2.6	97.4				31.9
96-107	11.6	POORLY GRADED SAND with SILT and GRAVEL	SP-SM				NP	NP	34.7	54.9	10.4				3.9
96-107	16.6	SANDY LEAN CLAY	CL				25.2	18.1	0.0	31.9	68.1				14.0
96-107	21.6	SANDY SILT	ML				NP	NP	0.0	35.4	64.6				11.4
96-107	36.6	SILT with SAND	ML				NP	NP	0.0	21.9	78.1		2.38		37.6
96-107	56.6	SILT	ML				NP	NP	0.0	11.3	88.7		2.31		36.2
96-107	71.6	LEAN CLAY	CL				41.3	21.1	0.0	11.4	88.6				25.2
96-108	3.0	SILTY SAND with GRAVEL	SM				NP	NP	14.8	50.6	34.6				9.1
96-108	8.5	SILTY SAND	SM				NP	NP	13.7	49.9	36.4				6.2
96-108	11.6	SILTY SAND with GRAVEL	SM				NP	NP	34.4	50.4	15.2				3.0
96-108	16.6	SILTY SAND with GRAVEL	SM				NP	NP	16.9	55.3	27.8				1.9
96-108	21.6	SANDY SILTY CLAY	CL-ML				23.3	16.5	0.0	40.5	59.5				12.2
96-108	26.6	SILTY SAND	SM				NP	NP	10.4	72.7	16.9				20.6
96-108	41.6	LEAN CLAY	CL				38.7	20.3	0.0	9.5	90.5				23.2
96-108	56.6	LEAN CLAY with SAND	CL				34.9	20.1	0.0	25.3	74.7				25.1
96-109	8.5	POORLY GRADED SAND with SILT and GRAVEL	SP-SM				NP	NP	34.7	55.9	9.4				0.4
96-109	11.7	SILTY SAND	SM				NP	NP	4.9	72.1	23.0				4.3
96-109	16.7	SANDY SILTY CLAY	CL-ML				22.9	17.1	0.0	40.9	59.1				9.0
96-109	36.7	SILT	ML				NP	NP	0.0	8.9	91.1		2.34		38.1
96-109	56.7	SILT	ML				NP	NP	0.0	0.9	99.1		2.29		34.3
96-109	71.7	LEAN CLAY	CL				40.3	21.8	0.0	6.8	93.2				23.7
96-110	5.0	SILTY SAND	SM				NP	NP	8.8	59.5	31.7				6.8
96-110	8.5	POORLY GRADED GRAVEL with SILT and SAND	GP-GM				NP	NP	53.3	38.0	8.7				0.1
96-110	16.6	LEAN CLAY with SAND	CL				25.5	17.6	0.0	29.1	70.9				11.5
96-110	21.6	SANDY SILTY CLAY	CL-ML				24.0	17.0	0.0	41.1	58.9				12.5
96-110	31.6	LEAN CLAY with SAND	CL				30.7	18.4	0.0	18.0	82.0				14.7
96-110	46.6	LEAN CLAY	CL				36.2	21.3	0.0	12.3	87.7				25.1
96-110	56.6	LEAN CLAY	CL				37.5	20.3	0.0	13.1	86.9				24.4
96-110	66.6	LEAN CLAY with SAND	CL				38.7	21.7	0.0	16.2	83.8				25.6

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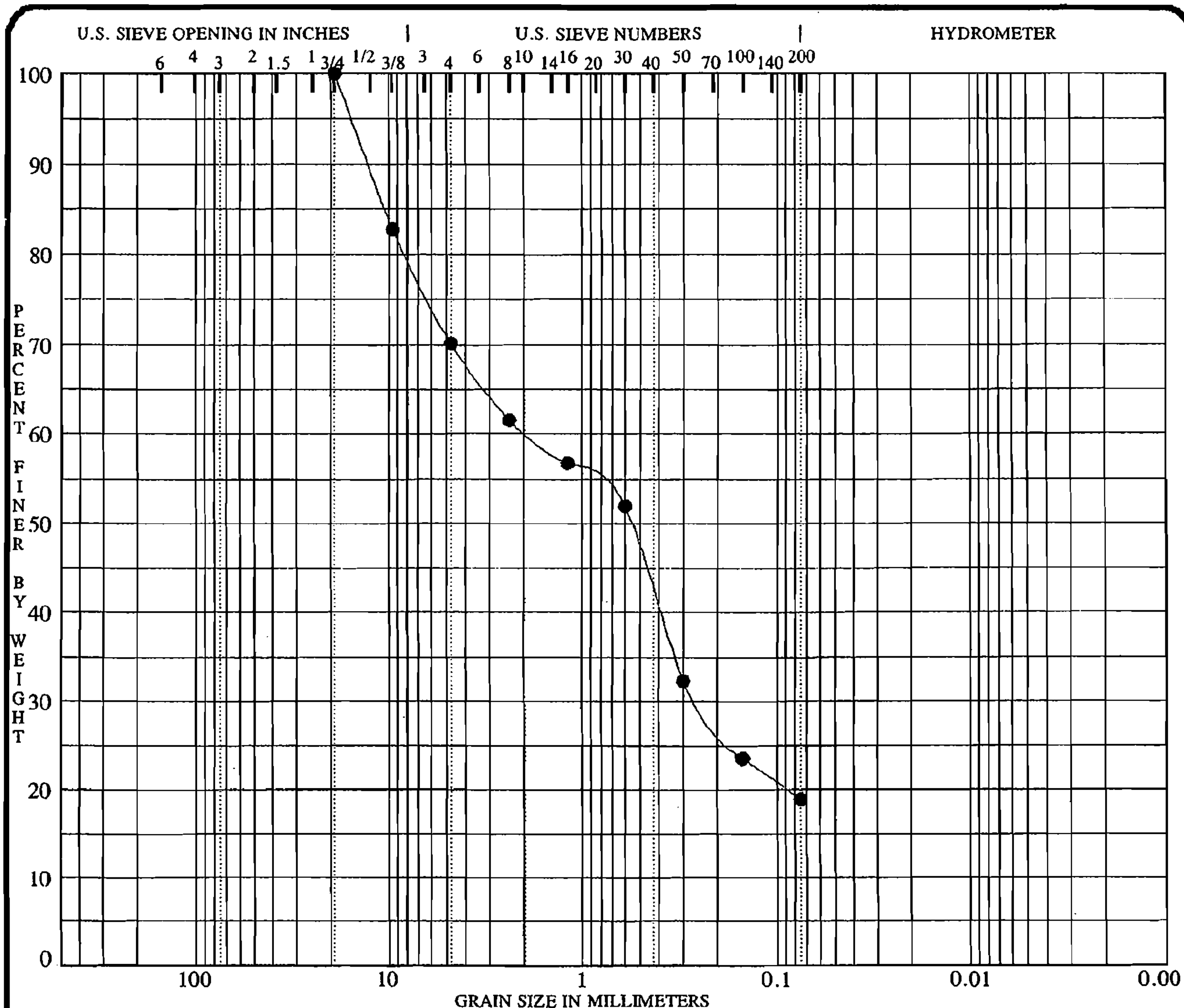

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-101	5.0	SILTY SAND with GRAVEL SM	6.5	NP	NP	NP		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
●	96-101	5.0	19.000	1.892	0.250		29.9	51.2	18.9	

PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO.

DATE 05/21/97

GRADATION CURVES

American Electric Power Service Corp.
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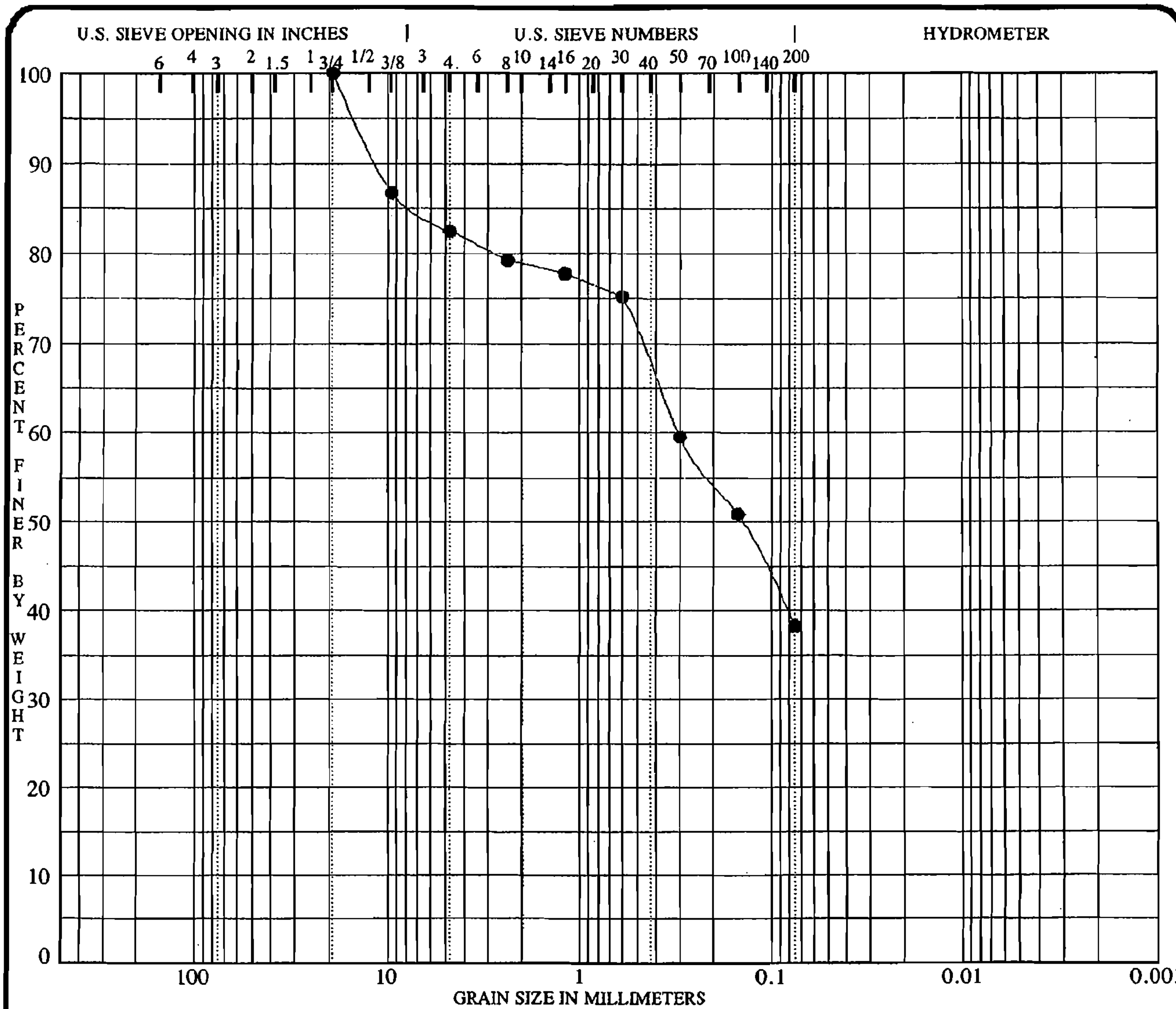
AEPSPP-000661

AEPSPP004039



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
● 96-101	8.5		10.0	NP	NP	NP	
		SILTY SAND with GRAVEL SM					

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
● 96-101	8.5	19.000	0.307			17.6	44.1	38.3	

PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO.

DATE 05/21/97

GRADATION CURVES

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Groveport, Ohio

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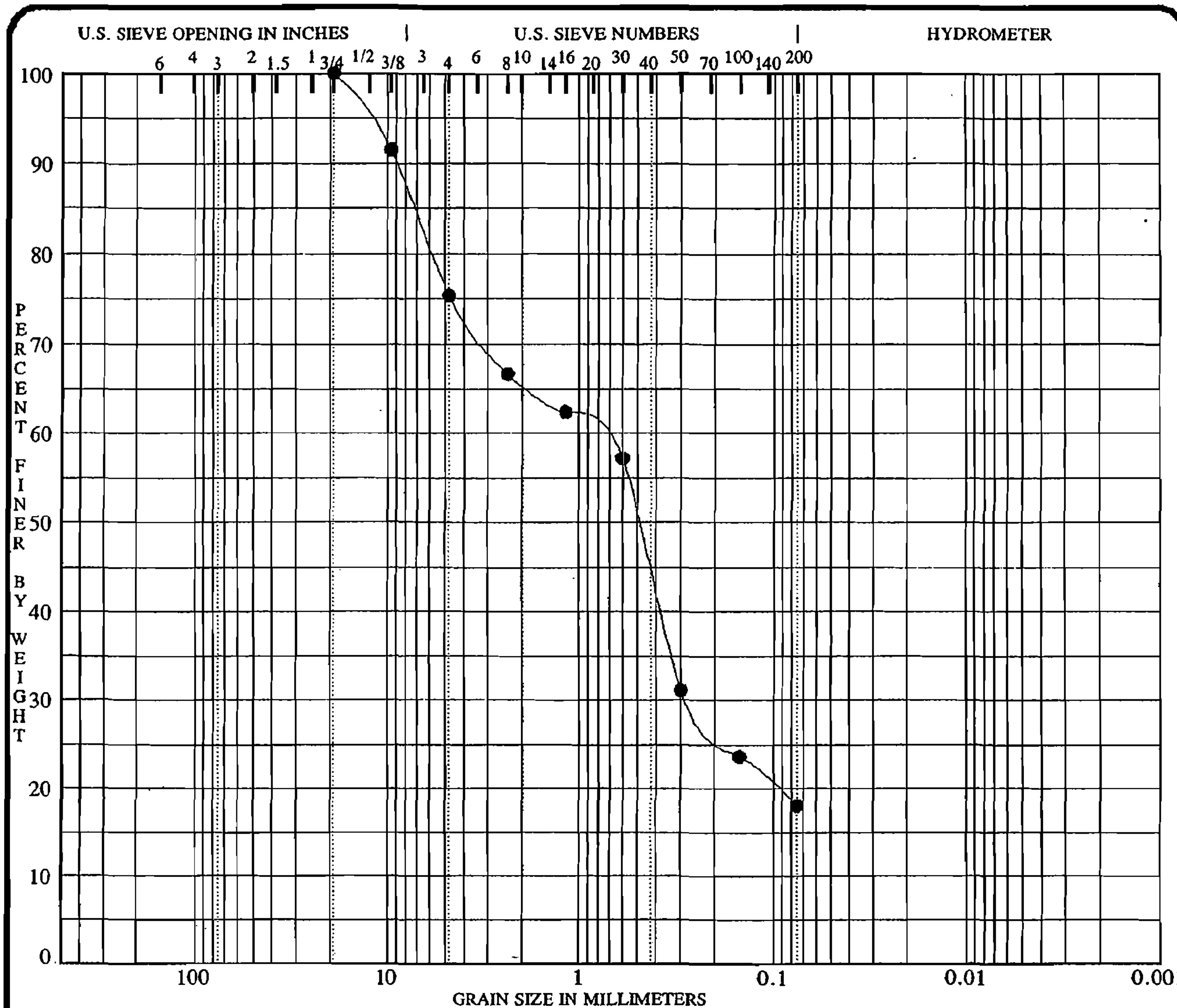
AEPSPP-000662

AEPSPP004040



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-101	16.5		4.2	NP	NP	NP		
			SILTY SAND with GRAVEL SM						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-101	16.5	19.000	0.864	0.271		24.7	57.3	18.0	

PROJECT **SPORN PLANT - FLY ASH POND DIKES**

JOB NO.

DATE 05/21/97

GRADATION CURVES

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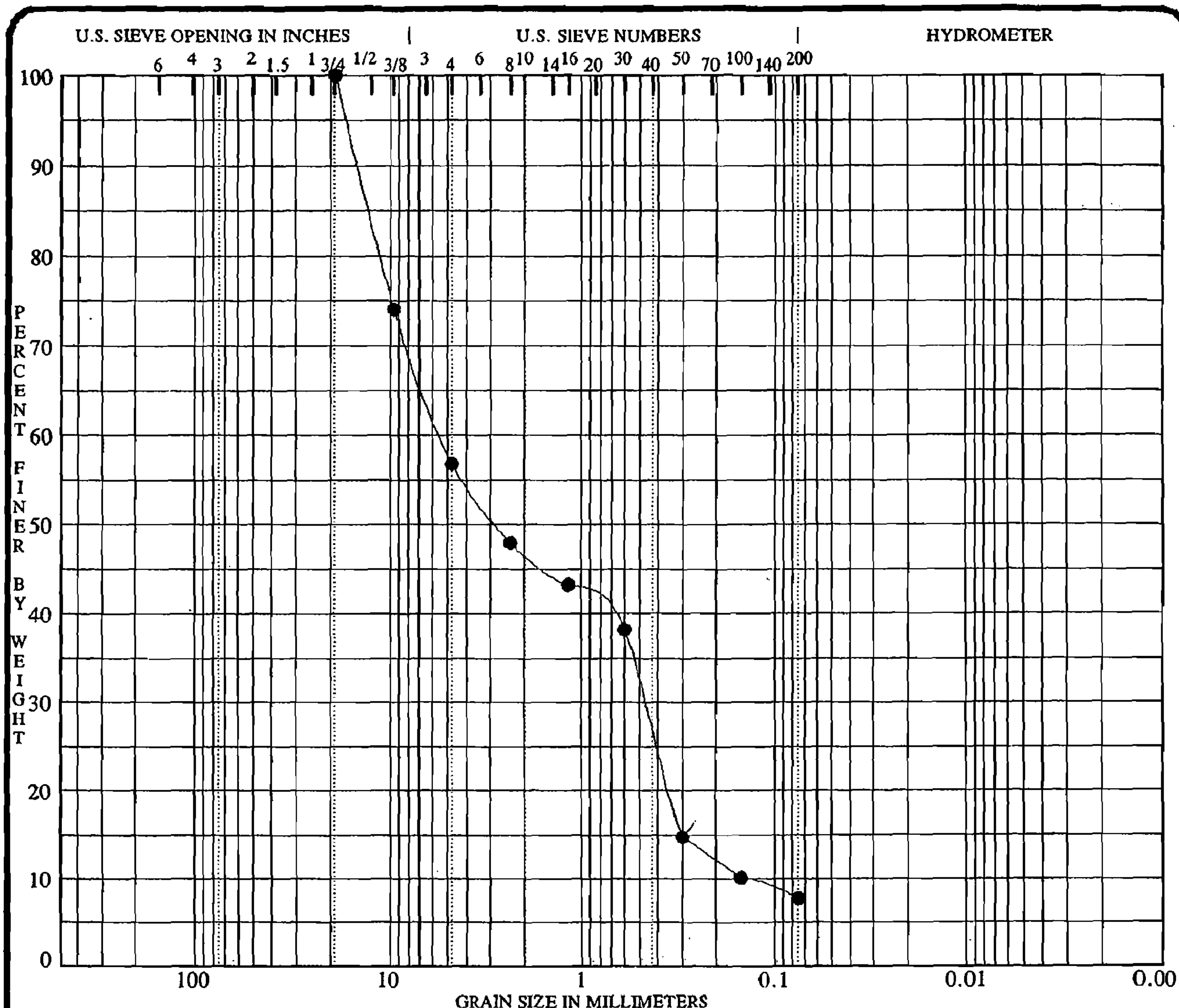

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
●	96-101	21.5		2.6	NP	NP	NP	
			POORLY GRADED SAND with SILT and GRAVEL SP-SM					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
●	96-101	21.5	19.000	5.404	0.471	0.146	43.2	49.1	7.7	

PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO.
DATE 05/21/97

GRADATION CURVES

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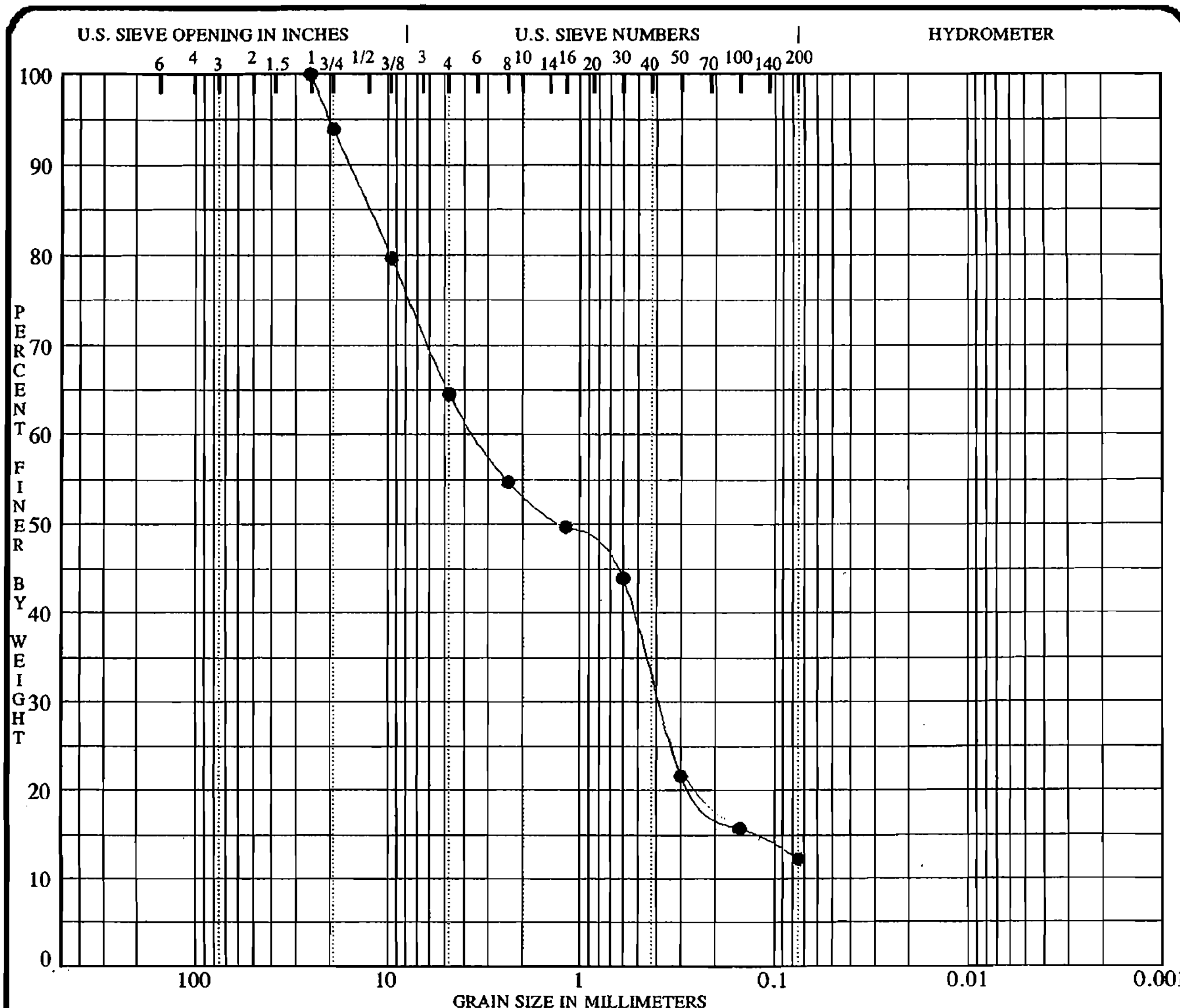

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-101	26.5		6.8	NP	NP	NP		
	POORLY GRADED SAND with SILT and GRAVEL SP-SM								

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
●	96-101	26.5	25.000	3.445	0.390		35.5	52.3	12.2	

PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO.

DATE 05/21/97

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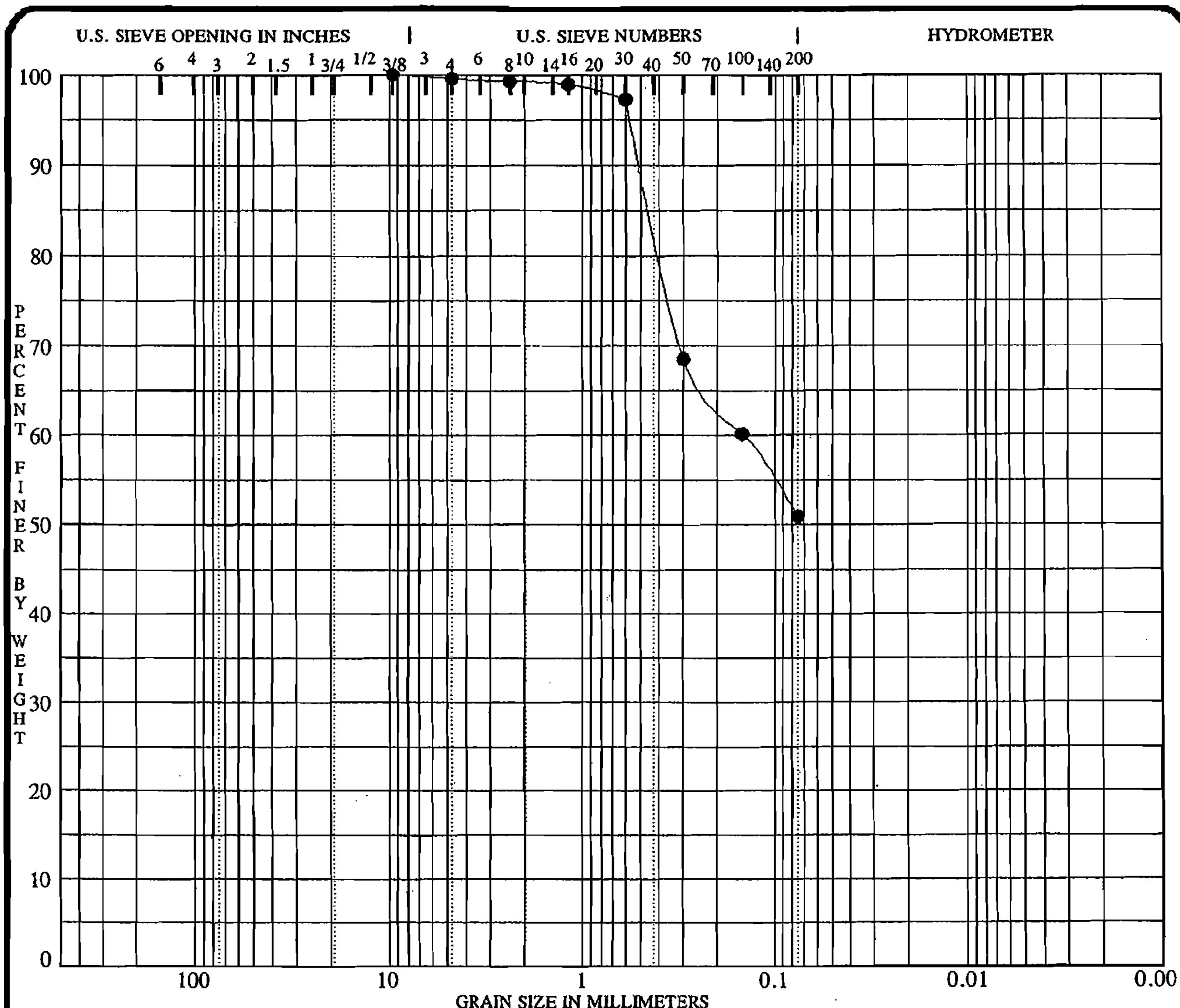

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
●	96-101	31.5		10.8	NP	NP	NP	
			SANDY SILT ML					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-101	31.5	9.500	0.148			0.4	48.7	50.9	

PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO.
DATE 05/21/97

GRADATION CURVES

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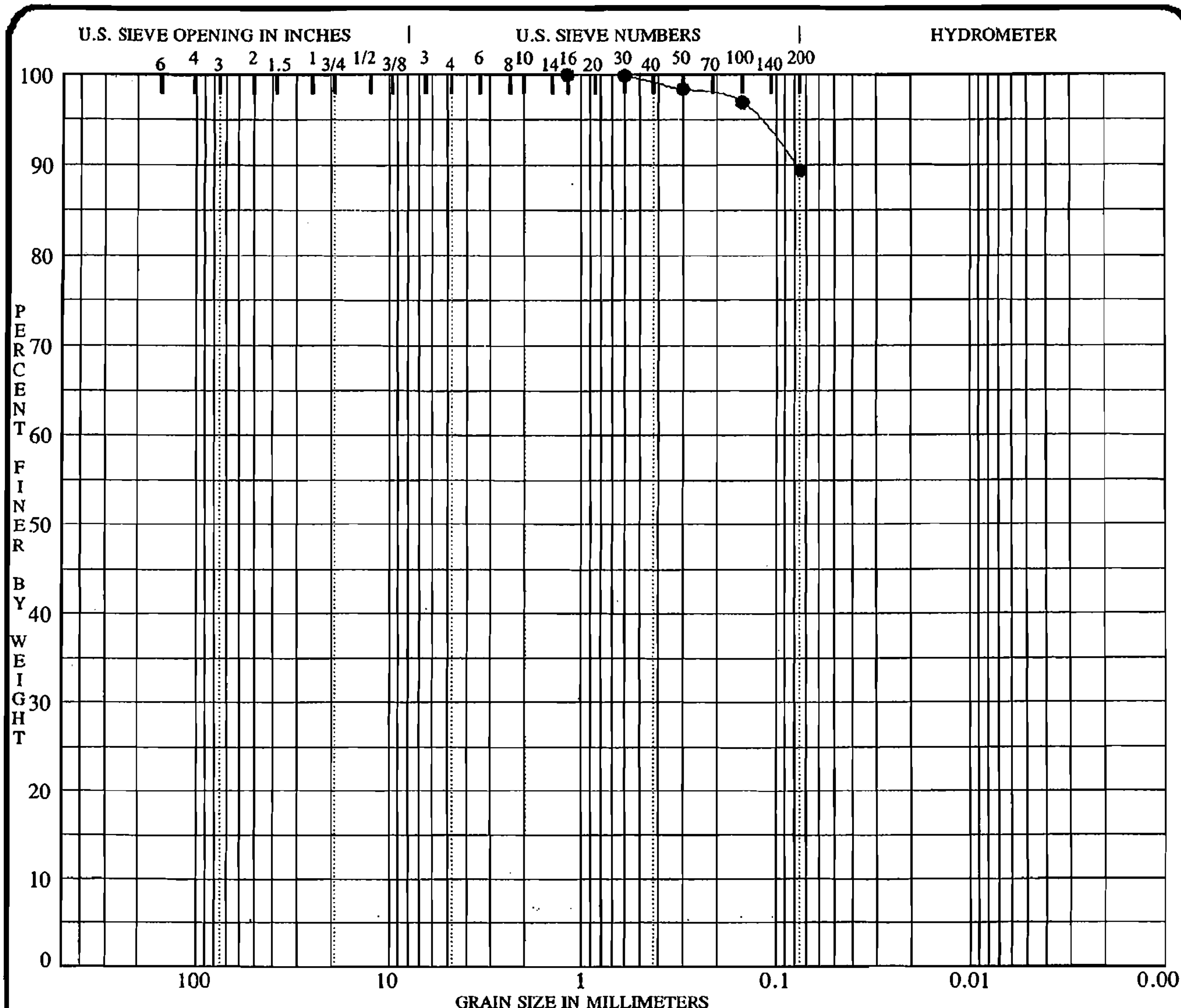

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-101	36.5		17.0	26.6	16.3	10.3		
			LEAN CLAY CL						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-101	36.5	1.180				0.0	10.7	89.3	

PROJECT **SPORN PLANT - FLY ASH POND DIKES**

JOB NO.

DATE **05/21/97**

GRADATION CURVES

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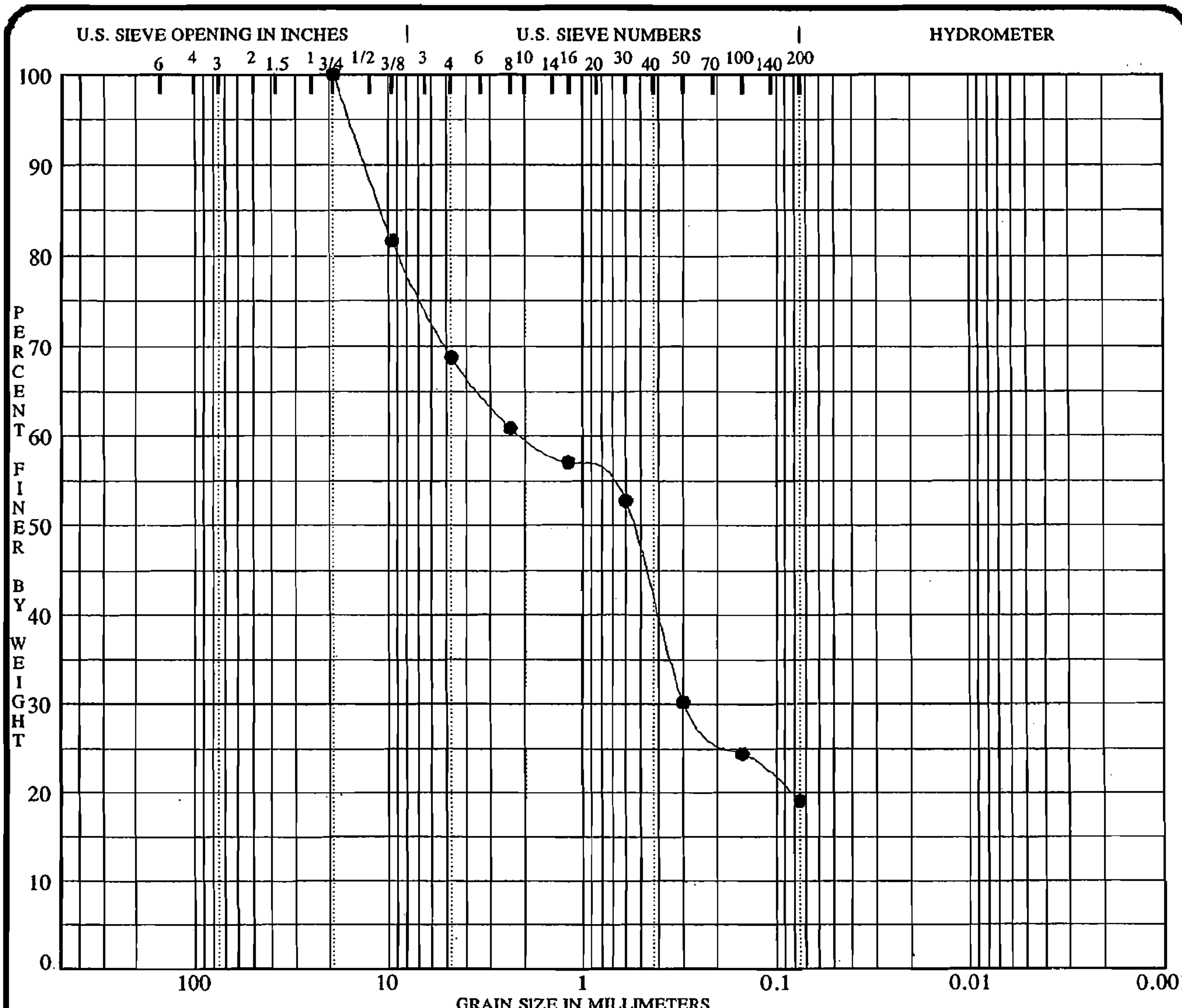

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
● 96-102	8.5		6.5	NP	NP	NP		
		SILTY SAND with GRAVEL SM						

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
● 96-102	8.5	19.000	2.003	0.293		31.3	49.7	19.0	

PROJECT SPORN PLANT - FLY ASH POND DIKES
JOB NO.
DATE 05/21/97

GRADATION CURVES

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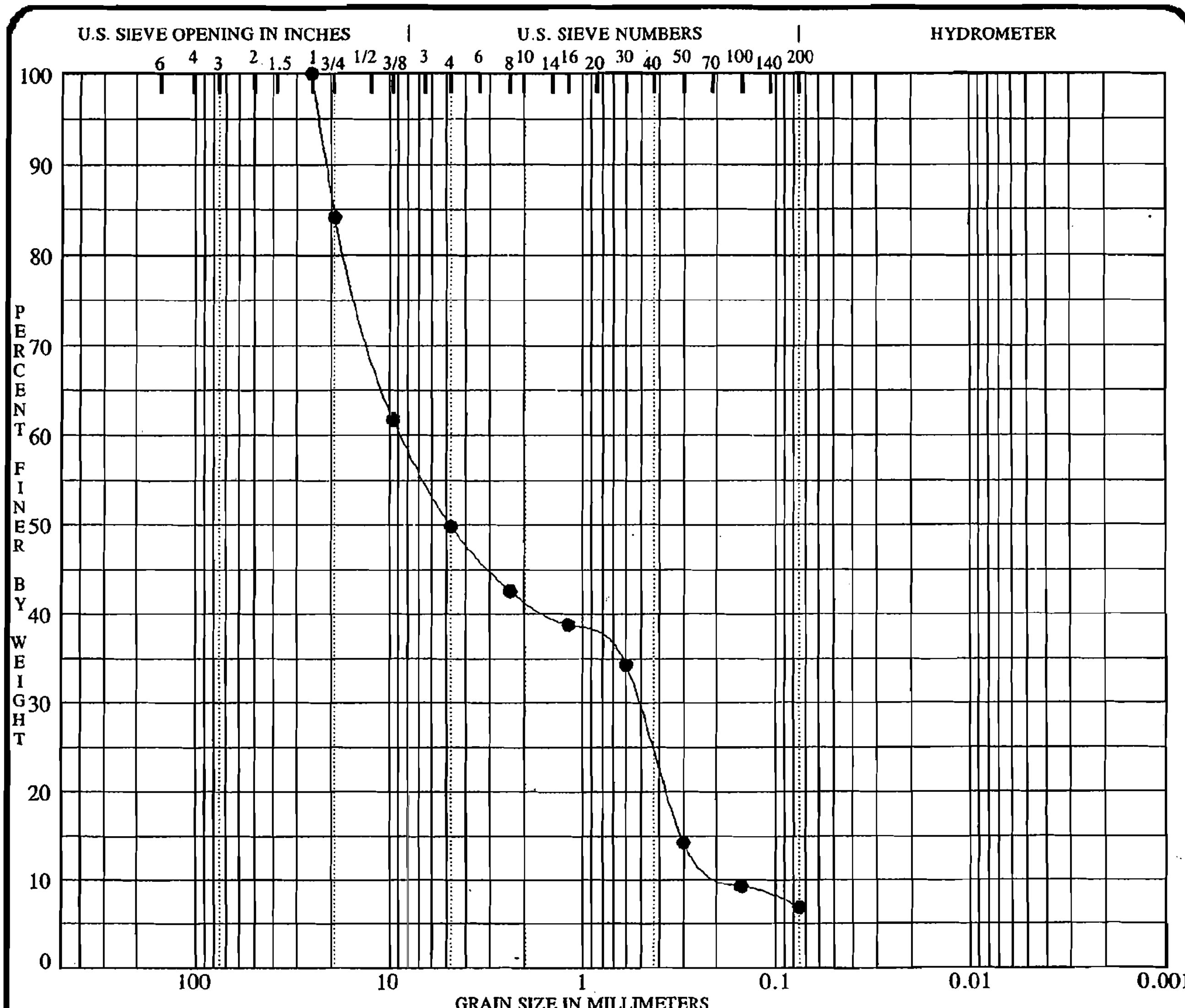

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
●	96-102	16.7		2.8	NP	NP	NP	
	POORLY GRADED GRAVEL with SILT and SAND GP-GM							

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-102	16.7	25.000	8.604	0.517	0.166	50.2	42.9	6.9	

PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO.

DATE 05/21/97

GRADATION CURVES

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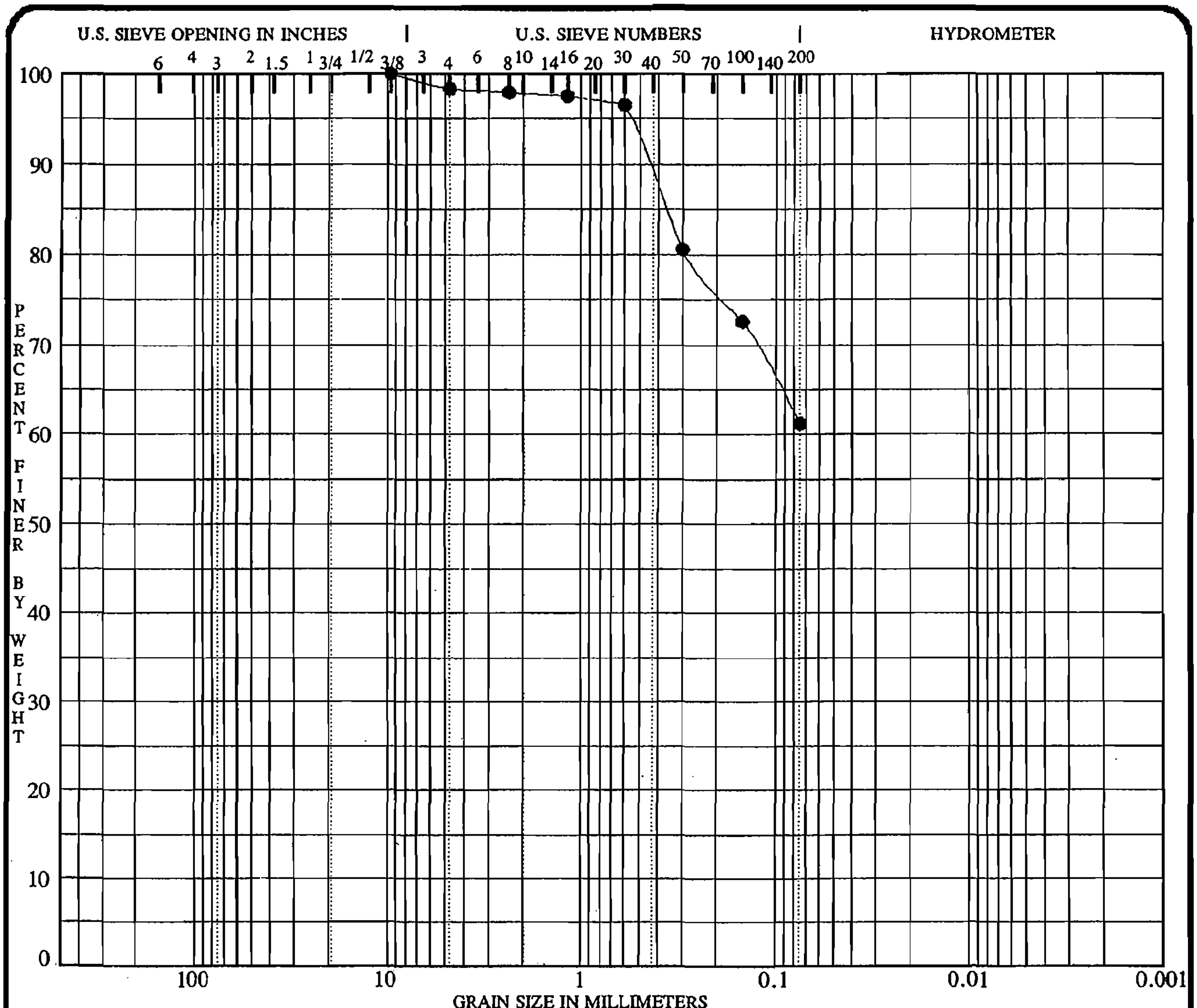

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-102	26.7		11.8	NP	NP	NP		
			SANDY SILT ML						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
●	96-102	26.7	9.500				1.7	37.1	61.2	

PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO.
DATE 05/21/97

GRADATION CURVES

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AEPSPP-000670

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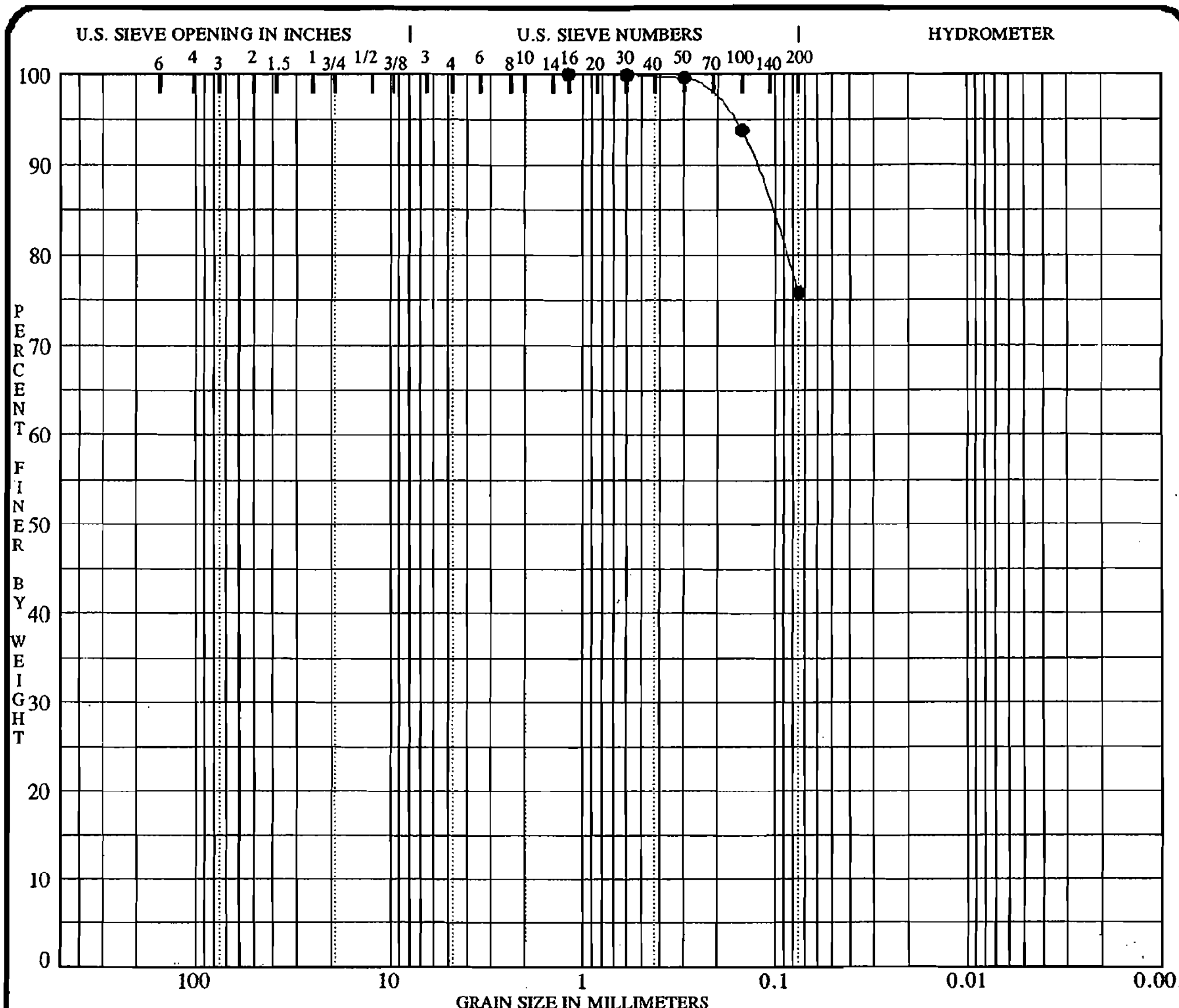

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
●	96-102	31.7		18.4	27.7	18.4	9.3	
			LEAN CLAY with SAND CL					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-102	31.7	1.180				0.0	24.2	75.8	

PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO.
DATE 05/21/97

GRADATION CURVES

American Electric Power Service Corp.
Groveport, Ohio

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AEPSPP-000671

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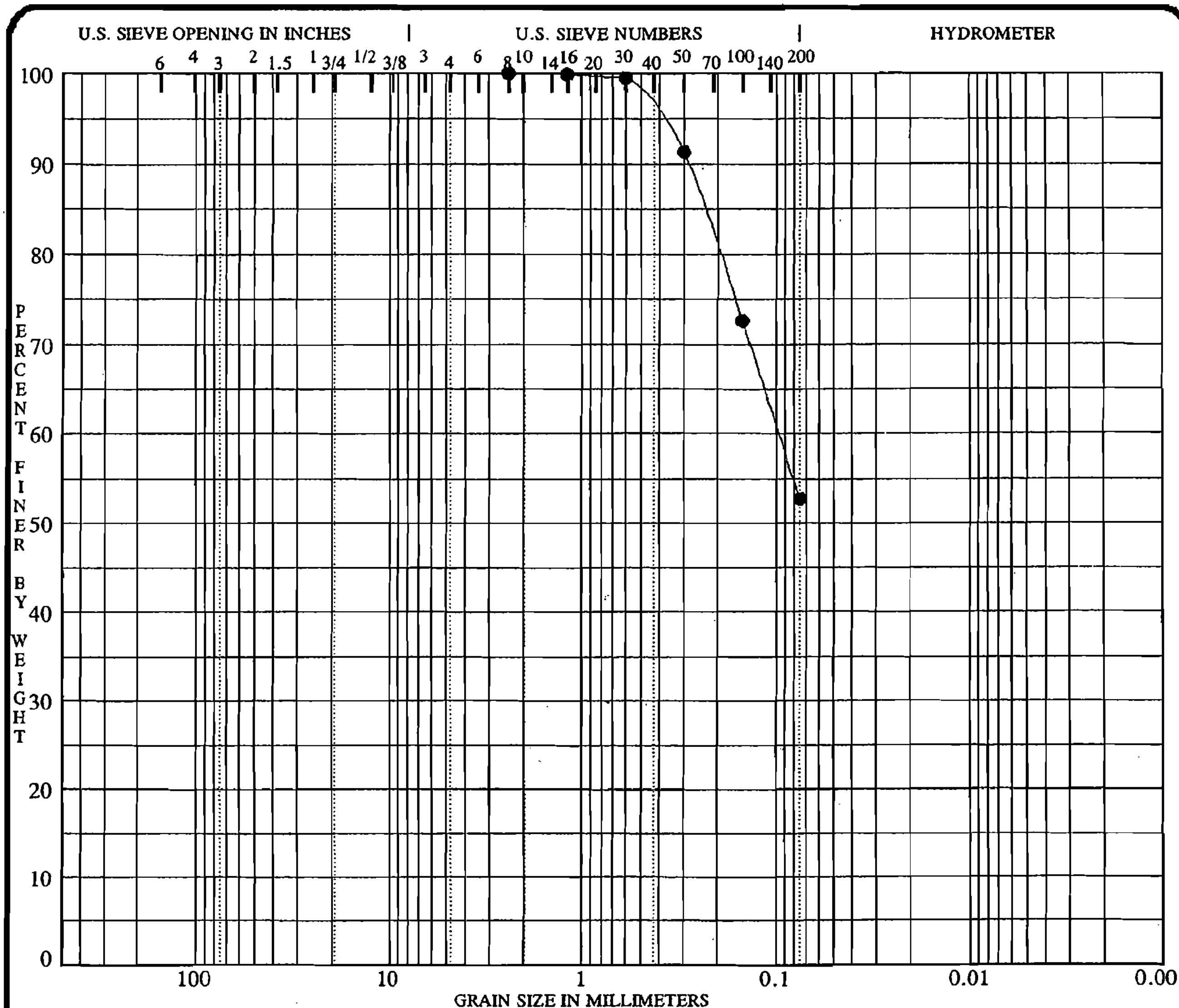

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-102	36.7		15.6	23.8	16.2	7.6		
			SANDY LEAN CLAY CL						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-102	36.7	2.360	0.097			0.0	47.3	52.7	

PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO.

DATE 05/21/97

GRADATION CURVES

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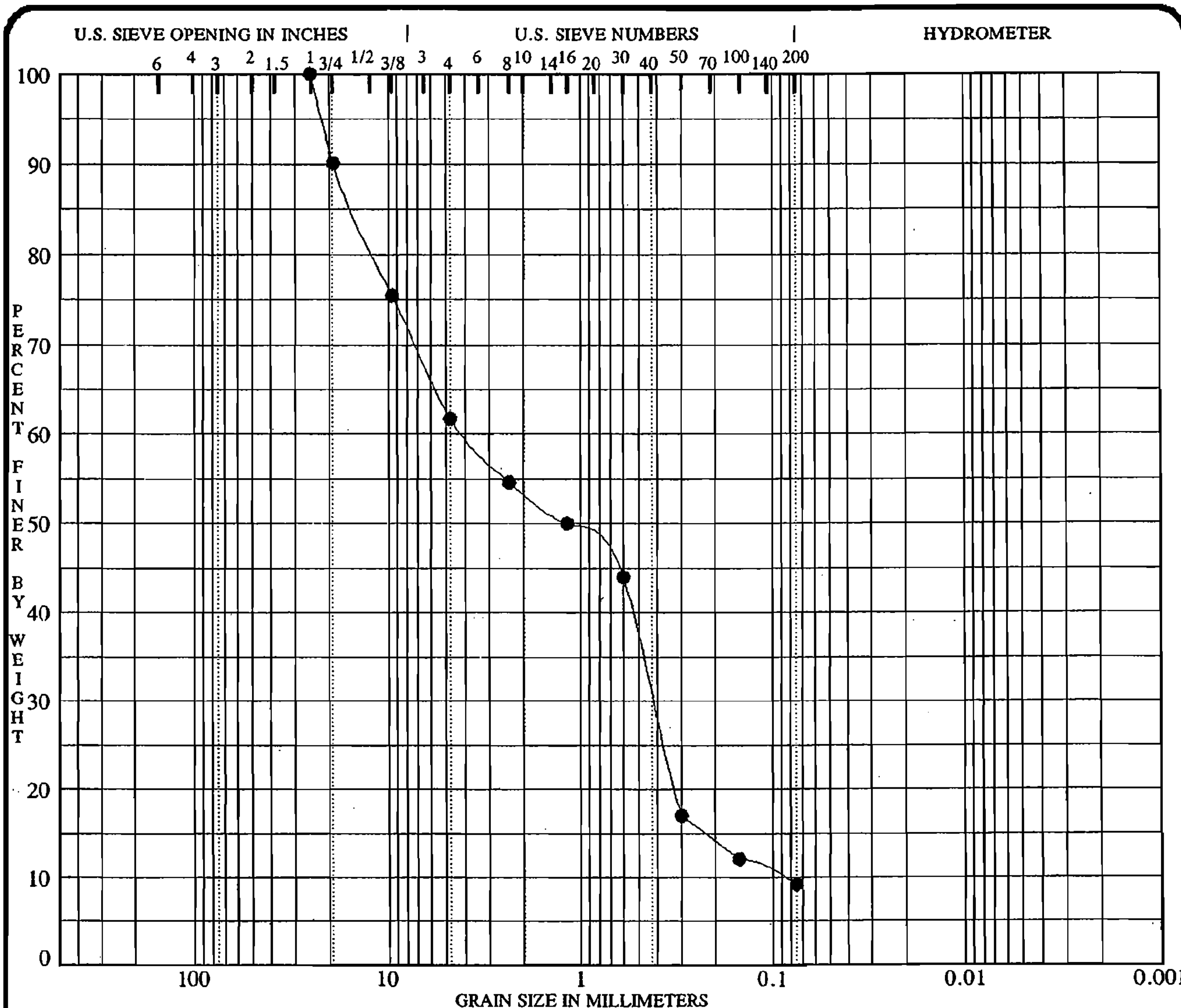


COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
● 96-102	41.7		5.3	NP	NP	NP		
POORLY GRADED SAND with SILT and GRAVEL SP-SM								

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
● 96-102	41.7	25.000	4.018	0.419	0.091	38.3	52.5	9.2	

PROJECT SPORN PLANT - FLY ASH POND DIKES JOB NO. ______
DATE 05/21/97

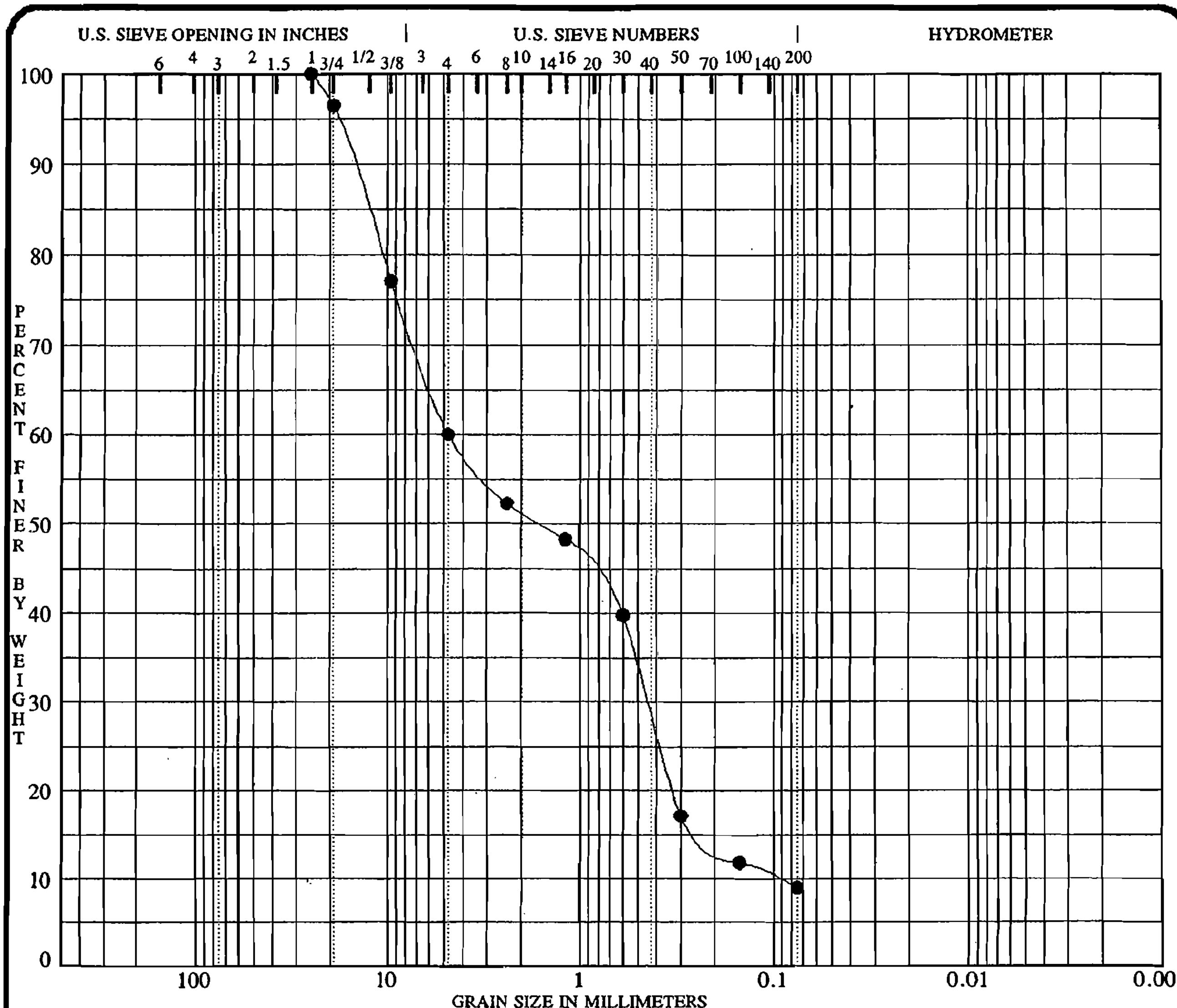
GRADATION CURVES

American Electric Power Service Corp.
Groveport, Ohio

AEP

AEPSPP-000673

AEPSPP004051



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-103	21.6		4.7	NP	NP	NP		
			POORLY GRADED SAND with SILT and GRAVEL SP-SM						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
●	96-103	21.6	25.000	4.750	0.445	0.096	40.0	51.0	9.0	

PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO.

DATE 05/21/97

GRADATION CURVES

American Electric Power Service Corp.

Groveport, Ohio

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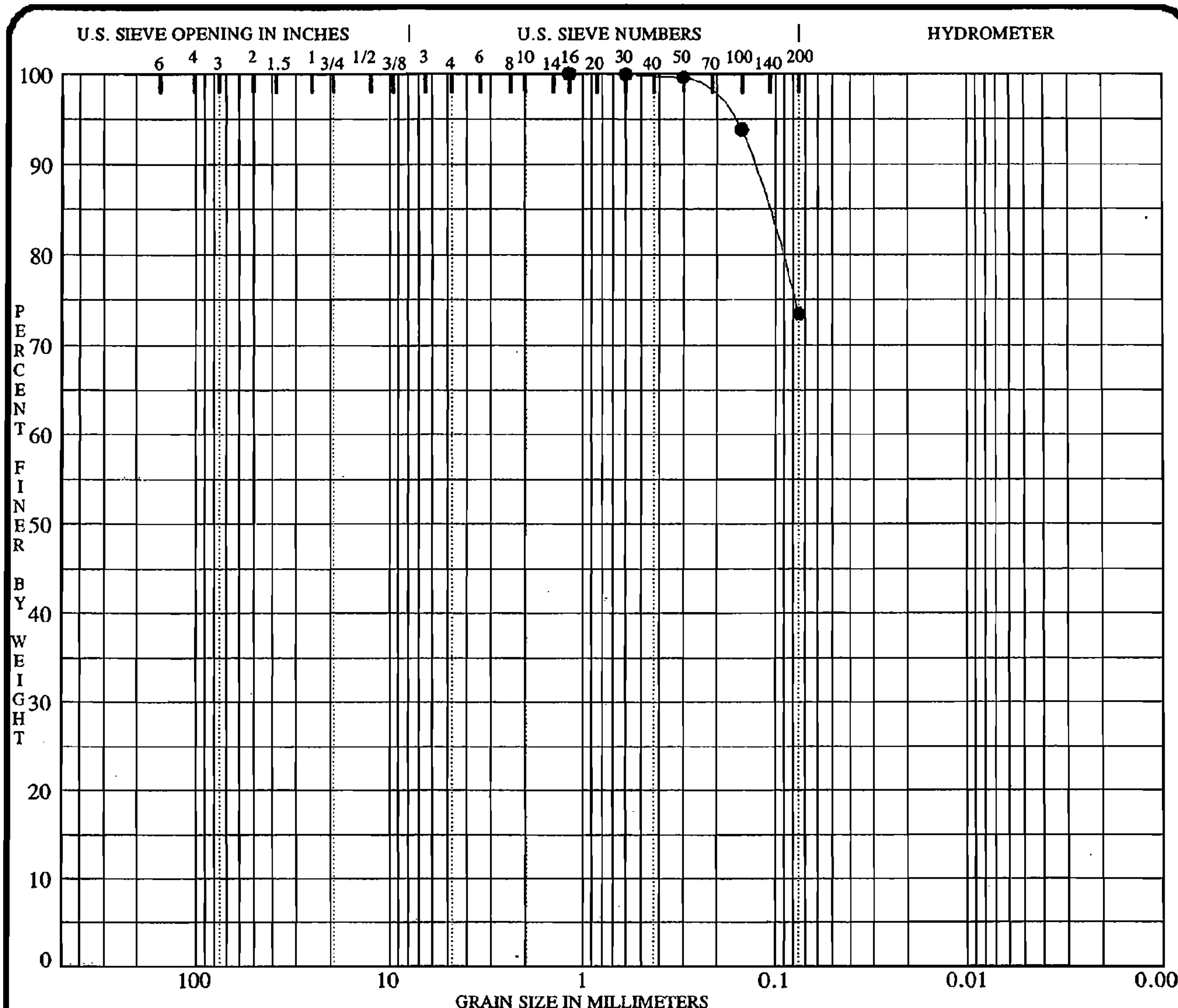


COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-103	31.6		14.5	28.6	18.8	9.8		
			LEAN CLAY with SAND CL						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-103	31.6	1.180				0.0	26.6	73.4	

PROJECT **SPORN PLANT - FLY ASH POND DIKES**

JOB NO.

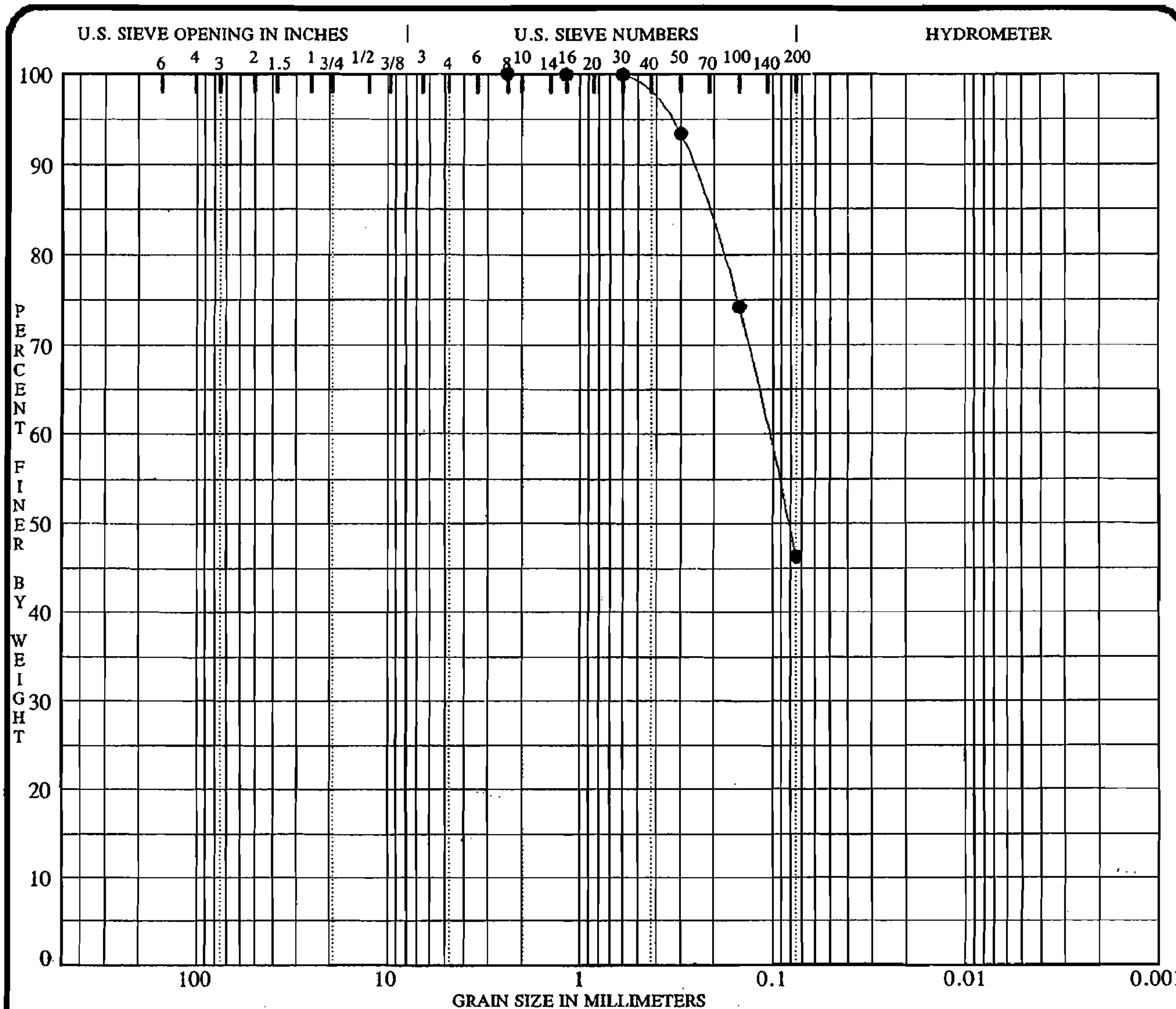
DATE **05/21/97**

GRADATION CURVES

American Electric Power Service Corp.

Groveport, Ohio

AEP



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
●	96-103	41.6		11.4	NP	NP	NP	
			SILTY SAND SM					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
●	96-103	41.6	2.360	0.105			0.0	53.7	46.3	

PROJECT **SPORN PLANT - FLY ASH POND DIKES**

JOB NO.

DATE 05/22/97

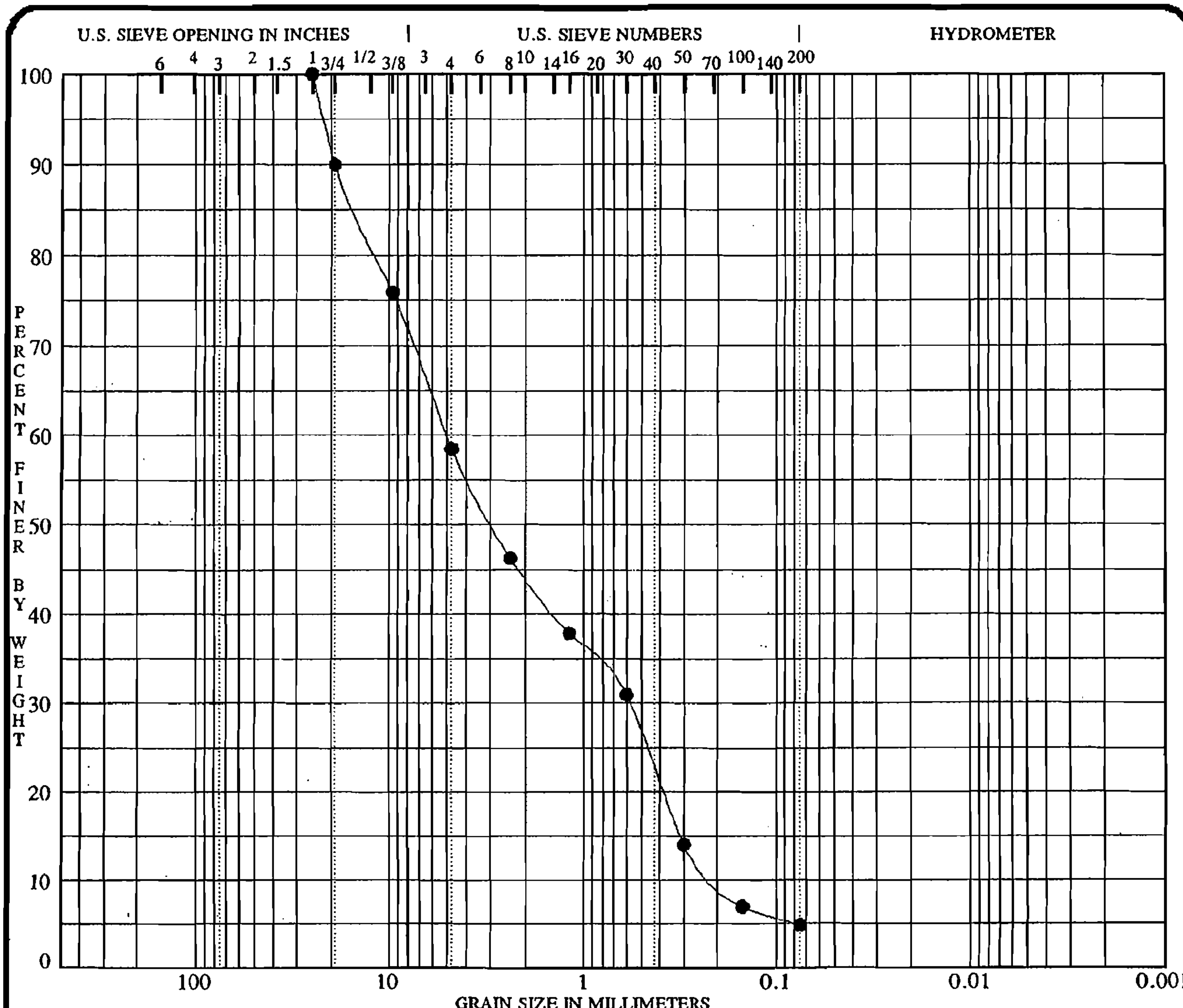
GRADATION CURVES

American Electric Power Service Corp.

Groveport, Ohio

AEPSPP-000676

AEPSPP004054



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
● 96-104	3.0		1.1	NP	NP	NP	
		POORLY GRADED SAND with SILT and GRAVEL SP-SM					

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
● 96-104	3.0	25.000	5.044	0.578	0.202	41.5	53.6	4.9	

PROJECT **SPORN PLANT - FLY ASH POND DIKES**

JOB NO.

DATE **05/21/97**

GRADATION CURVES

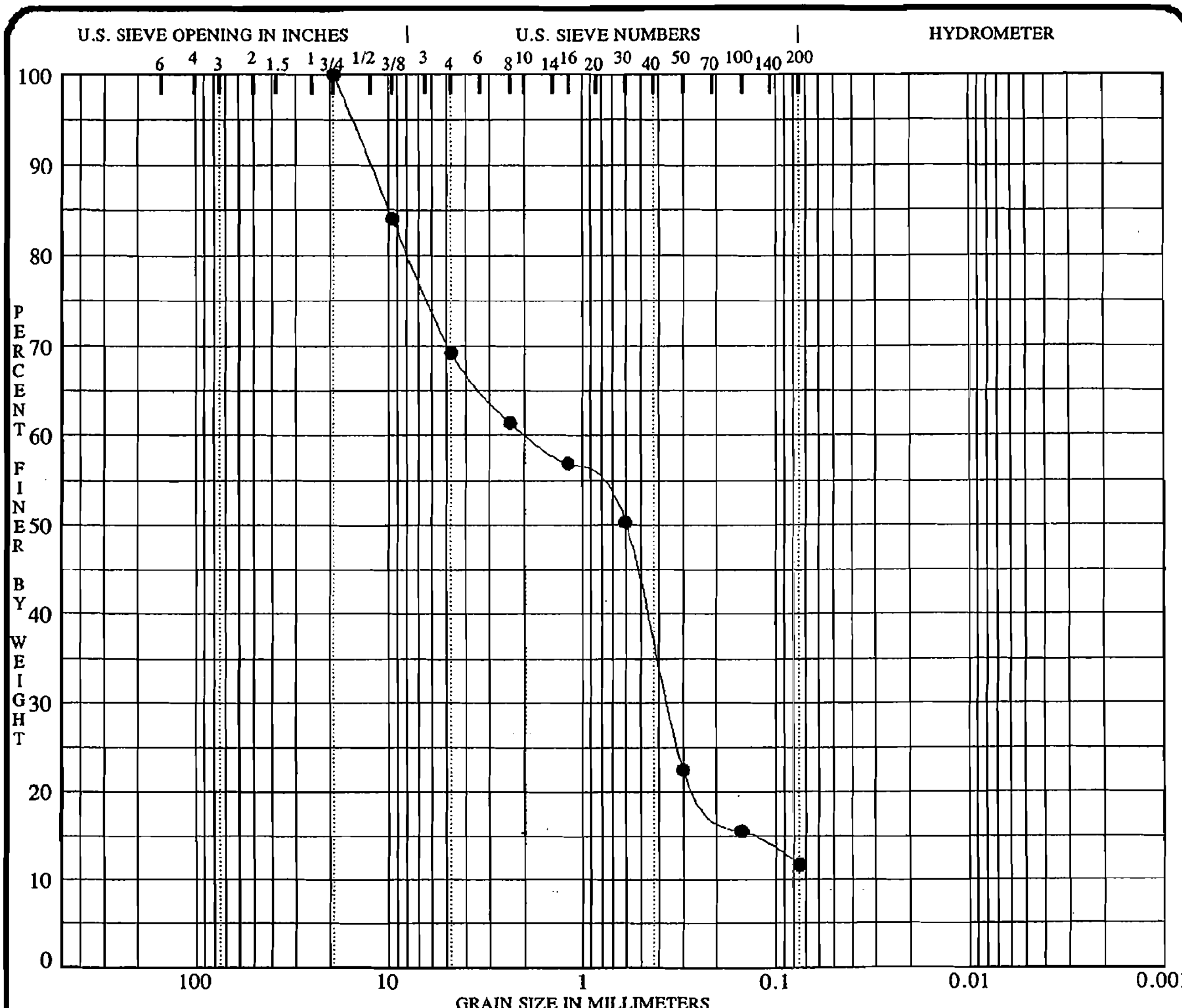
American Electric Power Service Corp.

Groveport, Ohio

AEP

AEPSPP-000677

AEPSPP004055



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
● 96-104	8.5		1.0	NP	NP	NP	
		POORLY GRADED SAND with SILT and GRAVEL SP-SM					

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
● 96-104	8.5	19.000	1.902	0.362		30.8	57.5	11.7	

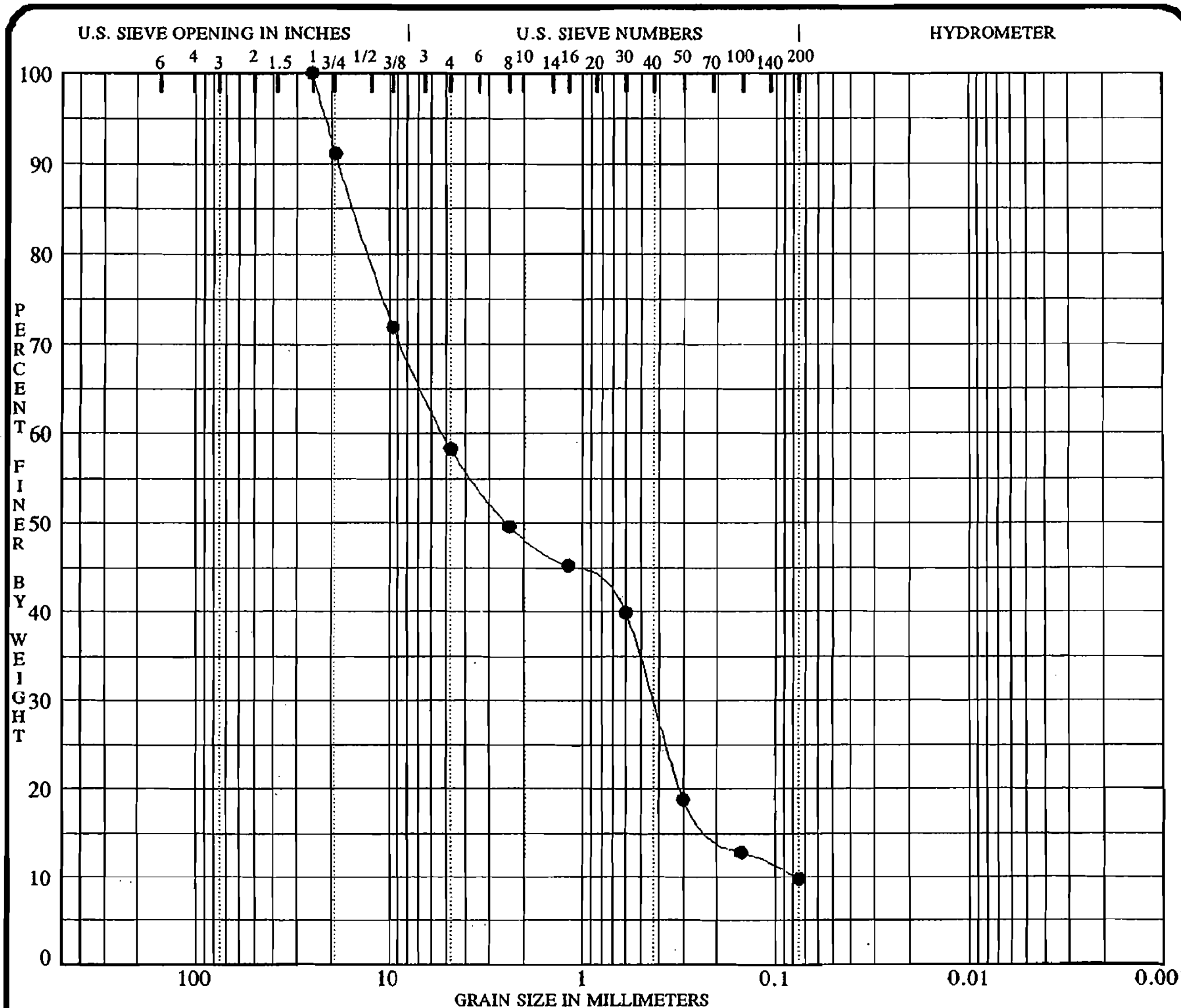
PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO.
DATE 05/21/97

GRADATION CURVES

American Electric Power Service Corp.
Groveport, Ohio

AEP



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-104	11.7		1.2	NP	NP	NP		
	POORLY GRADED SAND with SILT and GRAVEL SP-SM								

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-104	11.7	25.000	5.180	0.433	0.079	41.7	48.5	9.8	

PROJECT **SPORN PLANT - FLY ASH POND DIKES**

JOB NO.

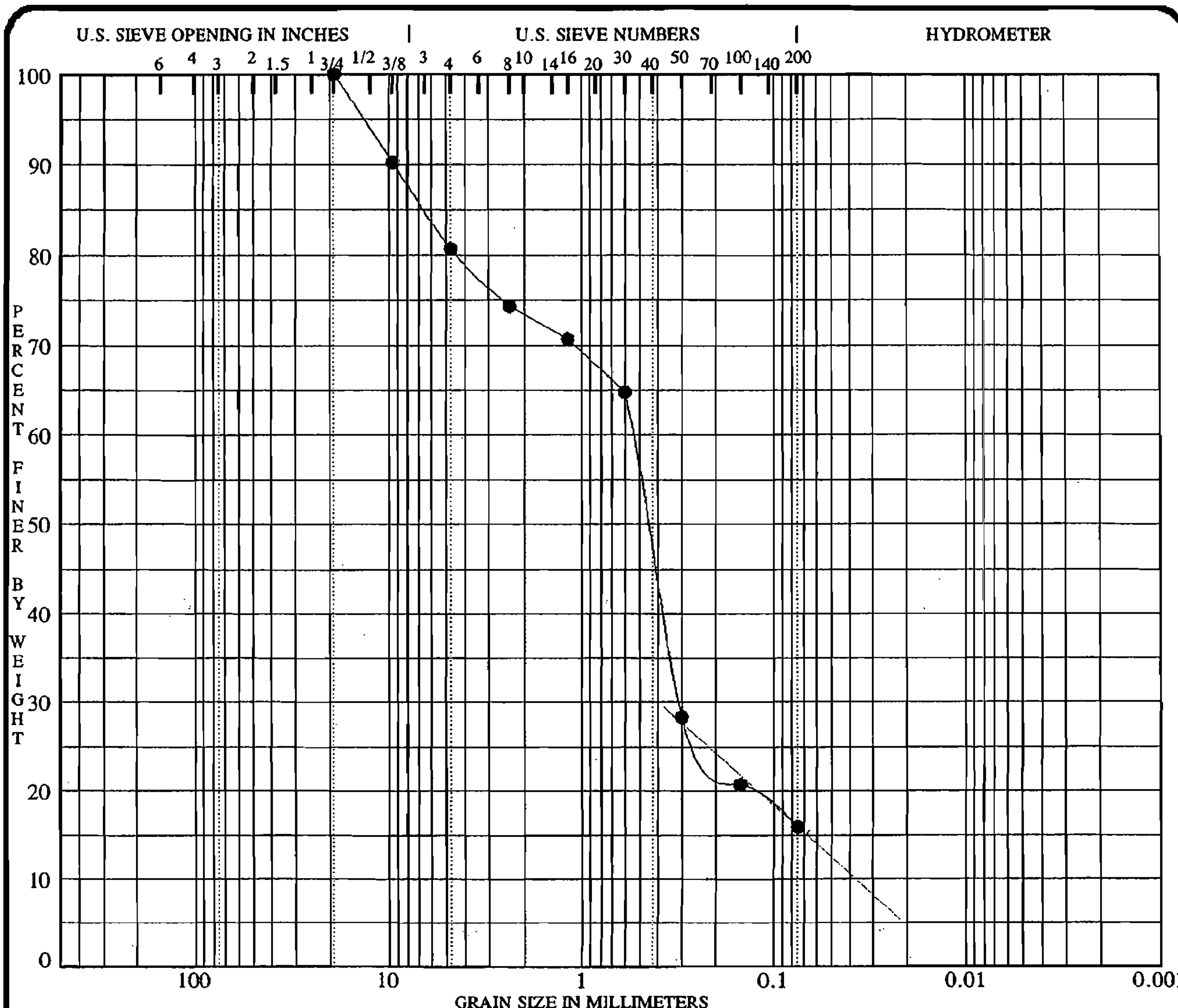
DATE **05/21/97**

GRADATION CURVES

American Electric Power Service Corp.

Groveport, Ohio

AEP



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
● 96-104	16.7		4.0	NP	NP	NP	
		SILTY SAND with GRAVEL SM					

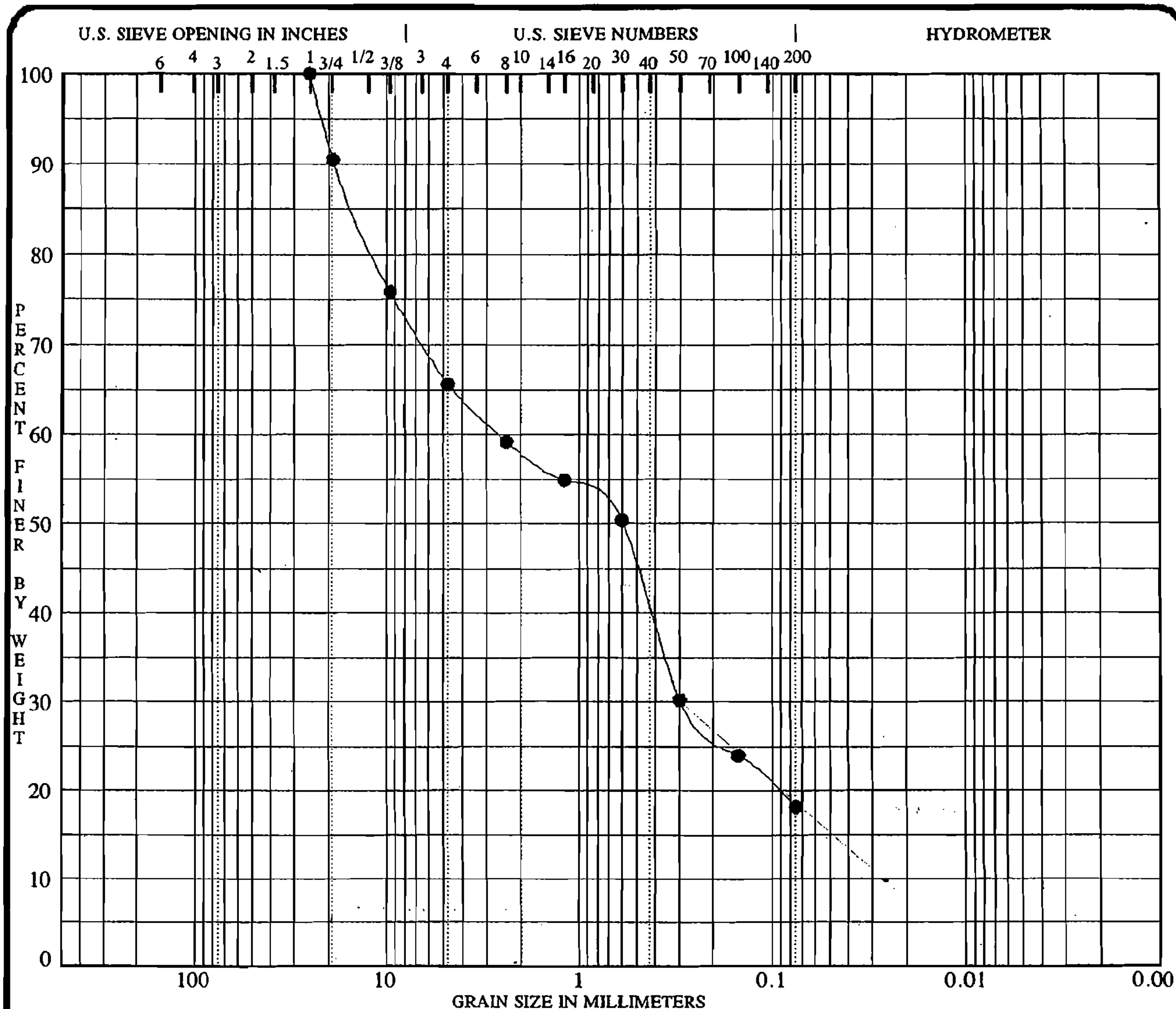
Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% <.002
● 96-104	16.7	19.000	0.548	0.310		19.4	64.7	15.9	

PROJECT SPORN PLANT - FLY ASH POND DIKES
JOB NO.
DATE 05/21/97

GRADATION CURVES

American Electric Power Service Corp.
Groveport, Ohio

AEP



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
●	96-104	21.7		2.9	NP	NP	NP	
			SILTY SAND with GRAVEL SM					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-104	21.7	25.000	2.576	0.293		34.4	47.5	18.1	

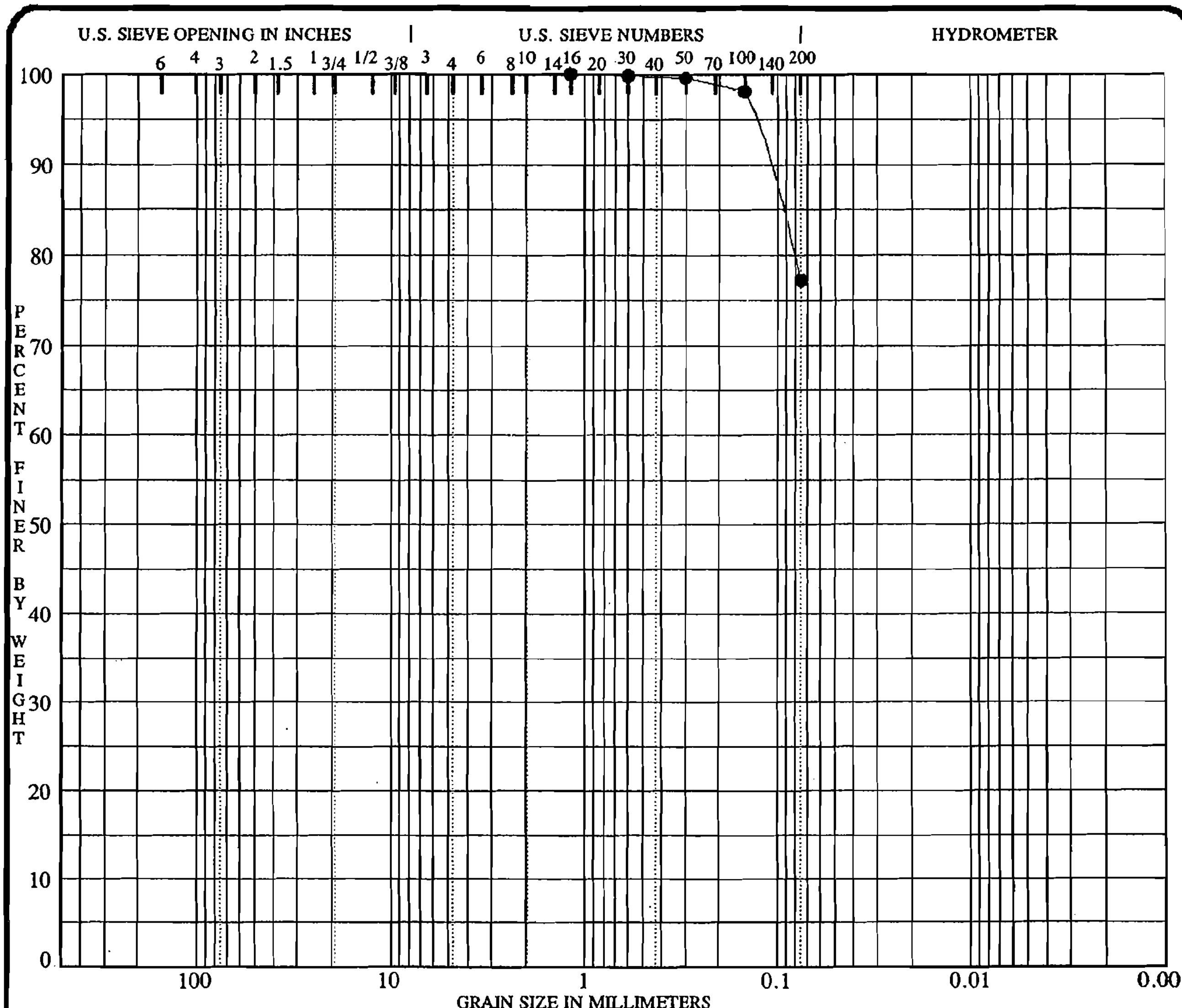
PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO.
DATE 05/21/97

GRADATION CURVES

American Electric Power Service Corp.
Groveport, Ohio

AEP



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-104	36.7		18.9	27.2	19.0	8.2		
			LEAN CLAY with SAND CL						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
●	96-104	36.7	1.180				0.0	22.8	77.2	

PROJECT **SPORN PLANT - FLY ASH POND DIKES**

JOB NO.

DATE 05/21/97

GRADATION CURVES

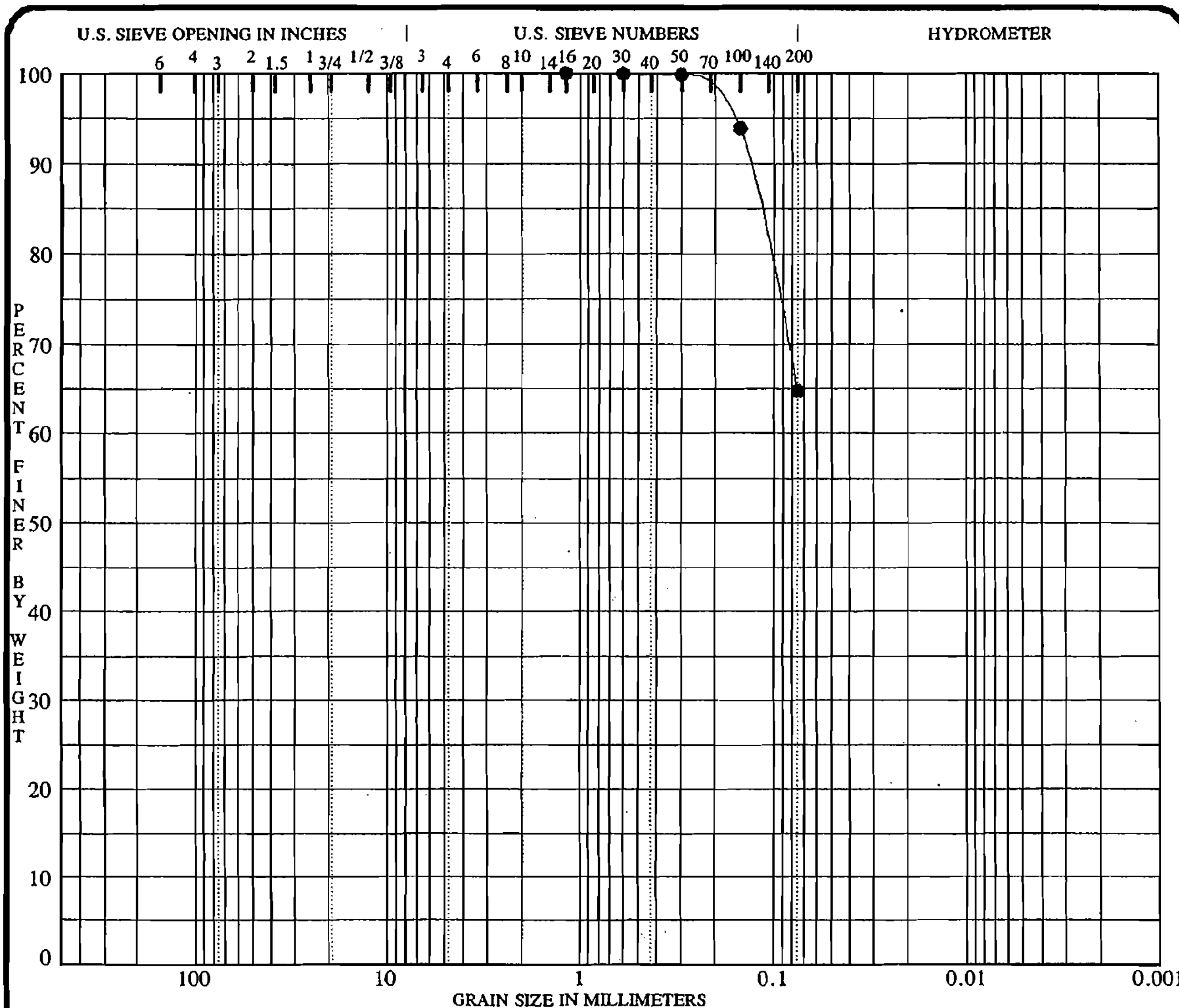
American Electric Power Service Corp.

Groveport, Ohio

AEP

AEPSPP-000682

AEPSPP004060



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-104	41.7		8.1	NP	NP	NP		
			SANDY SILT ML						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-104	41.7	1.180				0.0	35.3	64.7	

PROJECT **SPORN PLANT - FLY ASH POND DIKES**

JOB NO.

DATE **05/21/97**

GRADATION CURVES

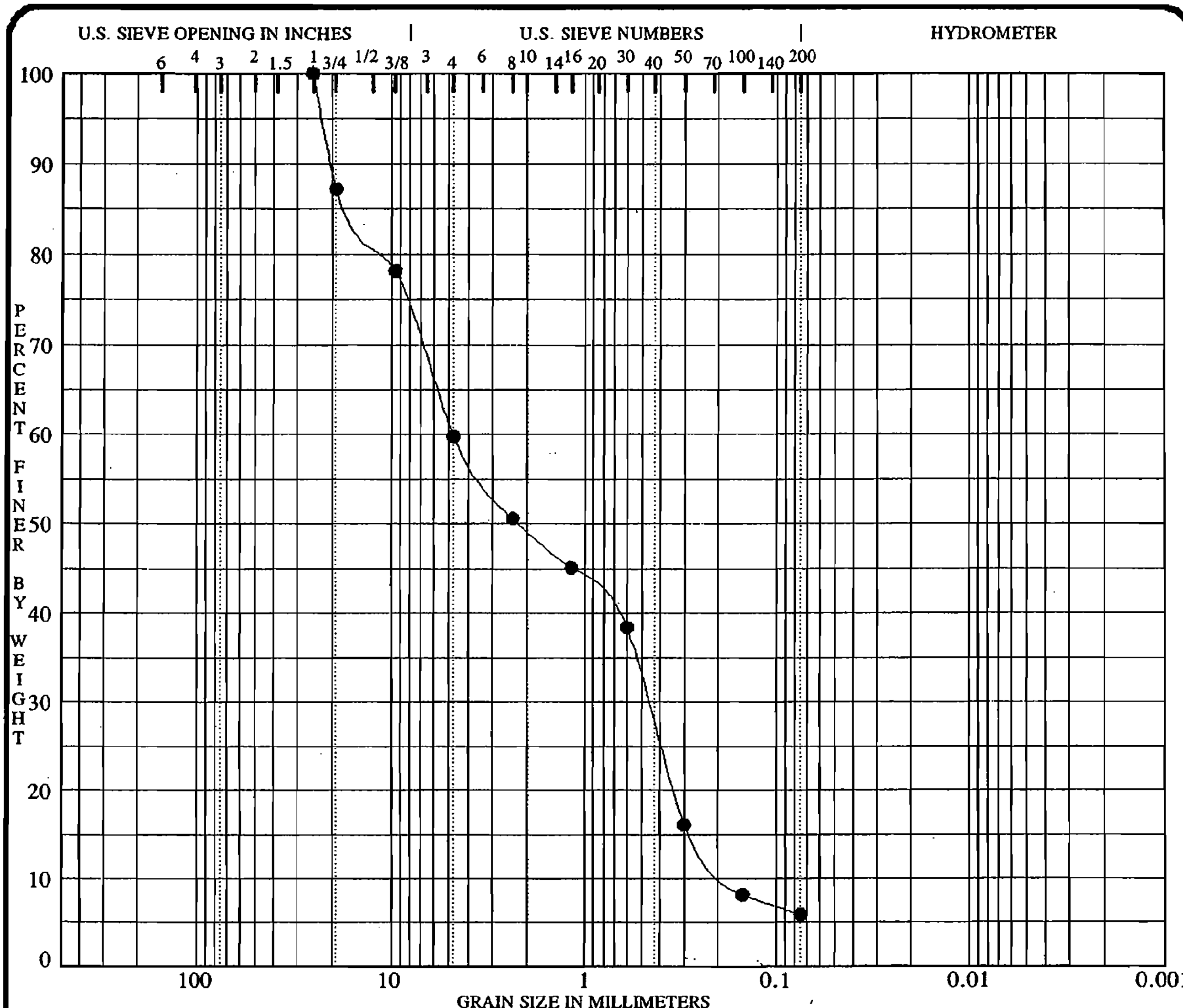
American Electric Power Service Corp.

Groveport, Ohio

AEP

AEPSPP-000683

AEPSPP004061



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-105	3.0		1.6	NP	NP	NP		
	POORLY GRADED SAND with SILT and GRAVEL SP-SM								

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-105	3.0	25.000	4.786	0.462	0.176	40.2	53.9	5.9	

PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO. ______

DATE 05/21/97

GRADATION CURVES

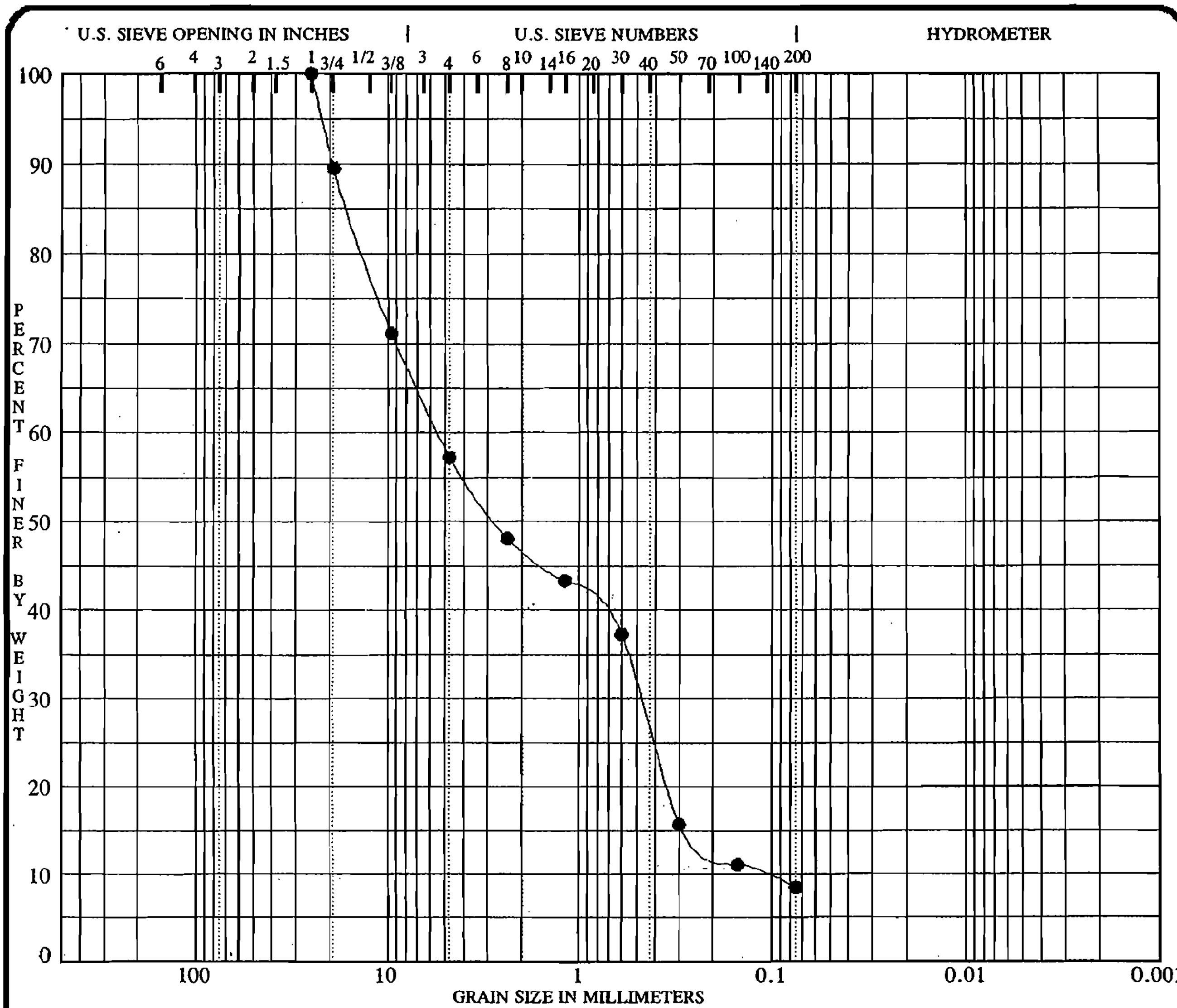
American Electric Power Service Corp.

Groveport, Ohio

AEP

AEPSPP-000684

AEPSPP004062



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
● 96-105	16.5		3.1	NP	NP	NP	
		POORLY GRADED SAND with SILT and GRAVEL SP-SM					

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
● 96-105	16.5	25.000	5.440	0.475	0.112	42.7	48.8	8.5	

PROJECT SPORN PLANT - FLY ASH POND DIKES
JOB NO.
DATE 05/21/97

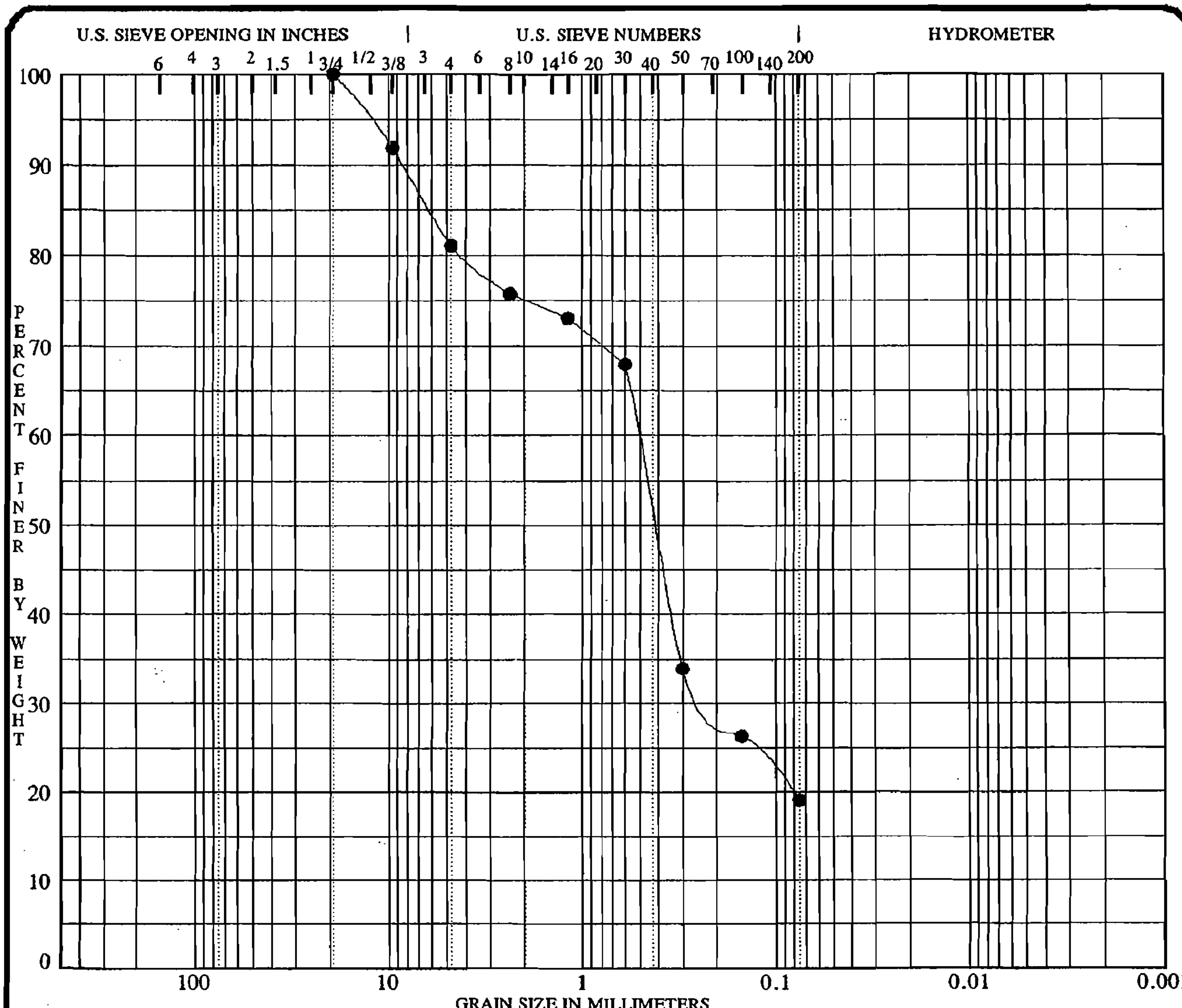
GRADATION CURVES

American Electric Power Service Corp.
Groveport, Ohio

AEP

AEPSPP-000685

AEPSPP004063



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
● 96-105	21.5		6.7	NP	NP	NP	
		SILTY SAND with GRAVEL SM					

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
● 96-105	21.5	19.000	0.511	0.210		19.0	61.9	19.1	

PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO.

DATE 05/21/97

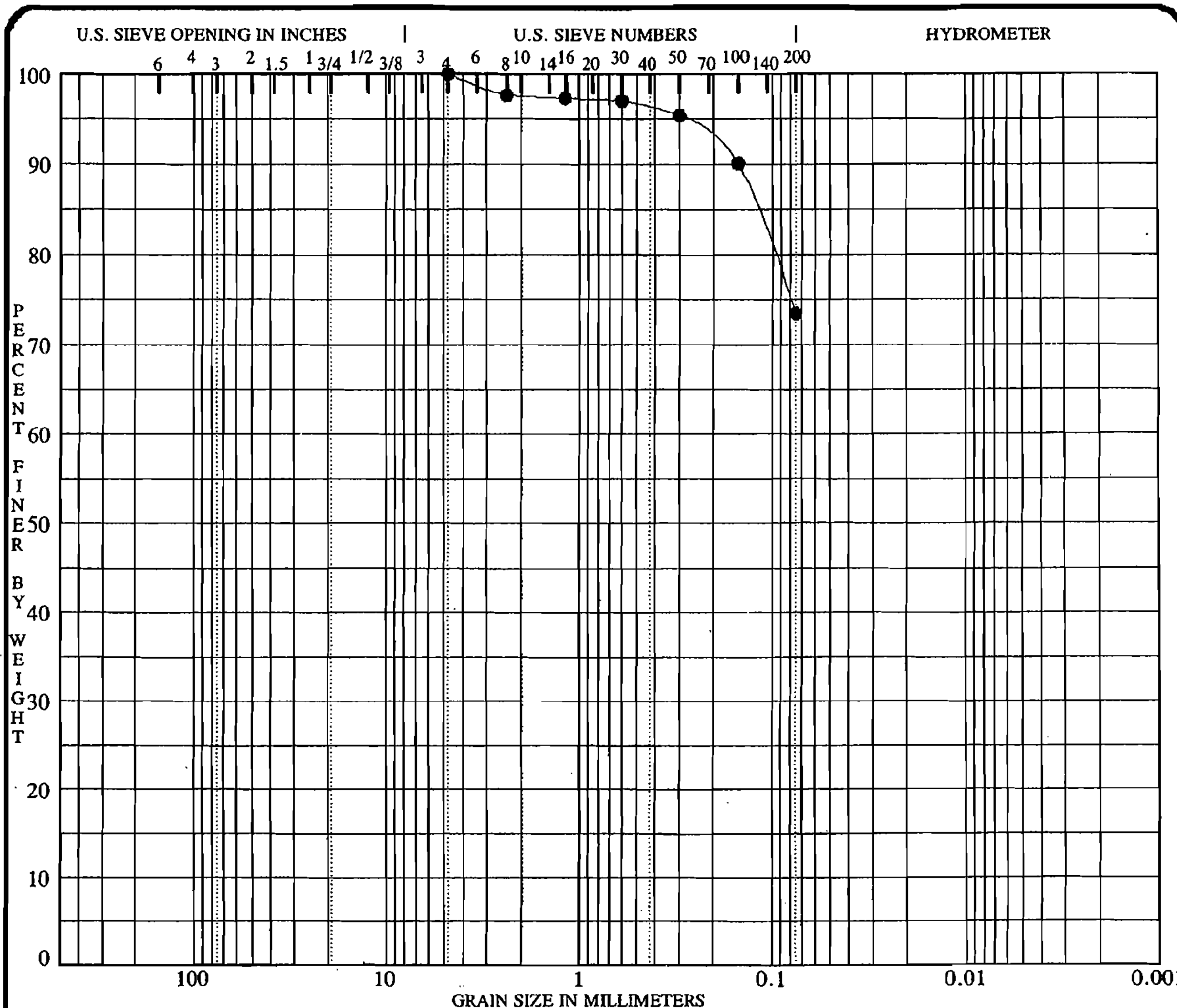
GRADATION CURVES

American Electric Power Service Corp.
Groveport, Ohio

AEP

AEPSPP-000686

AEPSPP004064



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-105	26.5		13.3	27.4	17.7	9.8		
			LEAN CLAY with SAND CL						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-105	26.5	4.750				0.0	26.6	73.4	

PROJECT SPORN PLANT - FLY ASH POND DIKES

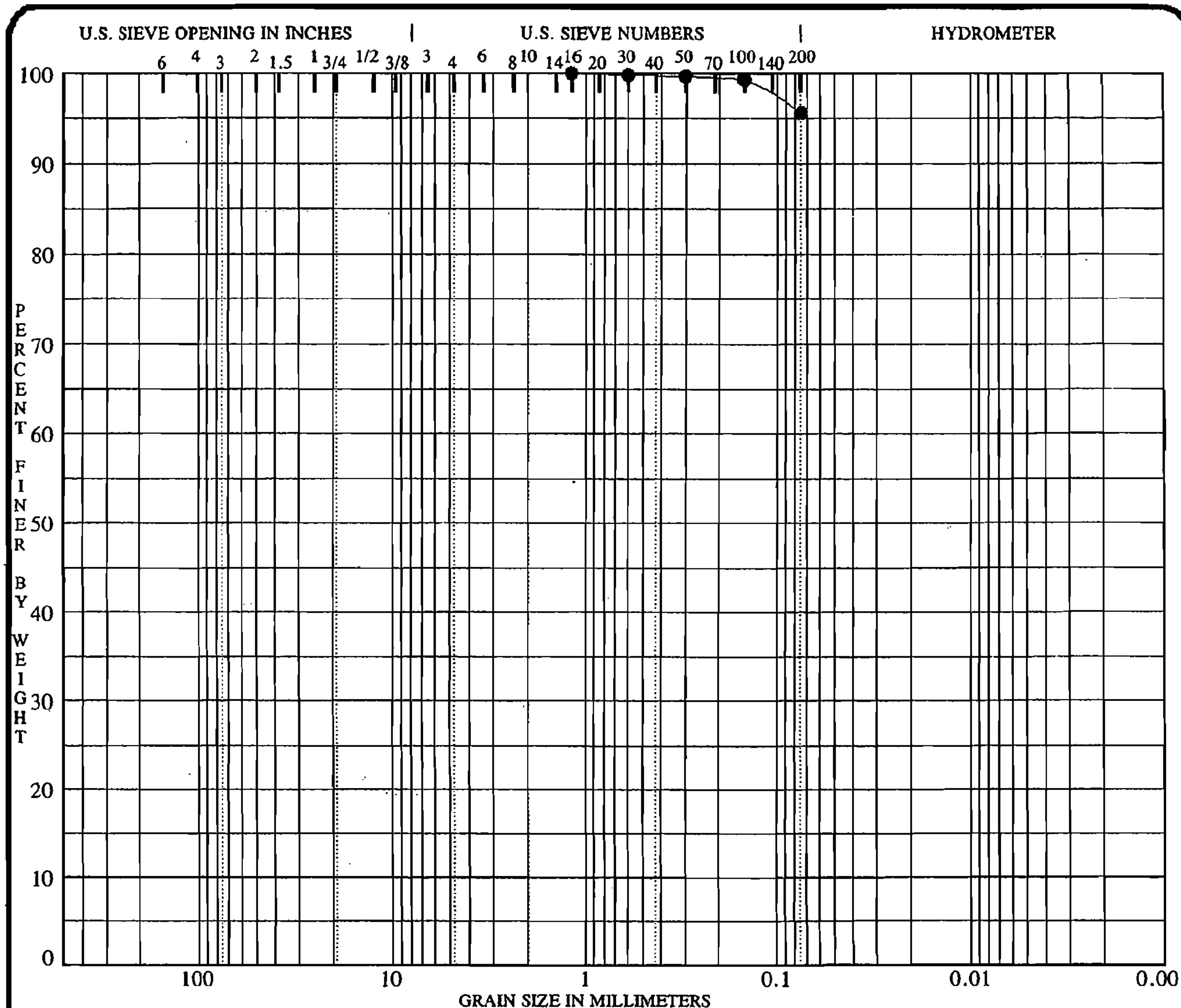
JOB NO.

DATE 05/21/97

GRADATION CURVES

American Electric Power Service Corp.
Groveport, Ohio

AEP



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
● 96-105	36.5		22.1	28.8	18.7	10.1		
		LEAN CLAY CL						

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
● 96-105	36.5	1.180				0.0	4.4	95.6	

PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO.

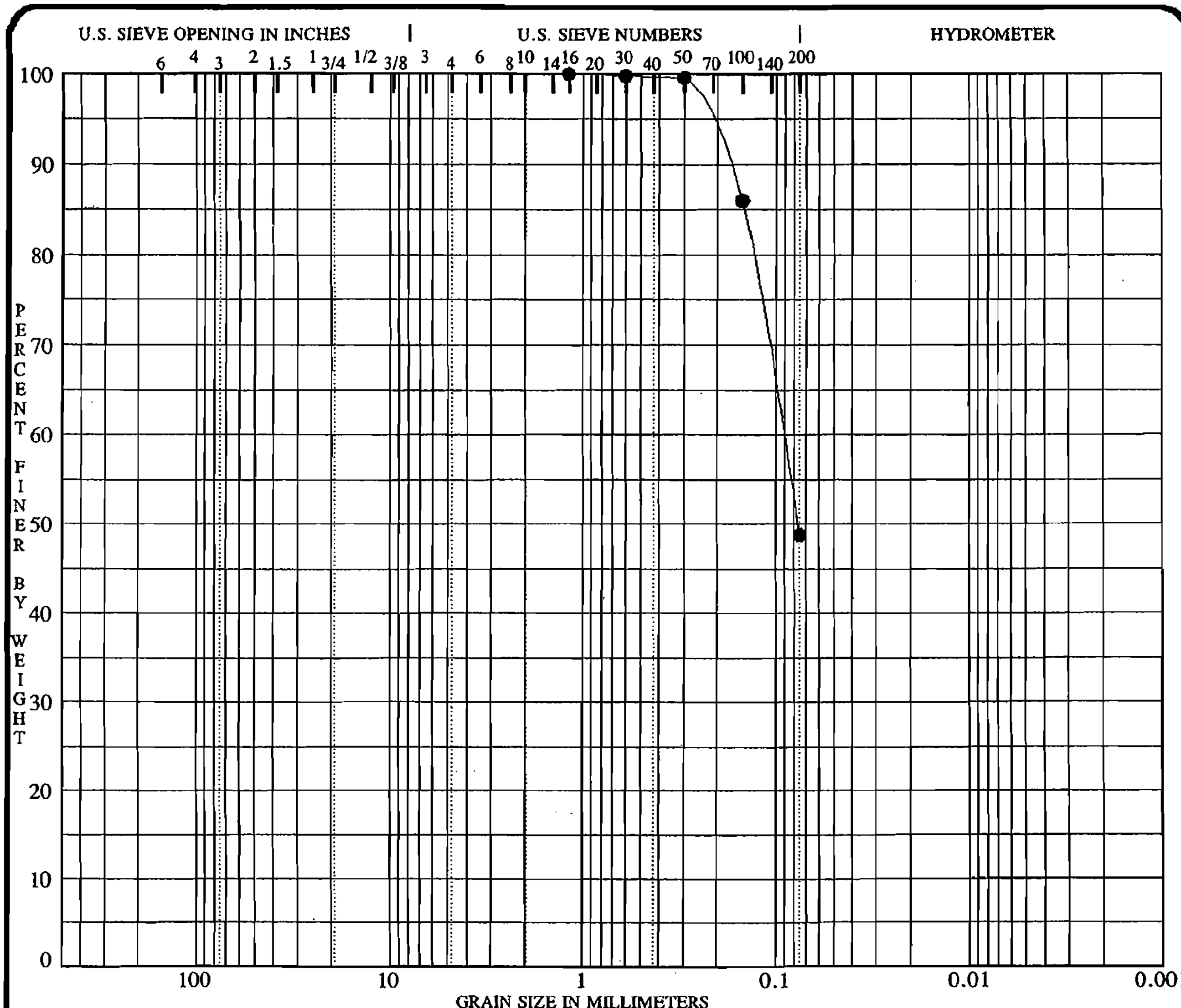
DATE 05/21/97

GRADATION CURVES

American Electric Power Service Corp.
Groveport, Ohio

AEPSPP-000688

AEPSPP004066



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-105	41.5		11.9	NP	NP	NP		
			SILTY SAND SM						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-105	41.5	1.180	0.093			0.0	51.2	48.8	

PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO.

DATE 05/21/97

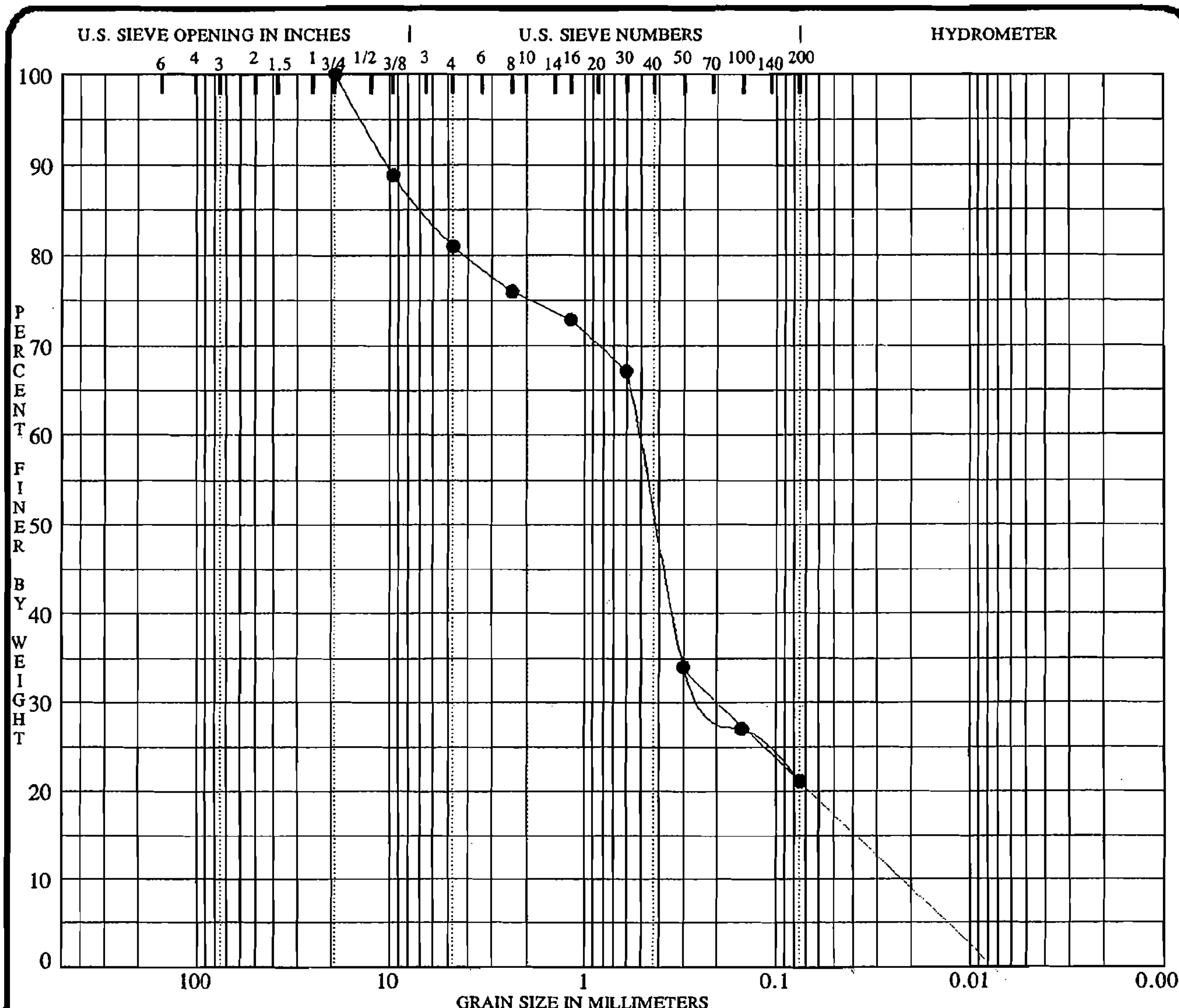
GRADATION CURVES

American Electric Power Service Corp.
Groveport, Ohio

AEP

AEPSPP-000689

AEPSPP004067



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
● 96-106	11.5		5.5	NP	NP	NP	
		SILTY SAND with GRAVEL SM					

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
● 96-106	11.5	19.000	0.517	0.202		19.1	59.8	21.1	

PROJECT **SPORN PLANT - FLY ASH POND DIKES**

JOB NO.
DATE 05/21/97

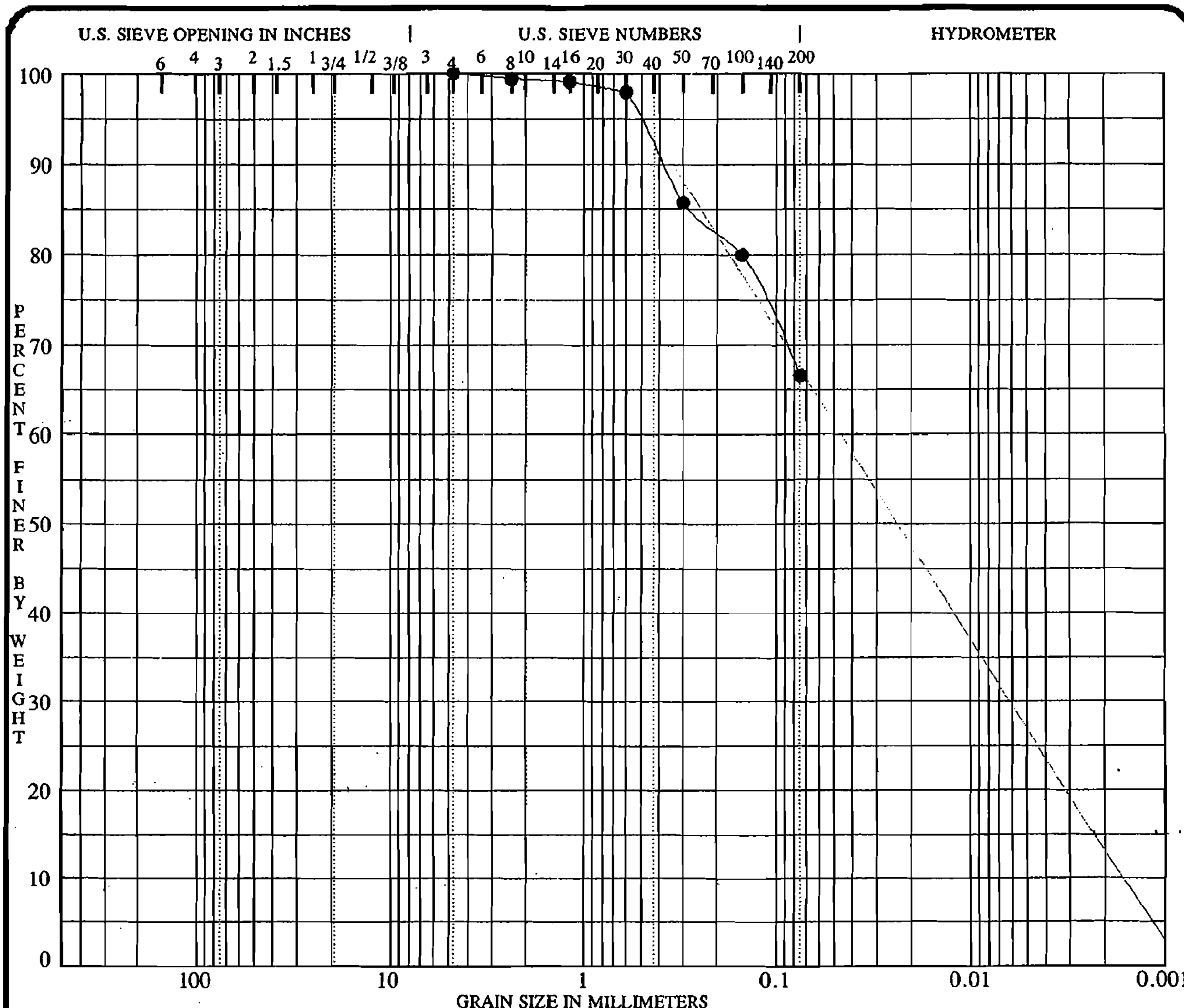
GRADATION CURVES

American Electric Power Service Corp.
Groveport, Ohio

AEP

AEPSPP-000690

AEPSPP004068



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
●	96-106	21.5		11.1	26.1	17.5	8.6	
			SANDY LEAN CLAY CL					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-106	21.5	4.750				0.0	33.4	66.6	

PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO.

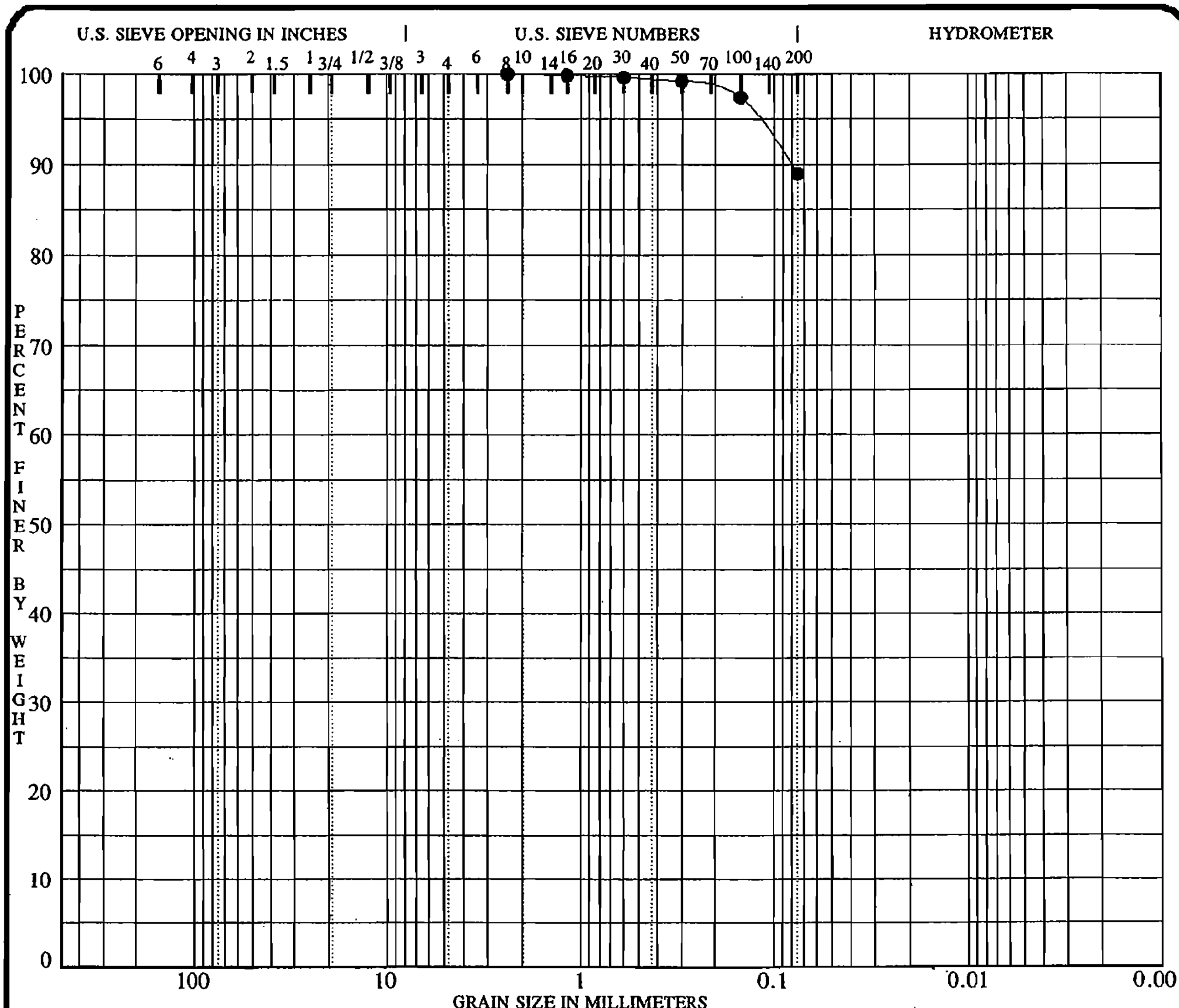
DATE 05/21/97

GRADATION CURVES

American Electric Power Service Corp.

Groveport, Ohio

AEP



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
●	96-106	31.5		42.6	NP	NP	NP	2.29
			SILT ML					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-106	31.5	2.360				0.0	11.1	88.9	

PROJECT **SPORN PLANT - FLY ASH POND DIKES**

JOB NO.
DATE 05/21/97

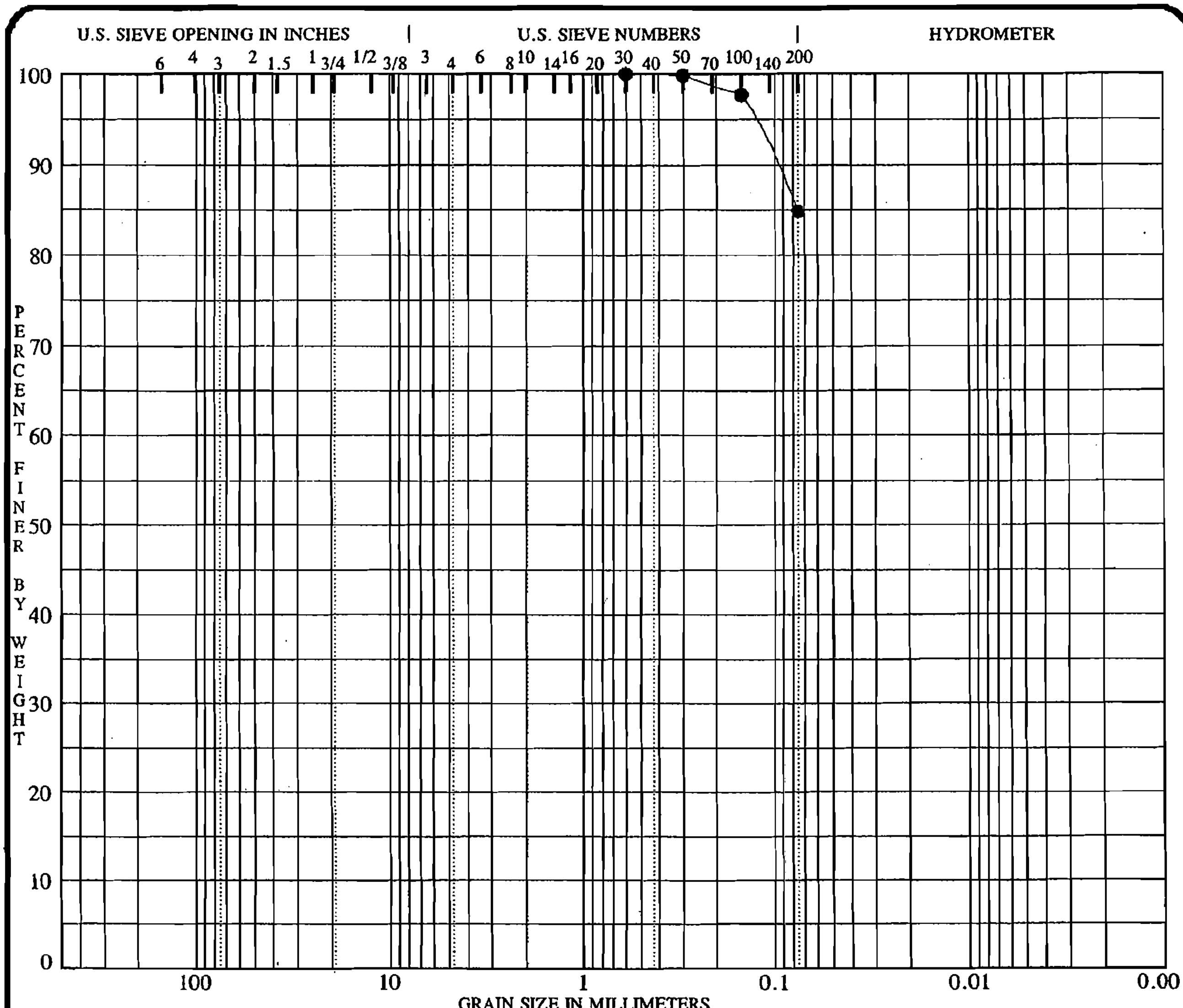
GRADATION CURVES

American Electric Power Service Corp.
Groveport, Ohio

AEP

AEPSPP-000692

AEPSPP004070



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
●	96-106	51.5	SILT with SAND ML	35.7	NP	NP	NP	2.42

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-106	51.5	0.600				0.0	15.2	84.8	

PROJECT SPORN PLANT - FLY ASH POND DIKES

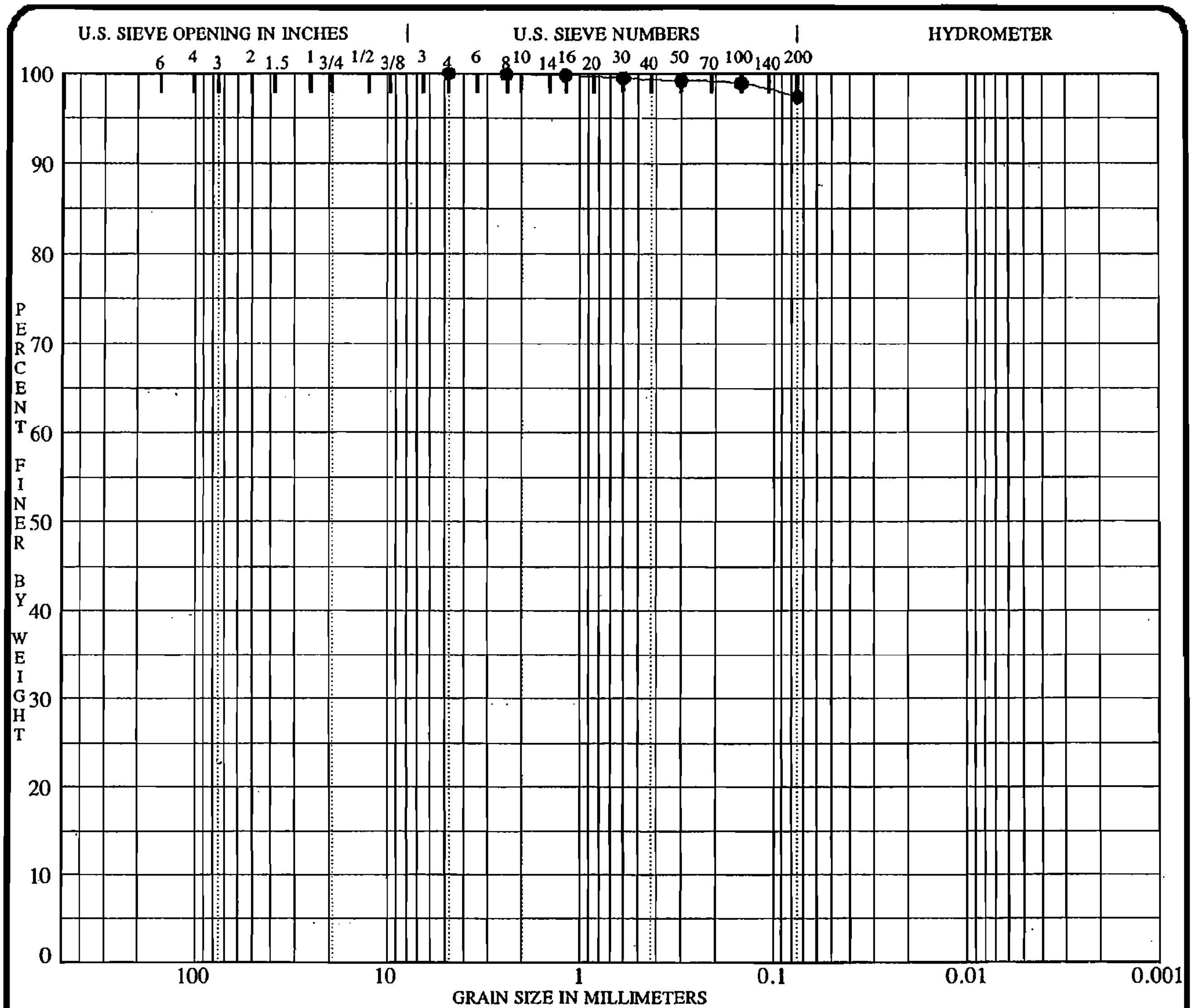
JOB NO.

DATE 05/21/97

GRADATION CURVES

American Electric Power Service Corp.
Groveport, Ohio

AEP



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-106	56.5		31.9	43.6	25.6	18.0		
			LEAN CLAY CL						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-106	56.5	4.750				0.0	2.6	97.4	

PROJECT SPORN PLANT - FLY ASH POND DIKES JOB NO.
DATE 05/21/97

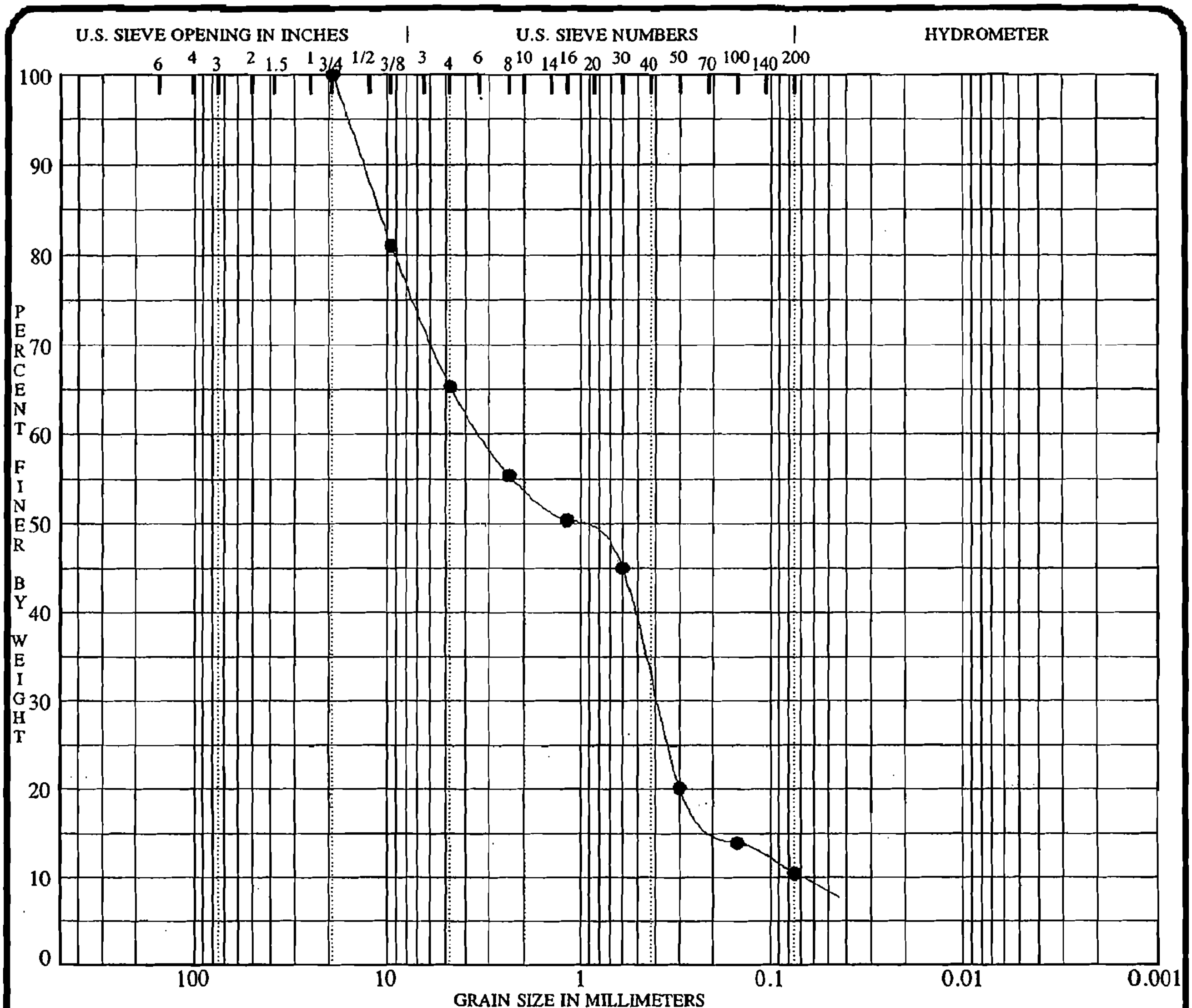
GRADATION CURVES

American Electric Power Service Corp.
Groveport, Ohio

AEP

AEPSPP-000694

AEPSPP004072



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
●	96-107	11.6		3.9	NP	NP	NP	
			POORLY GRADED SAND with SILT and GRAVEL SP-SM					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-107	11.6	19.000	3.266	0.395		34.7	54.9	10.4	

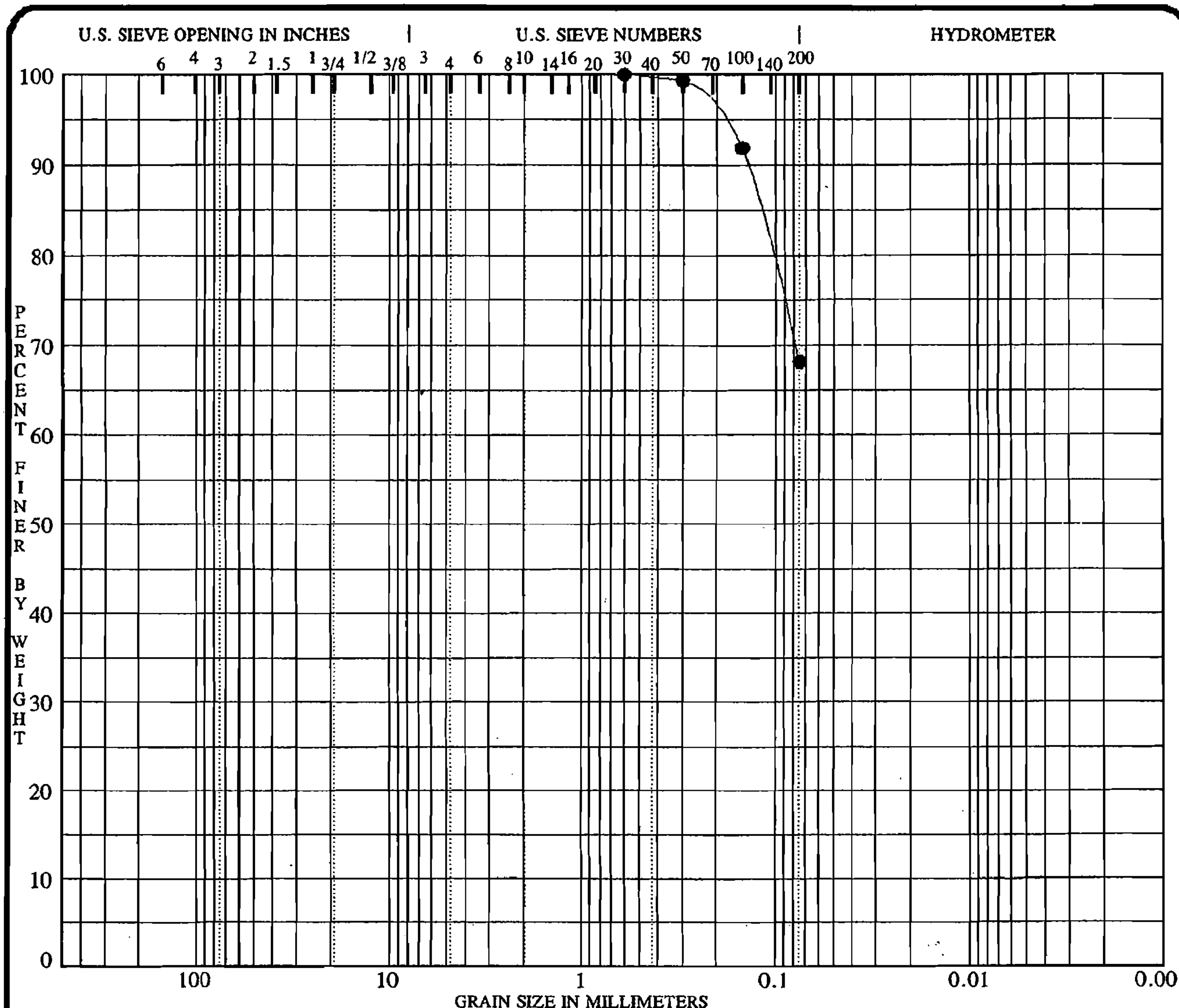
PROJECT **SPORN PLANT - FLY ASH POND DIKES** JOB NO.
DATE **05/21/97**

GRADATION CURVES

American Electric Power Service Corp.
Groveport, Ohio

AEP

AEPSPP-000695



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-107	16.6		14.0	25.2	18.1	7.1		
			SANDY LEAN CLAY CL						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-107	16.6	0.600				0.0	31.9	68.1	

PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO.

DATE 05/21/97

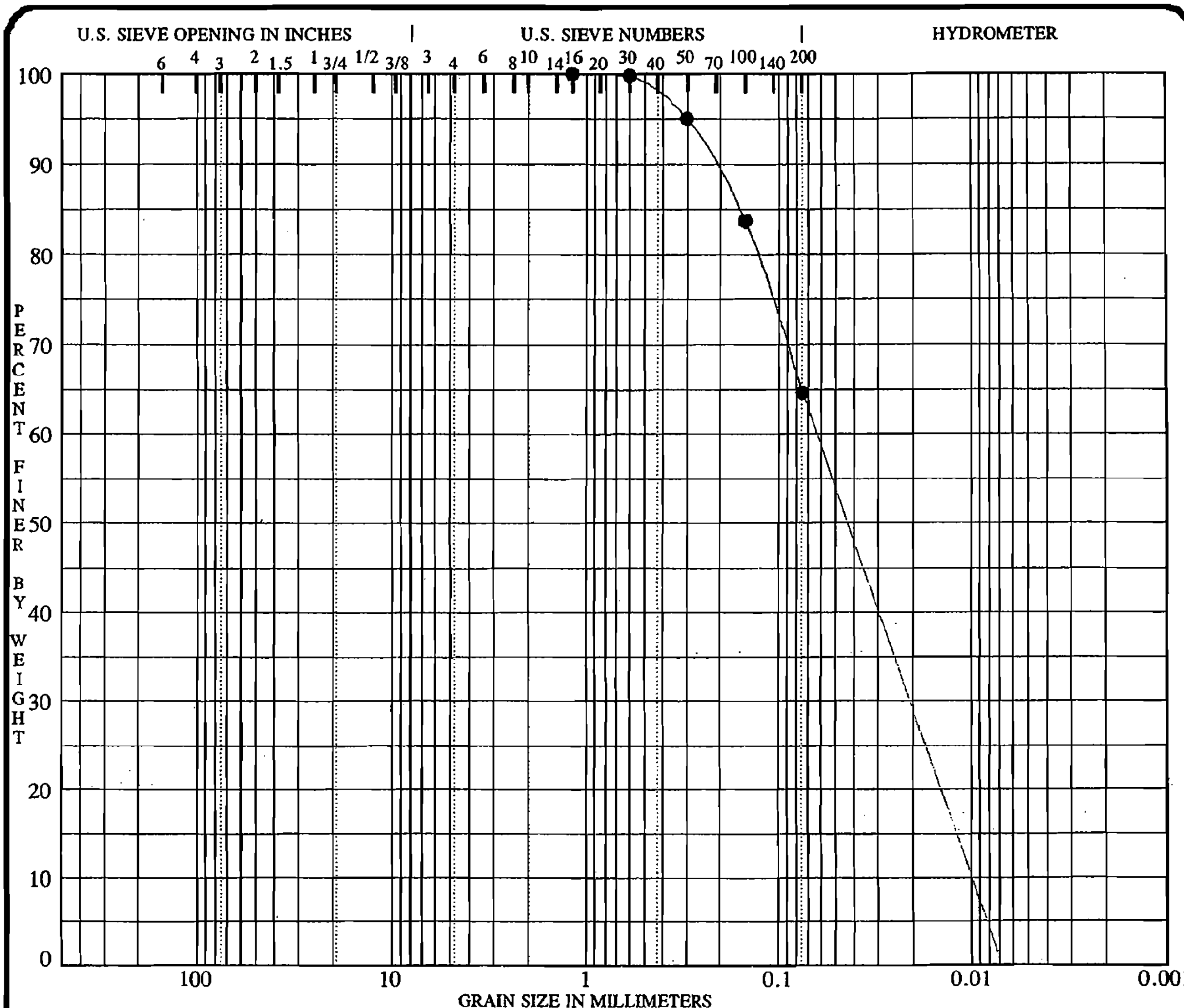
GRADATION CURVES

American Electric Power Service Corp.

Groveport, Ohio

AEPSPP-000696

AEPSPP004074



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
● 96-107	21.6		11.4	NP	NP	NP		
		SANDY SILT ML						

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
● 96-107	21.6	1.180				0.0	35.4	64.6	

PROJECT **SPORN PLANT - FLY ASH POND DIKES**

JOB NO. ____________

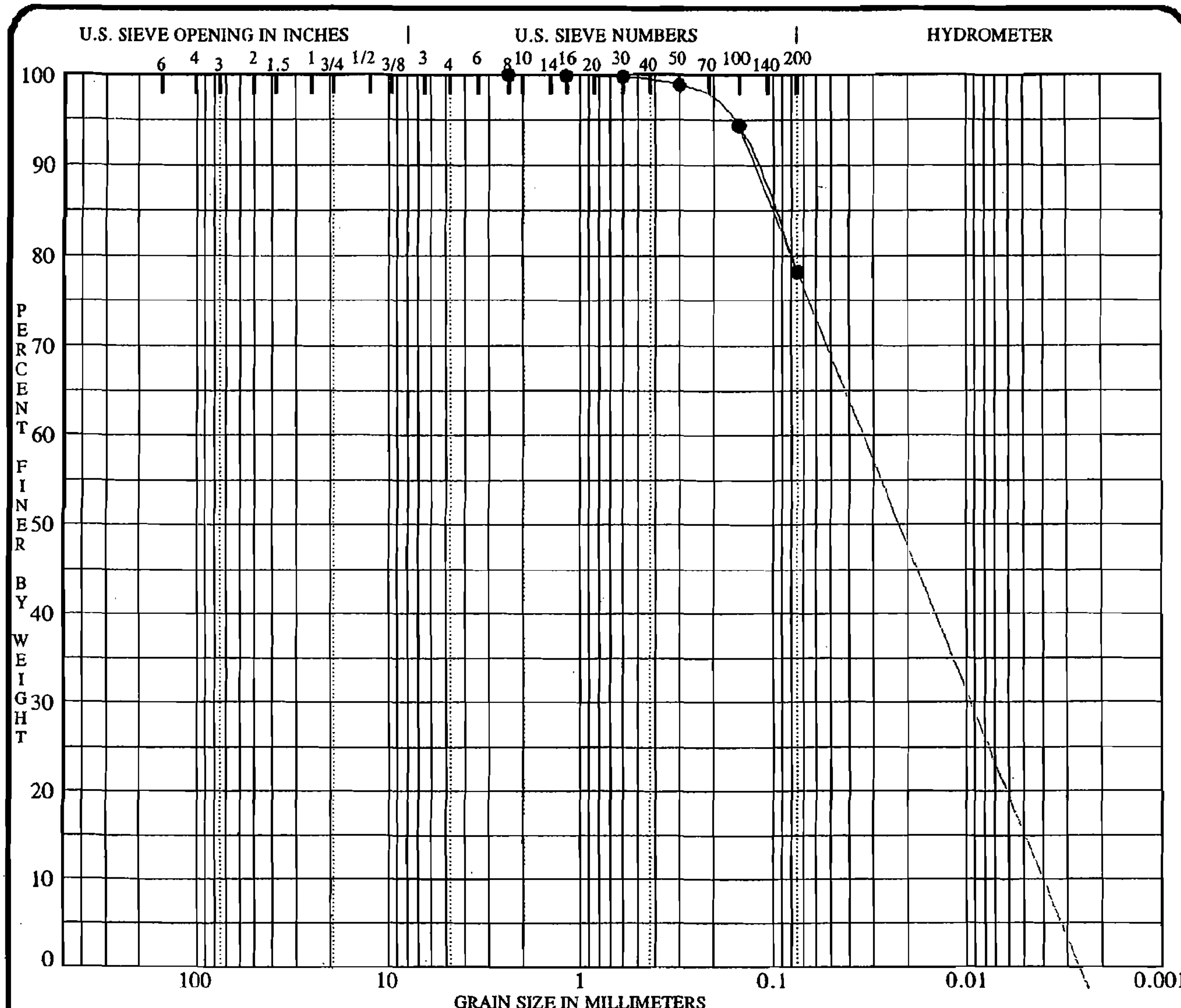
DATE **05/21/97**

GRADATION CURVES

American Electric Power Service Corp.

Groveport, Ohio

AEP



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-107	36.6	SILT with SAND ML	37.6	NP	NP	NP	2.38	

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-107	36.6	2.360				0.0	21.9	78.1	

PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO.

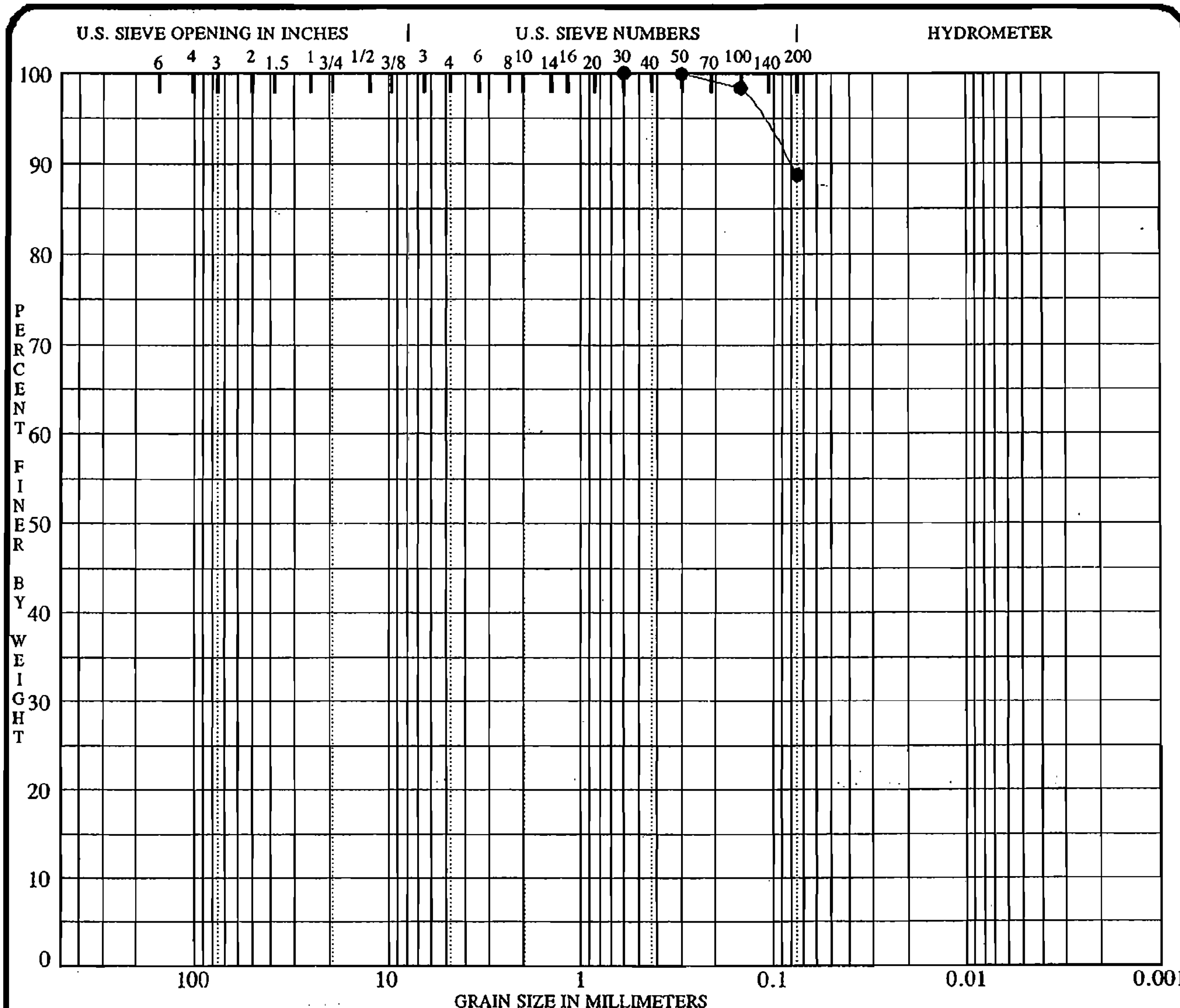
DATE 05/21/97

GRADATION CURVES

American Electric Power Service Corp.

Groveport, Ohio

AEP



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
●	96-107	56.6		36.2	NP	NP	NP	2.31
			SILT ML					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-107	56.6	0.600				0.0	11.3	88.7	

PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO.
DATE 05/21/97

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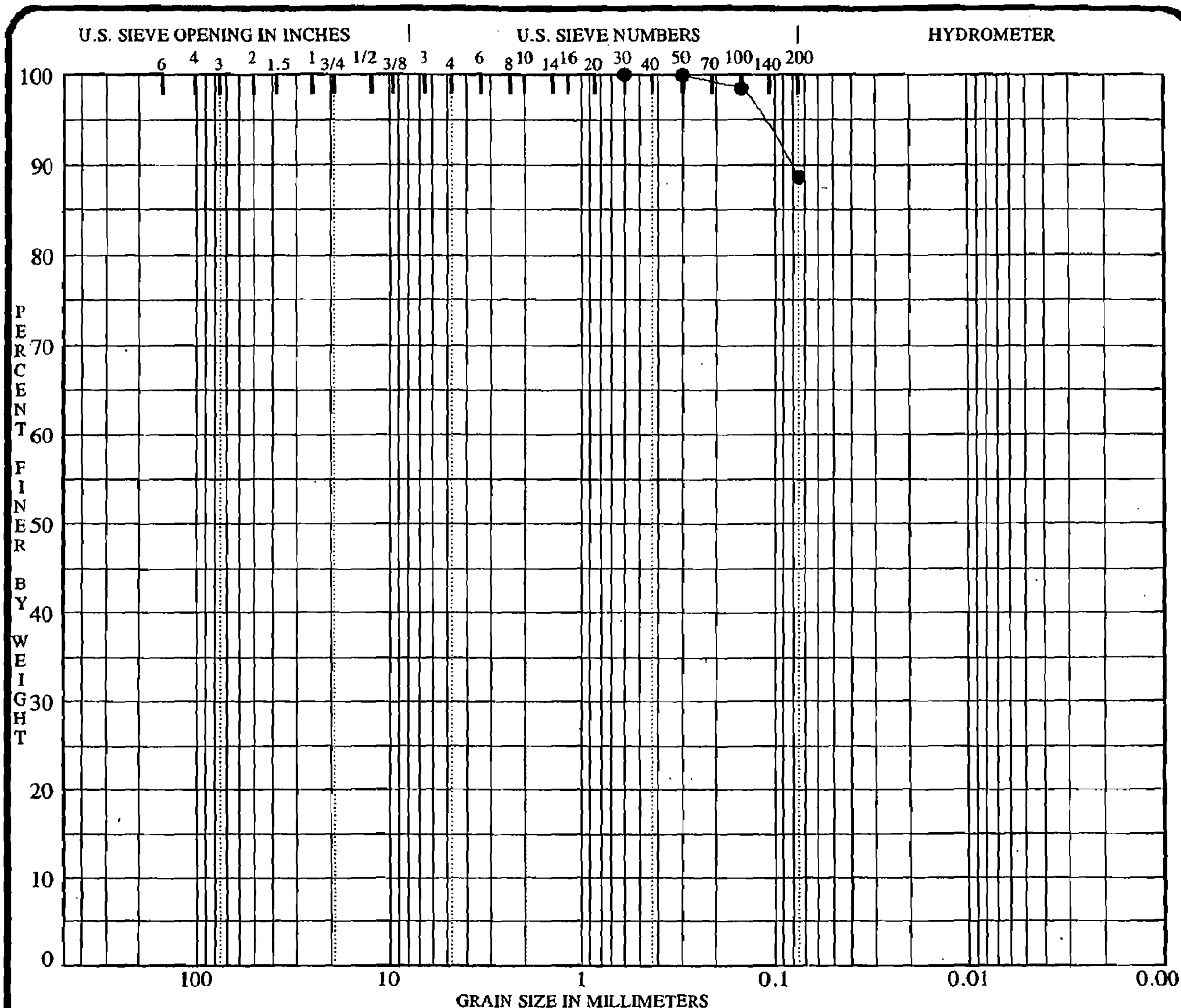
AEPSPP-000699

AEPSPP004077



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
● 96-107	71.6	LEAN CLAY CL	25.2	41.3	21.1	20.2	

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
● 96-107	71.6	0.600				0.0	11.4	88.6	

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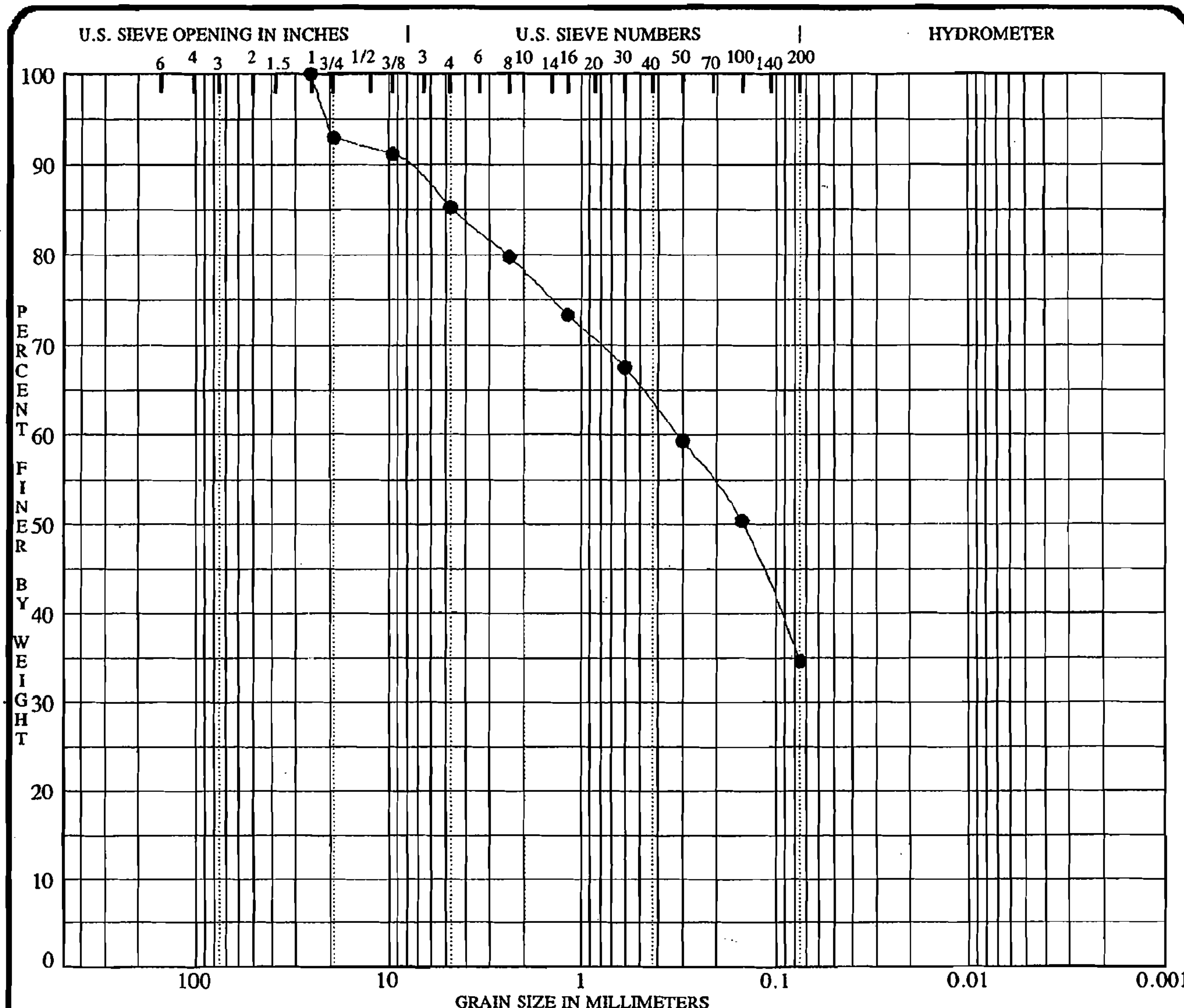

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-108	3.0		9.1	NP	NP	NP		
			SILTY SAND with GRAVEL SM						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-108	3.0	25.000	0.318			14.8	50.6	34.6	

PROJECT SPORN PLANT - FLY ASH POND DIKES

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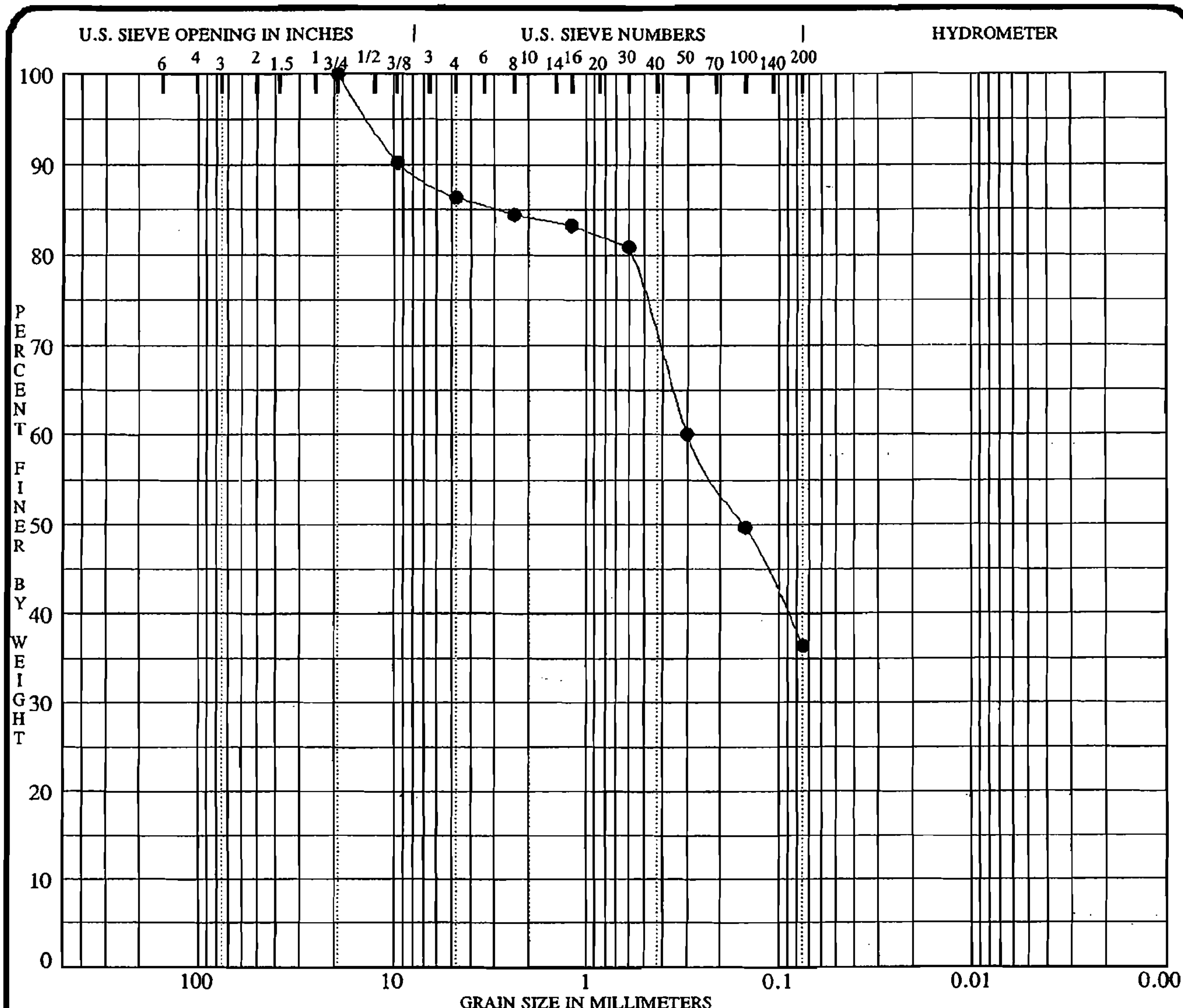

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification			Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-108	8.5		6.2	NP	NP	NP		
			SILTY SAND SM						

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-108	8.5	19.000	0.298			13.7	49.9	36.4	

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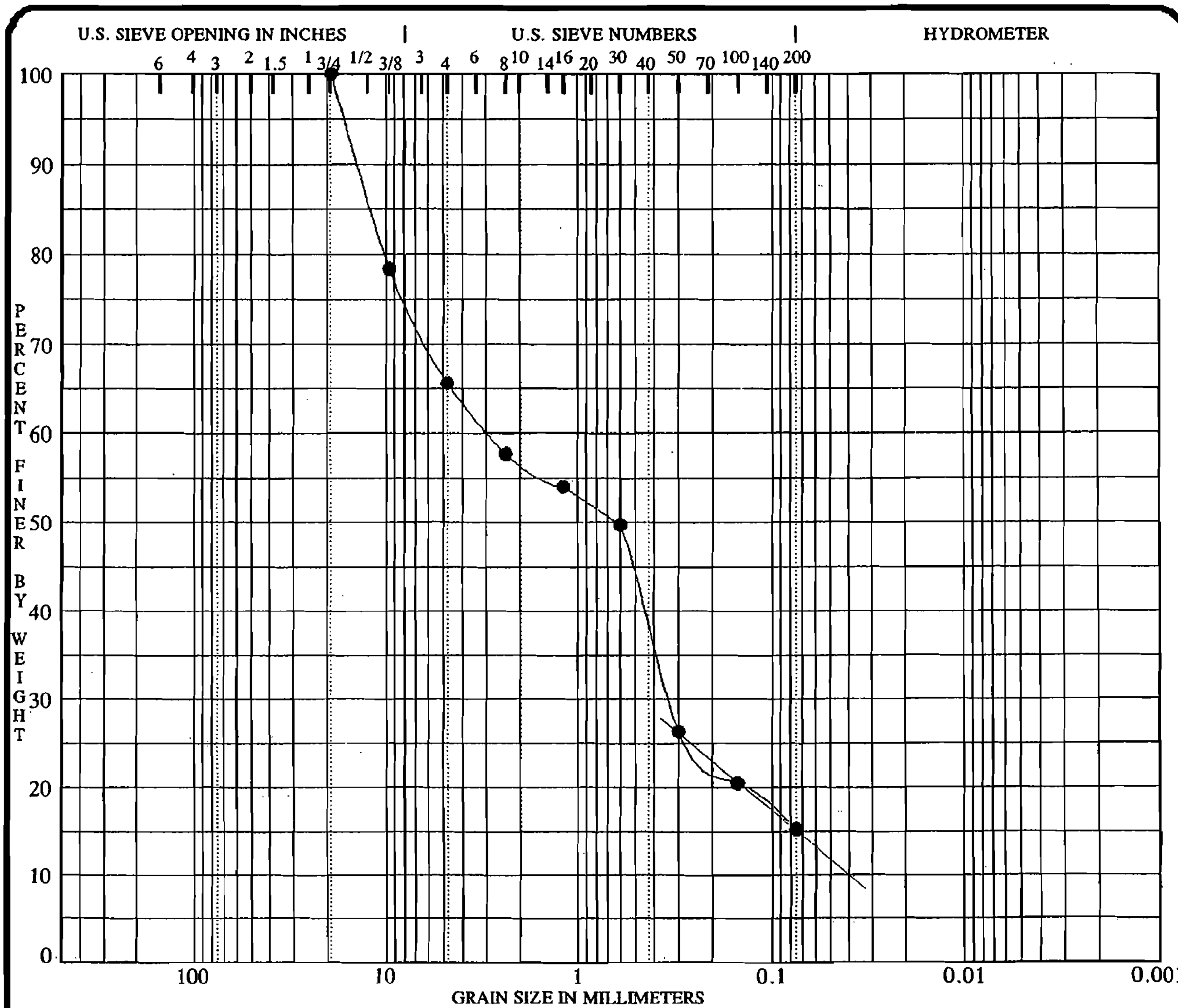

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-108	11.6		3.0	NP	NP	NP		
			SILTY SAND with GRAVEL SM						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
●	96-108	11.6	19.000	2.893	0.335		34.4	50.4	15.2	

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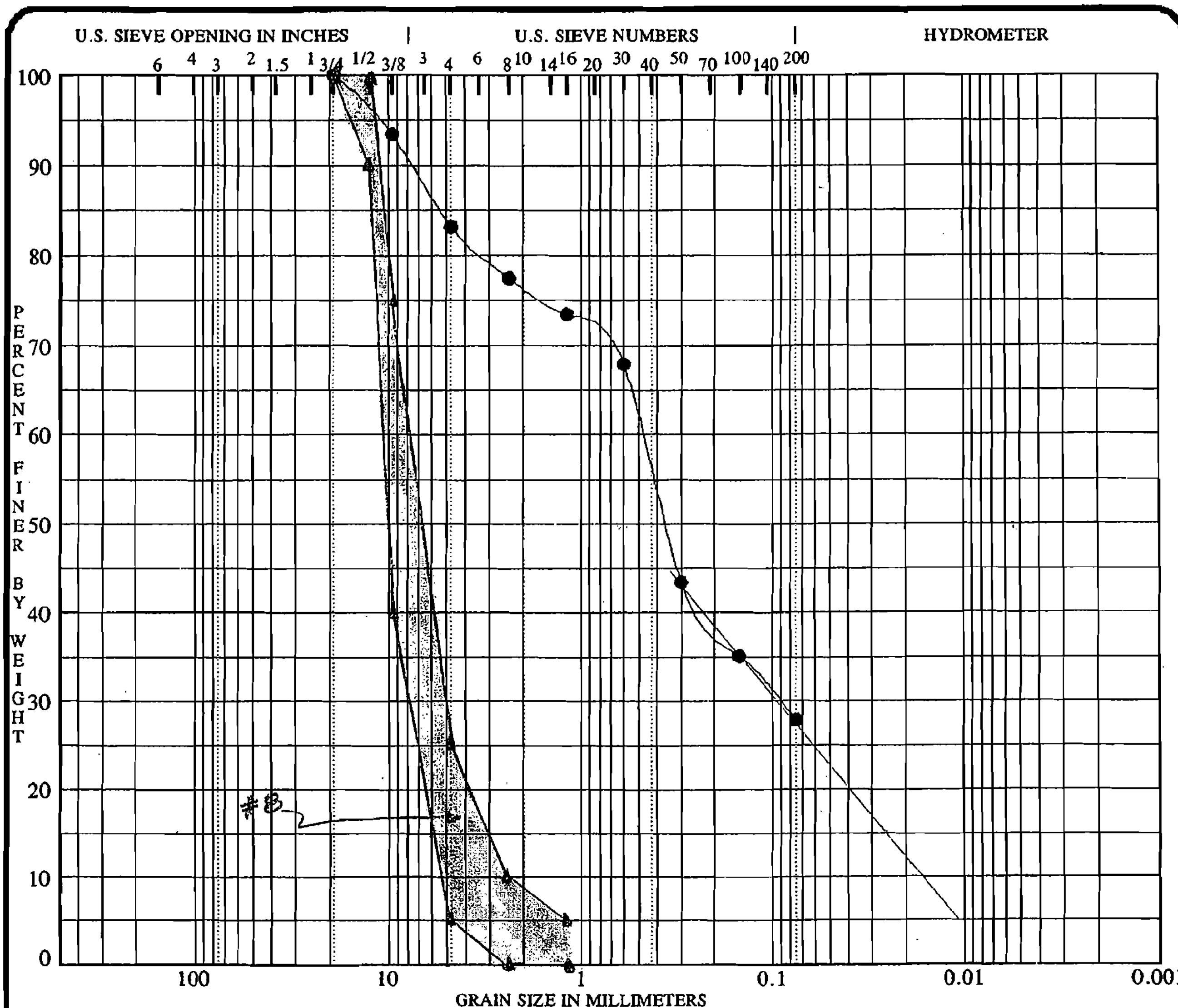

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
●	96-108	16.6		1.9	NP	NP	NP	
			SILTY SAND with GRAVEL SM					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
●	96-108	16.6	19.000	0.480	0.092		16.9	55.3	27.8	

PROJECT SPORN PLANT - FLY ASH POND DIKES

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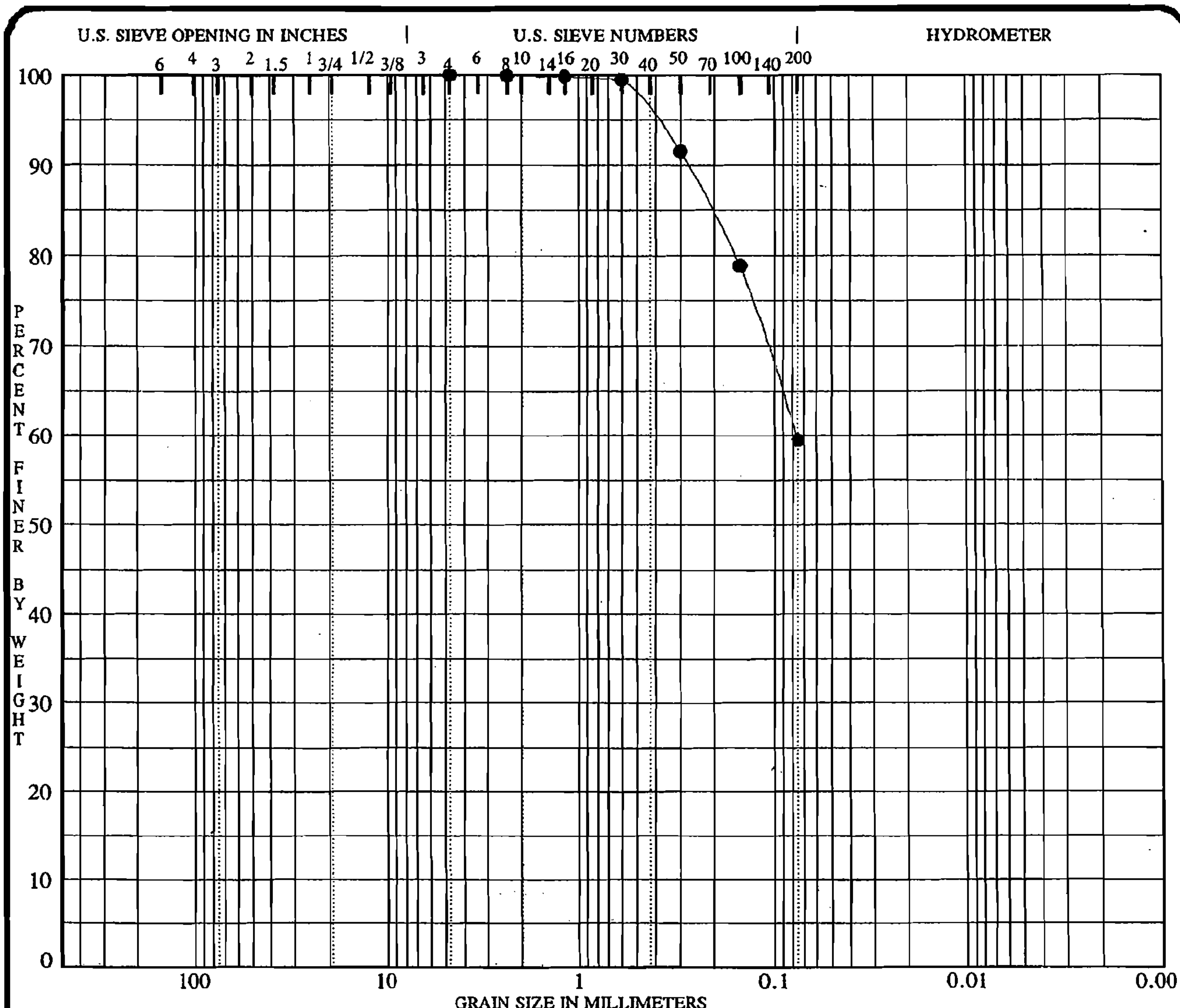
AEPSPP004082



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
●	96-108	21.6		12.2	23.3	16.5	6.7	
			SANDY SILTY CLAY CL-ML					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
●	96-108	21.6	4.750	0.076			0.0	40.5	59.5	

PROJECT **SPORN PLANT - FLY ASH POND DIKES**

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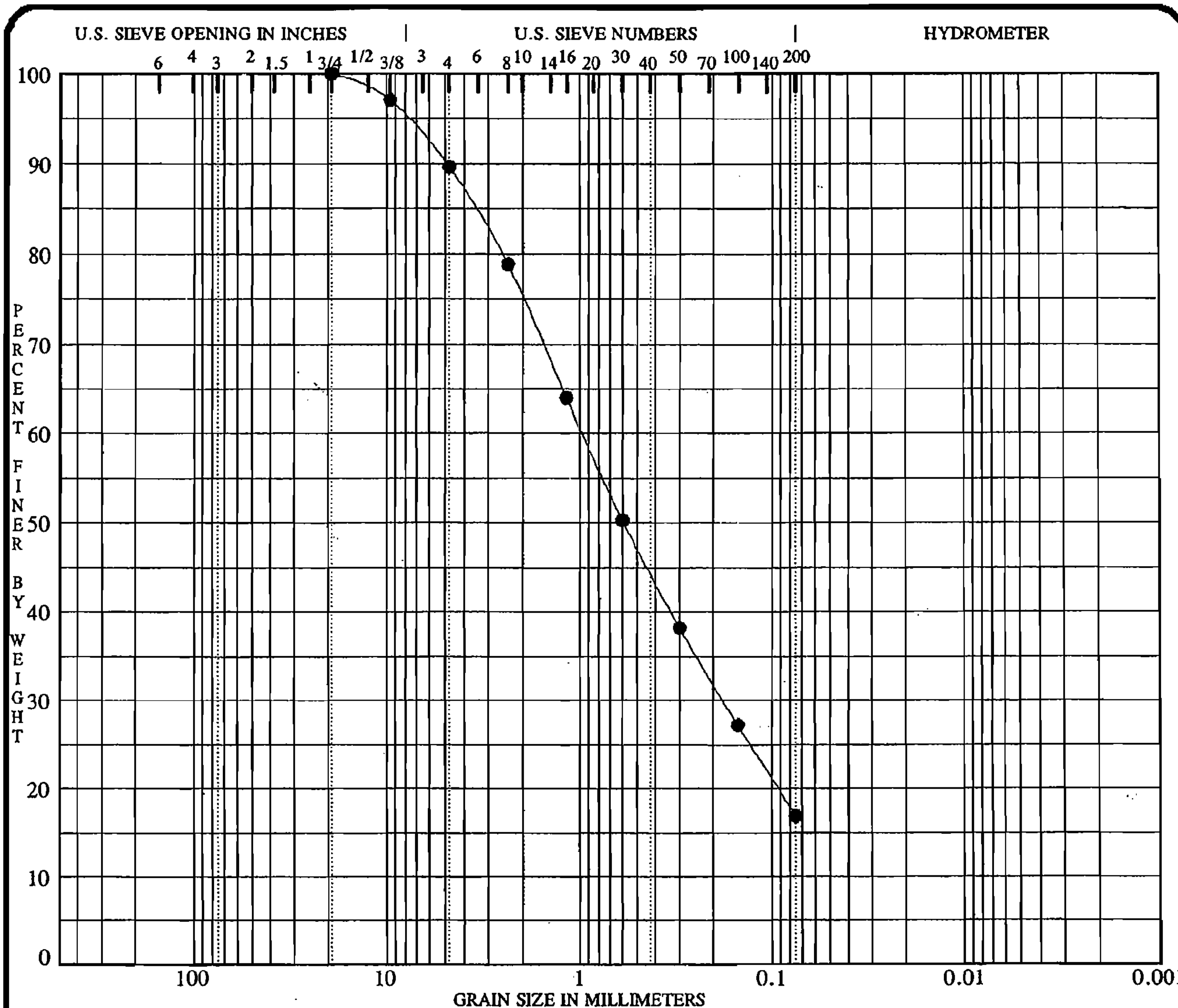

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-108	26.6		20.6	NP	NP	NP		
			SILTY SAND SM						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
●	96-108	26.6	19.000	0.969	0.179		10.4	72.7	16.9	

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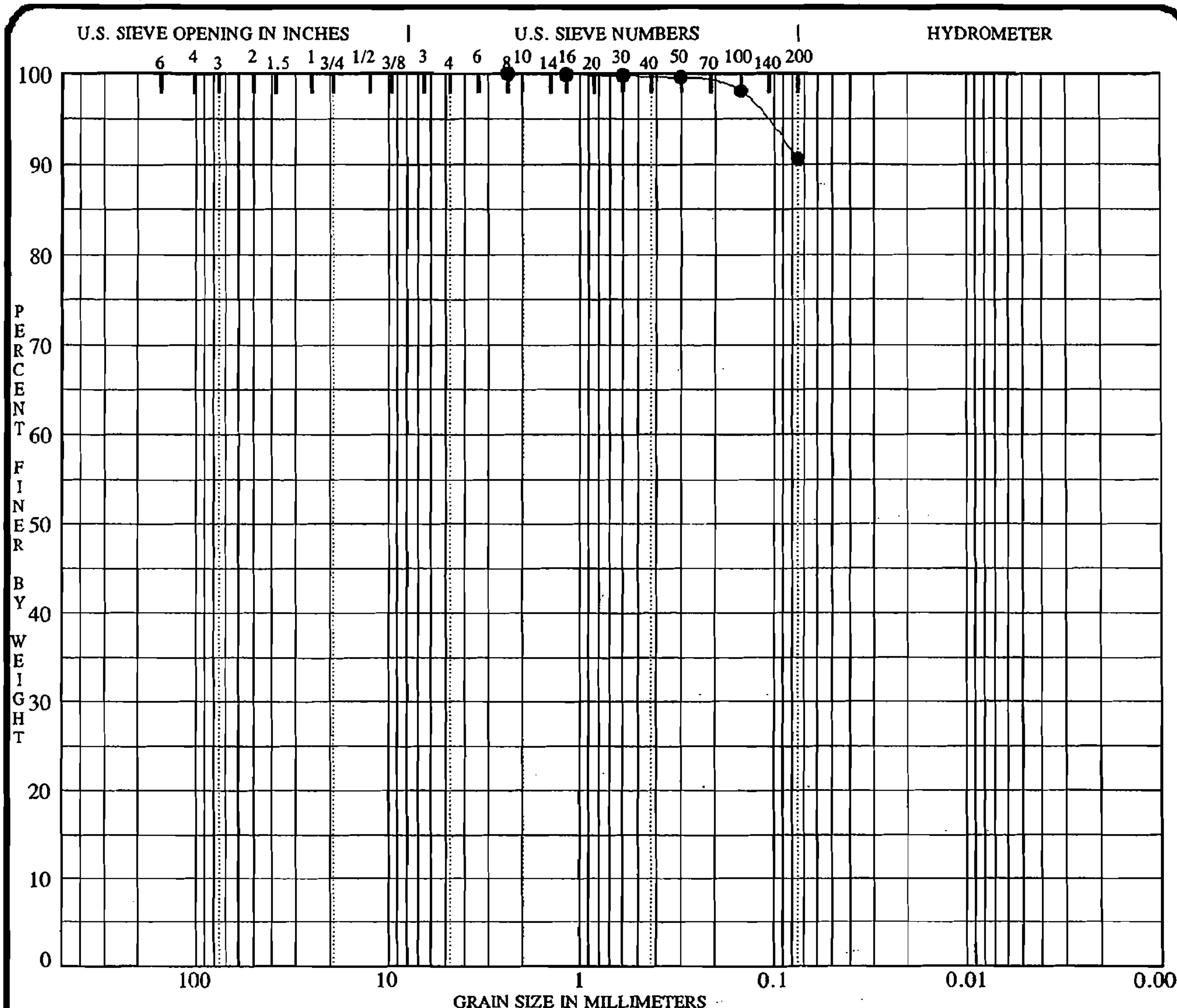

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-108	41.6		23.2	38.7	20.3	18.4		
			LEAN CLAY CL						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
●	96-108	41.6	2.360				0.0	9.5	90.5	

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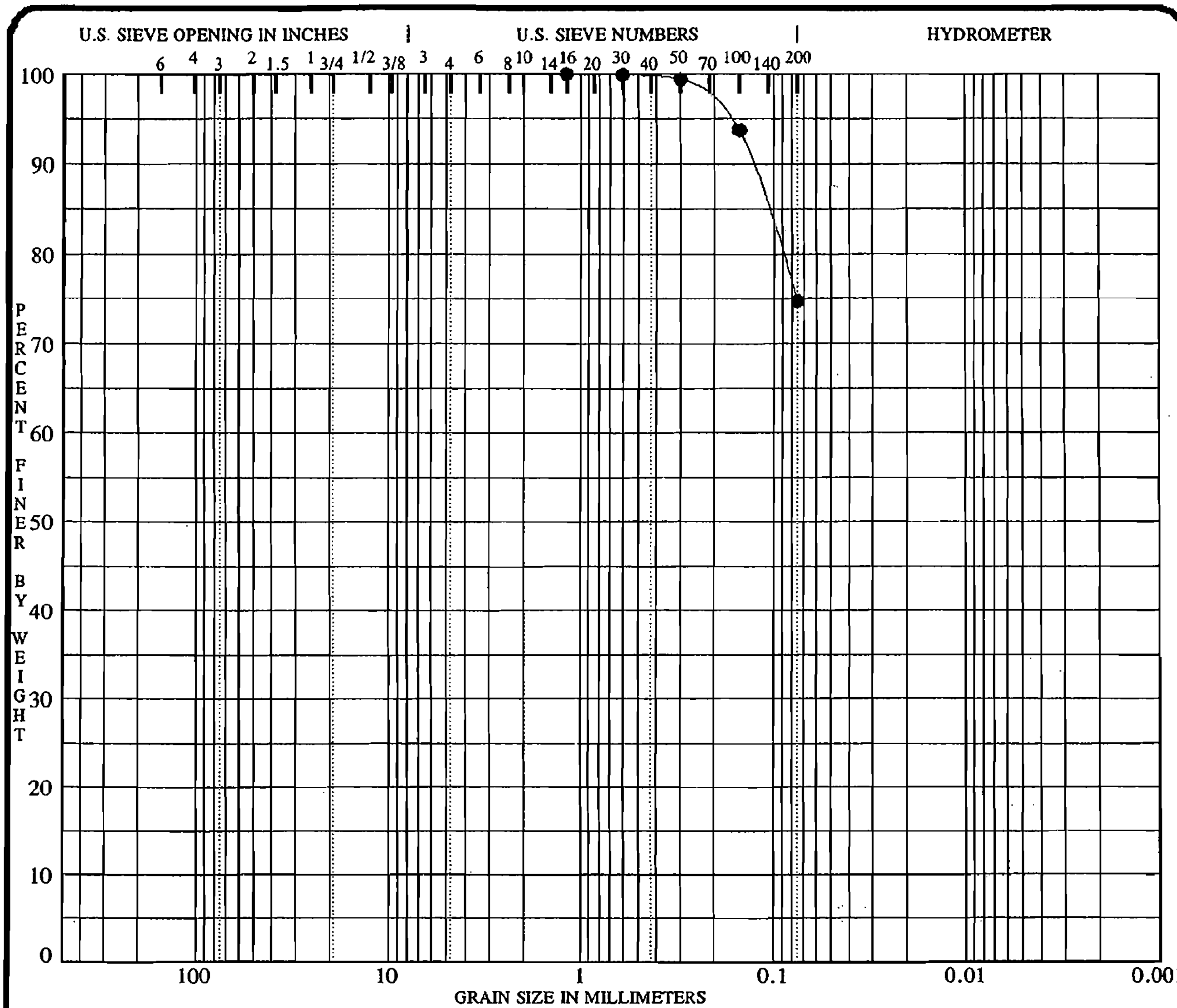

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification			Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-108	56.6		25.1	34.9	20.1	14.9		
			LEAN CLAY with SAND CL						

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
●	96-108	56.6	1.180				0.0	25.3	74.7	

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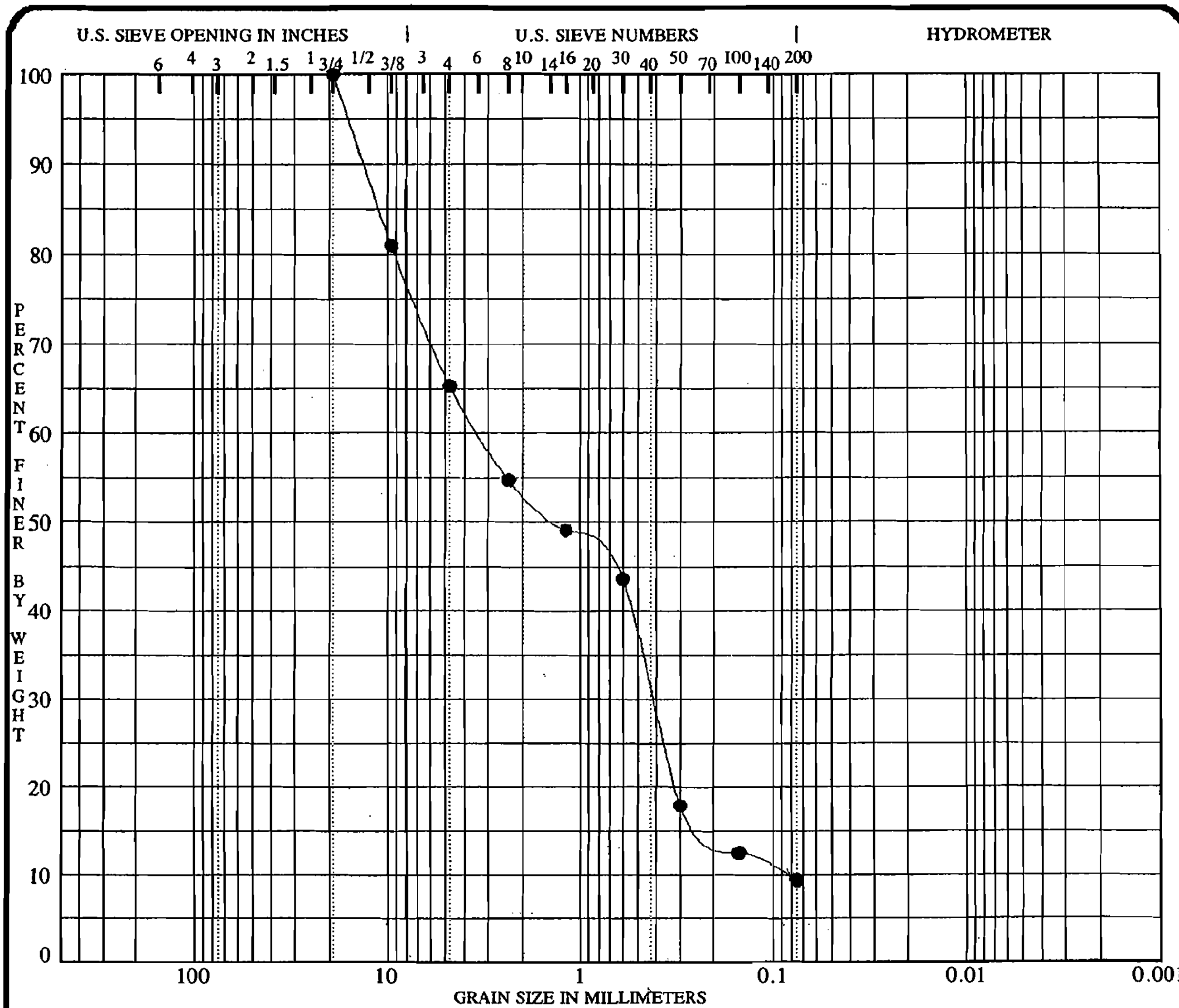

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
●	96-109	8.5		0.4	NP	NP	NP	
			POORLY GRADED SAND with SILT and GRAVEL SP-SM					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-109	8.5	19.000	3.348	0.416	0.086	34.7	55.9	9.4	

PROJECT **SPORN PLANT - FLY ASH POND DIKES**

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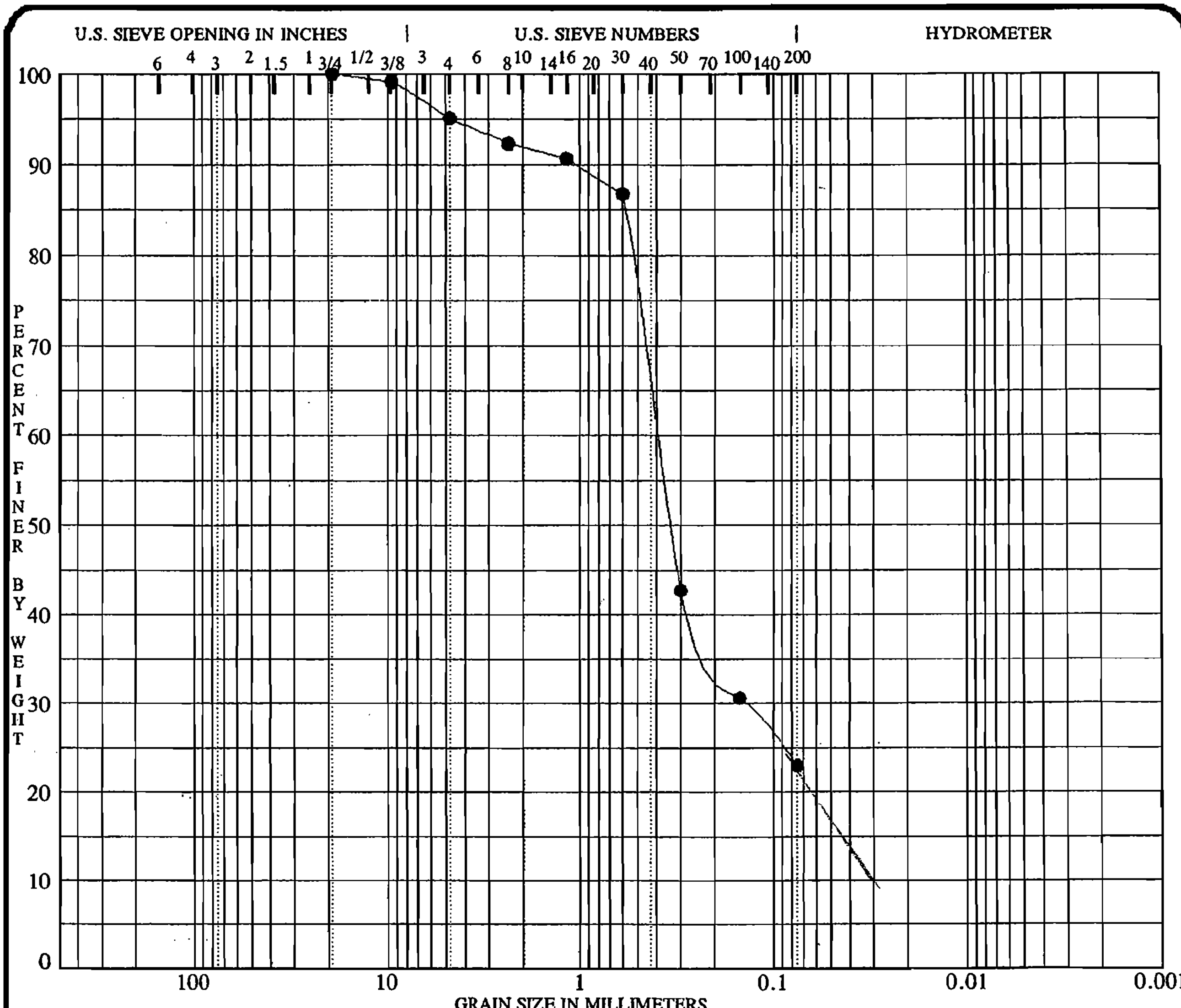

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
●	96-109	11.7	SILTY SAND SM	4.3	NP	NP	NP	

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
●	96-109	11.7	19.000	0.394	0.142		4.9	72.1	23.0	

PROJECT SPORN PLANT - FLY ASH POND DIKES

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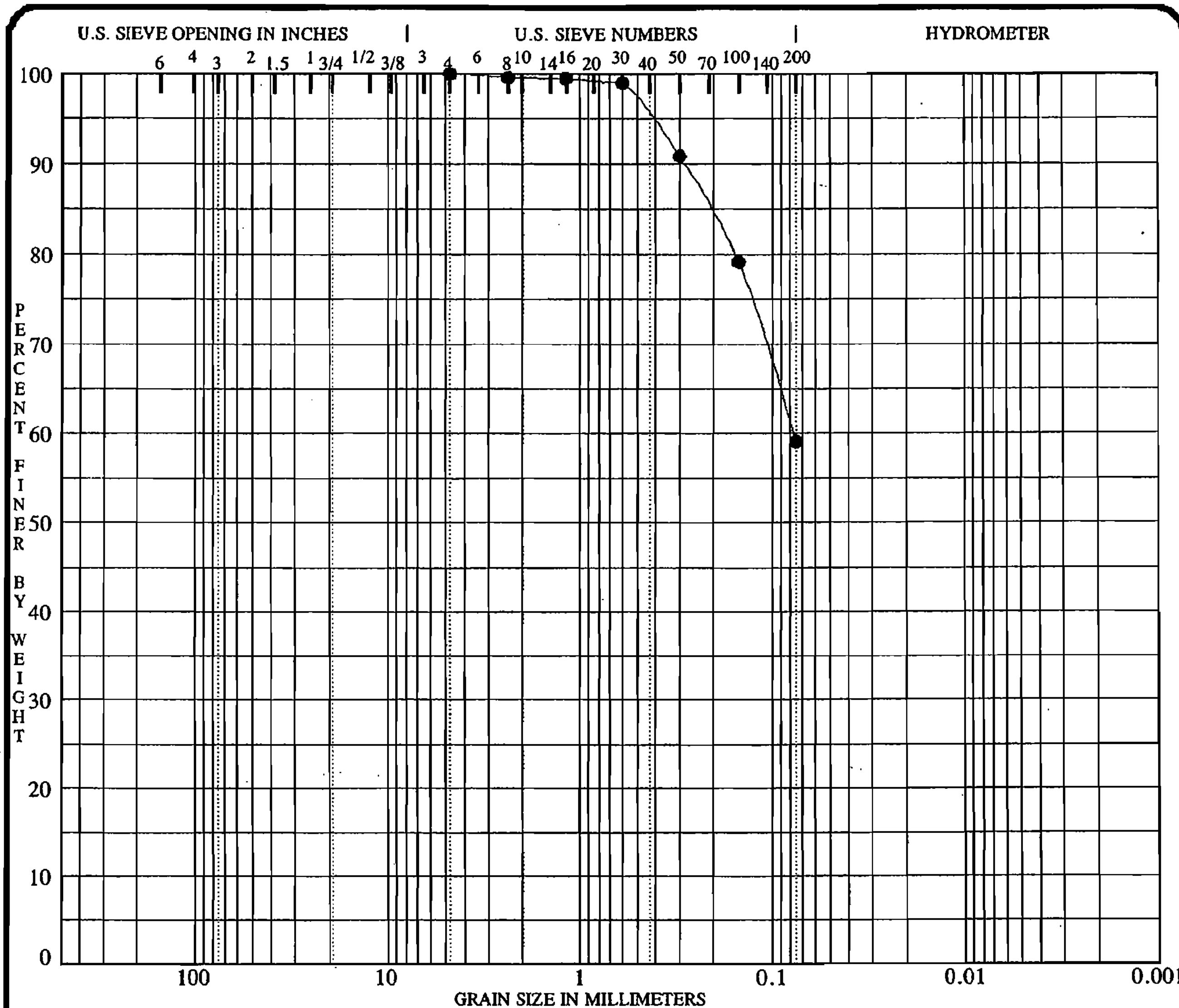

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-109	16.7		9.0	22.9	17.1	5.7		
			SANDY SILTY CLAY CL-ML						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
●	96-109	16.7	4.750	0.077			0.0	40.9	59.1	

PROJECT SPORN PLANT - FLY ASH POND DIKES

JOB NO.

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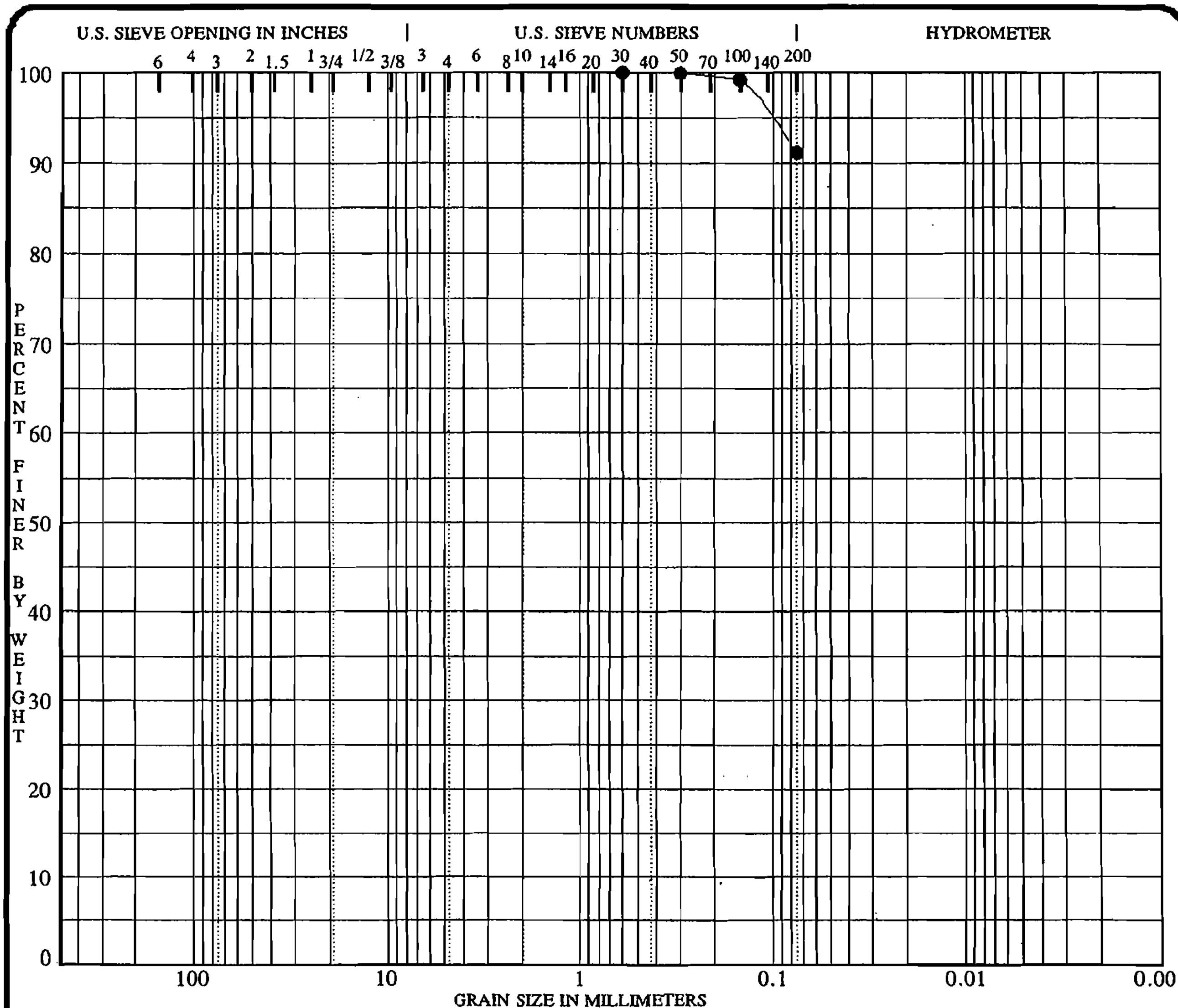
AEPSPP-000711

AEPSPP004089



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification			Classification	MC%	LL	PL	PI	Sp.Gr.
●	96-109	36.7		38.1	NP	NP	NP	2.34
			SILT ML					

Specimen Identification			D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-109	36.7	0.600				0.0	8.9	91.1	

PROJECT **SPORN PLANT - FLY ASH POND DIKES**

JOB NO.

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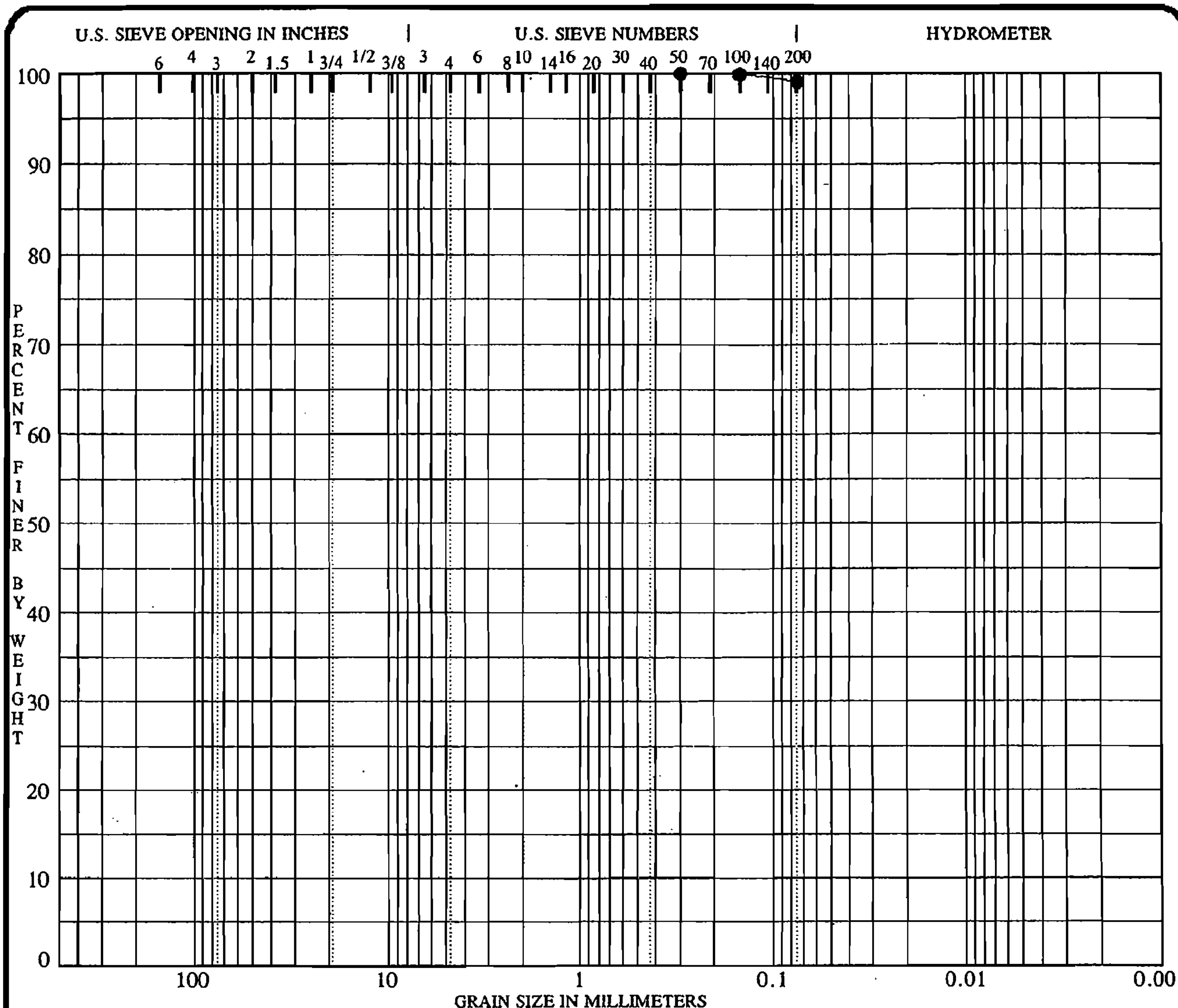
AEPSPP004090



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
● 96-109	56.7	SILT ML	34.3	NP	NP	NP	2.29

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
● 96-109	56.7	0.300				0.0	0.9	99.1	

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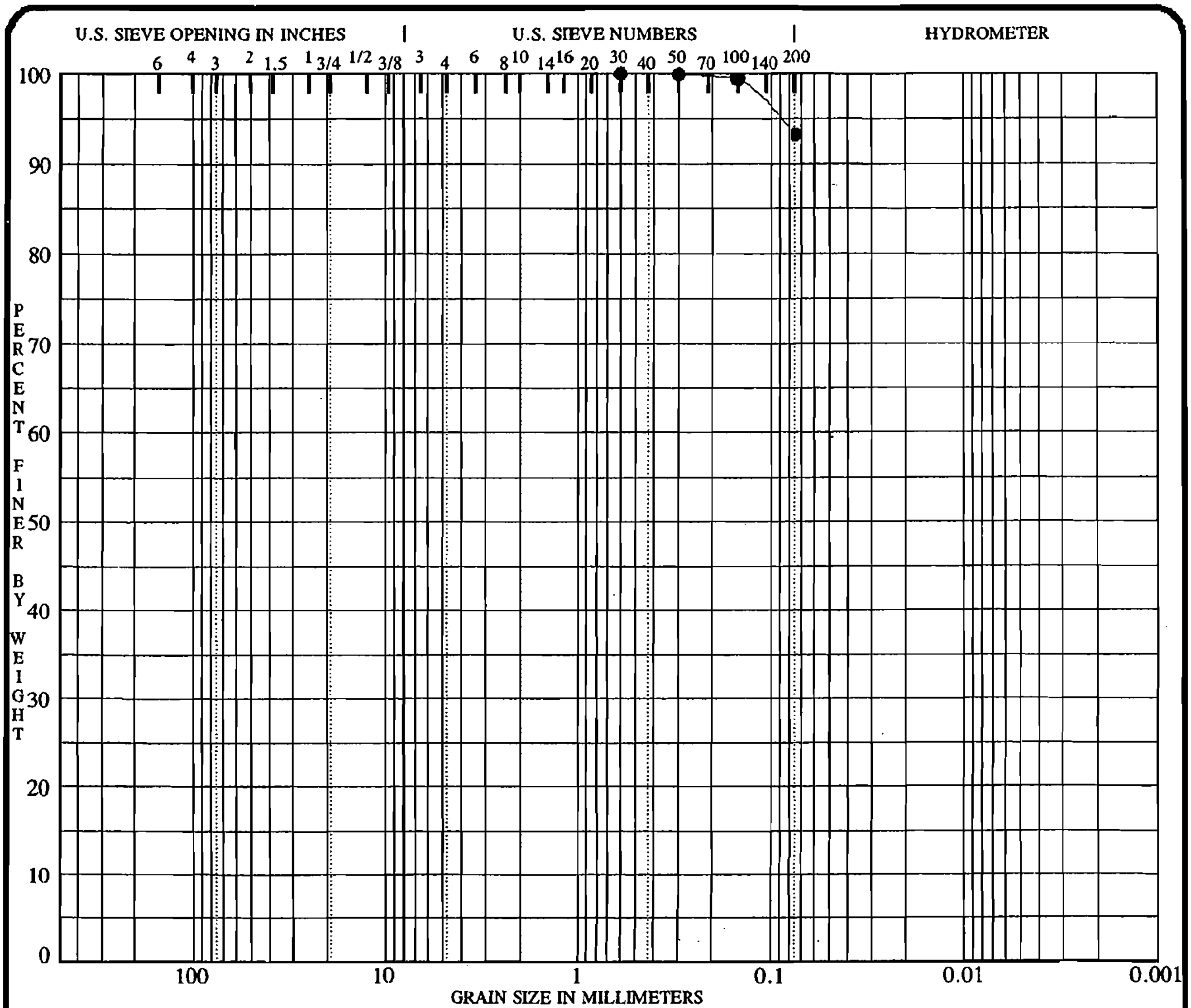

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-109	71.7		23.7	40.3	21.8	18.5		
			LEAN CLAY CL						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
●	96-109	71.7	0.600				0.0	6.8	93.2	

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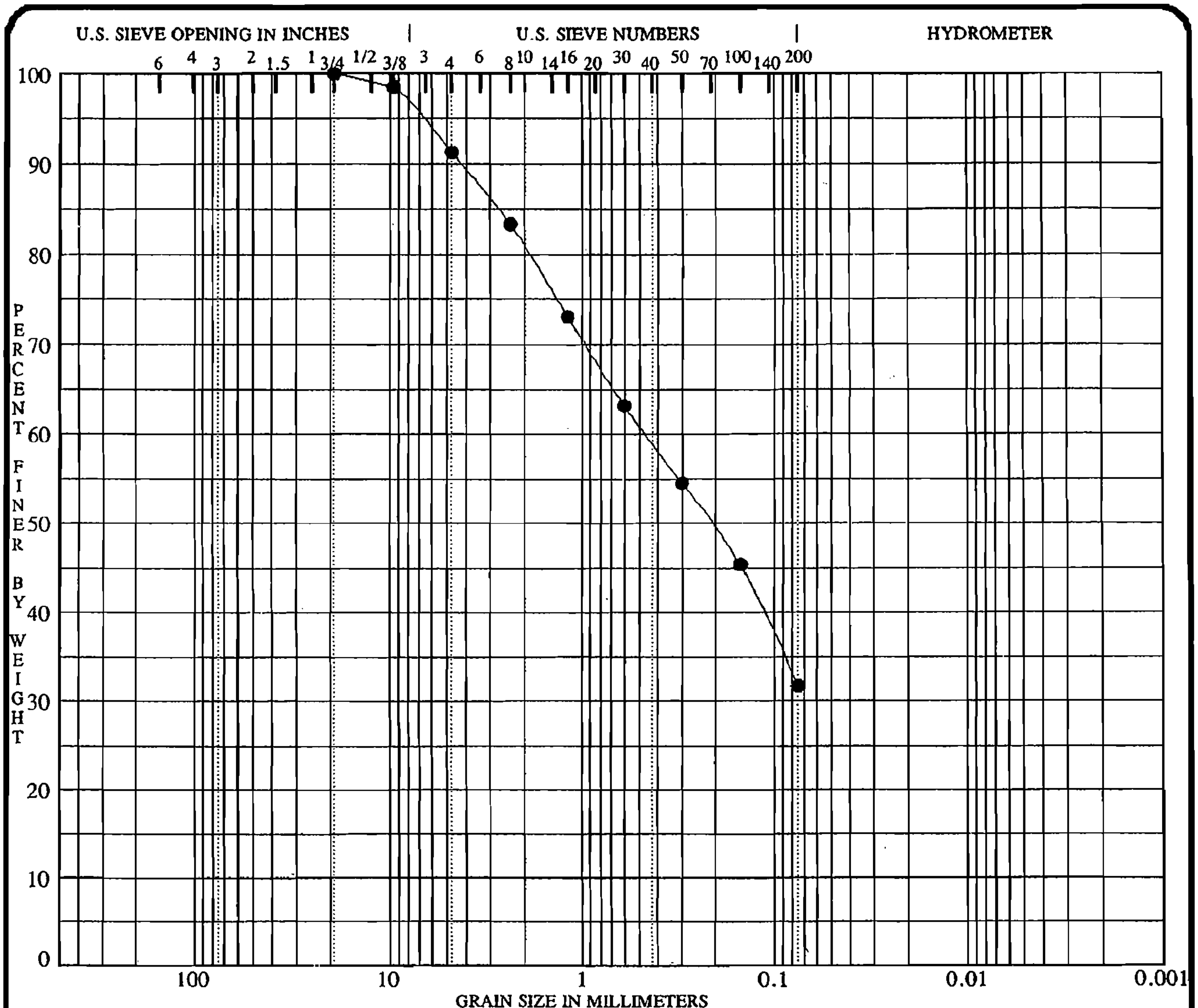

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
●	96-110	5.0		6.8	NP	NP	NP	
			SILTY SAND SM					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
●	96-110	5.0	19.000	0.465			8.8	59.5	31.7	

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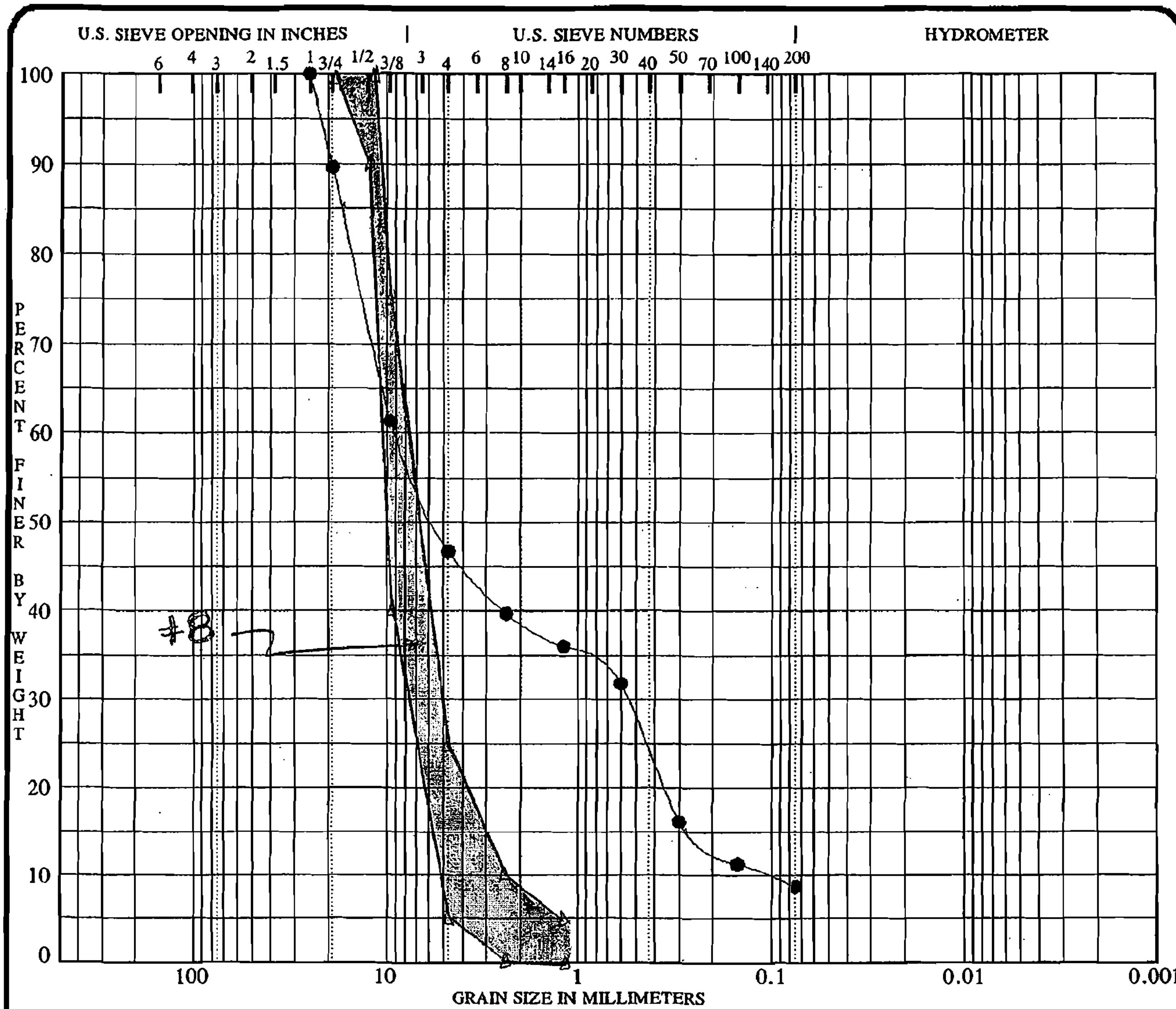

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
●	96-110	8.5		0.1	NP	NP	NP	
			POORLY GRADED GRAVEL with SILT and SAND GP-GM					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-110	8.5	25.000	8.931	0.554	0.106	53.3	38.0	8.7	

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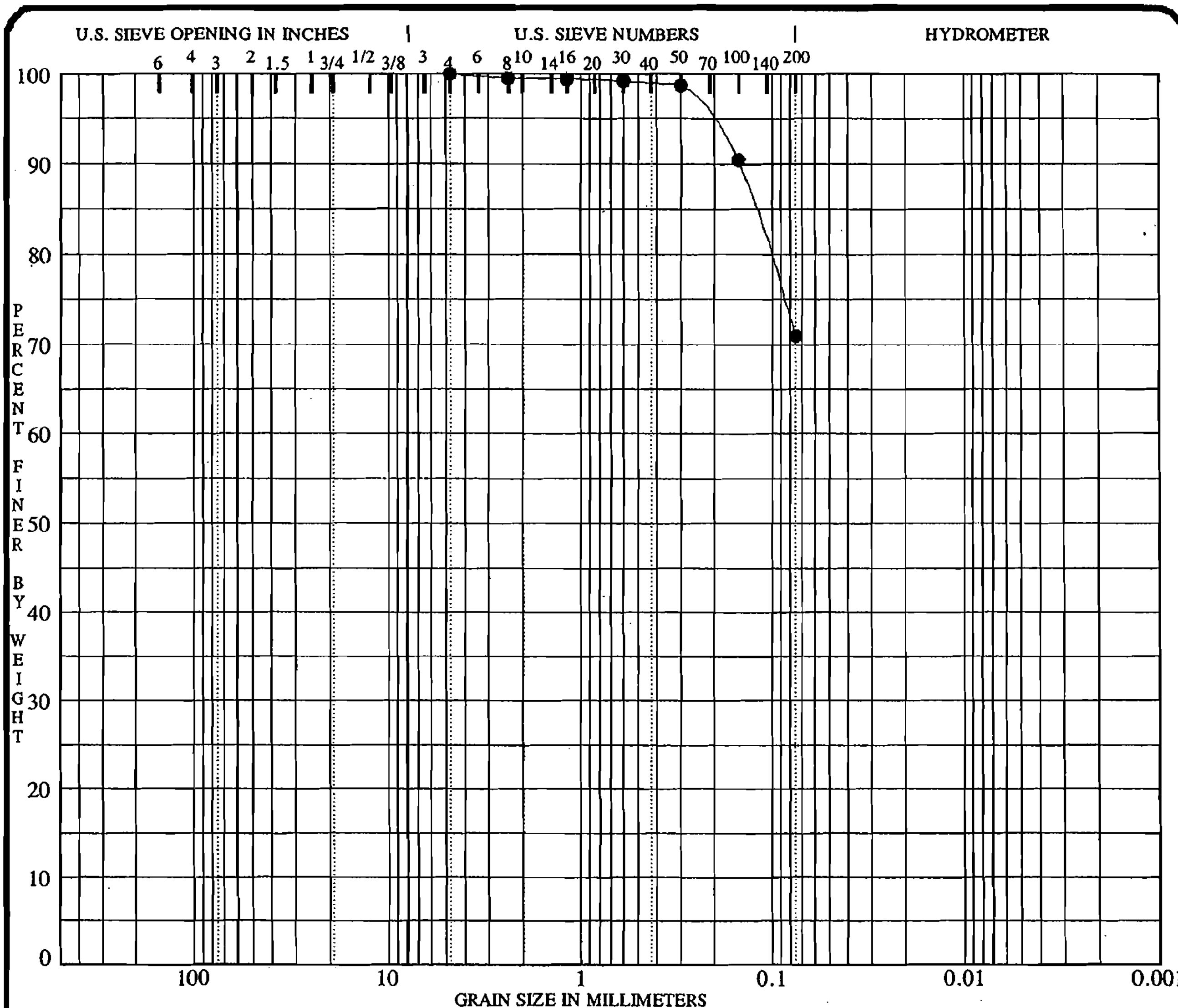

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-110	16.6		11.5	25.5	17.6	8.0		
			LEAN CLAY with SAND CL						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
●	96-110	16.6	4.750				0.0	29.1	70.9	

PROJECT **SPORN PLANT - FLY ASH POND DIKES**

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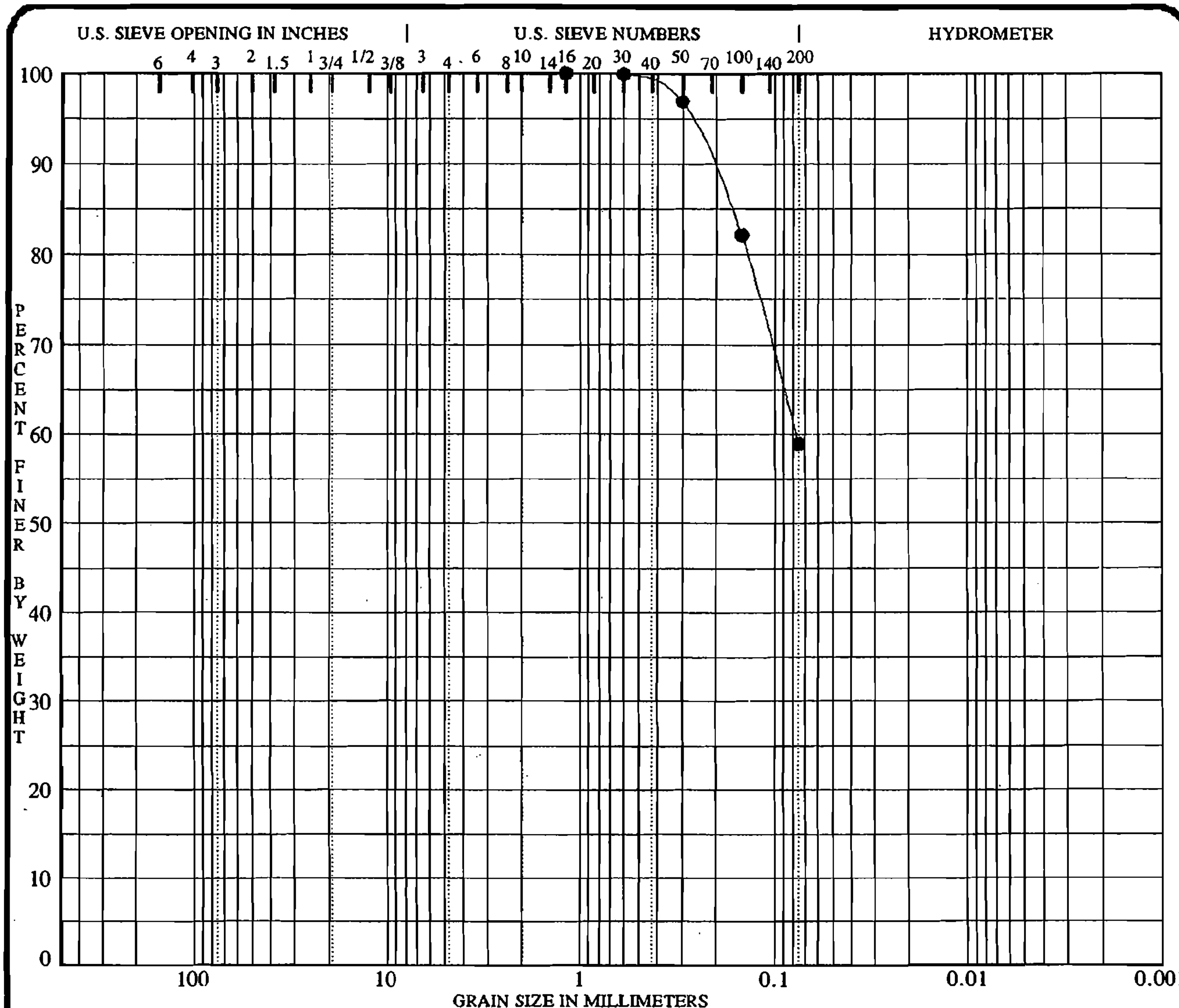

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-110	21.6		12.5	24.0	17.0	7.0		
			SANDY SILTY CLAY CL-ML						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
●	96-110	21.6	1.180	0.078			0.0	41.1	58.9	

PROJECT SPORN PLANT - FLY ASH POND DIKES

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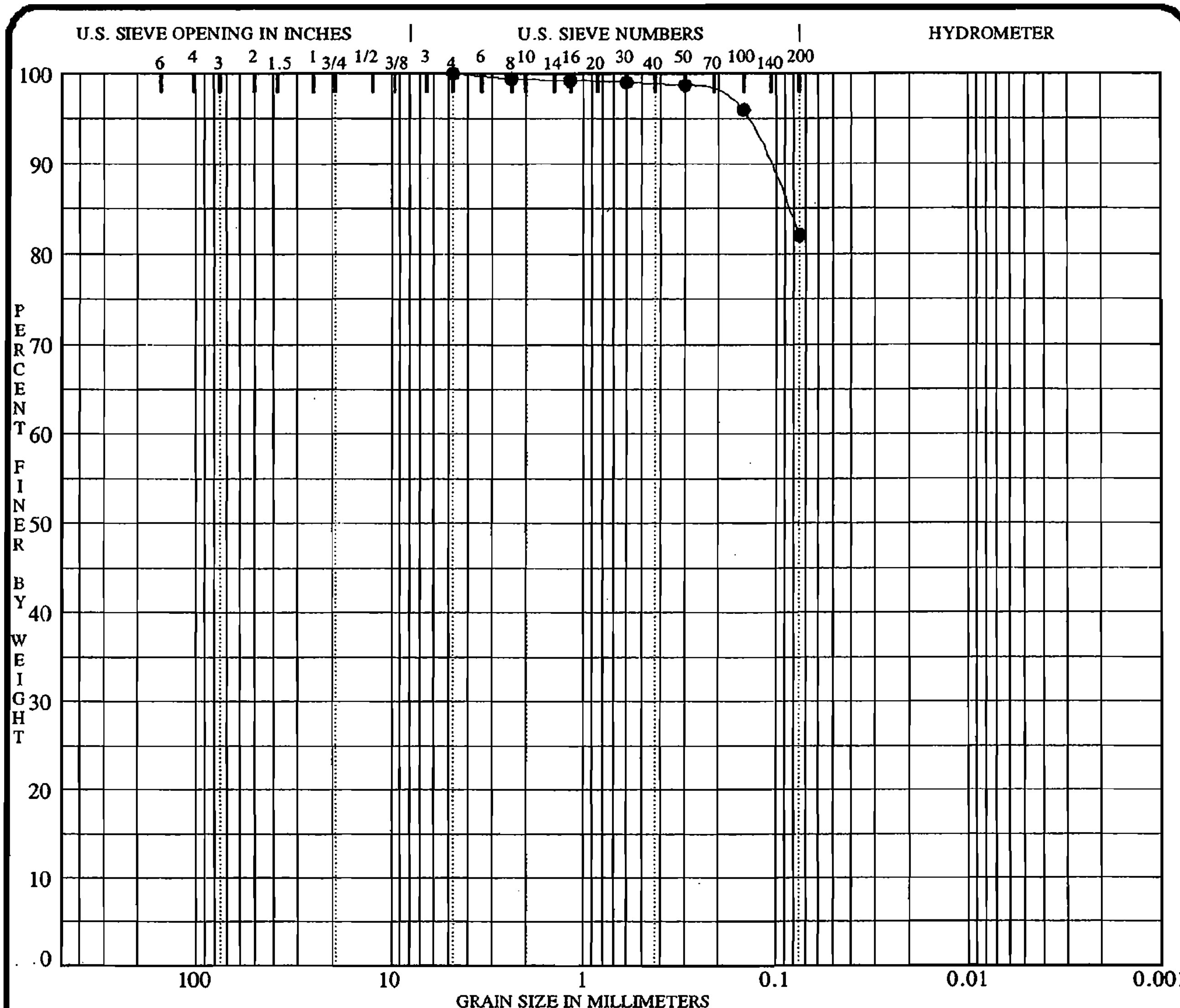

COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
● 96-110	31.6		14.7	30.7	18.4	12.3	
		LEAN CLAY with SAND CL					

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	% < .002
● 96-110	31.6	4.750				0.0	18.0	82.0	

PROJECT SPORN PLANT - FLY ASH POND DIKES

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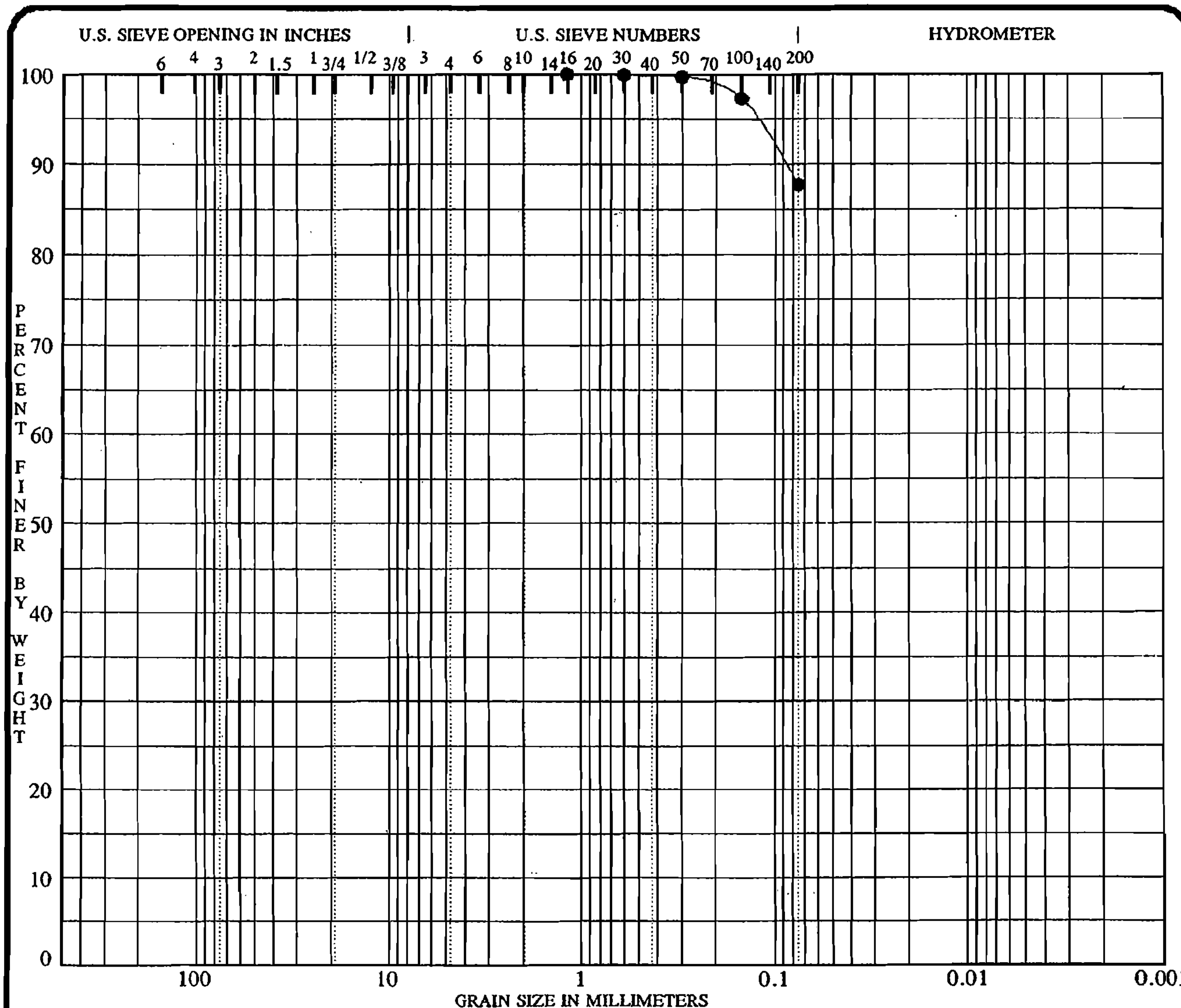
AEPSPP-000719

AEPSPP004097



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	**96-110**	**46.6**		**25.1**	**36.2**	**21.3**	**14.9**		
			LEAN CLAY CL						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	**96-110**	**46.6**	**1.180**				**0.0**	**12.3**	**87.7**	

PROJECT **SPORN PLANT - FLY ASH POND DIKES**

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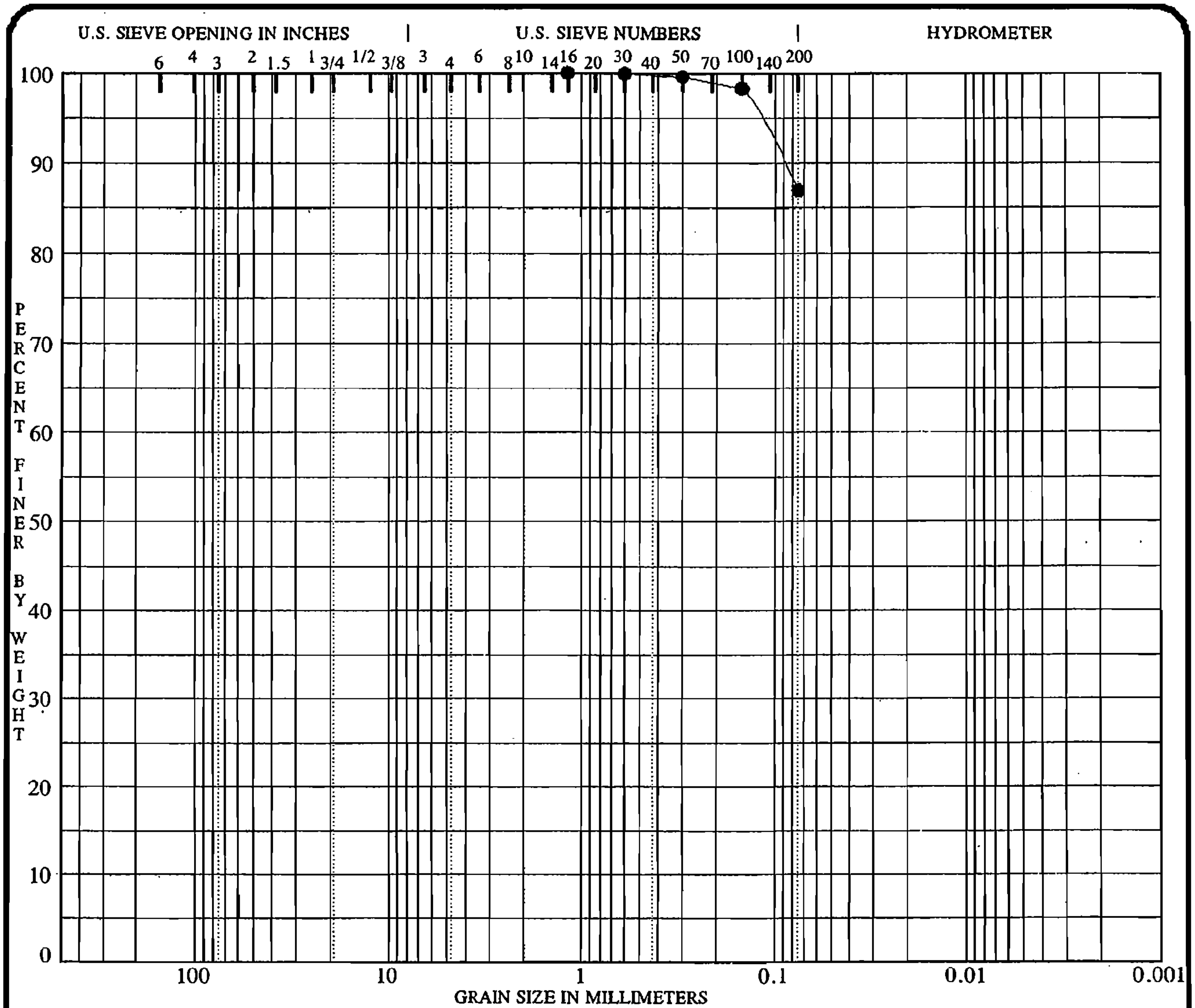
AEPSPP004098



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	96-110	56.6		24.4	37.5	20.3	17.1		
			LEAN CLAY CL						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-110	56.6	1.180				0.0	13.1	86.9	

PROJECT SPORN PLANT - FLY ASH POND DIKES

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DATE 05/21/97

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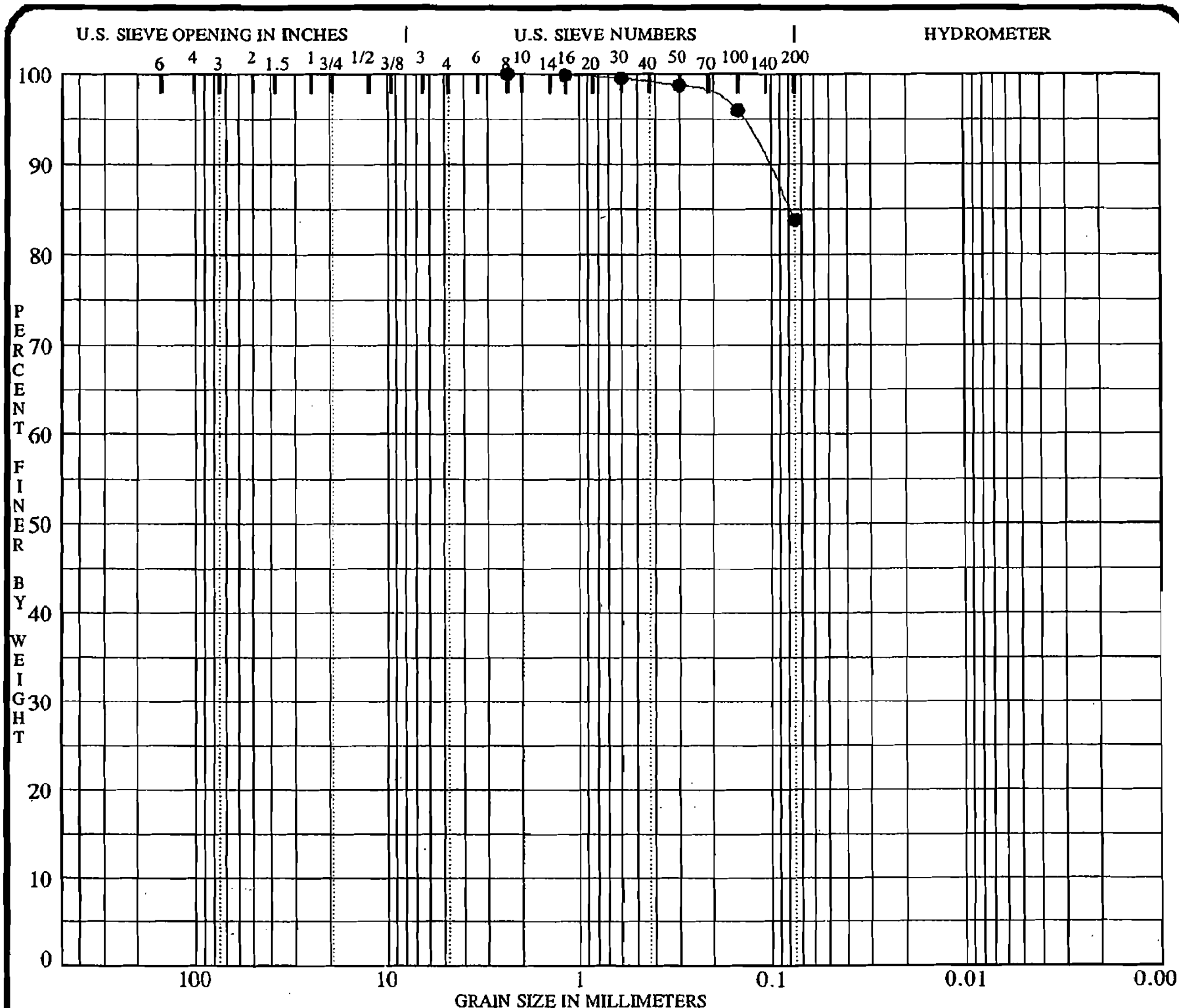
AEPSPP-000721

AEPSPP004099



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
●	96-110	66.6		25.6	38.7	21.7	17.0	
			LEAN CLAY with SAND CL					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	96-110	66.6	2.360				0.0	16.2	83.8	

PROJECT SPORN PLANT - FLY ASH POND DIKES

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AEPSPP-000722

AEPSPP004100

APPENDIX 5

AEPSPP-000723

AEPSPP004101

TABLE 3.7
COMMON PROPERTIES OF CLAY SOILS‡

Consistency	N	Hand test	γ_{sat},* g/cm³	Strength† U_c, kg/cm²
Hard	>30	Difficult to indent	>2.0	>4.0
Very stiff	15-30	Indented by thumbnail	2.08-2.24	2.0-4.0
Stiff	8-15	Indented by thumb	1.92-2.08	1.0-2.0
Medium (firm)	4-8	Molded by strong pressure	1.76-1.92	0.5-1.0
Soft	2-4	Molded by slight pressure	1.60-1.76	0.25-0.5
Very soft	<2	Extrudes between fingers	1.44-1.60	0-0.25

*$\gamma_{sat} = \gamma_{dry} + \gamma_w \left(\frac{e}{1+e}\right)$

†Unconfined compressive strength U_c is usually taken as equal to twice the cohesion c or the undrained shear strength s_u. For the drained strength condition, most clays also have the additional strength parameter ϕ, although for most normally consolidated clays c = 0 (Lambe and Whitman (1969)[?]). Typical values for s_u and drained strength parameters are given in Table 3.30, Hunt (1984).[1]

‡From Hunt (1984).[1] Reprinted with permission of McGraw-Hill Book Company.

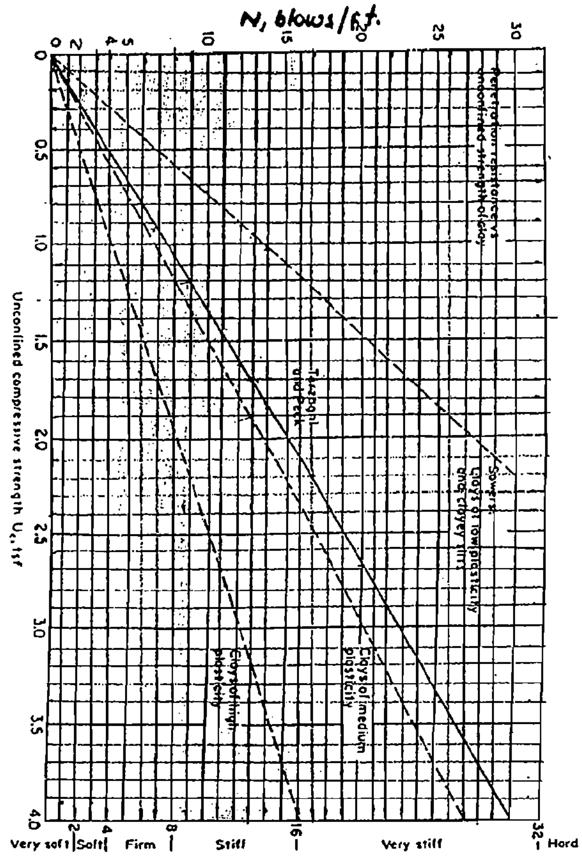


FIG. 3.35 Correlations of SPT N values with U_c for cohesive soils of varying plasticities. (From NAVFAC 1971)[14]

TABLE 3.5
COMMON PROPERTIES OF COHESIONLESS SOILS**

Material	Compactness	D_R, %	N*	γ dry,† g/cm³	Void ratio e	Strength‡ ϕ
GW: well-graded gravels, gravel-sand mixtures	Dense	75	90	2.21	0.22	40
	Medium dense	50	55	2.08	0.28	36
	Loose	25	<28	1.97	0.36	32
GP: poorly graded gravels, gravel-sand mixtures	Dense	75	70	2.04	0.33	38
	Medium dense	50	50	1.92	0.39	35
	Loose	25	<20	1.83	0.47	32
SW: well-graded sands, gravelly sands	Dense	75	65	1.89	0.43	37
	Medium dense	50	35	1.79	0.49	34
	Loose	25	<15	1.70	0.57	30
SP: poorly graded sands, gravelly sands	Dense	75	50	1.76	0.52	36
	Medium dense	50	30	1.67	0.60	33
	Loose	25	<10	1.59	0.65	29
SM: silty sands	Dense	75	45	1.65	0.62	35
	Medium dense	50	25	1.55	0.74	32
	Loose	25	<8	1.49	0.80	29
ML: inorganic silts, very fine sands	Dense	75	35	1.49	0.80	33
	Medium dense	50	20	1.41	0.90	31
	Loose	25	<4	1.35	1.0	27

*N is blows per foot of penetration in the SPT. Adjustments for gradation are after Burmister (1962).[24] See Table 6.4 for general relationships of D_R vs. N.

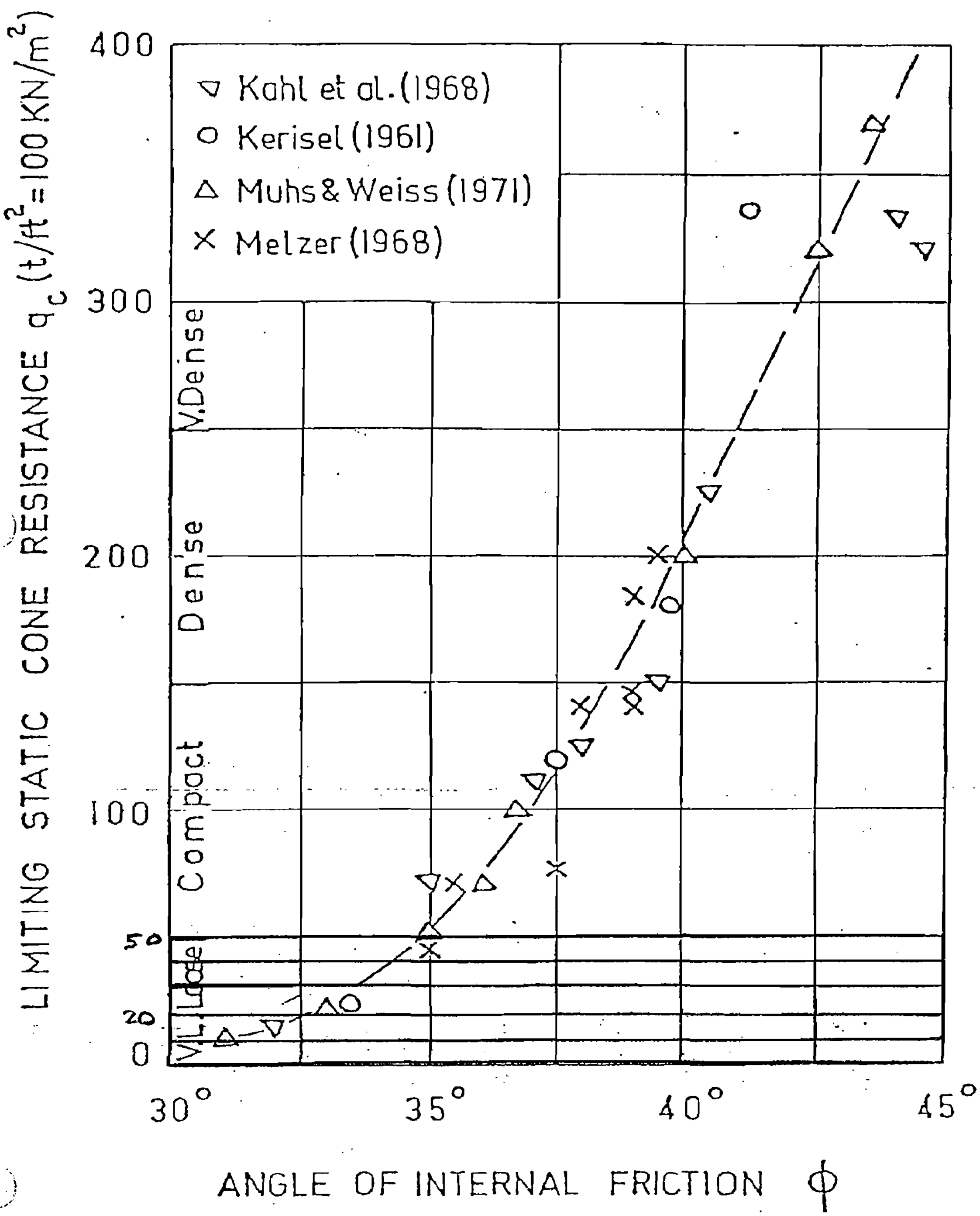
†Density given is for G_s = 2.68 (quartz grains).

‡Friction angle ϕ depends on mineral type, normal stress, and grain angularity as well as D_R and gradation (see Fig. 3.29).

**From Hunt (1984).[1] Reprinted with permission of McGraw-Hill Book Company.

"GEOTECHNICAL ENGINEERING TECHNIQUES AND PRACTICES", ROY. E. HUNT, McGRAW-HILL, INC., 1986, USA

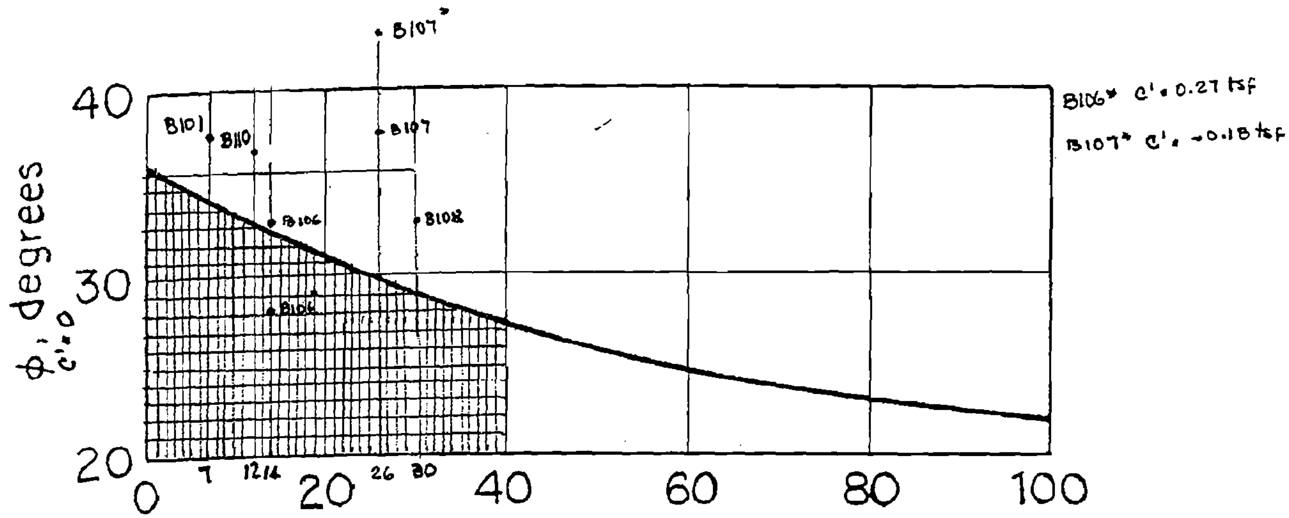
FIG. 11 APPROXIMATE RELATION BETWEEN STATIC CONE RESISTANCE AND ANGLE OF INTERNAL FRICTION OF SAND.



Meyerhof (1974)

SPORN FLY ASH FACILITY

ACTUAL
Ø' Vs. PI
(BASED ON TRIAXIAL C̄Ū TESTS)



F3.30 Approximate relationship between ϕ and PI clays of moderate to low sensitivity under drained Conditions. [From Terzaghi and Peck (1967).[21] Reprinted with permission of John Wiley & Sons, Inc.]

Roy E. Hunt, "Geotechnical Engineering Techniques and Practices", McGraw-Hill, Inc., 1986, USA.

AEPSPP-000726

7222(R3-84)IAP50
FORM GE-8 (C)

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

SHEET 1 OF
DATE 5/5/97 BY PJ Amaya CK.
COMPANY CENTRAL OPERATING G.O.
PLANT SPORN

SUBJECT Unit 5 Fly Ash Facility

STRENGTH PARAMETERS

NORTHERN DIKE:

BORING B-101 - ELEV. = 619.0

DEPTH	SN	DESCRIPTION	N	γ_d (PCF)	STRENGTH PARAMETER	SOURCE
3.0 to 4.5		Si. Gravelly Sand (SM) Mc = 6.5%	29	1.65 g/cm³	ϕ = 35°	TABLE 3.5 (1)
5.0 to 6.5		" "	18	1.55 g/cm³	ϕ = 32°	TABLE 3.5 (1)
8.5 to 10.0	(4)	Si, Gravelly Sand (SM) Mc = 10%	9	1.49 g/cm³	ϕ = [illegible]°	TABLE 3.5 (1)
11.5 to 13.0	(2)	Si - Gravelly Sand (SM) Mc = 4.2%	65	1.65 g/cm³	ϕ = 35°	TABLE 3.5 (1)
16.5 to 18.0		" " "	45	1.65 g/cm³	ϕ = 35°	TABLE 3.5 (1)
21.5 to 23.0		Si. Gravelly Sand (SP-SM) Mc = [illegible]	48	1.65 g/cm³	ϕ = 35°	TABLE 3.5 (1)
26.5 to 28.0		Si. [illegible] Sand (SP-SM) Mc = 6.8%	43	1.65 g/cm³	ϕ = 35°	TABLE 3.5 (1)
31.5 to 33.0	(3)	Br/Gr SiCL w Sa (CL-ML)	12	2.08 g/cm³ *	U_c = 0.9 tsf, ϕ = 34°	Fig 3.35 & 3.30 (1)
33.5 to 35.5	(1)	PI = 7.0, Mc = 17%	ST	111	C = 1600 psf ϕ = 26; c' = 0 - ϕ' = 38°	TRIAXIAL TESTING PERFORMED BY H.C. NUTTING.
36.5 to 38.0		PI = 10, Mc = 17%	14	2.08 g/cm³	U_c = 1.0 tsf; ϕ = 34°	Fig. 3.35 & 3.30 (1)
41.5 to 43.0	(5)	G. Silty Sand (SM)	11	1.55 g/cm³	ϕ = 32°	TABLE 3.5 (1)
[illegible]5 to 45.5	(6)	Gray Clay (CL)	ST	86.0	C = 750 psf ϕ = 15°; C' = 0 psf ϕ' = 33°	TRIAXIAL TESTING B-108
46.5 to 48.0		Gravelly Sand (SP)	20	1.67 g/cm³	ϕ = 33°	TABLE 3.5 (1)
	(7)					

* SATURATED

AEPSPP-000727

AEPSPP004105

7222(R3-84)IAP50
FORM GE-8 (C)

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

SHEET 2 OF
DATE 5/15/97 BY P.J. Amaya CK.
COMPANY CENTRAL OPERATING G.O.
PLANT SPORN

SUBJECT Unit 5 Fly Ash Facility

STRENGTH PARAMETERS

NORTHERN DIKE (CONTINUED)

BORING B-102 - ELEV. = 619.6

DEPTH	SN	DESCRIPTION	N	γ_d (PCF)	STRENGTH PARAMETERS	SOURCE
3.0 to 4.5	5	Si. Gravelly Sand (SM) Mc = 6.5%	35	1.67 g/cm³	ϕ = 33°	TABLE 3.5 (1)
5.0 to 6.5		" "	47	1.76 g/cm³	ϕ = 35°	TABLE 3.5 (1)
8.5 to 10.0	7	Si Gravelly Sand (SM) Mc = 6.5%	35	1.67 g/cm³	ϕ = 33°	TABLE 3.5 (1)
11.7 to 13.2		" "	60	1.76 g/cm³	ϕ = 35	TABLE 3.5 (1)
16.7 to 18.2	3	S. Sandy Gravel (GP) Mc = 2.8%	47	1.76 g/cm³	ϕ = 35°	TABLE 3.5 (1)
21.7 to 23.2		" "	45	1.76 g/cm³	ϕ = 35°	TABLE 3.5 (1)
26.7 to 28.2	2	SANDY SILT (ML) Mc = 11.8%	20	1.55 g/cm³	ϕ = 31°	TABLE 3.5 (1)
31.7 to 33.2	4	SANDY clay (CL) PI = 9, Mc = 18.%	9	1.92 g/cm³*	Uc 0.7 ksf; ϕ = 34°	Fig. 3.35 & 3.30 (1)
33.7 to 35.7	1	" " "	ST	" " "	c = 1600 PSF, c' = 0, ϕ = 26°, ϕ' = 38	TRIAXIAL TESTING — B-101 —
36.7 to 38.2		Sandy Clay (CL) PI 8 Mc [illegible]%	9	1.92 g/cm³*	Uc = 0.7 ksf; ϕ = 34°	Fig. 3.35 & 3.30 (1)
41.7 to 43.2	6	GRAVELLY SAND (SP) Mc 5%	13	1.59 g/cm³	ϕ = 29°	TABLE 3.5 (1)
[illegible].7 to 48.2		" " "	36	1.67 g/cm³	ϕ = 33°	TABLE 3.5 (1)

* SATURATED

AEPSPP-000728

AEPSPP004106

7222(R3-84)IAP50
FORM GE-8 (C)

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

SHEET 1 OF ____
DATE 5/15/97 BY PJ Amaya CK ____
COMPANY Central Operating G.O. ____
PLANT Sporn

SUBJECT Unit 5 Fly Ash Facility

STRENGTH PARAMETERS

WESTERN DIKE

BORING B-103 - Elev. = 618.

DEPTH	SN	DESCRIPTION	N	γ_d (PCF)	STRENGTH PARAMETER	SOURCE
3.0 to 4.5	②	s. GRAVELLY SAND (SP) Mc = 4.7%	43	1.76 g/cm³	φ = 35°	TABLE 3.5 (1)
5.0 to 6.5	③	" " "	36	1.67 g/cm³	φ = 33°	TABLE 3.5 (1)
8.5 to 10.0		" " "	46	1.76 g/cm³	φ = 36°	TABLE 3.5 (1)
11.6 to 13.1		" " "	53	1.76 g/cm³	φ = 36°	TABLE 3.5 (1)
16.6 to 18.1			44	1.76 g/cm³	φ = 35°	TABLE 3.5 (1)
21.6 to 23.1		" " "	45	1.76 g/cm³	φ = 36°	TABLE 3.5 (1)
26.6 to 28.1		" " "	45	1.76 g/cm³	φ = 36°	TABLE 3.5 (1)
31.6 to 33.1	①	Br SILTY CLAY (CL) PI = 10 Mc = 14.5%	19	2.08 g/cm³*	Uc = 1.4 tsf, φ = 34°	FIGURES 3.3 & 3.3
36.6 to 38.6	④	Silty SAND (SM)	ST	1.59 g/cm³	φ = 29°	TABLE 3.5 (1)
41.6 to 43.1		" Mc = 71% "	11	1.59 g/cm³	φ = 29°	TABLE 3.5 (1)
46.6 to 48.1		Silty SAND (SM)	11	1.59 g/cm³	φ = 29°	TABLE 3.5 (1)

* SATURATED

AEPSPP-000729

7222(R3-84)IAP50
FORM GE-8 (C)

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

SHEET 2 OF ____
DATE 5/15/97 BY PJAMAYA CK ____
COMPANY CENTRAL OPERATING G.O. ____
PLANT SPORN.

SUBJECT Unit 5 Fly Ash Facility

STRENGTH PARAMETERS (continue)

WESTERN DIKE (continue)

BORING B-104 - ELEV. 618.7

DEPTH	SN	DESCRIPTION	N	γ_d (pcf)	STRENGTH PARAMETER	SOURCE
0.0 to 1.5	④	Br silty Clay (CL)	12	1.92 g/cm³*	Uc 0.8 tsf ; Φ = 32°	FIGURE 3.35 (1)
3.0 to 4.5	③	Gravelly Sand (SP) Mc = 1%	32	1.67 g/cm³	Φ = 33°	TABLE 3.5 (1)
5.0 to 6.5		" " "	73	2.08 g/cm³	Φ = 36°	TABLE 3.5 (1)
8.5 to 10.0		" Mc = 1% "	43	1.97 g/cm³	Φ = 35°	TABLE 3.5 (1)
11.7 to 13.2		Gravelly Sand (SP) Mc = 1%	57	1.76 g/cm³	Φ = 36°	TABLE 3.5 (1)
16.7 to 18.2	②	Gr. silty Sand (SM) Mc = 5%	47	1.65 g/cm³	Φ = 35°	TABLE 3.5 (1)
21.7 to 23.2		" Mc = 3% " "	46	1.65 g/cm³	Φ = 35°	TABLE 3.5 (1)
26.7 to 28.2	①	Br silty Clay (CL) PI = 8, Mc = 19%	14	2.08 g/cm³*	Uc = 1.0 tsf ; Φ = 34°	FIGURE 3.35 (1)
31.7 to 33.7	⑤	Br. silty Sand (SM) Mc = 9% NP	ST	116	Φ = 31°	TRIAXIAL TEST H.C. NUTTING COMP.
36.7 to 38.2		" " "	8	116	Φ = 29°	TABLE 3.5 (1)
41.7 to 43.2	⑥	Br. Sandy Silt (ML) Mc = 8%	11	116	Φ = 27°	TABLE 3.5 (1)
[illegible]7 to 48.7		Br " "	ST	116	Φ = 27°	TABLE 3.5 (1)

* SATURATED

AEPSPP-000730

AEPSPP004108

7222(R3-84)IAP50
FORM GE-8(C)

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

SHEET 3 OF
DATE 5/15/97 BY P.J. Amaya CK.
COMPANY Central Operating G.O.
PLANT Sporn

SUBJECT Unit 5 Fly Ash Facility

STRENGTH PARAMETERS (continued)

WESTERN DIKE (continued)

BORING B-105 - ELEV. = 619.3

DEPTH	SN	DESCRIPTION	N	γd (pcf)	STRENGTH PARAMETER	SOURCE
3.0 to 4.5	④	Br. Gravelly Sand (SM) Mc 2%	21	1.59 g/cm³	Φ = 31°	Table 3.5 (1)
5.0 to 6.5	③	" " "	37	1.55 g/cm³	Φ = 35°	Table 3.5 (1)
8.5 to 10.0		" " "	32	1.55 g/cm³	Φ = 34°	Table 3.5 (1)
11.5 to 13.0		" " "	35	1.55 g/cm³	Φ = 34°	Table 3.5 (1)
16.5 to 18.0		" Mc 3% "	31	1.53 g/cm³	Φ = 33°	Table 3.5 (1)
21.5 to 23.0	②	Br. Silty Sand (SM) Mc 7	23	1.69 g/cm³	Φ = 32°	Table 3.5 (1)
26.5 to 28.0	①	Br. silty clay (CL) PI = 10, Mc 18	13	2.08 g/cm³*	Uc = 0.95 tsf, Φ = 34°	Figure 3.35 (1)
31.5 to 33.5		" " "	ST	2.08 g/cm³*	Uc = 0.95 tsf, Φ = 34°	Figure 3.35 (1)
36.5 to 38.0	⑤	" " " PI = 10", Mc = 22%	8	1.92 g/cm³*	Uc = 0.6 tsf; Φ = 34°	Figure 3.35 (1)
41.5 to 43.0	⑥	Br. Silty Sand (SM) Mc 12%	9	1.49 g/cm³	Φ = 29°	Table 3.5 (1)
46.5 to 48.0		" "	ST	1.49 g/cm³	Φ = 29°	Table 3.5 (1)

* Saturated

7222(R3-84)IAP50
FORM GE-8 (C)

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

SHEET 1 OF ____
DATE 5/16/97 BY PJ Amaya CK. ____
COMPANY Central Operating G.O. ____
PLANT Sporn Plant

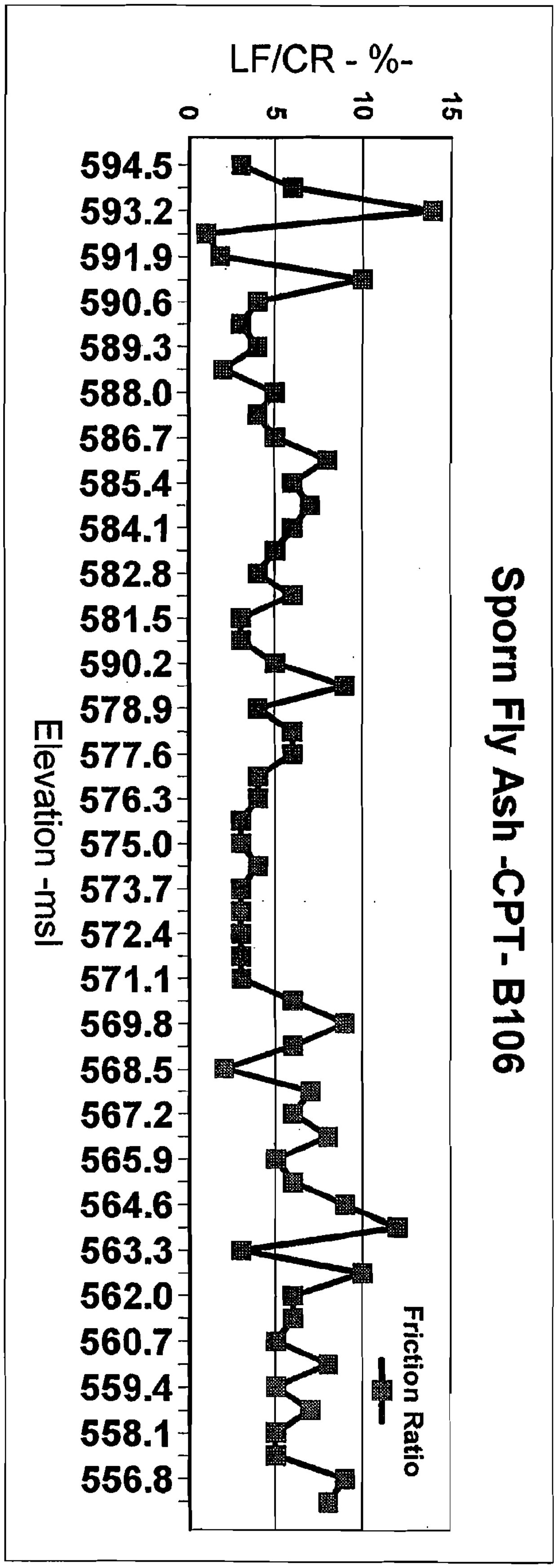
SUBJECT Unit 5 Fly Ash Facility

STRENGTH PARAMETERS

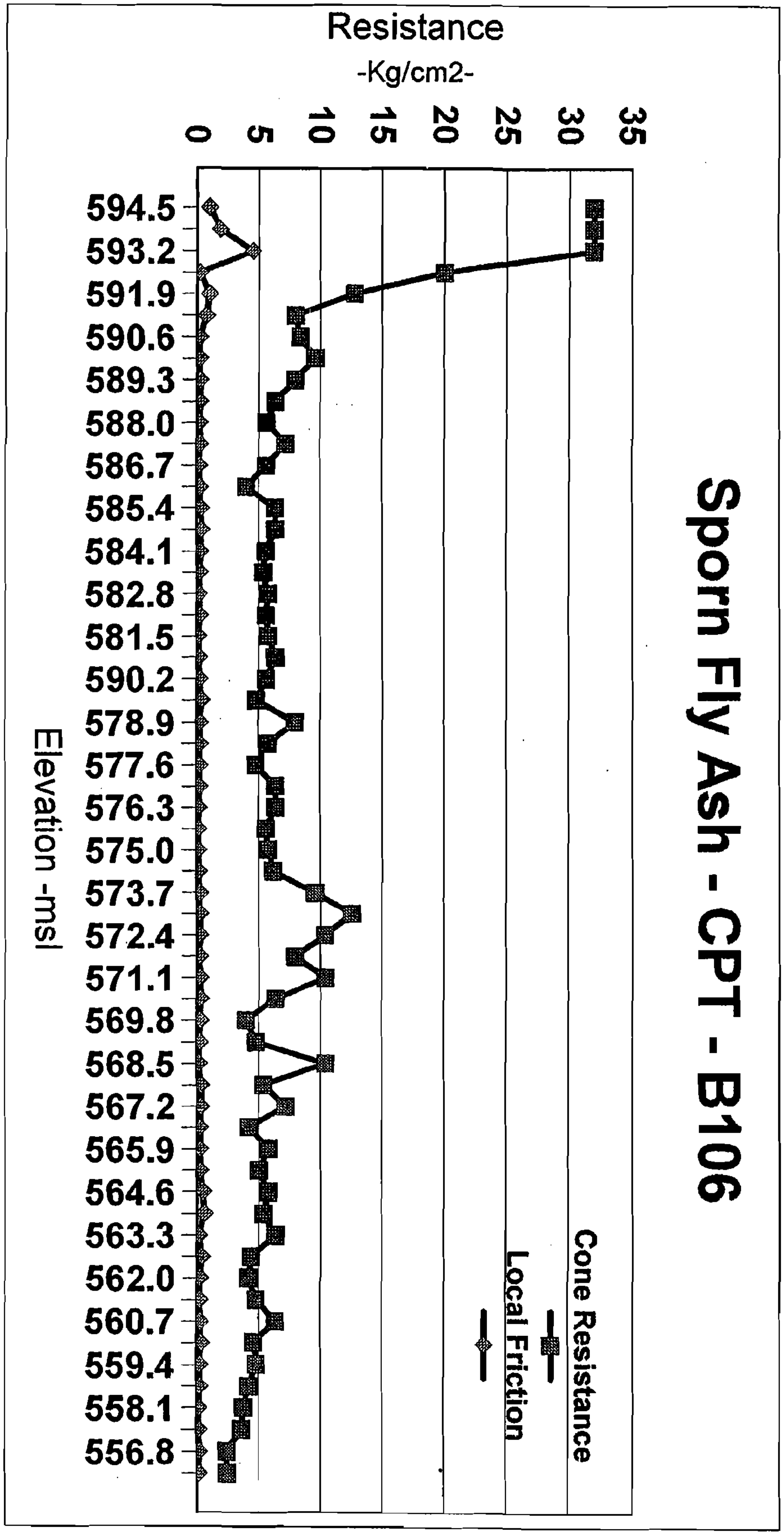
SOUTHERN DIKE:

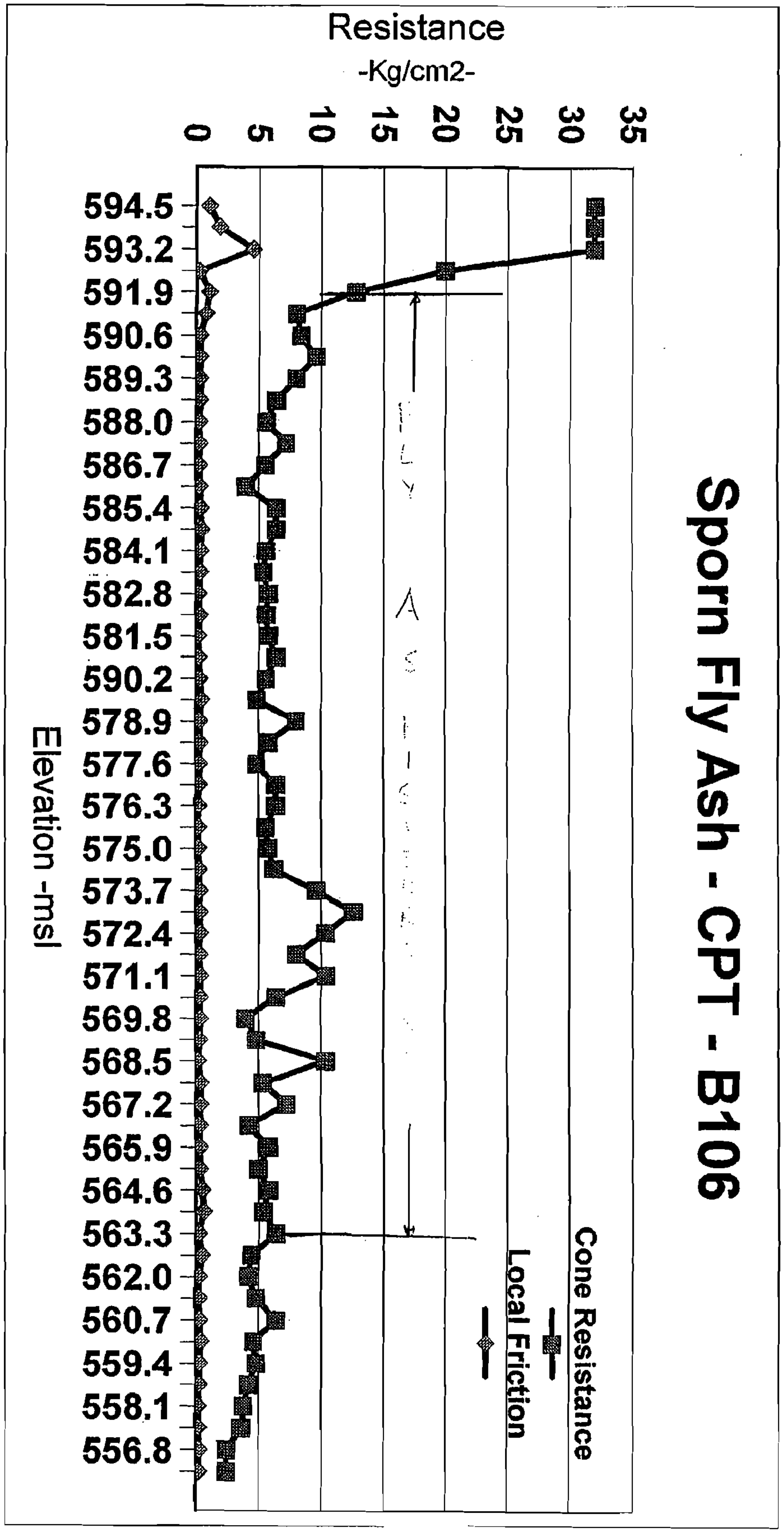
BORING B-106 - Elev.=618.9.

DEPTH	SN	DESCRIPTION	N	γ_d (PCF)	STRENGTH PARAMETERS	SOURCE
3.0 to 4.5	5	Gravelly silty sand (SM)	38	1.55 g/cm³	$\phi = 33^\circ$	TABLE 3.5(1)
5.0 to 6.5			54	1.65 g/cm³	$\phi = 35^\circ$	TABLE 3.5(1)
8.5 to 10.	4		37	1.55 g/cm³	$\phi = 33^\circ$	TABLE 3.5(1)
11.5 to 13.	6	Mc: 6%	25	1.55 g/cm³	$\phi = 32^\circ$	TABLE 3.5(1)
16.5 to 18.			32	1.55 g/cm³	$\phi = 33^\circ$	TABLE 3.5(1)
21.5 to 23.	3	SANDY CLAY (CL)	18	2.08 g/cm³*	U_c = 1.3 tsf, $\phi = 34^\circ$	FIGURE 3.35(1)
		PI = 9, Mc = 11%				
26.5 to 28.		FLY ASH (ML)	12	74	$\phi = 29^\circ$	TABLE 3.5(1)
		Mc = 4%				
31.5 to 33			2	74	$\phi = 27^\circ$	TABLE 3.5(1)
	2	SG = 2.09 Mc = 43%				
36.5 to 38			2	74	$\phi = 27^\circ$	TABLE 3.5(1)
41.5 to 43			2	74	$\phi = 27^\circ$	TABLE 3.5(1)
46.5 to 48			4	74	$\phi = 27^\circ$	TABLE 3.5(1)
[illegible]5 to 53.0		SG = 2.42 Mc = 36%	4	74	$\phi = 27^\circ$	TABLE 3.5(1)
56.5 to 58		GRAY SILTY CLAY (CL)	8	1.92 g/cm³*	U_c = 1.0 tsf, $\phi = 32^\circ$	FIGURE 3.35(1)
	7	PI = 18 Mc = 32%			C = 1200 psf, $\phi = 9^\circ$	TRIAXIAL TEST
61.5 to 63.5	1	PI = 74, Mc = 26%	ST	98	$c' = 0$, $\phi' = 33^\circ$	By H.C. Nutting.
66.5 to 68			9	1.92 g/cm³*	U_c = 1.2 tsf, $\phi = 32^\circ$	FIGURE 3.35(1)



Sporn Fly Ash -CPT- B106
LF/CR - %-
0
5
10
15
594.5
593.2
591.9
590.6
589.3
588.0
586.7
585.4
584.1
582.8
581.5
590.2
578.9
577.6
576.3
575.0
573.7
572.4
571.1
569.8
568.5
567.2
565.9
564.6
563.3
562.0
560.7
559.4
558.1
556.8
Elevation -msl
Friction Ratio


Sporn Fly Ash - CPT - B106
Resistance
-Kg/cm2-
0
5
10
15
20
25
30
35
594.5
593.2
591.9
590.6
589.3
588.0
586.7
585.4
584.1
582.8
581.5
590.2
578.9
577.6
576.3
575.0
573.7
572.4
571.1
569.8
568.5
567.2
565.9
564.6
563.3
562.0
560.7
559.4
558.1
556.8
Elevation -msl
Cone Resistance
Local Friction



Sporn Fly Ash - CPT - B106
Resistance
-Kg/cm2-
0
5
10
15
20
25
30
35
594.5
593.2
591.9
590.6
589.3
588.0
586.7
585.4
584.1
582.8
581.5
590.2
578.9
577.6
576.3
575.0
573.7
572.4
571.1
569.8
568.5
567.2
565.9
564.6
563.3
562.0
560.7
559.4
558.1
556.8
Elevation -msl
Cone Resistance
Local Friction

7222(R3-84)AP50
FORM GE-8 (C)

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

SHEET 1 OF ____
DATE 5/5/97 BY PJ Amaya CK ____
COMPANY Central Operating G.O. ____
PLANT Sporn

SUBJECT Unit 5 Fly Ash Facility

STRENGTH PARAMETERS.

EASTERN DIKE:

BORING B-107 - ELEV. = 618.8.

DEPTH	USN	DESCRIPTION	N	γ_d (pcf)	STRENGTH PARAMETER	SOURCE.
3.0 to 4.5	②	Gr. silty Sand (SP)	38	1.67 g/cm³	ϕ = 33°	TABLE 3.5 (1)
5.0 to 6.5	③	Sand and Gravel	49	1.76 g/cm³	ϕ = 36°	TABLE 3.5 (1)
8.5 to 10.		" "	42	1.74 g/cm³	ϕ = 35°	TABLE 3.5 (1)
11.6 to 13.1		Mc 4% "	37	1.83 g/cm³	ϕ = 33°	TABLE 3.5 (1)
16.6 to 18.1	①	Silty Clay (CL) PI = 7, Mc = 14%	18	2.08 g/cm³ *	Uc = 1.3 tsf ; ϕ' = 36°	Fig 3.4 - 3.5 (1)
21.6 to 23.1	⑨	Sandy Silt (ML) Mc = 11%	19	1.41 g/cm³	ϕ = 31°	TABLE 3.5 (1)
26.6 to 28.1	⑧	Gray Fly Ash (ML)	14	74.3	ϕ = 30°	TABLE 3.5 (1)
31.6 to 33.1		" "	19	74.3	ϕ = 31°	TABLE 3.5 (1)
36.6 to 38.1		" " SG = 2.38 Mc = 38%	2	74.3	ϕ = 27°	TABLE 3.5 (1)
41.6 to 43.1		" "	2	74.3	ϕ = 27°	TABLE 3.5 (1)
46.6 to 48.1		" "	2	74.3	ϕ = 27°	TABLE 3.5 (1)
51.6 to 53.1		" "	2	74.3	ϕ = 27°	TABLE 3.5 (1)
56.6 to 58.1		SG = 2.31 Mc = 36%	0	74.3	ϕ = 27°	TABLE 3.5 (1)
61.6 to 73.1	⑪	PI = 20 Mc = 25% DARK BROWN CLAY (CL) PI = 26, Mc = 27%	17 - 13 ST	97.3	Uc = 1.7 tsf ; ϕ' = 30° C = 700 psf ϕ' = 17° C = 0 ϕ' = 39°	Fig. 3.35 & 3.70 (1) PEAK STRENGTH H.C. NUTTING Co. TRIAXIAL TESTING

AEPSPP-000736

AEPSPP004114

7222(R3-84)IAP50
FORM GE-8 (C)

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

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DATE 5/5/97 BY PJ Amaya CK.
COMPANY Central Operating G.O.
PLANT Sporn.

SUBJECT Unit 5 Fly Ash Facility

STRENGTH PARAMETERS (CONTINUED)

BORING B-108 - EL. 603.4

DEPTH	SN	DESCRIPTION	N	γd (PCF)	STRENGTH PARAMETERS	SOURCE
3.0 to 4.5	(4)	Bottom Ash (SM) Mc = 9%	31	56.0	φ = 32°	Table 3.5 (1)
5.0 to 6.5		" "	38	60.5	φ = 34°	Table 3.5 (1)
8.5 to 10.0	(5)	Silty Sand (SM) Mc = 6.1%	45	1.65 g/cm³	φ = 35°	Table 3.5 (1)
11.6 to 13.1		Gr. Silty Sand (SM) Mc = 3%	40	1.55 g/cm³	φ = 34°	Table 3.5 (1)
16.6 to 18.1		Gr. Silty Sand (SM) Mc = 12%	45	1.65 g/cm³	φ = [illegible]	Table 3.5 (1)
21.6 to 23.1	(6)	Silty Clay (CL) PI = 7 Mc = [illegible]	14	2.06 g/cm³	Uc 1.0 tsf φ 34°	Fig. 3.35 & 3.30
26.6 to 28.1	(7) (8)	Bottom Ash (SM)	8	52.2	φ = 29°	Table 3.5 (1)
31.6 to 33.1		Gray Fly Ash (ML) Mc. 4%	3	74.3	φ = 27°	Table 3.5 (1)
36.6 to 38.1		" "	2	74.3	φ = 27°	Table 3.5 (1)
41.6 to 53.1	(10)	PI = 15 Mc = [illegible] Gray Clay (CL) PI = 30, Mc = 37%	S-12 ST	86.0	Uc [illegible] φ = [illegible]; C = 750 psf φ = 15°; C' = 0 psf φ' = 33°	Fig. 3.3 & 3.3; Peak Strength H.C. Nutting Co. Triaxial Testing
56.6 to 73.1	(11)	Gray Silty Clay (CL) PI [illegible], Mc 25%	ST * S-11	94.2	C = 100 psf φ = 17°; C' = 0 psf φ' = 37°; Uc [illegible]	Triaxial Testing - B-110 -; [illegible]

* - Saturated

AEPSPP-000737

7222(R3-84)IAP50
FORM GE-8 (C)

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

SHEET 3 OF
DATE 5/5/97 BY P.J. Amaya CK.
COMPANY Central Operating G.O.
PLANT Sporn

SUBJECT Unit 5 Fly Ash Facility

STRENGTH PARAMETERS (CONTINUED)

BORING B-109 - ELEV. = 619.6

DEPTH	SN	DESCRIPTION	N	γ_d (PCF)	STRENGTH PARAMETER	SOURCE
3.0 to 4.5	②	Gravelly Sand (SP)	43	1.76 g/cm³	$\phi = 35°$	TABLE 3.5 (1)
5.0 to 6.5	③	" "	39	1.76 g/cm³	$\phi = 34°$	TABLE 3.5 (1)
8.5 to 10.0		" Mc = 1% "	39	1.76 g/cm³	$\phi = 34°$	TABLE 3.5 (1)
	④					
11.7 to 13.2		Si SAND (SM) Mc = 4%	27	1.55 g/cm³	$\phi = 32°$	TABLE 3.5 (1)
16.7 to 18.2	⑩	Sandy Silty Clay (CL) Mc = 9%	11	1.92 g/cm³*	U_c = 0.8 ksf; ϕ = 34°	Fig. 3.30 & 3.30 [illegible]
21.7 to 23.2		" PE = 6 "	14	2.08 g/cm³	U_c = 1.0 ksf; ϕ = 34°	Fig. 3.31 & 3.3[illegible]
26.7 to 28.7	⑪	Gray Fly Ash (ML) Mc = 4%	ST	74.3	ϕ = 3[illegible]°	H.C. MUTTING COMP. TESTING & TABLE [illegible]
31.7 to 33.2		" "	17	74.3	$\phi = 30°$	TABLE 3.5 (1)
36.7 to 38.2		SG = 2.24" Mc = 38%	2	74.3	$\phi = 27°$	TABLE 3.5 (1)
41.7 to 43.2		" "	2	74.3	$\phi = 27°$	TABLE 3.5 (1)
46.7 to 48.2		" "	4	74.3	$\phi = 27°$	TABLE 3.5 (1)
51.7 to 66.7		" "	3	74.3	$\phi = 27°$	TABLE 3.5 (1)
[illegible].7 to 58.2		SG = [illegible] [illegible]	5	74.3	$\phi = 27°$	TABLE 3.5 (1)
61.7 to 73.2	⑫	Brown Clay (CL) [illegible] = 18%, [illegible]	ST 9-14	97.3	c = 700 psf, ϕ = 17°; c' = 0, ϕ' = 39°; U_c = 1.2 ksf, ϕ' = 32°	TRIAXIAL TESTING = B-107 —

* Satu[illegible]

AEPSPP-000738

AEPSPP004116

7222(R3-84)IAP50
FORM GE-8 (C)

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

SHEET 4 OF
DATE 5/5/97 BY P.J. Amaya CK.
COMPANY Central Operating G.O.
PLANT Sporn

SUBJECT Unit 5 Fly Ash Facility

STRENGTH PARAMETERS (CONTINUED)

BORING B-110 - ELEV: 602.3

DEPTH	SN	DESCRIPTION	N	γ_d (PCF)	STRENGTH PARAMETERS	SOURCE
3.0 to 4.5	5	BOTTOM ASH (SM)	42	60.5	ϕ = 35°	TABLE 3.5 (1)
5.0 to 6.5		" [illegible] "	25	56.0	ϕ = 32°	TABLE 3.5 (1)
8.5 to 10.0	6	SAND & GRAVEL (GP) Mc 11%	16	1.83 g/cm³	ϕ = 32°	TABLE 3.5 (1)
11.6 to 13.1		" "	17	1.83 g/cm³	ϕ = 32°	TABLE 3.5 (1)
16.6 to 18.1	9	Sandy silty clay (CL) PI 8, Mc [illegible]	20	2.08 g/cm³*	Uc = 1.5 tsf; ϕ = 31	Fig. 3.35 & 3.30
18.6 to 20.1		Sandy silty CLAY (CL) PI = 7, Mc = 12%	23	2.08 g/cm³*	Uc = 1.7 tsf; ϕ = 31°	Fig. 3.35 & 3.30(1)
21.6 to 23.1		" "	18	2.08 g/cm³*	Uc = 1.3 tsf, ϕ = 31	Fig. 3.35 & 3.30(1)
26.6 to 28.1		" "	18	2.08 g/cm³*	Uc = 1.3 tsf; ϕ = 31	Fig. 3.35 & 3.30(1)
31.6 to 33.1	10	Reddish Br. Clay (CL) PI = 12, Mc = 15%	19	2.08 g/cm³*	Uc = 1.4 tsf; ϕ = 33°	Fig. 3.35 & 3.30(1)
					Uc = 1.2 tsf; ϕ = [illegible]	Fig. 3.35 & 3.30
36.6 to 50.0	7	GRAY CLAY (CL) PI = 15, Mc 25%	ST 8 to 12	86.0	C = 750 psf ϕ = 15°; C' = 0 ϕ' = 33°	TRIAXIAL TESTING - 13108 -
51.6 to 73.1	8	Gray Silty Clay (CL) PI = 12, Mc 28%	ST.	94.2	C = 100 psf ϕ = 17°; C' = 0 ϕ' = 37°	PEAK STRENGTH H.C. NUTTING CO. TRIAXIAL TESTING
		PI 17, Mc 24%	9 to		Uc 1.2 tsf; ϕ = 31°	Fig. 3.35 & 3.30(1)
		PI 17, Mc 2[illegible]	17			
	13			*SATURATED		

AEPSPP-000739

AEPSPP004117

7222(R3-84)IAP50
FORM GE-8 (C)

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

SHEET 1 OF
DATE 5/6/97 BY PJAmaya CK.
COMPANY Central Operating G.O.
PLANT Sporn

SUBJECT Unit 5 Fly Ash Facility

STRENGTH PARAMETERS

BORING SI-3 (1988)

Depth	SN	Description	N	γ_d (pcf)	Strength Parameters	Source
3.0 to 4.5	⑤	Silty Sand (SM)	30	1.55 g/cm³	φ = 32°	Table 3.5 (1)
8.0 to 9.5		Gravelly Sand (SP)	7	1.59 g/cm³	φ = 29°	Table 3.5 (1)
13.0 to 14.5		Silty Sand-Gravel (GP	9	1.97 g/cm³	φ = 32°	Table 3.5 (1)
18.0 to 19.5	⑥	Sandy Silt (ML)	23	1.41 g/cm³	φ = 31	Table 3.5 (1)
23.0 to 24.5		" " "	14	1.41 g/cm³	φ = 31°	Table 3.5 (1)
28.0 to 29.5		" " "	17	1.41 g/cm³	φ = 31°	Table 3.5 (1)
33.0 to 34.5	⑦	Brown Clay	20	2.08 g/cm³ *	U_c 1.4 tsf; φ = 33°	B-110 (31.6 - 33)
38.0 to 39.5	⑧	Organic Silty Clay	17	2.08 g/cm³ *	U_c 1.2 tsf; φ = 32°	B-110 (36.6 - 50)
43.0 to 49.0	⑨	Gray Clay	9	1.92 g/cm³ *	c' = 0 φ' = 33°	B-110 (36.6 - 50)
53.0 to 54.5	⑫	Silty Sand & Gravel (GW)	>50	2.08 g/cm³	φ = 36°	Table 3.5 (1)
58.0 to 59.5		" " "	55	2.08 g/cm³	φ = 36	Table 3.5 (1)
63 to 64.5		Sand & Gravel (GP)	53	1.92 g/cm³	φ = 35°	Table 3.5 (1)
68 to 69.5		" " "	24	1.83 g/cm³	φ = 32°	Table 3.5 (1)
73.0 to 74.5		Silty Sand (SM)	29	1.55 g/cm³	φ = 32°	Table 3.5 (1)
78 to 89.5		Sand (SP)	27	1.67 g/cm³	φ = 33°	Table 3.5 (1)
93 to 94.5		Silty Sand & Gravel (GW)	35	1.97 g/cm³	φ = 32	Table 3.5 (1)

• 10 feet replaced with reinforced bottom ash - 1995

• Underdrain placed in the sandy silt soil - 1995

AEPSPP-000740

AEPSPP004118

7222(R3-84)IAP50
FORM GE-8 (C)

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

SHEET 2 OF
DATE 5/6/97 BY [illegible] CK.
COMPANY CENTRAL OPERATING G.O.
PLANT SPORN

SUBJECT Unit 5 Fly Ash Facility

STRENGTH PARAMETERS (CONTINUED)

BORING 9301 (1993)

DEPTH	SN	DESCRIPTION	N	γ_d (PCF)	STRENGTH PARAMETERS	SOURCE
0.0 to 1.5	1	Silty Clay (CL)	7	1.92 g/cm³ *	U_c = 1.1 tsf ; ϕ = 30°	TABLE 3.3S [1]
1.5 to 3.0		Sandy Clay (CL)	30	2.24 g/cm³ *	U_c = 4.0 tsf ; ϕ = 30°	TABLE 3.3S [1]
3.0 to 4.5	4	BOTTOM ASH (SM)	25	52.2	ϕ = 32°	TABLE 3.5 [1]
4.5 to 6.0	11	GRAY FLY ASH (ML)	42	74.3	ϕ = 33°	TABLE 3.5 [1]
6.0 to 7.5		" " "	38	74.3	ϕ = 33°	TABLE 3.5 [1]
7.5 to 9.0		" " "	36	74.3	ϕ = 33°	TABLE 3.5 [1]
9.0 to 10.5		" " "	29	74.3	ϕ = 33°	TABLE 3.5 [1]
10.5 to 12.0		" " "	21	74.3	ϕ = 31°	TABLE 3.5 [1]
12.0 to 13.5		" " "	25	74.3	ϕ = 31°	TABLE 3.5 [1]
13.5 to 15.0		" " "	16	74.3	ϕ = 31°	TABLE 3.5 [1]
15.0 to 16.5		" " "	6	74.3	ϕ = 27°	TABLE 3.5 [1]
16.5 to 18.0		" " "	2	74.3	ϕ = 27°	TABLE 3.5 [1]
18.0 to 19.5		" " "	0	74.3	ϕ = 27°	TABLE 3.5 [1]
19.5 to 21.0		" " "	5	74.3	ϕ = 27°	TABLE 3.5 [1]
21.0 to 22.5		Sand and Gravel (GP)	15	1.83 g/cm³	ϕ = 32°	TABLE 3.5 [1]

7222(R3-84)IAP50
FORM GE-8 (C)

ENGINEERING DEPT.
AMERICAN ELECTRIC POWER SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OHIO

SHEET 3 OF
DATE 5/7/97 BY PJ Amaya CK.
COMPANY Central Operating G.O.
PLANT Sporn

SUBJECT Unit 5 Fly Ash Facility

STRENGTH PARAMETERS (CONTINUED)

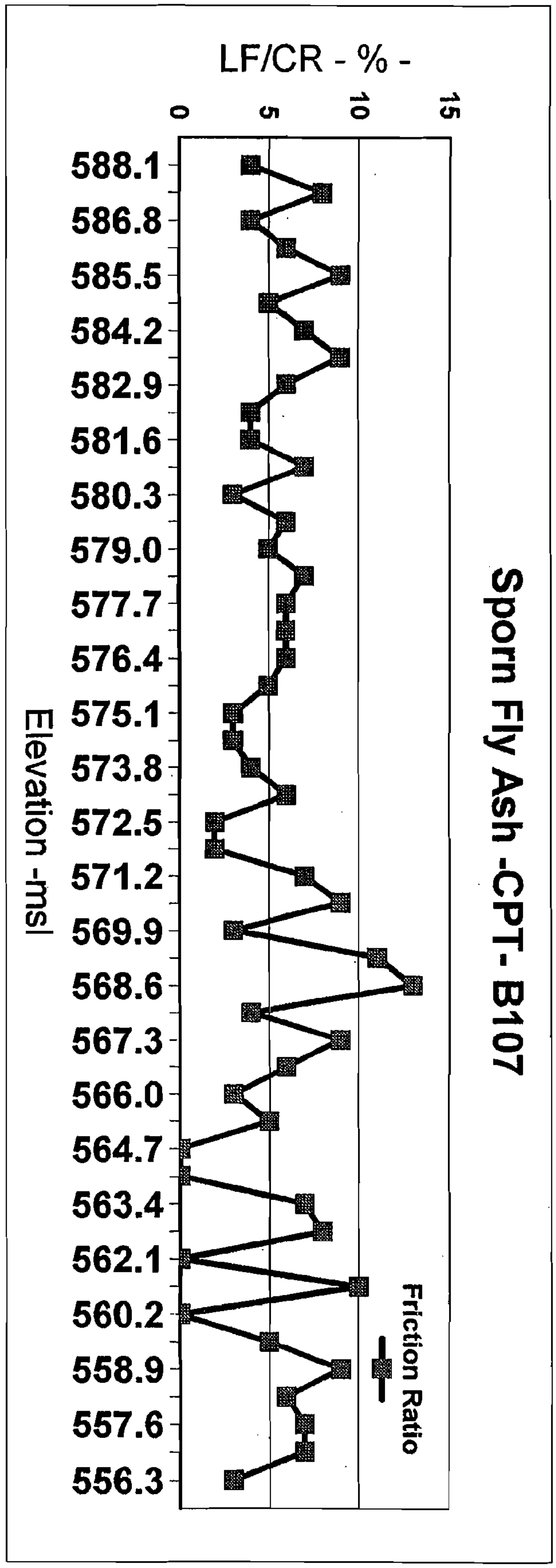
BORING 9301 (Continued)

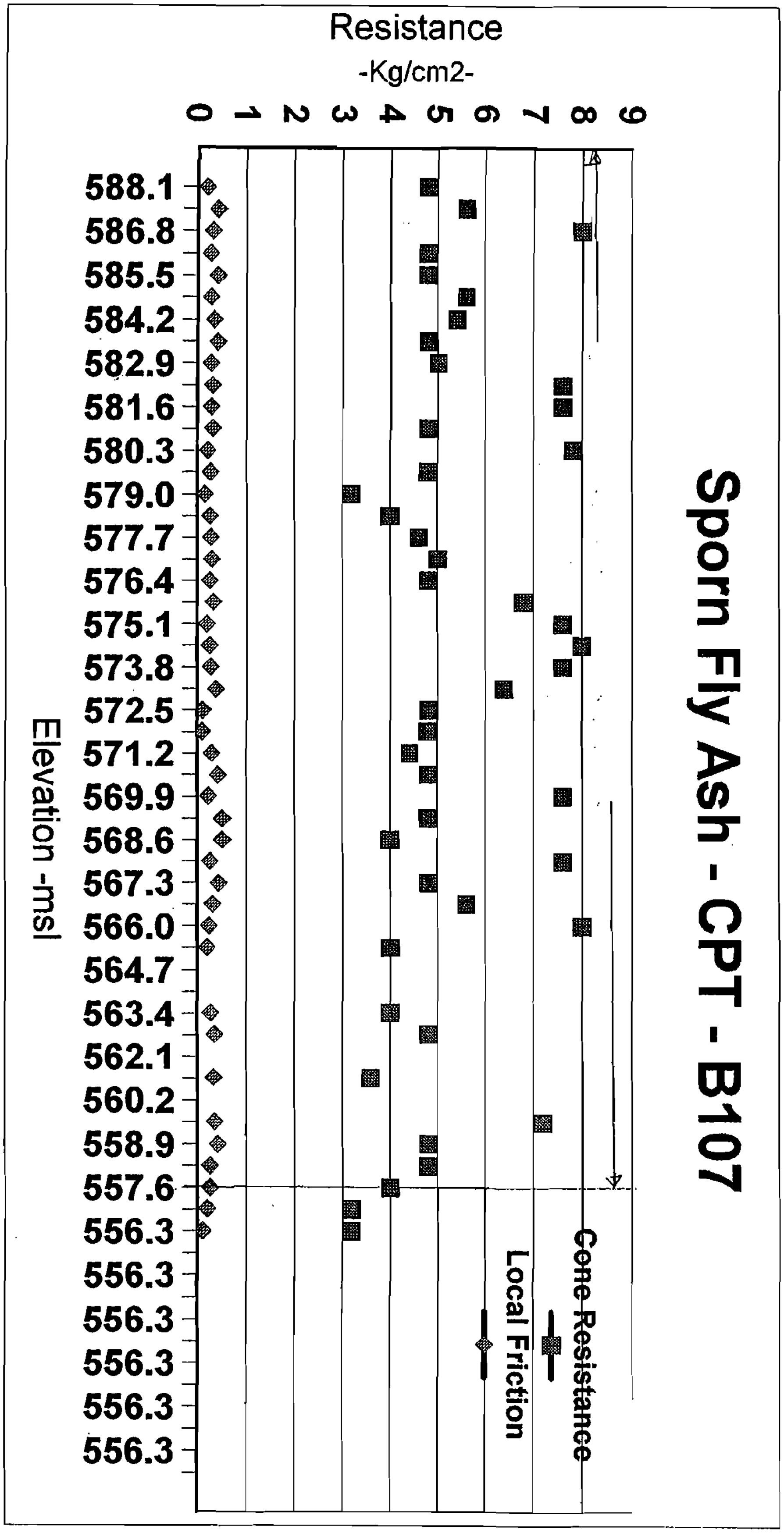
DEPTH	SU	DESCRIPTION	N	γd (pcf)	STRENGTH PARAMETERS	SOURCE
22.5 to 24.0	(10)	Sandy silty clay (CL)	11	1.92 g/cm³ *	Uc = 0.6; Φ' = 34°	B-110 (21.6-23.6
24.0 to 27.5		Brown silty clay (CL)	20	2.08 g/cm³ *	Uc 1.4 tsf; Φ' 33°	B-110
27.5 to 31.0		" " "	14	2.08 g/cm³ *	Uc 1.0 tsf; Φ' 32	B-110
31.0 to 34.5		" " "	16	2.08 g/cm³ *	Uc 1.7 tsf; Φ' 32°	B-110
34.5 to 38.0		" " "	16	2.08 g/cm³ *	Uc 1.2 tsf; Φ 32°	B-110
38.0 to 41.5		" " "	15	2.08 g/cm³ *	Uc 1.1 tsf; Φ 32°	B-110
41.5 to 45	(9)	gray clay (CL)	10	1.92 g/cm³ *	Uc = 0.75 tsf; Φ 33°	Table 3.3
45.0 to 46.5	(12)	Sand & Gravel (GP)	7	1.83 g/cm³	Φ = 32°	Table 3.5

* Saturated

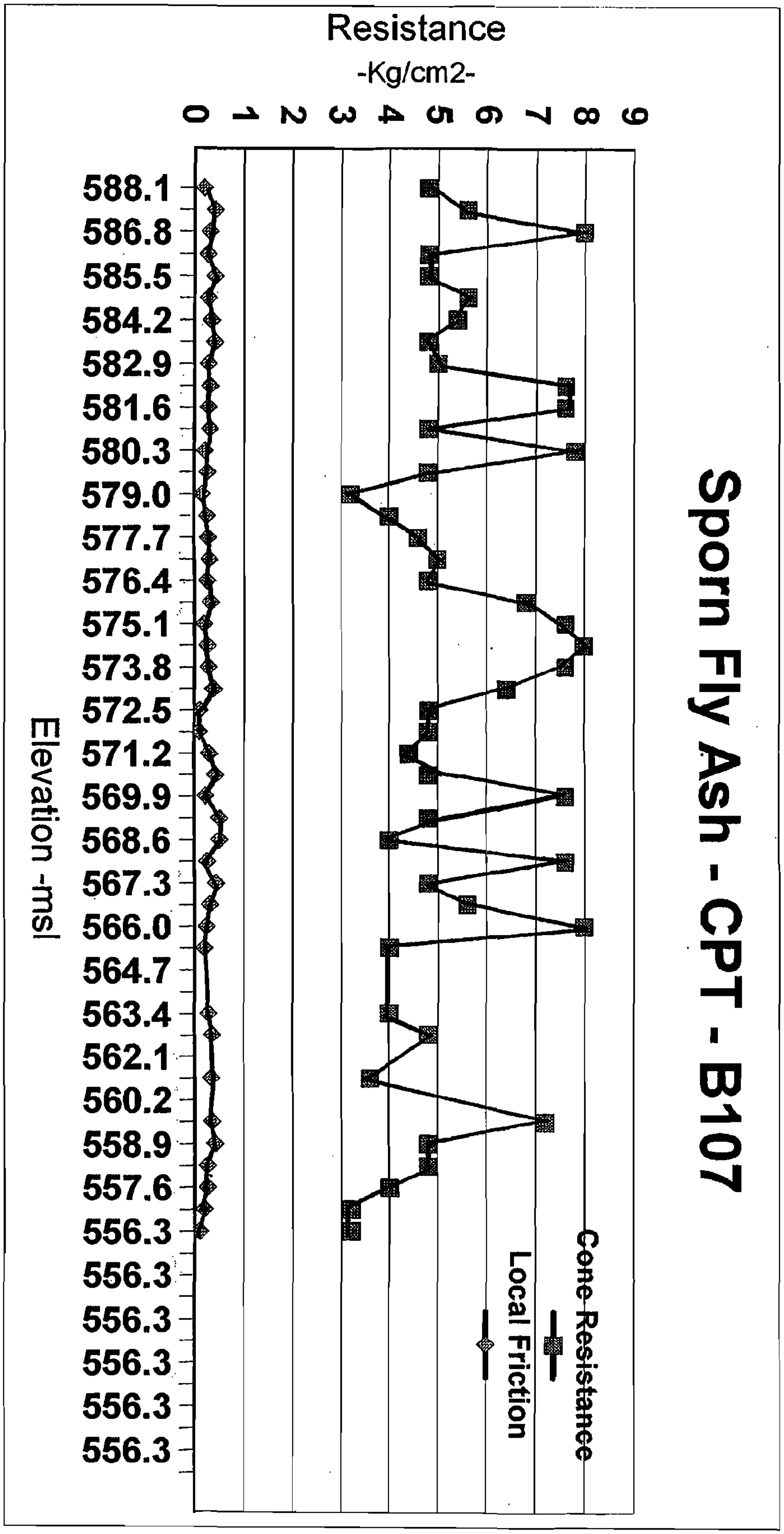
AEPSPP-000742

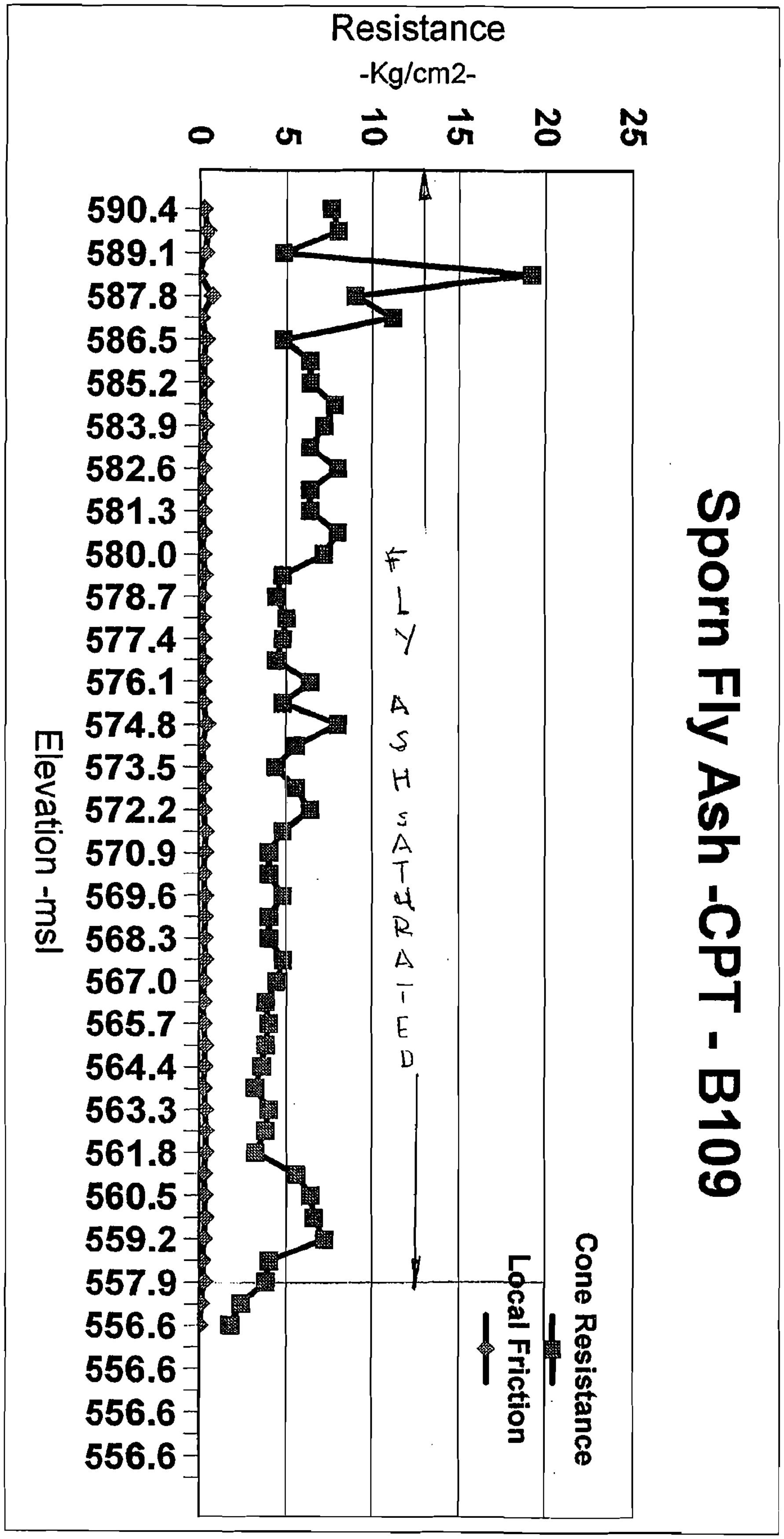
AEPSPP004120

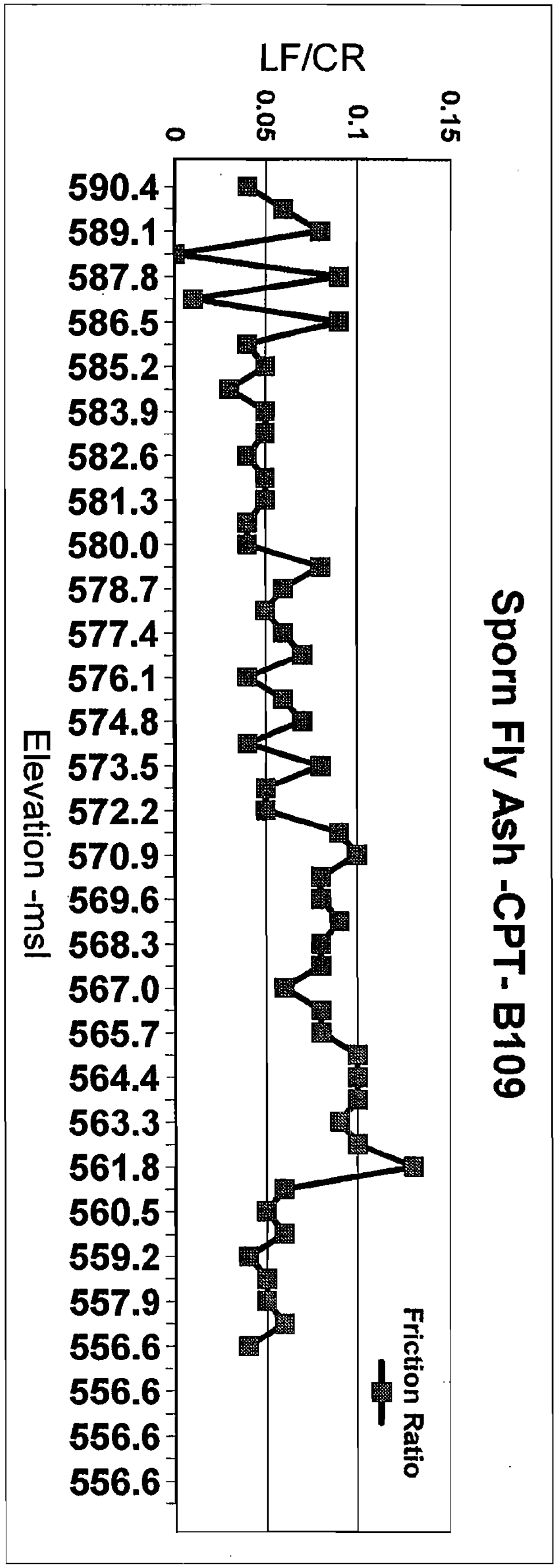

Sporn Fly Ash -CPT- B107
LF/CR - % -
0
5
10
15
588.1
586.8
585.5
584.2
582.9
581.6
580.3
579.0
577.7
576.4
575.1
573.8
572.5
571.2
569.9
568.6
567.3
566.0
564.7
563.4
562.1
560.2
558.9
557.6
556.3
Elevation -msl
Friction Ratio



Sporn Fly Ash - CPT - B107
Resistance
-Kg/cm2-
0 1 2 3 4 5 6 7 8 9
Elevation -msl
588.1
586.8
585.5
584.2
582.9
581.6
580.3
579.0
577.7
576.4
575.1
573.8
572.5
571.2
569.9
568.6
567.3
566.0
564.7
563.4
562.1
560.2
558.9
557.6
556.3
556.3
556.3
556.3
556.3
556.3
Cone Resistance
Local Friction


Sporn Fly Ash - CPT - B107
Resistance
-Kg/cm2-
0 1 2 3 4 5 6 7 8 9
Elevation -msl
588.1
586.8
585.5
584.2
582.9
581.6
580.3
579.0
577.7
576.4
575.1
573.8
572.5
571.2
569.9
568.6
567.3
566.0
564.7
563.4
562.1
560.2
558.9
557.6
556.3
556.3
556.3
556.3
556.3
556.3
Cone Resistance
Local Friction


Sporn Fly Ash -CPT - B109
Resistance
-Kg/cm2-
0
5
10
15
20
25
Elevation -msl
590.4
589.1
587.8
586.5
585.2
583.9
582.6
581.3
580.0
578.7
577.4
576.1
574.8
573.5
572.2
570.9
569.6
568.3
567.0
565.7
564.4
563.3
561.8
560.5
559.2
557.9
556.6
556.6
556.6
556.6
Cone Resistance
Local Friction
FLY ASH SATURATED



Sporn Fly Ash -CPT- B109
LF/CR
0
0.05
0.1
0.15
Elevation -msl
590.4
589.1
587.8
586.5
585.2
583.9
582.6
581.3
580.0
578.7
577.4
576.1
574.8
573.5
572.2
570.9
569.6
568.3
567.0
565.7
564.4
563.3
561.8
560.5
559.2
557.9
556.6
556.6
556.6
556.6
Friction Ratio

BORING B-106 – CPT - STRENGTH PARAMETERS – FLY-ASH

AVERAGE γ = 119.7 lbs/ft³

@ 27' ELEVATION = 591.9 ; σ_v' = 27' x 119.7 lbs/ft³ = 3,231.9 lbs/ft²

= 1.62 tsf = 1.6 Kg/cm²

USING FIG. 3.28 (1) (OR 5 (2)) STATIC CONE RESISTANCE q_c VS. D_r,

THE FLY ASH AT THIS LOCATION HAS A RELATIVE DENSITY

D_r = 0%.

FROM FIG. 3.29 (1) (OR 11 (2)) FRICTION ANGLE AND RELATIVE DENSITY RELATIONSHIPS FOR GRANULAR SOILS, THE FLY ASH AT THIS LOCATION HAS A $\phi'_{MAX.}$ = 28° (1) OR ϕ = 30° (2)

| ϕ BASED ON SPT = 27° to 29° |

BORING B-107 – CPT - STRENGTH PARAMETERS

AVERAGE γ = 1.69 Kg/cm³ = 105.7 lbs/ft³

@ 26.6', ELEVATION 592.2 ; σ_v = 26.6 x 105.7 2,811.6 lbs/ft²

= 1.4 tsf = 1.4 Kg/cm²

USING FIG 3.28 (1) or FIG (5) (2) STATIC CONE RESISTANCE q_c V.S. D_r,

THE FLY ASH AT THIS LOCATION HAS A RELATIVE DENSITY,

D_r = 0%

FROM FIG. 3.29 (1) or FIG. 11 (2) THE FLY ASH AT THIS LOCATION HAS A ϕ'_{max} = 28° (1) or ϕ = 30° (2)

| ϕ BASED ON SPT = 27° to 31° |

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(1) "GEOTECHNICAL ENGINEERING, TECHNIQUES AND PRACTICE" Roy E. Hunt.

(2) "INTERPRETATION OF THE CONE PENETRATION TEST" – THE DUTCH CONE PENETROMETER CONVERSION KIT - Hogentogler & Co. INC.

BORING B-109 – CPT - STRENGTH PARAMETERS

AVERAGE γ = 1.71 Kg/cm³ = 106.6 lbs/ft³

@ 26.7' ELEVATION, 592.9; σ_v' = 20.5'x(106.6) + 6.2(106.6 - 62.4) =

σ_v' = 2459.3 lbs/ft² = 1.23 tsf = 1.2 Kg/cm

USING FIG. 3.28 (1) or FIG 5. (2) STATIC CONE RESISTANCE q_c VS. D_r, THE FLY ASH AT THIS LOCATION HAS A RELATIVE DENSITY,

D_r = 0%

FROM FIG. 3.29 (1) OR FIG. 11 (2) THE FLY ASH AT THIS LOCATION HAS A ϕ'_{MAX} = 28° (1) or ϕ = 30° (2)

ϕ BASED ON SPT = 27° to 30°

AEPSPP-000749

AEPSPP004127

LABORATORY DATA FROM:
"PHILIP SPORN POWER PLANT – STABILITY ANALYSIS"

PREPARED/COMPILED BY:
THE GEOTECHNICAL ENGINEERING SECTION OF AMERICAN ELECTRIC POWER SERVICE CORPORATION

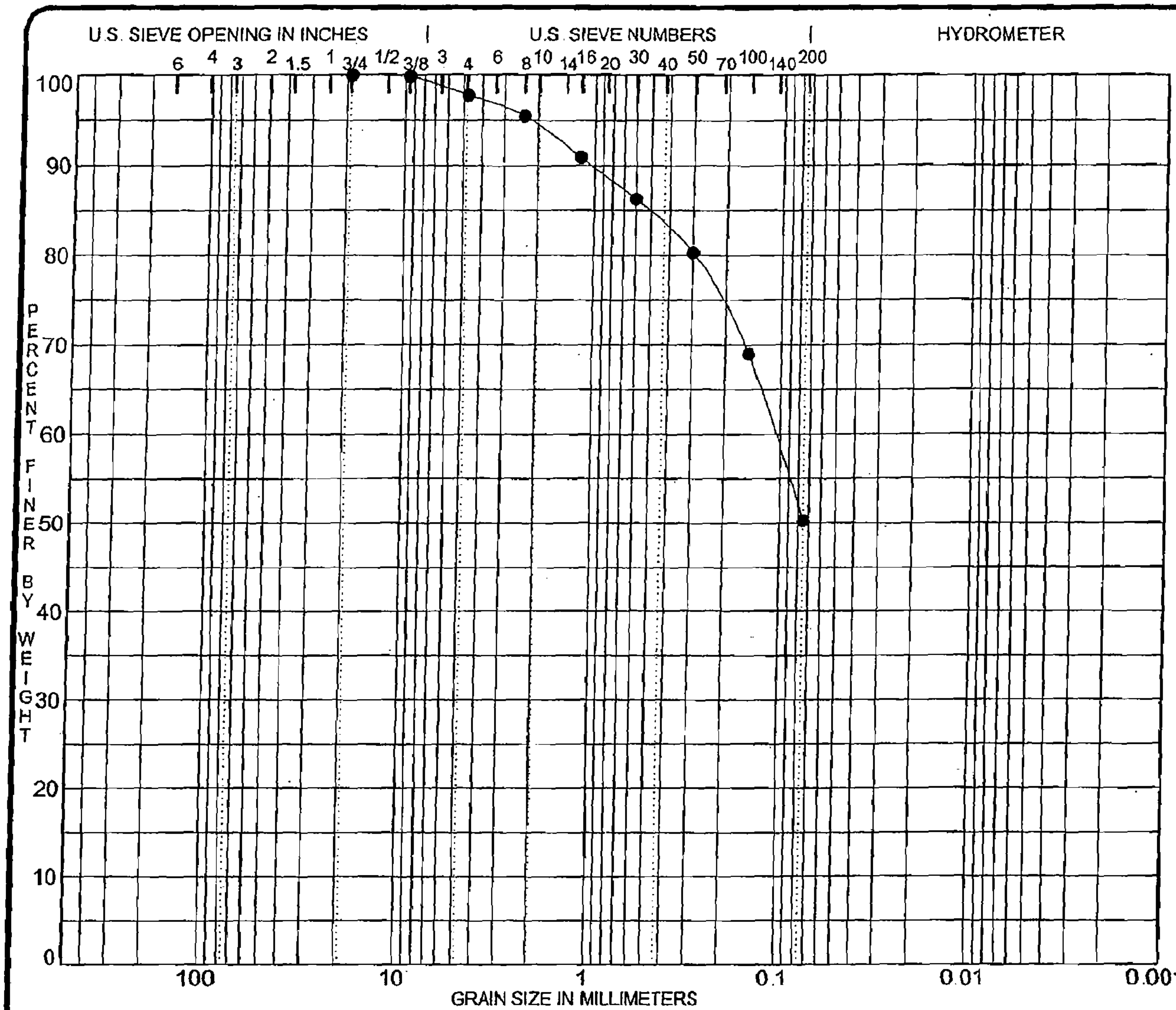
DATED: MARCH 2009

SUMMARY OF MATERIAL PROPERTIES

PROJECT: SPORN PLANT - FLY ASH POND DIKES - FLY ASH POND DIKES
NUMBER:

Sample Number	Depth ft.	ASTM Description	ASTM Class.	Max. Dry Density pcf	Optimum Moisture %	Liquid Limit %	Plastic Limit %	Gravel %	Sand %	<#200 Sieve %	<.002 mm %	Sp.G	Prmblty cm/sec	Nat. Moist. %
PZ-0901	3.5	SANDY SILT	ML			NP	NP	2.2	47.6	50.2				
PZ-0901	26.0					34.9	19.3						3.61E-07	
PZ-0902	8.5	SILTY SAND with GRAVEL	SM			NP	NP	33.0	52.9	14.0				
PZ-0902	18.5					25.6	18.2							13.3
PZ-0902	31.0	LEAN CLAY with SAND	CL			29.5	17.4	0.0	20.6	79.4	21.3			
PZ-0902	31.0					27.5	17.1							
PZ-0903	16.0					33.3	19.5							18.1
PZ-0903	23.5	SILTY SAND	SM			NP	NP	8.9	57.5	33.5				
PZ-0903	46.0	LEAN CLAY	CL			45.6	24.7	0.0	0.9	99.1	32.6		1.08E-07	
PZ-0904	8.0					29.2	19.8							16.5
PZ-0904	43.5					36.9	22.3							28.4
PZ-0905	11.0	SILTY SAND with GRAVEL	SM			NP	NP	19.6	61.2	19.2				
PZ-0905	38.0	LEAN CLAY	CL			31.2	19.1	0.0	6.5	93.5	22.6			25.3

AEP Civil Engineering Laboratory, Groveport, Ohio



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
● PZ-0901	3.5			NP	NP	NP		
		SANDY SILT ML						
		Ash Mixture - Samples 2,3,4 Combined						

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
● PZ-0901	3.5	19.000	0.108			2.2	47.6	50.2	

PROJECT SPORN PLANT - FLY ASH POND DIKES - FLY ASH POND DIKES

JOB NO. ______

DATE 8/14/09

GRADATION CURVES

American Electric Power Service Corp.
Groveport, OH 43125

AEPSPP004130

JOB NO. ______ DATE: Jul 17, 09

PROJECT SPORN PLANT - FLY ASH POND DIKES

LOCATION: FLY ASH POND DIKES

SOURCE OF MATERIAL PZ-0901 DEPTH 27.0 ft.

DESCRIPTION OF MATERIAL ______

ASTM DESCRIPTION ______

MAX. DRY DENSITY, pcf		OPTIMUM MOISTURE, %	
SPECIFIC GRAVITY	2 70		
SAMPLE HGT., mm	146.130	SAMPLE DIA., mm	72.310
CHAMBER PRESSURE, psi	70 0	BACK PRESSURE, psi	60.0
B-PARAMETER	1.00	EFFECTIVE PRESSURE, psi	10.0
INITIAL HEAD, mm	2373.2		

	BEFORE	AFTER
WATER CONTENT, %	26.7	27.0
WET DENSITY, pcf	122.4	
DRY DENSITY, pcf	96.6	
SATURATION, %	96.79	
VOID RATIO	0.7441	

PERMEABILITY COEFFICIENT K, cm/sec 3.61E-07

FLEXIBLE-MEMBRANE PERMEABILITY TEST

American Electric Power Service Corp.

Groveport, Ohio

AEP

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AMERICAN ELECTRIC POWER SERVICE CORPORATION
4001 BIXBY ROAD
GROVEPORT, OHIO 43125
(614) 836-4200

AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP

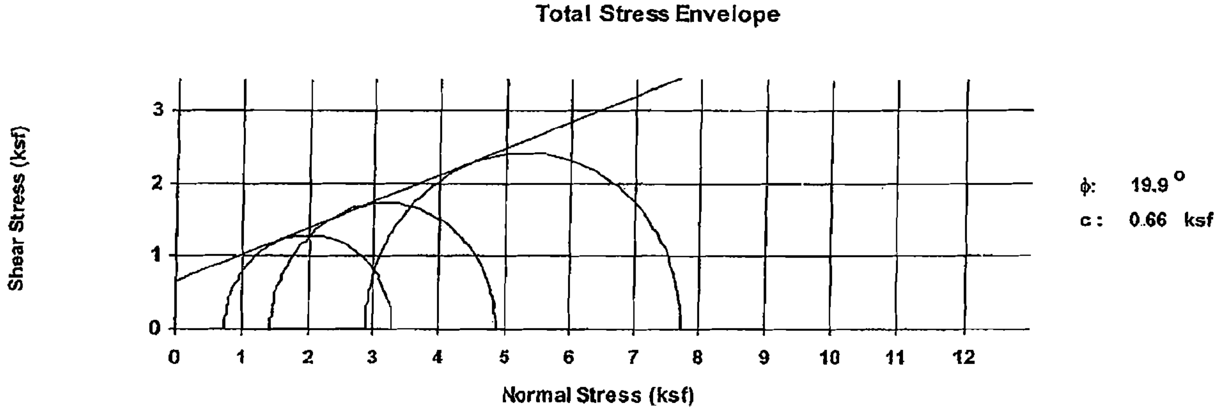
Project: SPORN ASH DISP. FACILITY

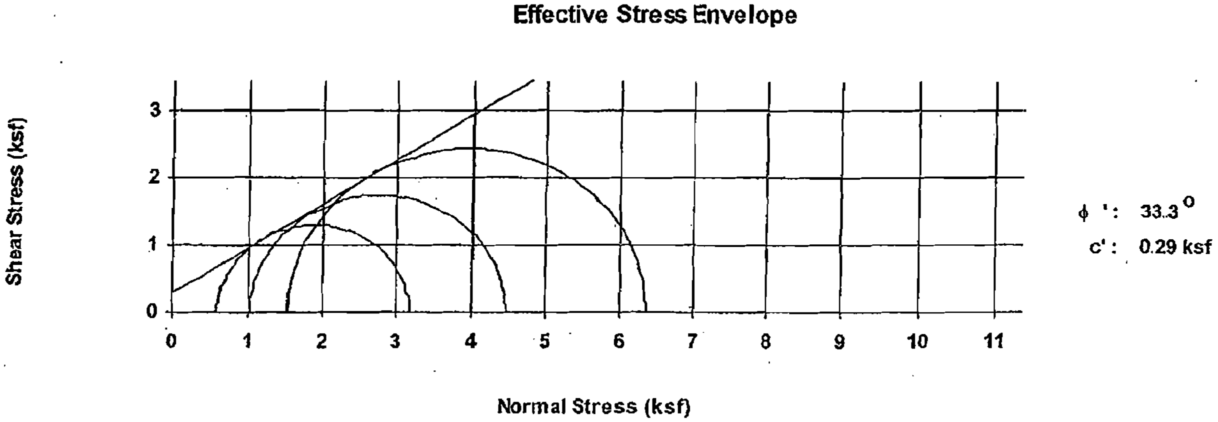
Sample No: 10906

Material Description: Boring PZ-0901, Shelby Tube - 26' - 28'; Lab # S-10906

Point Designation	Initial Conditions			Final Conditions			
	Water Content, %	Dry Density, pcf	Degree of Saturation	Water Content, %	Confining Stress, (ksf)	Deviator Stress	Induced Pore Pressure (ksf)
A	23.9%	102.1	99 2%	24 39%	0.72	2 57	0.13
B	26 7%	96 6	96 8%	27.0%	1.44	3.44	0 42
C	22.8%	104 5	100.4%	22.6%	2 88	4 84	1 35

Point Designation	Axial Strain, %	q, (ksf)	Effective Stresses, (ksf)			Total Stresses, (ksf)		
			Major, (ksf)	Minor, (ksf)	p', (ksf)	Major, (ksf)	Minor, (ksf)	p, (ksf)
A	15.0%	1 29	3 16	0.59	1 88	3.29	0 72	2 01
B	15.0%	1 72	4 46	1.02	2 74	4.88	1 44	3.16
C	11.0%	2 42	6 36	1 53	3.94	7 72	2 88	5 30





Report Date: Friday August 14, 2009

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Company: AEP
Project: SPORN ASH DISP. FACILITY
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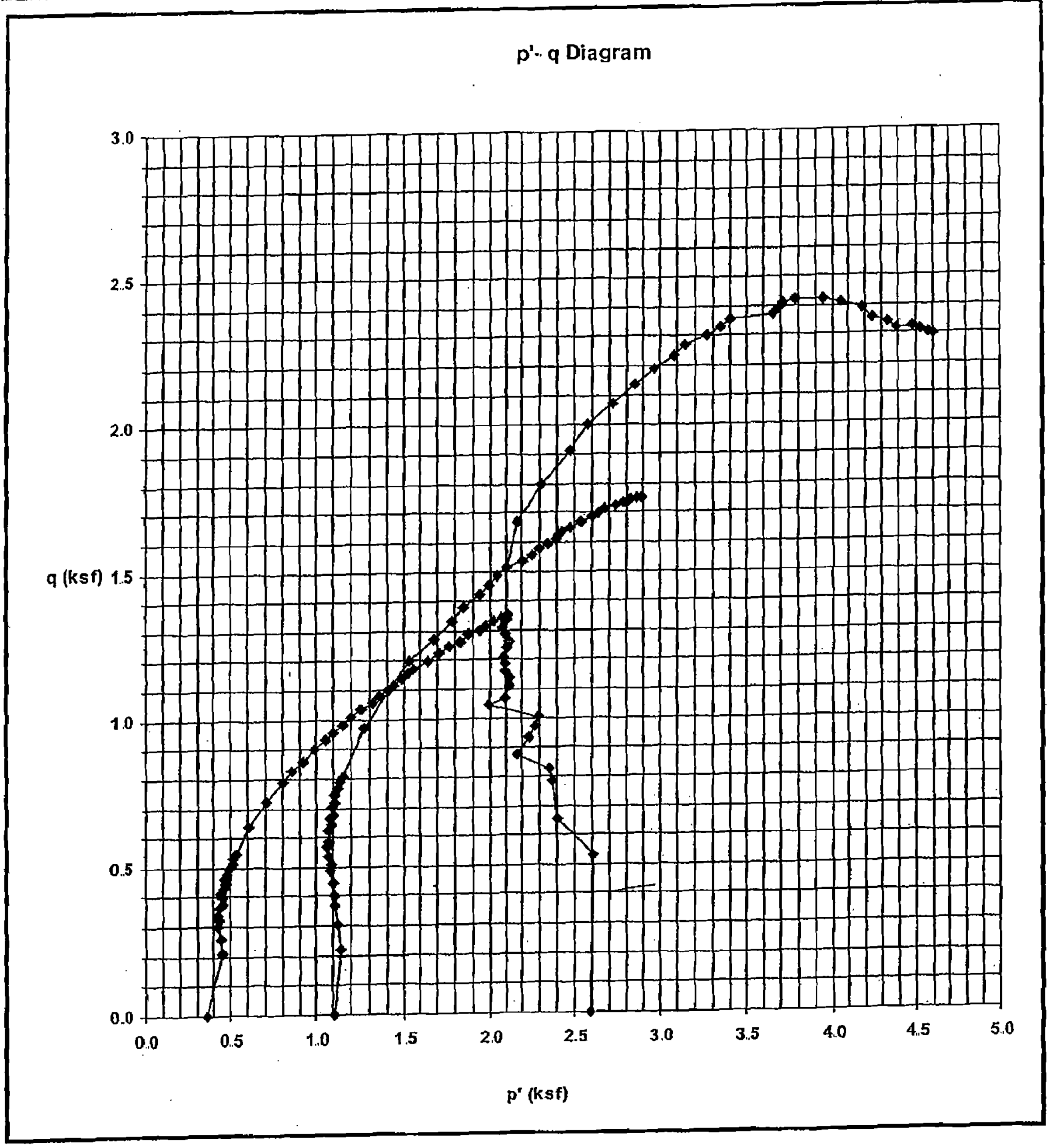

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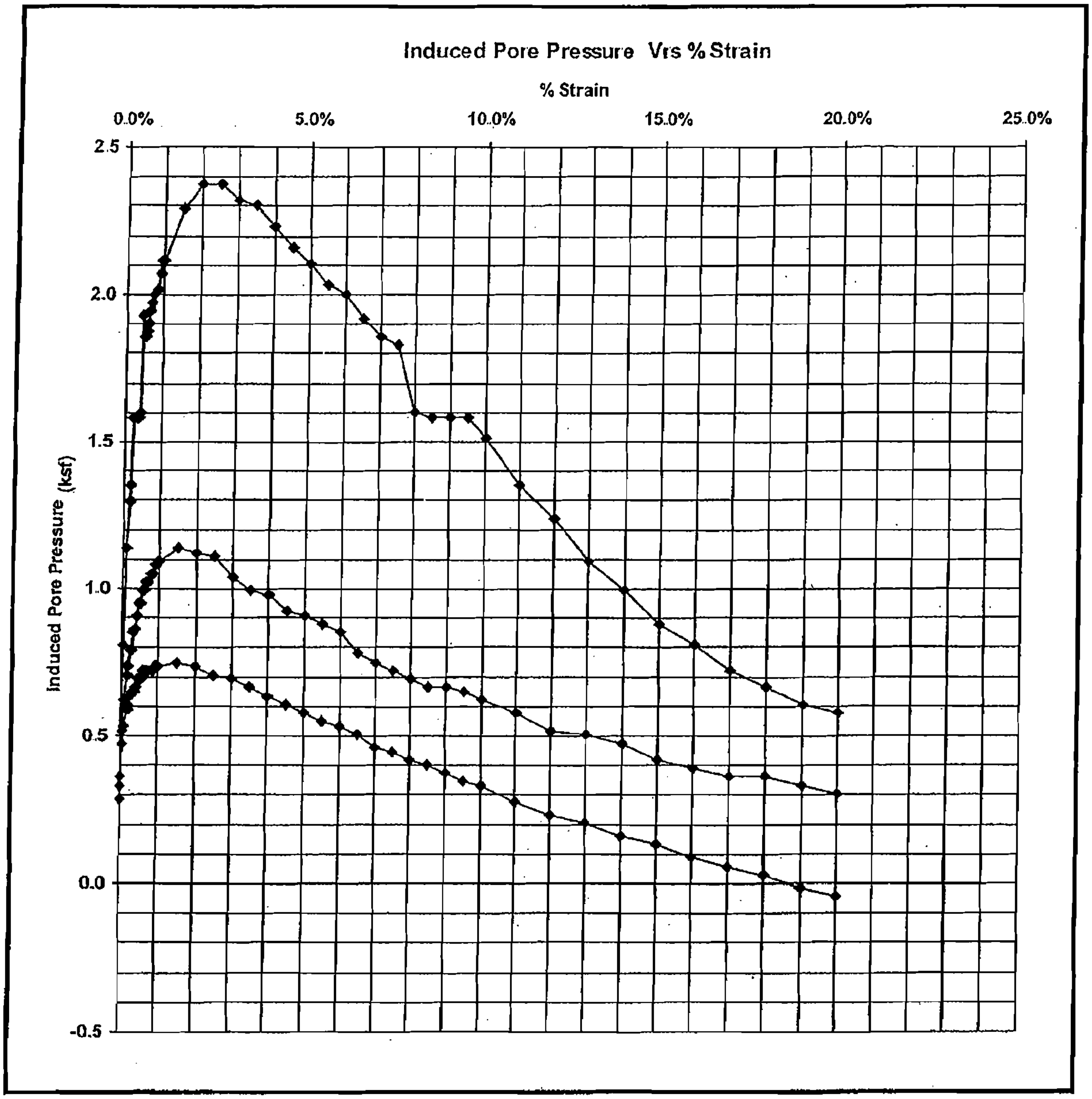

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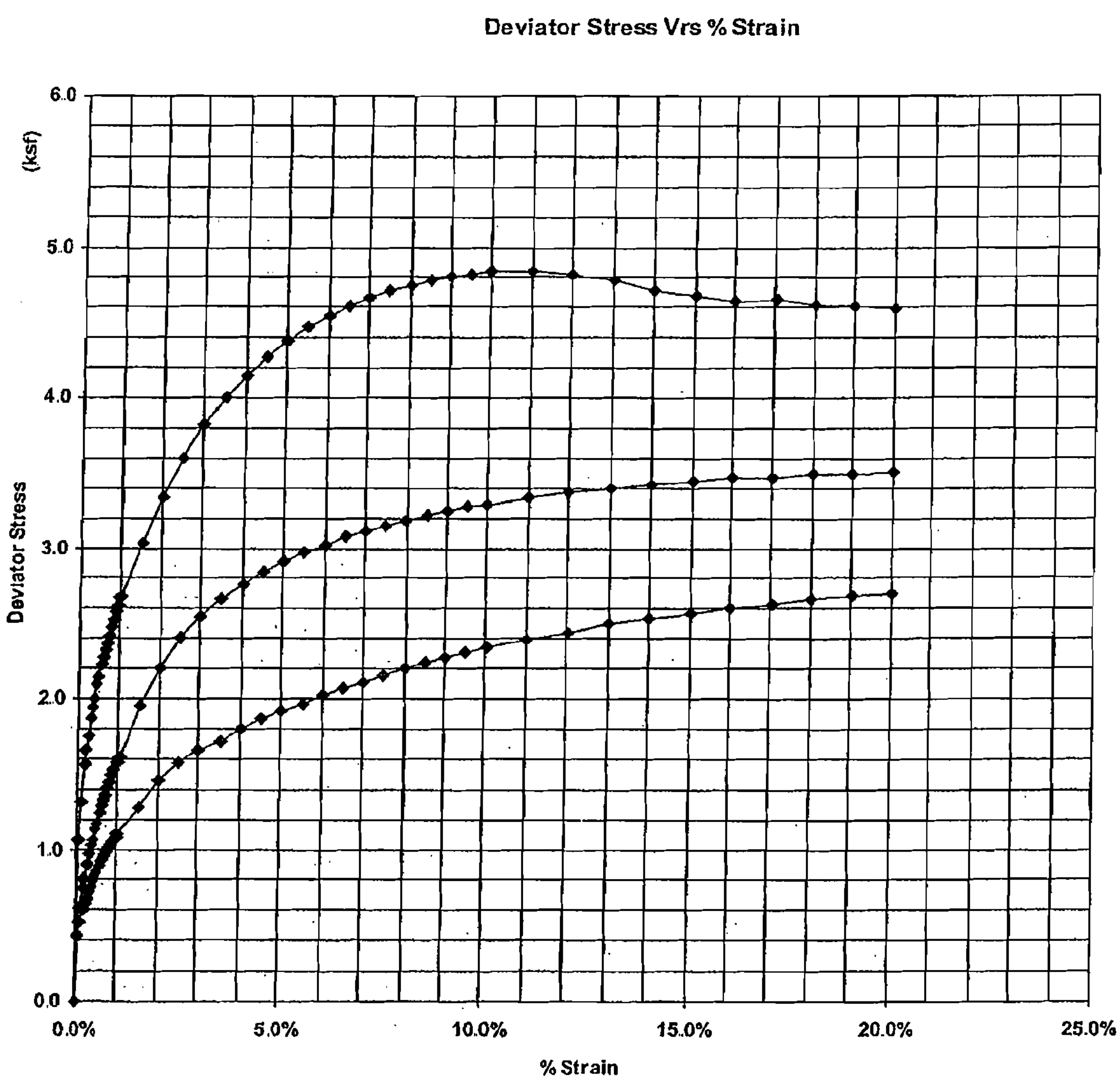

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Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10906
Point: A

Material Description: Boring PZ-0901, Shelby Tube - 26' - 28'; Lab # S-10906

Moisture Determination ASTM D2216

	Before Testing	After Testing
Tare No.	T-100	T-100
Mass of Container and Wet Specimen (Mcws), grams	1425.44	1429.80
Mass of Container and Over Dry Specimen (Mcs), grams	1190.68	1190 68
Mass of Container (Mc), grams	210.10	210 10
Mass of Water (Mw), grams:	234.76	239.12
Mass of Solid Particles (Ms), grams:	980.58	980 58
Moisture Content (w), %	23.94%	24.39%

Initial Condition of Speciman ASTM D2435

	(1)	(2)	(3)	Average
Diameter Measurents, Inches:	2.835	2 838	2.825	2.833
Height Measurements, Inches:	5.815	5.808	5.801	5.808
Initial Volume of Specimen (Vo), In.3:	36.60			
Dry Mass of Specimen After Testing, (Md), grams:	980.58			
Dry Unit Weight, (γ d) pcf:	102.06			
Specific Gravity of the Solids, (G):	2 70			
Volume of Solids, (Vs), Cu. In.:	22.1626			
Height of Solids,(Hs),In.:	3 5167			
Void Ratio Before Consolidation (Eo):	0.6515			
Intitall Degree of Saturation: (So)	99 21%			

Saturation - ASTM D4767 Section 8.2

Dial Indicator Reading Prior to Saturation (Rb:) In.	0
Cell Pressure AfterSaturation, psi:	63 00
Back Presssure After Saturation After, psi:	60.00
Pore Pressure Paramenter B:	1
Dial Indicator Reading After Saturation, (Ra) In.:	0.016
Change in Height during Satureation, (Delta Hs) In.	0.016
Change In Volume of Specimen during Saturation (Delta Vsat), In.3:	0.302

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Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10906
Point: A

Consolidation- ASTM D2435, Section 11.5:

Sample No:	T:	Burette 2:	Burette3:	Rc:
10906	0	23.6	23.7	0.016
10906	0.25	23.5	23.5	
10906	0.5	23.5	23.5	
10906	1	23.4	23.4	
10906	2	23.4	23.3	
10906	4	23.3	23.2	
10906	8	23.2	23	
10906	15	23.1	22.8	0.019
10906	30	23	22.6	0.02
10906	60	22.9	22.5	0.021
10906	120	22.7	22.2	0.022
10906	240	22.5	22.3	0.022
10906	450	22.3	22.2	0.022
10906	1440	22.2	22.2	0.023

Specimen Height After Consolidation, (Hc), In.: 5.79

Volume Change During Consolidation (Delta Vc), In.3: 0.18

Cross-Sectional Area of Specimen After Consolidation (Ac), In.2: 6.24

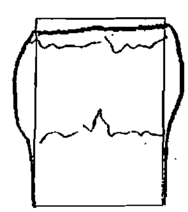
Triaxial Compression Testing ASTM D 4767

Sample Depth: 0 ft.
Cell Pressure: 65 psi
Back Pressure: 60 psi
Confining Pressure: 5 psi
Strain Rate: 0.006 in./min.

Specimen Height After Consolidation, (Hc), In.: 5.79
Correction for Vert Displacement, In.: 0
Load due to Friction and Uplift: 16.3 lbs.
Correction for Filter Paper: 0
Thickness of Membrane (tm), In.: 0.012

$\sigma 1-\sigma 3=$ Deviator Stress at Failure, ksf: 2.57
$\sigma 3$ f= Effective Consolidation Stress at Failure, ksf: 0.72
$\sigma 1=$ Total Major Principal Stress at Failure: 3.29
$\sigma '3f=$ $\sigma 3-\Delta u=$ Effective Minor Principal Stress at Failure, ksf: 0.59
$\sigma '1f=$ Effective Major Principal Stress at Failure, ksf: 3.16
Axial Strain at Failure: 15.01%

Failure Sketch



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Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP

Project: SPORN ASH DISP. FACILITY

Sample No: 10906

Point: A

Pa: Applied Force	Vertical Displacement Reading In.:	Pore Pressure psi:	Axial Strain (E1):	(P) - Force Adj for U and F lbs:	Corrected Vertical Displac In :	Correction for Membrane ksf:	(A) Area In.2:	(σ1−σ3) Deviator Stress ksf:	[Δu] Induced Pore Water Pressure ksf:	σ3 Effective Consolidation Stress ksf	σ1 Total Major Principal Stress ksf	σ3 Effective Minor Principal Stress ksf	σ1 ' Effective Major Principal Stress ksf	p'	q
16.3	0 000	62.5	0 00%	0 0	0 000	0.00002	6 244	0 00	0.3600	0.72	0 72	0 36	0.36	0 36	0 00
34.6	0.003	63.3	0.05%	18 3	0 003	0.00024	6.247	0 42	0.4752	0 72	1.14	0 24	0 67	0 46	0.21
38.7	0.006	63 7	0.10%	22 4	0 006	0 00047	6 250	0.52	0 5328	0 72	1.24	0.19	0 70	0 45	0 26
42 3	0 009	64 1	0.16%	26.0	0 009	0 00080	6 254	0.60	0.5904	0.72	1 32	0 13	0.73	0 43	0 30
44 1	0 012	64 2	0.20%	27.8	0.012	0.00100	6 257	0 64	0.6048	0 72	1 36	0.12	0 75	0.43	0.32
45.8	0 014	64.4	0.25%	29.5	0 014	0.00120	6.260	0.68	0 6336	0 72	1 40	0.09	0.76	0 43	0.34
48.0	0 018	64.5	0 31%	31.7	0 018	0.00151	6.263	0.73	0 6480	0.72	1.45	0 07	0.80	0.44	0 36
49 2	0.020	64.5	0 35%	32 9	0 020	0.00169	6 266	0 75	0.6480	0.72	1 47	0.07	0 83	0.45	0 38
50 9	0 023	64 6	0.40%	34 6	0 023	0 00197	6 269	0 79	0.6624	0 72	1 51	0.06	0.85	0 45	0 40
52 5	0 026	64.8	0.46%	36 2	0.026	0 00224	6 273	0.83	0.6912	0 72	1.55	0 03	0.86	0.44	0.41
53 7	0.029	64 8	0.50%	37.4	0.029	0 00246	6 276	0.86	0 6912	0 72	1 58	0 03	0 88	0.46	0 43
55 1	0.032	64.8	0.56%	38.8	0 032	0.00275	6.279	0 89	0 6912	0.72	1 61	0 03	0.92	0 47	0.44
56 9	0.035	65.0	0.61%	40.6	0 035	0 00300	6 283	0 93	0.7200	0 72	1.65	0 00	0.93	0.46	0.46
57 3	0.038	65 0	0 65%	41 0	0 038	0 00319	6 285	0 94	0.7200	0.72	1 66	0.00	0 94	0 47	0 47
58 4	0.041	65.0	0 70%	42 1	0.041	0 00344	6.288	0.96	0 7200	0.72	1 68	0 00	0 96	0.48	0.48
59 4	0 043	65.0	0 75%	43 1	0.043	0.00366	6.291	0.98	0.7200	0 72	1.70	0.00	0.98	0.49	0.49
60.5	0 046	65.0	0.80%	44 2	0.046	0.00392	6.294	1 01	0.7200	0 72	1 73	0.00	1 01	0 50	0 50
61.6	0 049	65 0	0.85%	45 3	0.049	0.00417	6 298	1 03	0.7200	0.72	1 75	0.00	1 03	0 52	0.52
62.8	0 053	65 1	0.91%	46 5	0 053	0 00446	6 302	1 06	0.7344	0.72	1.78	-0 01	1.04	0.51	0.53
63 8	0.056	65 1	0.96%	47 5	0 056	0.00473	6 305	1 08	0.7344	0 72	1.80	-0.01	1.07	0 53	0 54
64 5	0.058	65 1	1 00%	48 2	0 058	0 00492	6.307	1.10	0.7344	0 72	1 82	-0 01	1 08	0 53	0.55
73 0	0.087	65 2	1 50%	56.7	0 087	0 00736	6.339	1 28	0.7488	0.72	2.00	-0 03	1.25	0.61	0.64
80.9	0.116	65.1	2 00%	64.6	0.116	0.00981	6 372	1 45	0.7344	0.72	2.17	-0.01	1.44	0.71	0 73
86.9	0 145	64.9	2 50%	70.6	0 145	0.01227	6.405	1 58	0.7056	0 72	2 30	0.01	1 59	0 80	0 79
91 0	0 174	64 8	3.00%	74.7	0 174	0.01473	6 438	1.66	0 6912	0 72	2 38	0 03	1.69	0.86	0 83
94 4	0 203	64 6	3.50%	78.1	0 203	0 01717	6.471	1 72	0.6624	0.72	2.44	0.06	1 78	0 92	0 86
98 4	0 231	64 4	4 00%	82 1	0 231	0 01961	6.504	1 80	0.6336	0 72	2 52	0.09	1 88	0.99	0 90
102 2	0 261	64.2	4 50%	85.9	0 261	0.02209	6 539	1 87	0.6048	0 72	2 59	0 12	1.98	1.05	0.93
104.7	0.290	64.0	5 01%	88 4	0.290	0.02454	6.573	1.91	0.5760	0 72	2.63	0.14	2 06	1 10	0 96
107.9	0 318	63.8	5.50%	91 6	0 318	0.02698	6 608	1 97	0 5472	0.72	2.69	0.17	2 14	1.16	0 98
110 9	0.347	63 7	6.00%	94.6	0 347	0.02942	6 643	2.02	0.5328	0 72	2.74	0 19	2 21	1 20	1.01
113 7	0.376	63 5	6.51%	97.4	0.376	0.03190	6 679	2.07	0.5040	0 72	2 79	0 22	2 28	1 25	1 03
116.4	0.406	63 2	7.01%	100.1	0.406	0 03437	6.715	2.11	0.4608	0 72	2.83	0.26	2 37	1 32	1 06
119.1	0.434	63 1	7.51%	102.8	0 434	0 03680	6.751	2.16	0 4464	0.72	2.88	0 27	2.43	1.35	1.08
122.0	0.463	62.9	8.01%	105.7	0.463	0.03926	6 788	2 20	0 4176	0.72	2 92	0 30	2 51	1.40	1.10
124 3	0.492	62.8	8 50%	108 0	0 492	0 04170	6 825	2.24	0.4032	0.72	2.96	0.32	2 55	1 44	1 12
126 6	0 521	62.6	9.01%	110 3	0 521	0.04415	6 862	2.27	0.3744	0 72	2.99	0.35	2.62	1.48	1.14
128.9	0 550	62.4	9.51%	112.6	0.550	0.04661	6.900	2 30	0.3456	0.72	3.02	0 37	2.68	1.53	1.15

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Company: **AEP**

Project: **SPORN ASH DISP. FACILITY**

Sample No: **10906**

Point: **A**

131.3	0 579	62.3	10 01%	115.0	0.579	0 04907	6 939	2 34	0 3312	0.72	3 06	0 39	2 73	1.56	1 17
135.5	0.637	61.9	11 01%	119 2	0.637	0.05399	7 017	2 39	0 2736	0 72	3 11	0 45	2.84	1.64	1 20
139 6	0.695	61.6	12 01%	123 3	0.695	0.05890	7.097	2.44	0.2304	0.72	3.16	0.49	2.93	1.71	1 22
143 7	0 753	61.4	13 01%	127 4	0 753	0 06380	7 178	2 49	0 2016	0.72	3 21	0 52	3 01	1 76	1 25
147 2	0.810	61.1	14.01%	130.9	0.810	0 06868	7 261	2.53	0 1584	0 72	3 25	0.56	3.09	1 83	1 26
151 3	0 868	60 9	15.01%	135.0	0.868	0 07360	7 347	2.57	0.1296	0 72	3 29	0 59	3 16	1 88	1 29
154 6	0.926	60 6	16.01%	138 3	0.926	0 07851	7.435	2.60	0 0864	0.72	3 32	0 63	3 23	1.93	1.30
158 0	0 984	60 4	17.02%	141 7	0 984	0 08343	7.525	2 63	0 0576	0 72	3 35	0.66	3.29	1 98	1.31
161 5	1 042	60 2	18.02%	145 2	1 042	0 08833	7 616	2 66	0 0288	0 72	3 38	0 69	3 35	2.02	1 33
165 0	1 100	59 9	19 01%	148.7	1 100	0 09322	7 710	2.68	-0 0144	0 72	3.40	0 73	3 42	2.08	1.34
168.1	1.158	59.7	20 02%	151 8	1 158	0.09814	7 807	2.70	-0 0432	0.72	3 42	0.76	3.47	2.11	1.35

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Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10906
Point: B

Material Description: Boring PZ-0901, Shelby Tube - 26' - 28'; Lab # S-10906

Moisture Determination ASTM D2216

	Before Testing	After Testing
Tare No.	4	4
Mass of Container and Wet Specimen (Mcws), grams	1389.93	1393.24
Mass of Container and Over Dry Specimen (Mcs), grams	1142.12	1142.12
Mass of Container (Mc), grams	213.10	213 10
Mass of Water (Mw), grams:	247.81	251.12
Mass of Solid Particles (Ms), grams:	929.02	929.02
Moisture Content (w), %	26.67%	27.03%

Initial Condition of Speciman ASTM D2435

	(1)	(2)	(3)	Average
Diameter Measurents, Inches:	2.854	2.852	2.835	2.847
Height Measurements, Inches:	5.75	5.75	5.76	5.753

Initial Volume of Specimen (Vo), In.3:	36 63
Dry Mass of Specimen After Testing, (Md), grams:	929.02
Dry Unit Weight, (γ d) pcf:	96.63
Specific Gravity of the Solids, (G):	2.70
Volume of Solids, (Vs), Cu. In.:	20.9972
Height of Solids,(Hs),In.:	3 2983
Void Ratio Before Consolidation (Eo):	0.7443
Intitail Degree of Saturation: (So)	96.76%

Saturation - ASTM D4767 Section 8.2

Dial Indicator Reading Prior to Saturation (Rb:) In.	0
Cell Pressure AfterSaturation, psi:	65.00
Back Presssure After Saturation After, psi:	60 00
Pore Pressure Paramenter B:	1
Dial Indicator Reading After Saturation, (Ra) In.:	0.024
Change in Height during Satureation, (Delta Hs) In.	0.024
Change in Volume of Specimen during Saturation (Delta Vsat), In.3:	0.458

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Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10906
Point: B

Consolidation- ASTM D2435, Section 11.5:

Sample No:	T:	Burette 2:	Burette3:	Rc:
10906	0	23.8	23.8	0.024
10906	0.25	23.7	23.7	
10906	0.5	23.6	23.6	
10906	1	23.6	23.6	
10906	2	23.5	23.5	
10906	4	23.4	23.3	
10906	8	23.2	23.2	
10906	15	23	23	0.028
10906	30	22.8	22.8	0.03
10906	60	22.6	22.5	0.031
10906	120	22.4	22.3	0.031
10906	240	22.3	22.2	0.032
10906	450	22.1	22.1	0.032
10906	1440	22	22	0.032

Specimen Height After Consolidation, (Hc), In.: 5.72

Volume Change During Consolidation (Delta Vc), In.3: 0.22

Cross-Sectional Area of Specimen After Consolidation (Ac), In.2: 6.28

Triaxial Compression Testing
ASTM D 4767

Sample Depth: 0 ft.

Cell Pressure: 70 psi

Back Pressure: 60 psi

Confining Pressure: 10 psi

Strain Rate: 0.006 In/min.

Specimen Height After Consolidation, (Hc), In.: 5.72

Correction for Vert Displacement, In.: 0

Load due to Friction and Uplift: 19.1 lbs.

Correction for Filter Paper: 0

Thickness of Membrane (tm), In.: 0.012

$\sigma 1-\sigma 3=$ Deviator Stress at Failure, ksf: 3.44

$\sigma 3$ f= Effective Consolidation Stress at Failure, ksf: 1.44

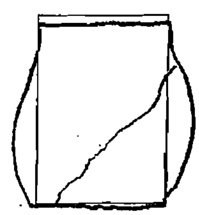
$\sigma 1=$ Total Major Principal Stress at Failure: 4.88

σ'3f= $\sigma 3-\Delta \upsilon=$ Effective Minor Principal Stress at Failure,ksf: 1.02

σ'1f= Effective Major Principal Stress at Failure, ksf: 4.46

Axial Strain at Failure: 15.00%

Failure Sketch



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Company: AEP

Project: SPORN ASH DISP. FACILITY

Sample No: 10906

Point: B

Pa: Applied Force	Vertical Displacement Reading In.:	Pore Pressure psi:	Axial Strain (E1):	(P) - Force Adj for U and F lbs:	Corrected Vertical Displac In.:	Correction for Membrane ksf:	(A) Area In 2:	(σ1−σ3) Deviator Stress ksf:	[Δυ] Induced Pore Water Pressure ksf:	σ3 Effective Consolidation Stress ksf	σ1 Total Major Principal Stress ksf	σ3 Effective Minor Principal Stress ksf	σ1' Effective Major Principal Stress ksf	p'	q
19.1	0.000	62.3	0.00%	0.0	0.000	0.00002	6.283	0.00	0.3312	1.44	1.44	1.11	1.11	1.11	0.00
38.3	0.003	63.6	0.05%	19.2	0.003	0.00026	6.286	0.44	0.5184	1.44	1.88	0.92	1.36	1.14	0.22
45.8	0.006	64.3	0.10%	26.7	0.006	0.00048	6.289	0.61	0.6192	1.44	2.05	0.82	1.43	1.13	0.31
51.7	0.009	64.9	0.16%	32.6	0.009	0.00079	6.293	0.75	0.7056	1.44	2.19	0.73	1.48	1.11	0.37
54.5	0.011	65.1	0.20%	35.4	0.011	0.00096	6.295	0.81	0.7344	1.44	2.25	0.71	1.51	1.11	0.40
58.3	0.014	65.5	0.25%	39.2	0.014	0.00123	6.299	0.89	0.7920	1.44	2.33	0.65	1.54	1.10	0.45
61.7	0.018	65.9	0.31%	42.6	0.018	0.00152	6.303	0.97	0.8496	1.44	2.41	0.59	1.56	1.08	0.49
64.0	0.020	66.0	0.35%	44.9	0.020	0.00171	6.305	1.02	0.8640	1.44	2.46	0.58	1.60	1.09	0.51
66.0	0.023	66.3	0.40%	46.9	0.023	0.00193	6.308	1.07	0.9072	1.44	2.51	0.53	1.60	1.07	0.53
69.1	0.026	66.6	0.46%	50.0	0.026	0.00224	6.312	1.14	0.9504	1.44	2.58	0.49	1.63	1.06	0.57
70.5	0.029	66.6	0.50%	51.4	0.029	0.00244	6.315	1.17	0.9504	1.44	2.61	0.49	1.66	1.07	0.58
73.7	0.032	66.9	0.56%	54.6	0.032	0.00273	6.318	1.24	0.9936	1.44	2.68	0.45	1.69	1.07	0.62
75.7	0.035	66.9	0.61%	56.6	0.035	0.00299	6.322	1.29	0.9936	1.44	2.73	0.45	1.73	1.09	0.64
77.6	0.037	67.1	0.65%	58.5	0.037	0.00316	6.324	1.33	1.0224	1.44	2.77	0.42	1.75	1.08	0.66
78.9	0.040	67.1	0.70%	59.8	0.040	0.00342	6.327	1.36	1.0224	1.44	2.80	0.42	1.78	1.10	0.68
81.0	0.043	67.3	0.75%	61.9	0.043	0.00367	6.331	1.40	1.0512	1.44	2.84	0.39	1.79	1.09	0.70
82.7	0.046	67.3	0.80%	63.6	0.046	0.00390	6.334	1.44	1.0512	1.44	2.88	0.39	1.83	1.11	0.72
85.1	0.048	67.5	0.85%	66.0	0.048	0.00413	6.337	1.50	1.0800	1.44	2.94	0.36	1.86	1.11	0.75
86.7	0.052	67.5	0.91%	67.6	0.052	0.00444	6.341	1.53	1.0800	1.44	2.97	0.36	1.89	1.13	0.77
88.9	0.055	67.6	0.96%	69.8	0.055	0.00470	6.344	1.58	1.0944	1.44	3.02	0.35	1.93	1.14	0.79
90.2	0.057	67.6	1.00%	71.1	0.057	0.00490	6.347	1.61	1.0944	1.44	3.05	0.35	1.95	1.15	0.80
105.7	0.086	67.9	1.50%	86.6	0.086	0.00733	6.379	1.95	1.1376	1.44	3.39	0.30	2.25	1.28	0.97
117.4	0.114	67.8	2.00%	98.3	0.114	0.00976	6.411	2.20	1.1232	1.44	3.64	0.32	2.51	1.42	1.10
126.9	0.143	67.7	2.50%	107.8	0.143	0.01220	6.444	2.40	1.1088	1.44	3.84	0.33	2.73	1.53	1.20
134.3	0.172	67.2	3.00%	115.2	0.172	0.01468	6.478	2.55	1.0368	1.44	3.99	0.40	2.95	1.68	1.27
140.4	0.200	66.9	3.50%	121.3	0.200	0.01709	6.511	2.67	0.9936	1.44	4.11	0.45	3.11	1.78	1.33
145.5	0.229	66.8	4.00%	126.4	0.229	0.01953	6.545	2.76	0.9792	1.44	4.20	0.46	3.22	1.84	1.38
150.1	0.257	66.4	4.50%	131.0	0.257	0.02199	6.579	2.85	0.9216	1.44	4.29	0.52	3.36	1.94	1.42
154.0	0.286	66.3	5.00%	134.9	0.286	0.02445	6.614	2.91	0.9072	1.44	4.35	0.53	3.45	1.99	1.46
157.5	0.315	66.1	5.50%	138.4	0.315	0.02688	6.649	2.97	0.8784	1.44	4.41	0.56	3.53	2.05	1.49
160.8	0.343	65.9	6.00%	141.7	0.343	0.02930	6.684	3.02	0.8496	1.44	4.46	0.59	3.61	2.10	1.51
163.9	0.372	65.4	6.50%	144.8	0.372	0.03178	6.720	3.07	0.7776	1.44	4.51	0.66	3.73	2.20	1.54
166.8	0.400	65.2	6.99%	147.7	0.400	0.03419	6.756	3.11	0.7488	1.44	4.55	0.69	3.81	2.25	1.56
169.5	0.429	65.0	7.49%	150.4	0.429	0.03663	6.792	3.15	0.7200	1.44	4.59	0.72	3.87	2.30	1.58
172.1	0.458	64.8	8.00%	153.0	0.458	0.03909	6.829	3.19	0.6912	1.44	4.63	0.75	3.94	2.34	1.59
174.4	0.486	64.6	8.49%	155.3	0.486	0.04152	6.866	3.22	0.6624	1.44	4.66	0.78	3.99	2.39	1.61
176.8	0.515	64.6	8.99%	157.7	0.515	0.04396	6.904	3.25	0.6624	1.44	4.69	0.78	4.02	2.40	1.62
179.2	0.543	64.5	9.49%	160.1	0.543	0.04640	6.942	3.27	0.6480	1.44	4.71	0.79	4.07	2.43	1.64

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CIVIL LABORATORY
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4001 BIXBY ROAD
GROVEPORT, OHIO 43125
(614) 836-4200

AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10906
Point: B

181 2	0 572	64.3	10 00%	162 1	0.572	0 04886	6 981	3 29	0.6192	1 44	4.73	0.82	4.12	2.47	1.65
185 4	0 629	64 0	11 00%	166 3	0 629	0 05375	7 059	3.34	0.5760	1 44	4.78	0 86	4 20	2 53	1 67
189 0	0 686	63.6	11.99%	169 9	0 686	0.05862	7.139	3 37	0 5184	1.44	4 81	0 92	4.29	2.61	1.68
192.6	0.744	63.5	13.00%	173.5	0.744	0.06352	7.222	3 40	0.5040	1 44	4 84	0.94	4 33	2.63	1 70
196 1	0.801	63.3	13.99%	177.0	0.801	0.06839	7.305	3 42	0.4752	1 44	4.86	0 96	4 39	2 68	1 71
199.5	0.858	62 9	15 00%	180.4	0.858	0 07331	7.392	3.44	0.4176	1 44	4.88	1.02	4.46	2 74	1.72
203 0	0 915	62.7	16 00%	183 9	0.915	0 07818	7.480	3.46	0.3888	1.44	4 90	1.05	4 51	2 78	1 73
206.0	0 972	62.5	16 99%	186 9	0 972	0 08305	7 569	3.47	0 3600	1.44	4.91	1 08	4 55	2.82	1 74
209 4	1 029	62.5	17 99%	190 3	1 029	0 08794	7 662	3.49	0 3600	1 44	4.93	1 08	4.57	2 82	1.74
212 4	1 087	62 3	19 00%	193 3	1 087	0 09284	7 756	3 50	0 3312	1 44	4.94	1 11	4.60	2 86	1 75
215.5	1 144	62 1	20 00%	196.4	1 144	0 09773	7 853	3 50	0 3024	1 44	4 94	1.14	4 64	2.89	1 75

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AEP AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10906
Point: C

Material Description: Boring PZ-0901, Shelby Tube - 26' - 28'; Lab # S-10906

Moisture Determination ASTM D2216

	Before Testing	After Testing
Tare No.	T-29	T-29
Mass of Container and Wet Specimen (Mcws), grams	1460 95	1459.15
Mass of Container and Over Dry Specimen (Mcs), grams	1228 10	1228.10
Mass of Container (Mc), grams	207.93	207 93
Mass of Water (Mw), grams:	232.85	231 05
Mass of Solid Particles (Ms), grams:	1020 17	1020.17
Moisture Content (w), %	22 82%	22 65%

Initial Condition of Speciman ASTM D2435

	(1)	(2)	(3)	Average
Diameter Measurents, Inches:	2.853	2.842	2 843	2.846
Height Measurements, Inches:	5.85	5.842	5.853	5.848
Initial Volume of Specimen (Vo), In.3:	37 20			
Dry Mass of Specimen After Testing, (Md), grams:	1020.17			
Dry Unit Weight, (γ d) pcf:	104.46			
Specific Gravity of the Solids, (G):	2 70			
Volume of Solids, (Vs), Cu. In.:	23.0574			
Height of Solids,(Hs),In.:	3.6245			
Void Ratio Before Consolidation (Eo):	0.6136			
Intitail Degree of Saturation: (So)	100.44%			

Saturation - ASTM D4767 Section 8.2

Dial Indicator Reading Prior to Saturation (Rb:) In.	0
Cell Pressure AfterSaturation, psi:	80.00
Back Presssure After Saturation After, psi:	60.00
Pore Pressure Paramenter B:	1
Dial Indicator Reading After Saturation, (Ra) In.:	-0.008
Change in Height during Satureation, (Delta Hs) In.	-0.008
Change In Volume of Specimen during Saturation (Delta Vsat), In.3:	-0.153

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Sample No: 10906

Point: C

Consolidation- ASTM D2435, Section 11.5:

Sample No:	T:	Burette 2:	Burette3:	Rc:
10906	0	23.7	23.6	-0.008
10906	0.25	23.2	23.4	
10906	0.5	23.1	23.3	
10906	1	22.9	23.3	
10906	2	22.7	23.2	
10906	4	22.3	23.1	
10906	8	21.9	22.9	
10906	15	21.3	22.7	0.004
10906	30	20.4	22.4	0.006
10906	60	19.3	22	0.012
10906	120	18	21.5	0.018
10906	240	17	21	0.022
10906	450	16.3	20.7	0.026
10906	1440	15.8	20.5	0.029

Specimen Height After Consolidation, (Hc), In.: 5.82

Volume Change During Consolidation (Delta Vc), In.3: 0.67

Cross-Sectional Area of Specimen After Consolidation (Ac), In.2: 6.30

Triaxial Compression Testing
ASTM D 4767

Sample Depth: 26 ft.

Cell Pressure: 80 psi

Back Pressure: 60 psi

Confining Pressure: 20 psi

Strain Rate: 0.006 in/min.

Specimen Height After Consolidation, (Hc), In.: 5.82

Correction for Vert Displacement, In.: 0

Load due to Friction and Uplift: 17.9 lbs.

Correction for Filter Paper: 0

Thickness of Membrane (tm), In.: 0.012

$\sigma 1-\sigma 3=$ **Deviator Stress at Failure, ksf:** 4.84

$\sigma 3$ f= **Effective Consolidation Stress at Failure, ksf:** 2.88

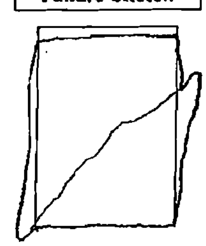
$\sigma 1=$ **Total Major Principal Stress at Failure:** 7.72

$\sigma '3f=$ $\sigma 3-\Delta u=$ **Effective Minor Principal Stress at Failure,ksf:** 1.53

$\sigma '1f=$ **Effective Major Principal Stress at Failure, ksf:** 6.36

Axial Strain at Failure: 11.00%

Failure Sketch



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Pa: Applied Force	Vertical Displacement Reading In.:	Pore Pressure psi:	Axial Strain (E1):	(P) - Force Adj for U and F lbs:	Corrected Vertical Displac In.:	Correction for Membrane ksf:	(A) Area In 2:	(σ1−σ3) Deviator Stress ksf:	[Δu] Induced Pore Water Pressure ksf:	σ3 Effective Consolidation Stress ksf	σ1 Total Major Principal Stress ksf	σ3 Effective Minor Principal Stress ksf	σ1 ' Effective Major Principal Stress ksf	p'	q
17.9	0.000	62.0	0.00%	0.0	0.000	0.00000	6.304	0.00	0.2880	2.88	2.88	2.59	2.59	2.59	0.00
64.6	0.003	65.6	0.05%	46.7	0.003	0.00025	6.307	1.07	0.8064	2.88	3.95	2.07	3.14	2.61	0.53
75.4	0.006	67.9	0.10%	57.5	0.006	0.00047	6.310	1.31	1.1376	2.88	4.19	1.74	3.05	2.40	0.66
86.6	0.009	69.0	0.16%	68.7	0.009	0.00079	6.314	1.57	1.2960	2.88	4.45	1.58	3.15	2.37	0.78
90.4	0.011	69.4	0.20%	72.5	0.011	0.00096	6.316	1.65	1.3536	2.88	4.53	1.53	3.18	2.35	0.83
94.7	0.014	71.0	0.25%	76.8	0.014	0.00121	6.320	1.75	1.5840	2.88	4.63	1.30	3.04	2.17	0.87
100.0	0.018	71.0	0.31%	82.1	0.018	0.00151	6.324	1.87	1.5840	2.88	4.75	1.30	3.16	2.23	0.93
103.4	0.020	71.0	0.35%	85.5	0.020	0.00169	6.326	1.94	1.5840	2.88	4.82	1.30	3.24	2.27	0.97
106.1	0.023	71.1	0.40%	88.2	0.023	0.00195	6.329	2.00	1.5984	2.88	4.88	1.28	3.29	2.28	1.00
109.9	0.027	73.4	0.46%	92.0	0.027	0.00223	6.333	2.09	1.9296	2.88	4.97	0.95	3.04	2.00	1.04
112.2	0.029	72.9	0.50%	94.3	0.029	0.00243	6.336	2.14	1.8576	2.88	5.02	1.02	3.16	2.09	1.07
115.9	0.033	73.0	0.56%	98.0	0.033	0.00275	6.340	2.22	1.8720	2.88	5.10	1.01	3.23	2.12	1.11
118.3	0.036	73.2	0.61%	100.4	0.036	0.00298	6.343	2.28	1.9008	2.88	5.16	0.98	3.26	2.12	1.14
120.1	0.038	73.5	0.65%	102.2	0.038	0.00317	6.345	2.32	1.9440	2.88	5.20	0.94	3.25	2.09	1.16
122.4	0.041	73.7	0.70%	104.5	0.041	0.00340	6.348	2.37	1.9728	2.88	5.25	0.91	3.27	2.09	1.18
124.8	0.044	73.9	0.75%	106.9	0.044	0.00366	6.352	2.42	2.0016	2.88	5.30	0.88	3.30	2.09	1.21
127.3	0.047	74.0	0.80%	109.4	0.047	0.00391	6.355	2.48	2.0160	2.88	5.36	0.86	3.34	2.10	1.24
129.4	0.049	74.0	0.85%	111.5	0.049	0.00414	6.358	2.52	2.0160	2.88	5.40	0.86	3.39	2.12	1.26
131.9	0.053	74.4	0.91%	114.0	0.053	0.00443	6.362	2.58	2.0736	2.88	5.46	0.81	3.38	2.09	1.29
133.9	0.056	74.7	0.96%	116.0	0.056	0.00466	6.365	2.62	2.1168	2.88	5.50	0.76	3.38	2.07	1.31
136.3	0.058	74.7	1.00%	118.4	0.058	0.00488	6.368	2.67	2.1168	2.88	5.55	0.76	3.44	2.10	1.34
152.8	0.087	75.9	1.50%	134.9	0.087	0.00733	6.400	3.03	2.2896	2.88	5.91	0.59	3.62	2.10	1.51
167.3	0.116	76.5	2.00%	149.4	0.116	0.00974	6.433	3.33	2.3760	2.88	6.21	0.50	3.84	2.17	1.67
180.1	0.146	76.5	2.50%	162.2	0.146	0.01221	6.466	3.60	2.3760	2.88	6.48	0.50	4.10	2.30	1.80
191.1	0.174	76.1	3.00%	173.2	0.174	0.01462	6.499	3.82	2.3184	2.88	6.70	0.56	4.38	2.47	1.91
200.1	0.204	76.0	3.50%	182.2	0.204	0.01707	6.533	4.00	2.3040	2.88	6.88	0.58	4.58	2.58	2.00
207.7	0.233	75.5	4.00%	189.8	0.233	0.01952	6.567	4.14	2.2320	2.88	7.02	0.65	4.79	2.72	2.07
214.5	0.262	75.0	4.50%	196.6	0.262	0.02195	6.601	4.27	2.1600	2.88	7.15	0.72	4.99	2.85	2.13
220.7	0.291	74.6	5.00%	202.8	0.291	0.02440	6.636	4.38	2.1024	2.88	7.26	0.78	5.15	2.97	2.19
226.2	0.320	74.1	5.50%	208.3	0.320	0.02683	6.671	4.47	2.0304	2.88	7.35	0.85	5.32	3.08	2.23
230.7	0.349	73.9	6.00%	212.8	0.349	0.02926	6.706	4.54	2.0016	2.88	7.42	0.88	5.42	3.15	2.27
234.8	0.378	73.3	6.50%	216.9	0.378	0.03173	6.743	4.60	1.9152	2.88	7.48	0.96	5.57	3.27	2.30
238.9	0.407	72.9	7.00%	221.0	0.407	0.03416	6.779	4.66	1.8576	2.88	7.54	1.02	5.68	3.35	2.33
242.5	0.437	72.7	7.50%	224.6	0.437	0.03661	6.815	4.71	1.8288	2.88	7.59	1.05	5.76	3.41	2.35
245.5	0.466	71.1	8.00%	227.6	0.466	0.03904	6.852	4.74	1.5984	2.88	7.62	1.28	6.03	3.65	2.37
248.5	0.495	71.0	8.50%	230.6	0.495	0.04149	6.890	4.78	1.5840	2.88	7.66	1.30	6.07	3.69	2.39
250.9	0.524	71.0	9.00%	233.0	0.524	0.04392	6.928	4.80	1.5840	2.88	7.68	1.30	6.10	3.70	2.40
253.3	0.553	71.0	9.50%	235.4	0.553	0.04637	6.966	4.82	1.5840	2.88	7.70	1.30	6.12	3.71	2.41

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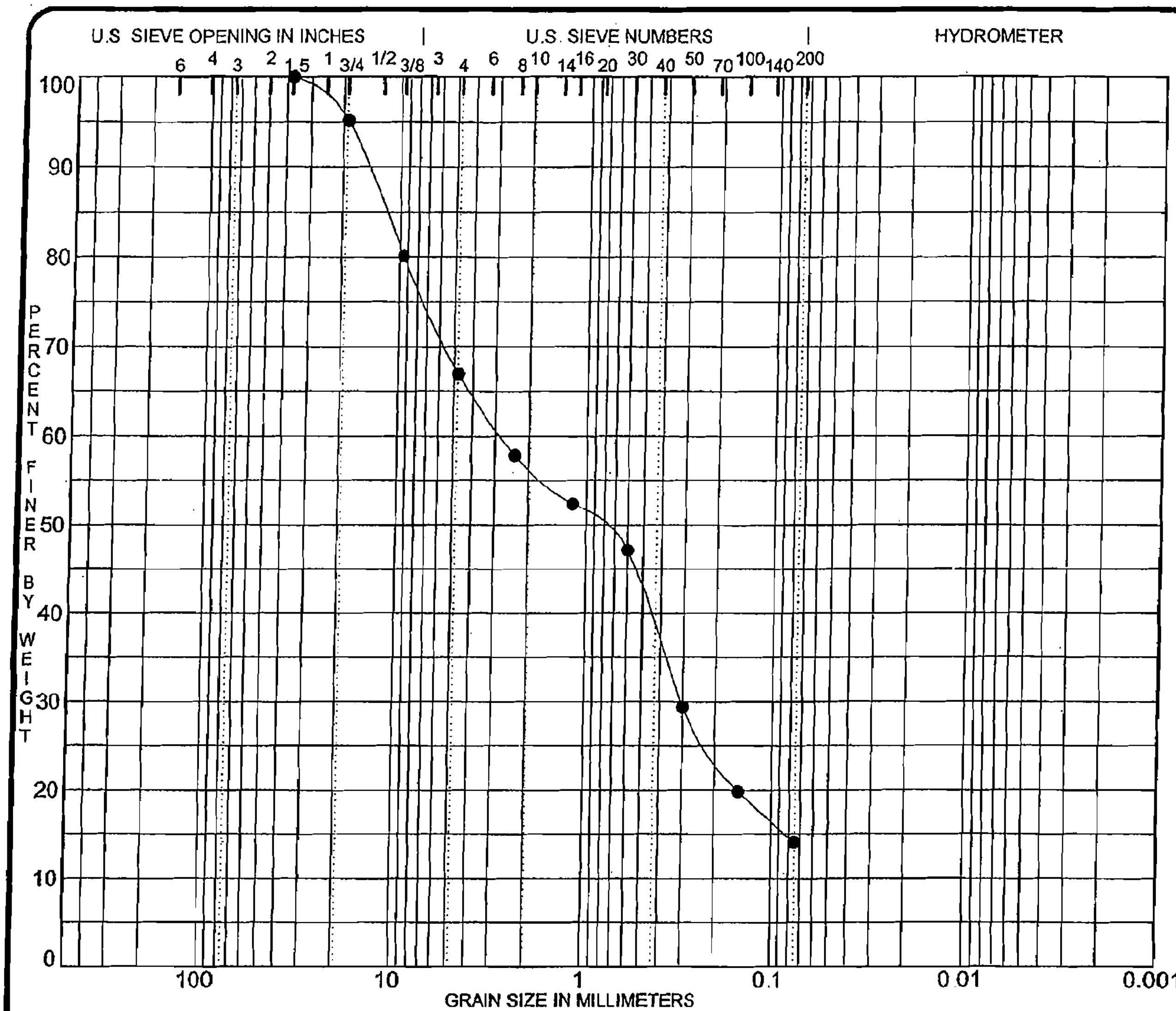
Sample No: 10906

Point: C

255.5	0 582	70.5	10 00%	237 6	0 582	0 04878	7.004	4.84	1 5120	2.88	7 72	1.37	6.20	3.79	2 42
258 4	0 640	69.4	11 00%	240 5	0.640	0.05366	7.083	4 84	1 3536	2.88	7 72	1 53	6 36	3 94	2.42
260.4	0.699	68.6	12 00%	242 5	0.699	0 05858	7 164	4 82	1.2384	2 88	7 70	1.64	6.46	4.05	2 41
261.6	0.756	67.6	13.00%	243.7	0.756	0 06342	7 246	4.78	1 0944	2.88	7.66	1 79	6 57	4.18	2.39
261.4	0.815	66 9	14.00%	243.5	0 815	0 06830	7.330	4 72	0.9936	2 88	7 60	1.89	6.60	4 24	2 36
262 5	0 873	66 1	15.00%	244 6	0 873	0.07320	7.417	4 68	0.8784	2 88	7 56	2 00	6 68	4.34	2.34
263 7	0 931	65 6	16.00%	245 8	0 931	0 07806	7 505	4 64	0.8064	2.88	7.52	2 07	6.71	4.39	2 32
267 4	0 990	65 0	17.01%	249 5	0.990	0.08298	7 596	4 65	0 7200	2.88	7 53	2 16	6 81	4 48	2 32
269 3	1 047	64.6	18 00%	251 4	1.047	0 08782	7.688	4.62	0 6624	2 88	7 50	2 22	6 84	4.53	2 31
271 6	1 106	64 2	19 00%	253.7	1.106	0 09270	7.783	4.60	0.6048	2.88	7.48	2 28	6.88	4 58	2 30
274 8	1 164	64.0	20 00%	256 9	1 164	0 09760	7.880	4 60	0.5760	2.88	7 48	2 30	6 90	4 60	2.30

Report Date: Friday, August 14, 2009



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	PZ-0902	8.5			NP	NP	NP		
			SILTY SAND with GRAVEL SM						
			Sand & Gravel Mixture - Samples 4,5,6 Combined						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	PZ-0902	8.5	37.500	2.790	0.307		33.0	52.9	14.0	

PROJECT SPORN PLANT - FLY ASH POND DIKES - FLY ASH POND DIKES

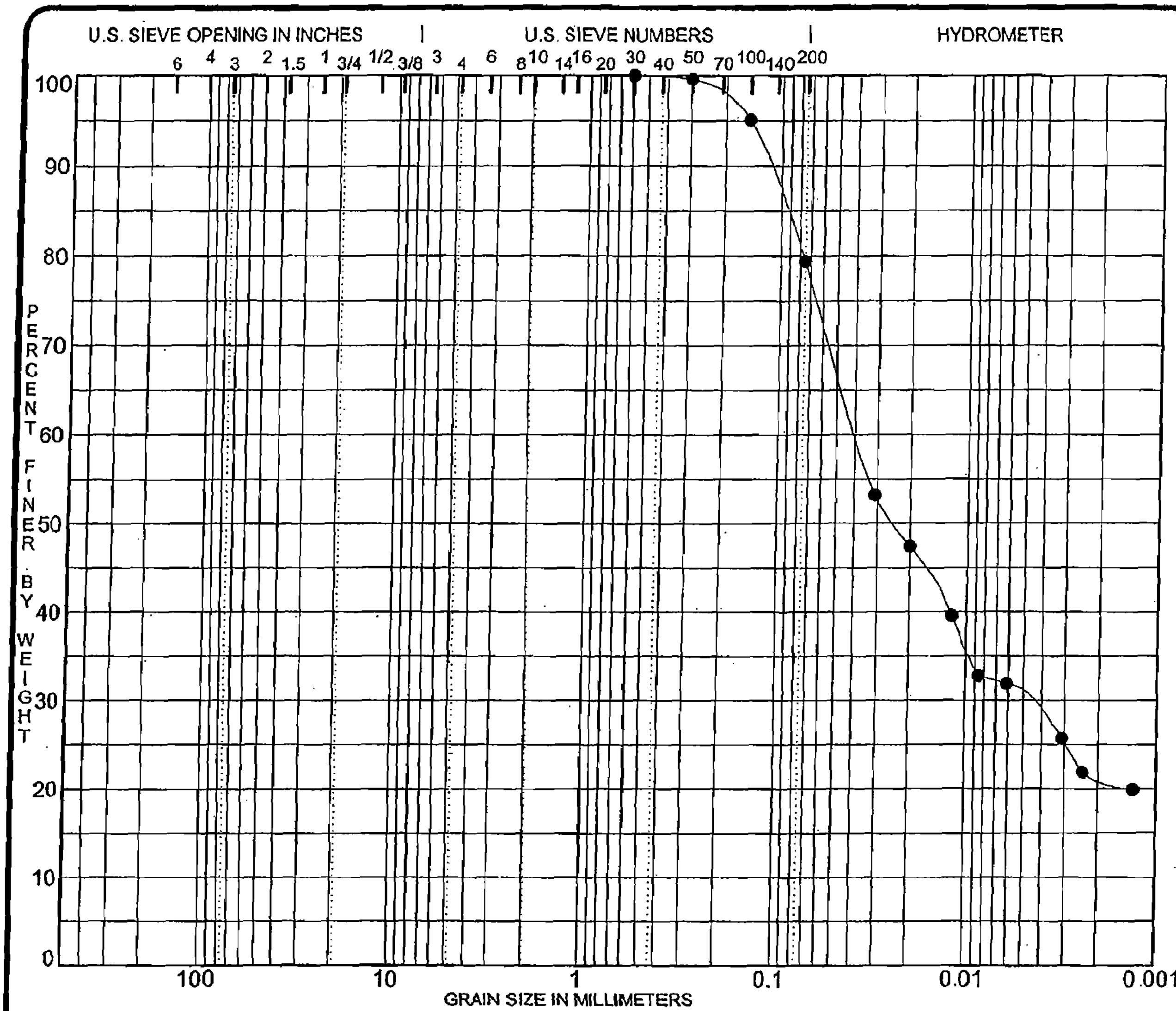
JOB NO.

DATE 8/14/09

GRADATION CURVES

American Electric Power Service Corp.
Groveport, OH 43125

AEP



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
●	PZ-0902	31.0			29.5	17.4	12.2	
			LEAN CLAY with SAND CL					
			Shelby Tube Sample - 31' - 33'					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	PZ-0902	31.0	0.600	0.039	0.005		0.0	20.6	79.4	21.3

PROJECT **SPORN PLANT - FLY ASH POND DIKES - FLY ASH POND DIKES**

JOB NO.

DATE 8/14/09

GRADATION CURVES

American Electric Power Service Corp.
Groveport, OH 43125

AEP

CIVIL LABORATORY
AMERICAN ELECTRIC POWER SERVICE CORPORATION
4001 BIXBY ROAD
GROVEPORT, OHIO 43125
(614) 836-4200

AEP AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

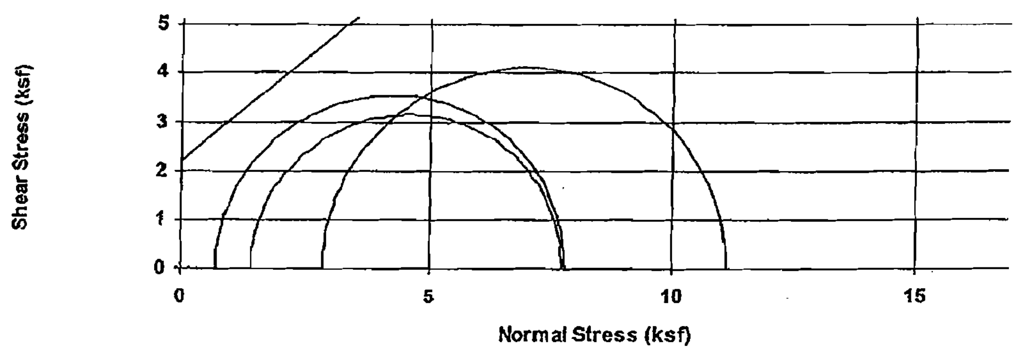
Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10918

Material Description: Boring PZ-0902, Shelby Tube - 31' - 33'; Lab # S-10918

Point Designation	Initial Conditions			Final Conditions			
	Water Content, %	Dry Density, pcf	Degree of Saturation	Water Content, %	Confining Stress, (ksf)	Deviator Stress	Induced Pore Pressure (ksf)
A	16.2%	117.4	100.5%	16.62%	0 72	7 09	-1.15
B	17.2%	114.3	98.1%	17.6%	1 44	6 30	-0 42
C	17.3%	114 5	98.8%	17.4%	2 88	8 24	0 60

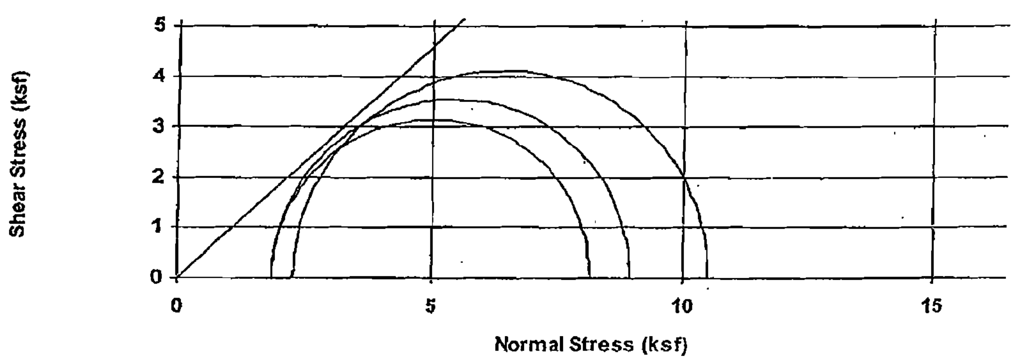
Point Designation	Axial Strain, %	q, (ksf)	Effective Stresses, (ksf)			Total Stresses, (ksf)		
			Major, (ksf)	Minor, (ksf)	p', (ksf)	Major, (ksf)	Minor, (ksf)	p, (ksf)
A	15.0%	3 54	8 96	1 87	5.42	7 81	0 72	4 26
B	15 0%	3.15	8 16	1 86	5 01	7 74	1.44	4 59
C	15 0%	4.12	10.52	2 28	6 40	11 12	2.88	7 00

Total Stress Envelope



φ: 40.0°
c: 2.20 ksf

Effective Stress Envelope



φ': 42.7°
c': 0.00 ksf

Report Date: Friday, August 14, 2009

FOSSIL AND HYDRO GENERATION
CIVIL AND MINING ENGINEERING DIVISION
CIVIL LABORATORY SECTION
AMERICAN ELECTRIC POWER SERVICE CORPORATION
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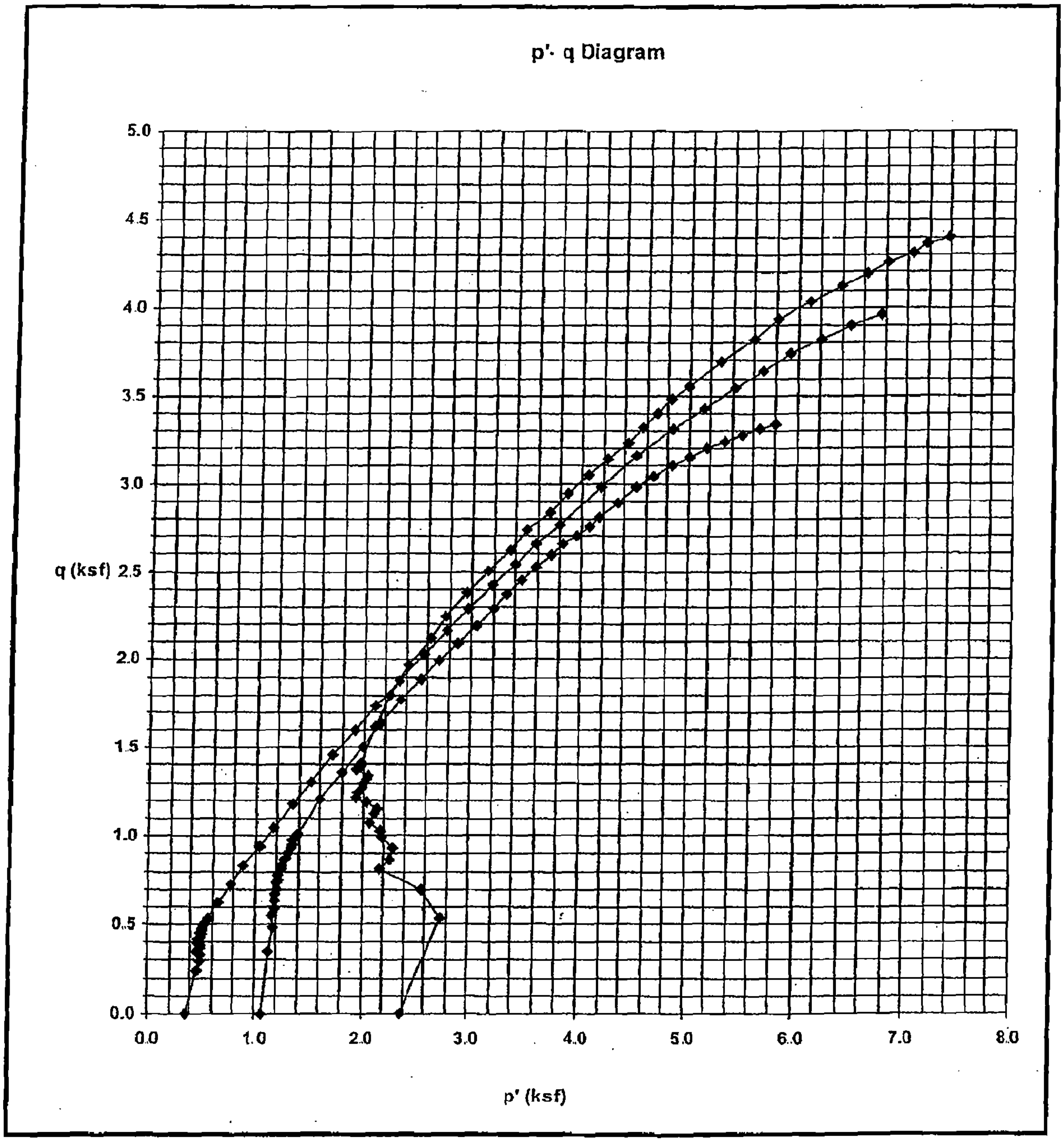
AEP AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10918



Report Date: Friday, August 14, 2009

FOSSIL AND HYDRO GENERATION
CIVIL AND MINING ENGINEERING DIVISION
CIVIL LABORATORY SECTION
AMERICAN ELECTRIC POWER SERVICE CORPORATION
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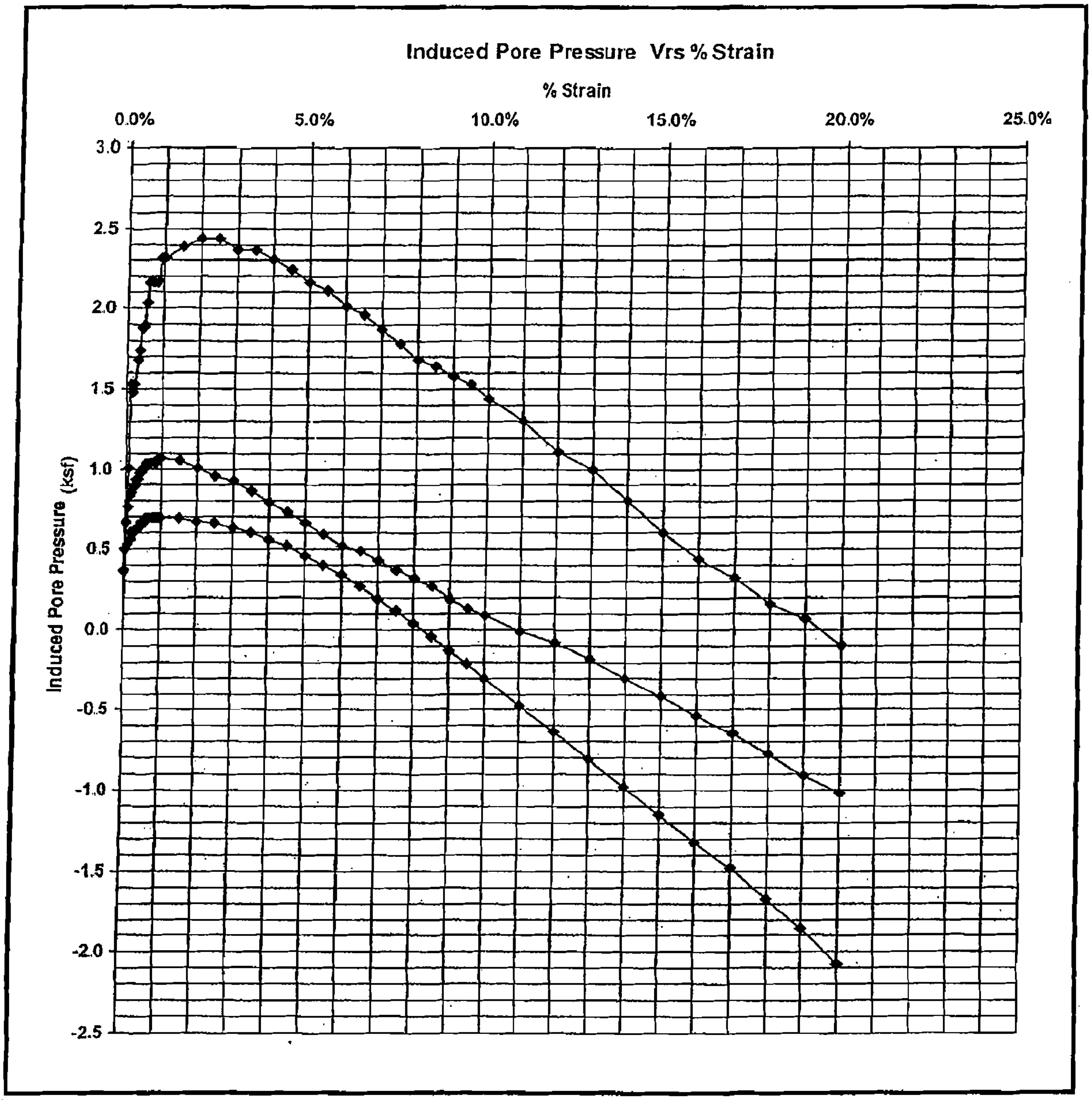
AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: **AEP**

Project: **SPORN ASH DISP. FACILITY**

Sample No: **10918**



Report Date: Friday, August 14 2009

FOSSIL AND HYDRO GENERATION
CIVIL AND MINING ENGINEERING DIVISION
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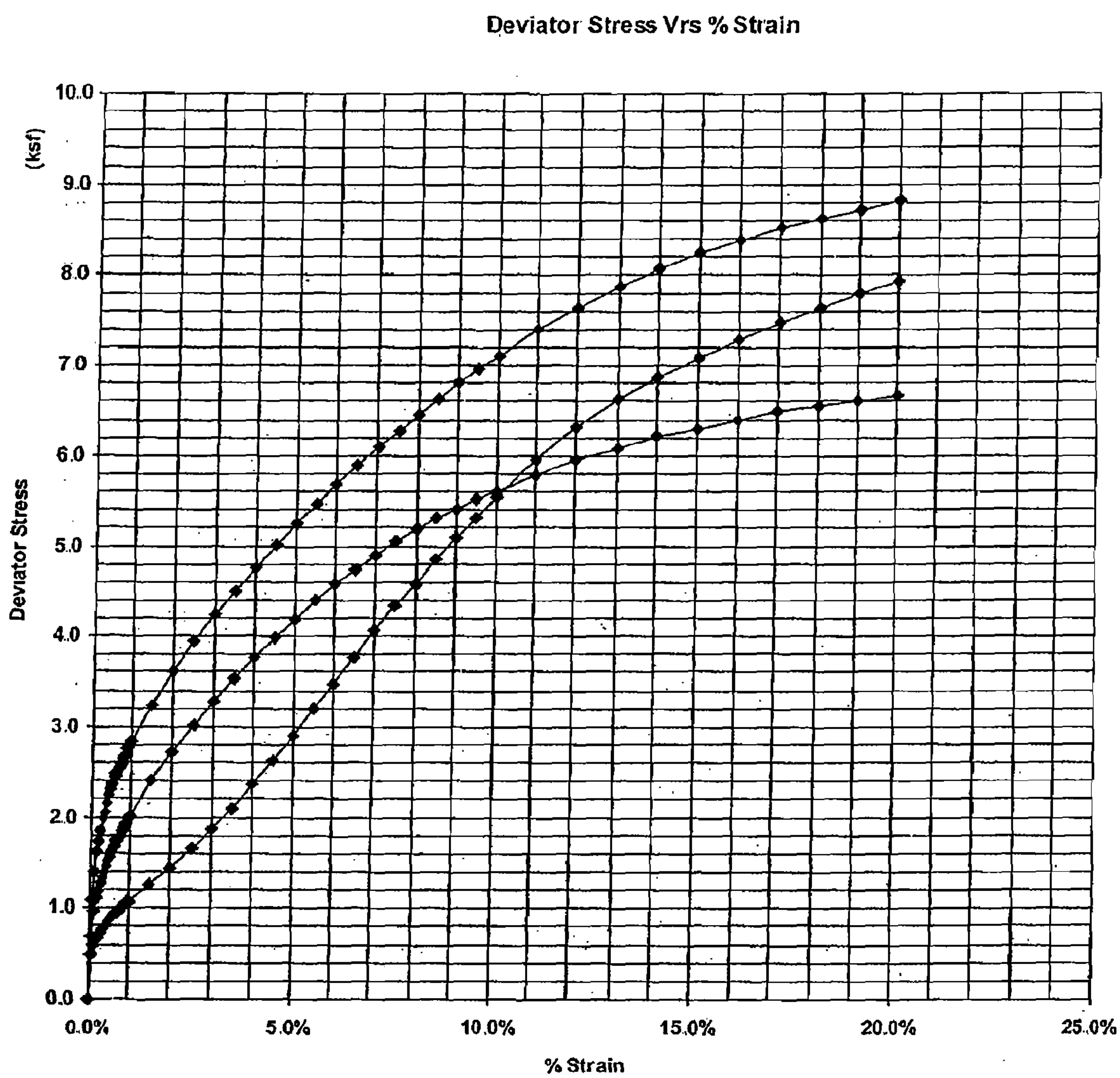
Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP

Project: SPORN ASH DISP. FACILITY

Sample No: 10918



Report Date: Friday, August 14, 2009

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AEP AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10918
Point: A

Material Description: Boring PZ-0902, Shelby Tube - 31' - 33'; Lab # S-10918

Moisture Determination ASTM D2216

	Before Testing	After Testing
Tare No.	#28	#28
Mass of Container and Wet Specimen (Mcws), grams	1493.00	1497.17
Mass of Container and Over Dry Specimen (Mcs), grams	1313 92	1313.92
Mass of Container (Mc), grams	211.24	211.24
Mass of Water (Mw), grams:	179.08	183.25
Mass of Solid Particles (Ms), grams:	1102.68	1102.68
Moisture Content (w), %	16.24%	16.62%

Initial Condition of Speciman ASTM D2435

	(1)	(2)	(3)	Average
Diameter Measurents, Inches:	2.813	2.803	2.824	2.813
Height Measurements, Inches:	5.763	5.753	5.757	5.758
Initial Volume of Specimen (Vo), In.3:	35 79			
Dry Mass of Specimen After Testing, (Md), grams:	1102.68			
Dry Unit Weight, (γ d) pcf:	117.37			
Specific Gravity of the Solids, (G):	2.70			
Volume of Solids, (Vs), Cu. In.:	24.9222			
Height of Solids,(Hs),In.:	4.0092			
Void Ratio Before Consolidation (Eo):	0.4361			
Intitail Degree of Saturation: (So)	100 54%			

Saturation - ASTM D4767 Section 8.2

Dial Indicator Reading Prior to Saturation (Rb:) In.	0
Cell Pressure AfterSaturation, psi:	73.00
Back Presssure After Saturation After, psi:	70.00
Pore Pressure Paramenter B:	1
Dial Indicator Reading After Saturation, (Ra) In.:	0.003
Change In Height during Satureation, (Delta Hs) In.	0.003
Change In Volume of Specimen during Saturation (Delta Vsat), In.3:	0.056

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AEP AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: **AEP**
Project: **SPORN ASH DISP. FACILITY**
Sample No: **10918**
Point: **A**

Consolidation- ASTM D2435, Section 11.5:

Sample No:	T:	Burette 2:	Burette3:	Rc:
10918	0	23.7	24.1	0.003
10918	0.25	23.6	24	
10918	0.5	23.6	24	
10918	1	23.5	24	
10918	2	23.5	23.9	
10918	4	23.4	23.8	
10918	8	23.3	23.8	
10918	15	23.2	23.7	0.005
10918	30	23	23.6	0.005
10918	60	23	23.5	0.006
10918	180	22.9	23.4	0.007
10918	240	22.8	23.3	0.008
10918	454	22.8	23.3	0.009
10918	1440	22.9	23.1	0.01

Specimen Height After Consolidation, (Hc), In.: 5.75

Volume Change During Consolidation (Delta Vc), In.3: 0.11

Cross-Sectional Area of Specimen After Consolidation (Ac), In.2: 6.20

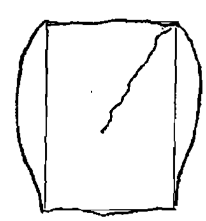
Triaxial Compression Testing
ASTM D 4767

Sample Depth: 31 ft.
Cell Pressure: 75 psi
Back Pressure: 70 psi
Confining Pressure: 5 psi
Strain Rate: 0.006 in./min.

Specimen Height After Consolidation, (Hc), In.: 5.75
Correction for Vert Displacement, In.: 0
Load due to Friction and Uplift: 15.3 lbs.
Correction for Filter Paper: 0
Thickness of Membrane (tm), In.: 0.012

$\sigma 1-\sigma 3=$ **Deviator Stress at Failure, ksf:** 7.09
$\sigma 3$ f= **Effective Consolidation Stress at Failure, ksf:** 0.72
$\sigma 1=$ **Total Major Principal Stress at Failure:** 7.81
$\sigma'3f=$ $\sigma 3-\Delta u=$ **Effective Minor Principal Stress at Failure,ksf:** 1.87
$\sigma'1f=$ **Effective Major Principal Stress at Failure, ksf:** 8.96
Axial Strain at Failure: 15.00%

Failure Sketch



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AEPSPP004155

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AEP AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: **AEP**

Project: **SPORN ASH DISP. FACILITY**

Sample No: **10918**

Point: **A**

Pa: Applied Force	Vertical Displacement Reading In.:	Pore Pressure psi:	Axial Strain (E1):	(P)-Force Adj for U and F lbs:	Corrected Vertical Displac In.:	Correction for Membrane ksf:	(A) Area In.2:	(σ1−σ3) Deviator Stress ksf:	[Δu] Induced Pore Water Pressure ksf:	σ3 Effective Consolidation Stress ksf	σ1 Total Major Principal Stress ksf	σ3 Effective Minor Principal Stress ksf	σ1' Effective Major Principal Stress ksf	p'	q
15.3	0.001	72.5	0.01%	0.0	0.001	0.00005	6.199	0.00	0.3600	0.72	0.72	0.36	0.36	0.36	0.00
36.2	0.003	73.5	0.05%	20.9	0.003	0.00024	6.201	0.49	0.5040	0.72	1.21	0.22	0.70	0.46	0.24
41.0	0.006	73.7	0.10%	25.7	0.006	0.00048	6.204	0.60	0.5328	0.72	1.32	0.19	0.78	0.49	0.30
44.2	0.009	73.9	0.16%	28.9	0.009	0.00079	6.208	0.67	0.5616	0.72	1.39	0.16	0.83	0.49	0.33
45.4	0.012	74.2	0.20%	30.1	0.012	0.00099	6.211	0.70	0.6048	0.72	1.42	0.12	0.81	0.46	0.35
47.1	0.014	74.2	0.25%	31.8	0.014	0.00123	6.214	0.74	0.6048	0.72	1.46	0.12	0.85	0.48	0.37
48.5	0.018	74.3	0.31%	33.2	0.018	0.00152	6.218	0.77	0.6192	0.72	1.49	0.10	0.87	0.48	0.38
49.3	0.020	74.4	0.35%	34.0	0.020	0.00171	6.220	0.79	0.6336	0.72	1.51	0.09	0.87	0.48	0.39
50.5	0.023	74.4	0.40%	35.2	0.023	0.00195	6.223	0.81	0.6336	0.72	1.53	0.09	0.90	0.49	0.41
51.8	0.026	74.6	0.46%	36.5	0.026	0.00224	6.227	0.84	0.6624	0.72	1.56	0.06	0.90	0.48	0.42
52.9	0.029	74.6	0.50%	37.6	0.029	0.00245	6.229	0.87	0.6624	0.72	1.59	0.06	0.92	0.49	0.43
54.1	0.032	74.6	0.56%	38.8	0.032	0.00274	6.233	0.89	0.6624	0.72	1.61	0.06	0.95	0.50	0.45
55.1	0.035	74.8	0.61%	39.8	0.035	0.00298	6.236	0.92	0.6912	0.72	1.64	0.03	0.94	0.49	0.46
55.9	0.037	74.8	0.65%	40.6	0.037	0.00320	6.239	0.93	0.6912	0.72	1.65	0.03	0.96	0.50	0.47
56.9	0.040	74.8	0.70%	41.6	0.040	0.00344	6.242	0.96	0.6912	0.72	1.68	0.03	0.99	0.51	0.48
57.8	0.043	74.8	0.75%	42.5	0.043	0.00370	6.245	0.98	0.6912	0.72	1.70	0.03	1.01	0.52	0.49
58.8	0.046	74.8	0.80%	43.5	0.046	0.00396	6.248	1.00	0.6912	0.72	1.72	0.03	1.03	0.53	0.50
59.6	0.049	74.8	0.85%	44.3	0.049	0.00418	6.251	1.02	0.6912	0.72	1.74	0.03	1.05	0.54	0.51
60.7	0.053	74.8	0.92%	45.4	0.053	0.00450	6.256	1.04	0.6912	0.72	1.76	0.03	1.07	0.55	0.52
61.5	0.055	74.8	0.96%	46.2	0.055	0.00473	6.258	1.06	0.6912	0.72	1.78	0.03	1.09	0.56	0.53
62.2	0.057	74.8	1.00%	46.9	0.057	0.00491	6.261	1.07	0.6912	0.72	1.79	0.03	1.10	0.57	0.54
70.4	0.086	74.8	1.50%	55.1	0.086	0.00740	6.293	1.25	0.6912	0.72	1.97	0.03	1.28	0.66	0.63
79.3	0.115	74.7	2.00%	64.0	0.115	0.00985	6.325	1.45	0.6768	0.72	2.17	0.04	1.49	0.77	0.72
89.3	0.144	74.6	2.50%	74.0	0.144	0.01231	6.357	1.66	0.6624	0.72	2.38	0.06	1.72	0.89	0.83
99.4	0.173	74.4	3.00%	84.1	0.173	0.01478	6.390	1.88	0.6336	0.72	2.60	0.09	1.97	1.03	0.94
109.4	0.201	74.2	3.50%	94.1	0.201	0.01721	6.423	2.09	0.6048	0.72	2.81	0.12	2.21	1.16	1.05
121.9	0.230	73.9	4.00%	106.6	0.230	0.01969	6.457	2.36	0.5616	0.72	3.08	0.16	2.52	1.34	1.18
134.4	0.259	73.6	4.50%	119.1	0.259	0.02214	6.490	2.62	0.5184	0.72	3.34	0.20	2.82	1.51	1.31
148.2	0.288	73.2	5.01%	132.9	0.288	0.02464	6.525	2.91	0.4608	0.72	3.63	0.26	3.17	1.71	1.45
162.0	0.316	72.8	5.50%	146.7	0.316	0.02705	6.559	3.19	0.4032	0.72	3.91	0.32	3.51	1.91	1.60
175.8	0.345	72.4	6.00%	160.5	0.345	0.02952	6.594	3.48	0.3456	0.72	4.20	0.37	3.85	2.11	1.74
190.0	0.374	71.9	6.50%	174.7	0.374	0.03199	6.629	3.76	0.2736	0.72	4.48	0.45	4.21	2.33	1.88
204.9	0.402	71.3	7.00%	189.6	0.402	0.03445	6.665	4.06	0.1872	0.72	4.78	0.53	4.59	2.56	2.03
218.5	0.431	70.8	7.50%	203.2	0.431	0.03690	6.701	4.33	0.1152	0.72	5.05	0.60	4.93	2.77	2.16
231.6	0.460	70.3	8.00%	216.3	0.460	0.03937	6.737	4.58	0.0432	0.72	5.30	0.68	5.26	2.97	2.29
245.2	0.489	69.7	8.50%	229.9	0.489	0.04183	6.774	4.85	-0.0432	0.72	5.57	0.76	5.61	3.19	2.42
257.8	0.517	69.1	9.00%	242.5	0.517	0.04430	6.811	5.08	-0.1296	0.72	5.80	0.85	5.93	3.39	2.54
270.3	0.546	68.5	9.50%	255.0	0.546	0.04675	6.849	5.31	-0.2160	0.72	6.03	0.94	6.25	3.59	2.66

Report Date: Friday August 14 2009

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AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10918
Point: A

282.4	0.575	67.9	10.00%	267.1	0.575	0.04921	6.887	5.54	-0.3024	0.72	6.26	1.02	6.56	3.79	2.77
306.0	0.632	66.7	11.00%	290.7	0.632	0.05414	6.965	5.96	-0.4752	0.72	6.68	1.20	7.15	4.17	2.98
326.7	0.690	65.6	12.00%	311.4	0.690	0.05906	7.044	6.31	-0.6336	0.72	7.03	1.35	7.66	4.51	3.15
346.2	0.747	64.4	13.00%	330.9	0.747	0.06399	7.125	6.62	-0.8064	0.72	7.34	1.53	8.15	4.84	3.31
362.1	0.805	63.2	14.00%	346.8	0.805	0.06890	7.207	6.86	-0.9792	0.72	7.58	1.70	8.56	5.13	3.43
378.0	0.862	62.0	15.00%	362.7	0.862	0.07383	7.292	7.09	-1.1520	0.72	7.81	1.87	8.96	5.42	3.54
392.6	0.920	60.8	16.00%	377.3	0.920	0.07875	7.379	7.28	-1.3248	0.72	8.00	2.04	9.33	5.69	3.64
407.1	0.977	59.7	17.01%	391.8	0.977	0.08368	7.468	7.47	-1.4832	0.72	8.19	2.20	9.67	5.94	3.74
421.0	1.035	58.4	18.00%	405.7	1.035	0.08859	7.559	7.64	-1.6704	0.72	8.36	2.39	10.03	6.21	3.82
434.8	1.092	57.1	19.01%	419.5	1.092	0.09353	7.653	7.80	-1.8576	0.72	8.52	2.58	10.38	6.48	3.90
447.2	1.150	55.6	20.01%	431.9	1.150	0.09846	7.749	7.93	-2.0736	0.72	8.65	2.79	10.72	6.76	3.96

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GROVEPORT, OHIO 43125
(614) 836-4200

AEP AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10918
Point: B

Material Description: Boring PZ-0902, Shelby Tube - 31' - 33'; Lab # S-10918

Moisture Determination ASTM D2216

	Before Testing	After Testing
Tare No.	#900	#900
Mass of Container and Wet Specimen (Mcws), grams	1499 01	1502 94
Mass of Container and Over Dry Specimen (Mcs), grams	1310.23	1310.23
Mass of Container (Mc), grams	215.43	215.43
Mass of Water (Mw), grams:	188.78	192.71
Mass of Solid Particles (Ms), grams:	1094.8	1094.8
Moisture Content (w), %	17.24%	17.60%

Initial Condition of Speciman ASTM D2435

	(1)	(2)	(3)	Average
Diameter Measurents, Inches:	2.849	2.839	2.834	2.841
Height Measurements, Inches:	5.756	5.766	5.751	5.758
Initial Volume of Specimen (Vo), In.3:	36.49			
Dry Mass of Specimen After Testing, (Md), grams:	1094.8			
Dry Unit Weight, (γ d) pcf:	114.30			
Specific Gravity of the Solids, (G):	2.70			
Volume of Solids, (Vs), Cu. In.:	24.7441			
Height of Solids,(Hs),In.:	3.9043			
Void Ratio Before Consolidation (Eo):	0.4747			
Intitail Degree of Saturation: (So)	98 07%			

Saturation - ASTM D4767 Section 8.2

Dial Indicator Reading Prior to Saturation (Rb:) In.	0
Cell Pressure AfterSaturation, psi:	75.00
Back Presssure After Saturation After, psi:	70.00
Pore Pressure Paramenter B:	0.99
Dial Indicator Reading After Saturation, (Ra) In.:	0.003
Change In Height during Satureation, (Delta Hs) In.	0.003
Change In Volume of Specimen during Saturation (Delta Vsat), In.3:	0.057

Report Date: Friday, August 14, 2009

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Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10918
Point: B

Consolidation- ASTM D2435, Section 11.5:

Sample No:	T:	Burette 2:	Burette3:	Rc:
10918	0	24.1	23.9	0.003
10918	0.25	24	23.8	
10918	0.5	24	23.8	
10918	1	24	23.8	
10918	2	23.9	23.7	
10918	4	23.9	23.7	
10918	8	23.8	23.5	
10918	15	23.7	23.4	0.005
10918	30	23.6	23.2	0.006
10918	60	23.5	23.1	0.006
10918	180	23.4	23	0.007
10918	240	23.4	22.9	0.007
10918	452	23.3	22.9	0.008
10918	1440	23.3	22.9	0.008

Specimen Height After Consolidation, (Hc), In.: 5.75

Volume Change During Consolidation (Delta Vc), In.3: 0.11

Cross-Sectional Area of Specimen After Consolidation (Ac), In.2: 6.32

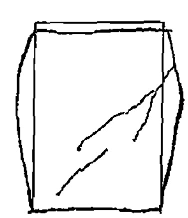
Triaxial Compression Testing ASTM D 4767

Sample Depth: 31 ft.
Cell Pressure: 80 psi
Back Pressure: 70 psi
Confining Pressure: 10 psi
Strain Rate: 0.006 In/min.

Specimen Height After Consolidation, (Hc), In.: 5.75
Correction for Vert Displacement, In.: 0
Load due to Friction and Uplift: 18.6 lbs.
Correction for Filter Paper: 0
Thickness of Membrane (tm), In.: 0.012

$\sigma 1 - \sigma 3 =$ Deviator Stress at Failure, ksf: 6.30
$\sigma 3$ f= Effective Consolidation Stress at Failure, ksf: 1.44
$\sigma 1 =$ Total Major Principal Stress at Failure: 7.74
$\sigma '3f =$ $\sigma 3 - \Delta \upsilon =$ Effective Minor Principal Stress at Failure, ksf: 1.86
$\sigma '1f =$ Effective Major Principal Stress at Failure, ksf: 8.16
Axial Strain at Failure: 15.00%

Failure Sketch



Report Date: Friday, August 14, 2009

AEPSPP004159

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

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AEP AMERICAN ELECTRIC POWER

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10918
Point: B

Fa: Applied Force	Vertical Displacement Reading In.:	Pore Pressure psi:	Axial Strain (ε1):	(P) - Force Adj for U and F lbs:	Corrected Vertical Displac In.:	Correction for Membrane ksf:	(A) Area In 2:	(σ1−σ3) Deviator Stress ksf:	[Δu] Induced Pore Water Pressure ksf:	σ3 Effective Consolidation Stress ksf	σ1 Total Major Principal Stress ksf	σ3 Effective Minor Principal Stress ksf	σ1' Effective Major Principal Stress ksf	p'	q
18.6	0.000	72.6	0.00%	0.0	0.000	0.00000	6.317	0.00	0.3744	1.44	1.44	1.07	1.07	1.07	0.00
49.0	0.003	74.6	0.05%	30.4	0.003	0.00022	6.320	0.69	0.6624	1.44	2.13	0.78	1.47	1.12	0.35
61.0	0.006	75.3	0.10%	42.4	0.006	0.00047	6.324	0.97	0.7632	1.44	2.41	0.68	1.64	1.16	0.48
67.3	0.009	75.8	0.16%	48.7	0.009	0.00076	6.327	1.11	0.8352	1.44	2.55	0.60	1.71	1.16	0.55
70.9	0.011	75.9	0.20%	52.3	0.011	0.00097	6.330	1.19	0.8496	1.44	2.63	0.59	1.78	1.18	0.59
74.7	0.015	76.2	0.25%	56.1	0.015	0.00124	6.334	1.27	0.8928	1.44	2.71	0.55	1.82	1.18	0.64
77.9	0.018	76.5	0.31%	59.3	0.018	0.00149	6.337	1.35	0.9360	1.44	2.79	0.50	1.85	1.18	0.67
80.1	0.020	76.5	0.35%	61.5	0.020	0.00171	6.340	1.40	0.9360	1.44	2.84	0.50	1.90	1.20	0.70
83.0	0.023	76.8	0.40%	64.4	0.023	0.00193	6.343	1.46	0.9792	1.44	2.90	0.46	1.92	1.19	0.73
85.3	0.026	76.8	0.46%	66.7	0.026	0.00222	6.346	1.51	0.9792	1.44	2.95	0.46	1.97	1.22	0.76
87.4	0.029	77.0	0.50%	68.8	0.029	0.00244	6.349	1.56	1.0080	1.44	3.00	0.43	1.99	1.21	0.78
90.3	0.032	77.0	0.56%	71.7	0.032	0.00271	6.353	1.62	1.0080	1.44	3.06	0.43	2.05	1.24	0.81
92.4	0.035	77.2	0.61%	73.8	0.035	0.00297	6.356	1.67	1.0368	1.44	3.11	0.40	2.07	1.24	0.83
95.1	0.038	77.2	0.65%	76.5	0.038	0.00319	6.359	1.73	1.0368	1.44	3.17	0.40	2.13	1.27	0.86
96.2	0.040	77.2	0.70%	77.6	0.040	0.00339	6.362	1.75	1.0368	1.44	3.19	0.40	2.16	1.28	0.88
98.3	0.043	77.2	0.75%	79.7	0.043	0.00365	6.365	1.80	1.0368	1.44	3.24	0.40	2.20	1.30	0.90
100.9	0.046	77.2	0.80%	82.3	0.046	0.00390	6.368	1.86	1.0368	1.44	3.30	0.40	2.26	1.33	0.93
102.6	0.049	77.2	0.85%	84.0	0.049	0.00414	6.372	1.89	1.0368	1.44	3.33	0.40	2.30	1.35	0.95
104.8	0.052	77.4	0.91%	86.2	0.052	0.00443	6.375	1.94	1.0656	1.44	3.38	0.37	2.32	1.35	0.97
106.7	0.055	77.4	0.96%	88.1	0.055	0.00468	6.379	1.98	1.0656	1.44	3.42	0.37	2.36	1.37	0.99
108.3	0.058	77.4	1.00%	89.7	0.058	0.00488	6.381	2.02	1.0656	1.44	3.46	0.37	2.39	1.38	1.01
126.1	0.086	77.3	1.50%	107.5	0.086	0.00729	6.413	2.41	1.0512	1.44	3.85	0.39	2.80	1.59	1.20
141.1	0.115	77.0	2.00%	122.5	0.115	0.00975	6.446	2.73	1.0080	1.44	4.17	0.43	3.16	1.80	1.36
154.6	0.144	76.6	2.50%	136.0	0.144	0.01221	6.480	3.01	0.9504	1.44	4.45	0.49	3.50	1.99	1.51
167.2	0.172	76.4	3.00%	148.6	0.172	0.01462	6.513	3.27	0.9216	1.44	4.71	0.52	3.79	2.15	1.64
180.0	0.201	76.0	3.50%	161.4	0.201	0.01706	6.547	3.53	0.8640	1.44	4.97	0.58	4.11	2.34	1.77
191.8	0.230	75.5	4.00%	173.2	0.230	0.01950	6.581	3.77	0.7920	1.44	5.21	0.65	4.42	2.53	1.89
202.7	0.259	75.1	4.50%	184.1	0.259	0.02194	6.615	3.99	0.7344	1.44	5.43	0.71	4.69	2.70	1.99
213.2	0.287	74.6	5.00%	194.6	0.287	0.02436	6.650	4.19	0.6624	1.44	5.63	0.78	4.97	2.87	2.09
223.6	0.316	74.1	5.50%	205.0	0.316	0.02681	6.685	4.39	0.5904	1.44	5.83	0.85	5.24	3.04	2.19
233.4	0.345	73.6	6.00%	214.8	0.345	0.02923	6.720	4.57	0.5184	1.44	6.01	0.92	5.49	3.21	2.29
242.5	0.374	73.4	6.50%	223.9	0.374	0.03167	6.756	4.74	0.4896	1.44	6.18	0.95	5.69	3.32	2.37
251.2	0.402	73.0	7.00%	232.6	0.402	0.03411	6.793	4.90	0.4320	1.44	6.34	1.01	5.90	3.46	2.45
259.6	0.431	72.6	7.50%	241.0	0.431	0.03655	6.830	5.04	0.3744	1.44	6.48	1.07	6.11	3.59	2.52
267.5	0.460	72.2	8.00%	248.9	0.460	0.03900	6.867	5.18	0.3168	1.44	6.62	1.12	6.30	3.71	2.59
275.0	0.489	71.9	8.50%	256.4	0.489	0.04145	6.905	5.31	0.2736	1.44	6.75	1.17	6.47	3.82	2.65
281.4	0.518	71.3	9.01%	262.8	0.518	0.04390	6.943	5.41	0.1872	1.44	6.85	1.25	6.66	3.96	2.70
288.3	0.546	70.9	9.50%	269.7	0.546	0.04632	6.981	5.52	0.1296	1.44	6.96	1.31	6.83	4.07	2.76

Report Date: Friday, August 14, 2009

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(614) 836-4200

AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10918
Point: B

294 5	0 575	70.6	10 00%	275 9	0.575	0 04873	7 019	5.61	0 0864	1 44	7 05	1.35	6.97	4 16	2.81
306.4	0.633	69 9	11 01%	287 8	0.633	0.05365	7.099	5 78	-0 0144	1 44	7 22	1 45	7 24	4 35	2 89
318.1	0.690	69 4	12 00%	299.5	0 690	0.05848	7 179	5 95	-0.0864	1.44	7 39	1.53	7.48	4 50	2 97
328.6	0.748	68.7	13 00%	310 0	0.748	0 06338	7 262	6.08	-0 1872	1.44	7.52	1 63	7 71	4.67	3.04
338 6	0 805	67.9	14 00%	320 0	0.805	0 06824	7.346	6.20	-0 3024	1.44	7 64	1.74	7.95	4 84	3 10
347 6	0 863	67.1	15.00%	329.0	0.863	0.07313	7.433	6 30	-0.4176	1.44	7 74	1 86	8 16	5.01	3.15
356 8	0 920	66.3	16.00%	338.2	0 920	0.07799	7 521	6 40	-0.5328	1 44	7.84	1.97	8 37	5 17	3 20
365 6	0.978	65 5	17.00%	347 0	0.978	0.08288	7.612	6.48	-0.6480	1.44	7 92	2.09	8 57	5 33	3.24
373 3	1.035	64 6	18.00%	354 7	1.035	0 08776	7.705	6 54	-0.7776	1.44	7 98	2 22	8 76	5.49	3.27
381.9	1 092	63 7	19 00%	363 3	1 092	0.09261	7 799	6 62	-0.9072	1 44	8 06	2.35	8.96	5 65	3 31
389.9	1 150	62 9	20 00%	371.3	1 150	0.09747	7 897	6.67	-1 0224	1.44	8 11	2.46	9 14	5.80	3.34

Report Date: Friday, August 14, 2009

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CIVIL AND MINING ENGINEERING DIVISION
CIVIL LABORATORY SECTION
AMERICAN ELECTRIC POWER SERVICE CORPORATION
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GROVEPORT, OHIO 43125
(614) 836-4200

AEP AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10918
Point: C

Material Description: Boring PZ-0902, Shelby Tube - 31' - 33'; Lab # S-10918

Moisture Determination ASTM D2216

	Before Testing	After Testing
Tare No.	R-3	R-3
Mass of Container and Wet Specimen (Mcws), grams	1515.47	1516.93
Mass of Container and Over Dry Specimen (Mcs), grams	1324.08	1324.08
Mass of Container (Mc), grams	216.28	216.28
Mass of Water (Mw), grams:	191.39	192.85
Mass of Solid Particles (Ms), grams:	1107.8	1107.8
Moisture Content (w), %	17.28%	17.41%

Initial Condition of Speciman ASTM D2435

	(1)	(2)	(3)	Average
Diameter Measurents, Inches:	2.843	2.848	2.837	2.843
Height Measurements, Inches:	5.801	5.809	5.811	5.807
Initial Volume of Specimen (Vo), In.3:	36.85			
Dry Mass of Specimen After Testing, (Md), grams:	1107.8			
Dry Unit Weight, (γd) pcf:	114.51			
Specific Gravity of the Solids, (G):	2.70			
Volume of Solids, (Vs), Cu. In.:	25.0379			
Height of Solids,(Hs),In.:	3.9451			
Void Ratio Before Consolidation (Eo):	0.4720			
Intitall Degree of Saturation: (So)	98.84%			

Saturation - ASTM D4767 Section 8.2

Dial Indicator Reading Prior to Saturation (Rb:) In.	0
Cell Pressure AfterSaturation, psi:	90.00
Back Presssure After Saturation After, psi:	70.00
Pore Pressure Paramenter B:	1
Dial Indicator Reading After Saturation, (Ra) In.:	-0.004
Change in Height during Satureation, (Delta Hs) In.	-0.004
Change in Volume of Specimen during Saturation (Delta Vsat), In.3:	-0.076

Report Date: Friday, August 14, 2009

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AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10918
Point: C

Consolidation- ASTM D2435, Section 11.5:

Sample No:	T:	Burette 2:	Burette3:	Rc:
10918	0	23.8	23.7	-0.004
10918	0.25	23.5	23.5	
10918	0.5	23.5	23.5	
10918	1	23.5	23.4	
10918	2	23.4	23.3	
10918	4	23.2	23.1	
10918	8	23.1	22.8	
10918	15	22.9	22.4	0.005
10918	30	22.5	22	0.008
10918	60	22	21.4	0.011
10918	180	21.2	20.6	0.015
10918	240	21.1	20.4	0.016
10918	450	20.8	20.1	0.018
10918	1440	20.7	20.4	0.02

Specimen Height After Consolidation, (Hc), In.: 5.79

Volume Change During Consolidation (Delta Vc), In.3: 0.39

Cross-Sectional Area of Specimen After Consolidation (Ac), In.2: 6.31

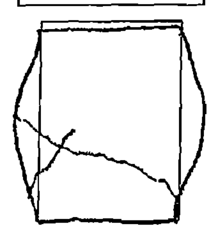
Triaxial Compression Testing
ASTM D 4767

Sample Depth: 31 ft.
Cell Pressure: 90 psi
Back Pressure: 70 psi
Confining Pressure: 20 psi
Strain Rate: 0.006 In/min.

Specimen Height After Consolidation, (Hc), In.: 5.79
Correction for Vert Displacement, In.: 0
Load due to Friction and Uplift: 20 lbs.
Correction for Filter Paper: 0
Thickness of Membrane (tm), In.: 0.012

$\sigma 1 - \sigma 3 =$ Deviator Stress at Failure, ksf: 8.24
$\sigma 3$ f= Effective Consolidation Stress at Failure, ksf: 2.88
$\sigma 1 =$ Total Major Principal Stress at Failure: 11.12
$\sigma '3f = \sigma 3 - \Delta u =$ Effective Minor Principal Stress at Failure, ksf: 2.28
$\sigma '1f =$ Effective Major Principal Stress at Failure, ksf: 10.52
Axial Strain at Failure: 15.01%

Failure Sketch



Report Date: Friday, August 14, 2009

AEPSPP004163

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CIVIL LABORATORY SECTION
AMERICAN ELECTRIC POWER SERVICE CORPORATION
4001 BIXBY ROAD
GROVEPORT, OHIO 43125
(614) 836-4200

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Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10918
Point: C

Pa: Applied Force	Vertical Displacement Reading In.:	Pore Pressure psi:	Axial Strain (El):	(P) - Force Adj for U and F lbs:	Corrected Vertical Displac In.:	Correction for Membrane ksf:	(A) Area In 2:	(σ1−σ3) Deviator Stress ksf:	[Δu] Induced Pore Water Pressure ksf:	σ3 Effective Consolidation Stress ksf	σ1 Total Major Principal Stress ksf	σ3 Effective Minor Principal Stress ksf	σ1' Effective Major Principal Stress ksf	p'	q
20.0	0.000	73.5	0.00%	0.0	0.000	0.00000	6.314	0.00	0.5040	2.88	2.88	2.38	2.38	2.38	0.00
67.4	0.003	74.7	0.05%	47.4	0.003	0.00025	6.317	1.08	0.6768	2.88	3.96	2.20	3.28	2.74	0.54
81.2	0.006	77.0	0.10%	61.2	0.006	0.00049	6.321	1.39	1.0080	2.88	4.27	1.87	3.27	2.57	0.70
91.2	0.009	80.6	0.16%	71.2	0.009	0.00076	6.324	1.62	1.5264	2.88	4.50	1.35	2.97	2.16	0.81
96.0	0.011	80.3	0.20%	76.0	0.011	0.00096	6.327	1.73	1.4832	2.88	4.61	1.40	3.13	2.26	0.86
101.8	0.014	80.6	0.25%	81.8	0.014	0.00120	6.330	1.86	1.5264	2.88	4.74	1.35	3.21	2.28	0.93
107.7	0.018	81.7	0.31%	87.7	0.018	0.00150	6.334	1.99	1.6848	2.88	4.87	1.20	3.19	2.19	1.00
110.5	0.020	82.1	0.35%	90.5	0.020	0.00170	6.336	2.06	1.7424	2.88	4.94	1.14	3.19	2.17	1.03
114.8	0.023	83.1	0.40%	94.8	0.023	0.00194	6.339	2.15	1.8864	2.88	5.03	0.99	3.15	2.07	1.08
119.0	0.027	83.1	0.46%	99.0	0.027	0.00224	6.343	2.25	1.8864	2.88	5.13	0.99	3.24	2.12	1.12
122.2	0.029	83.2	0.50%	102.2	0.029	0.00244	6.346	2.32	1.9008	2.88	5.20	0.98	3.30	2.14	1.16
124.7	0.032	84.1	0.56%	104.7	0.032	0.00271	6.350	2.37	2.0304	2.88	5.25	0.85	3.22	2.04	1.19
127.8	0.035	85.0	0.61%	107.8	0.035	0.00297	6.353	2.44	2.1600	2.88	5.32	0.72	3.16	1.94	1.22
129.6	0.038	85.1	0.65%	109.6	0.038	0.00317	6.356	2.48	2.1744	2.88	5.36	0.71	3.19	1.95	1.24
132.2	0.041	85.0	0.70%	112.2	0.041	0.00342	6.359	2.54	2.1600	2.88	5.42	0.72	3.26	1.99	1.27
134.4	0.043	85.0	0.75%	114.4	0.043	0.00366	6.362	2.59	2.1600	2.88	5.47	0.72	3.31	2.01	1.29
137.1	0.046	85.0	0.80%	117.1	0.046	0.00391	6.365	2.65	2.1600	2.88	5.53	0.72	3.37	2.04	1.32
139.0	0.049	85.1	0.85%	119.0	0.049	0.00413	6.368	2.69	2.1744	2.88	5.57	0.71	3.39	2.05	1.34
142.1	0.053	86.1	0.91%	122.1	0.053	0.00445	6.372	2.75	2.3184	2.88	5.63	0.56	3.32	1.94	1.38
143.8	0.055	86.0	0.96%	123.8	0.055	0.00467	6.375	2.79	2.3040	2.88	5.67	0.58	3.37	1.97	1.40
145.6	0.058	86.1	1.00%	125.6	0.058	0.00487	6.378	2.83	2.3184	2.88	5.71	0.56	3.39	1.98	1.42
164.2	0.087	86.6	1.50%	144.2	0.087	0.00730	6.410	3.23	2.3904	2.88	6.11	0.49	3.72	2.11	1.62
181.7	0.116	86.9	2.00%	161.7	0.116	0.00976	6.443	3.60	2.4336	2.88	6.48	0.45	4.05	2.25	1.80
197.6	0.145	86.9	2.50%	177.6	0.145	0.01218	6.476	3.94	2.4336	2.88	6.82	0.45	4.38	2.41	1.97
212.0	0.174	86.4	3.00%	192.0	0.174	0.01464	6.510	4.23	2.3616	2.88	7.11	0.52	4.75	2.63	2.12
224.9	0.203	86.4	3.50%	204.9	0.203	0.01707	6.543	4.49	2.3616	2.88	7.37	0.52	5.01	2.76	2.25
238.2	0.231	86.0	4.00%	218.2	0.231	0.01950	6.577	4.76	2.3040	2.88	7.64	0.58	5.33	2.95	2.38
251.3	0.260	85.6	4.50%	231.3	0.260	0.02194	6.612	5.02	2.2464	2.88	7.90	0.63	5.65	3.14	2.51
263.4	0.290	85.0	5.01%	243.4	0.290	0.02442	6.647	5.25	2.1600	2.88	8.13	0.72	5.97	3.34	2.62
275.0	0.318	84.7	5.50%	255.0	0.318	0.02682	6.682	5.47	2.1168	2.88	8.35	0.76	6.23	3.50	2.73
286.3	0.347	84.0	6.00%	266.3	0.347	0.02927	6.717	5.68	2.0160	2.88	8.56	0.86	6.54	3.70	2.84
297.9	0.376	83.6	6.50%	277.9	0.376	0.03169	6.753	5.89	1.9584	2.88	8.77	0.92	6.82	3.87	2.95
309.3	0.406	83.0	7.01%	289.3	0.406	0.03417	6.790	6.10	1.8720	2.88	8.98	1.01	7.11	4.06	3.05
319.5	0.434	82.4	7.51%	299.5	0.434	0.03660	6.827	6.28	1.7856	2.88	9.16	1.09	7.38	4.23	3.14
329.7	0.463	81.7	8.01%	309.7	0.463	0.03904	6.864	6.46	1.6848	2.88	9.34	1.20	7.65	4.42	3.23
340.0	0.492	81.4	8.51%	320.0	0.492	0.04147	6.901	6.64	1.6416	2.88	9.52	1.24	7.87	4.56	3.32
350.1	0.521	81.0	9.00%	330.1	0.521	0.04389	6.939	6.81	1.5840	2.88	9.69	1.30	8.10	4.70	3.40
359.3	0.550	80.6	9.50%	339.3	0.550	0.04632	6.977	6.96	1.5264	2.88	9.84	1.35	8.31	4.83	3.48

Report Date: Friday, August 14, 2009

FOSSIL AND HYDRO GENERATION
CIVIL AND MINING ENGINEERING DIVISION
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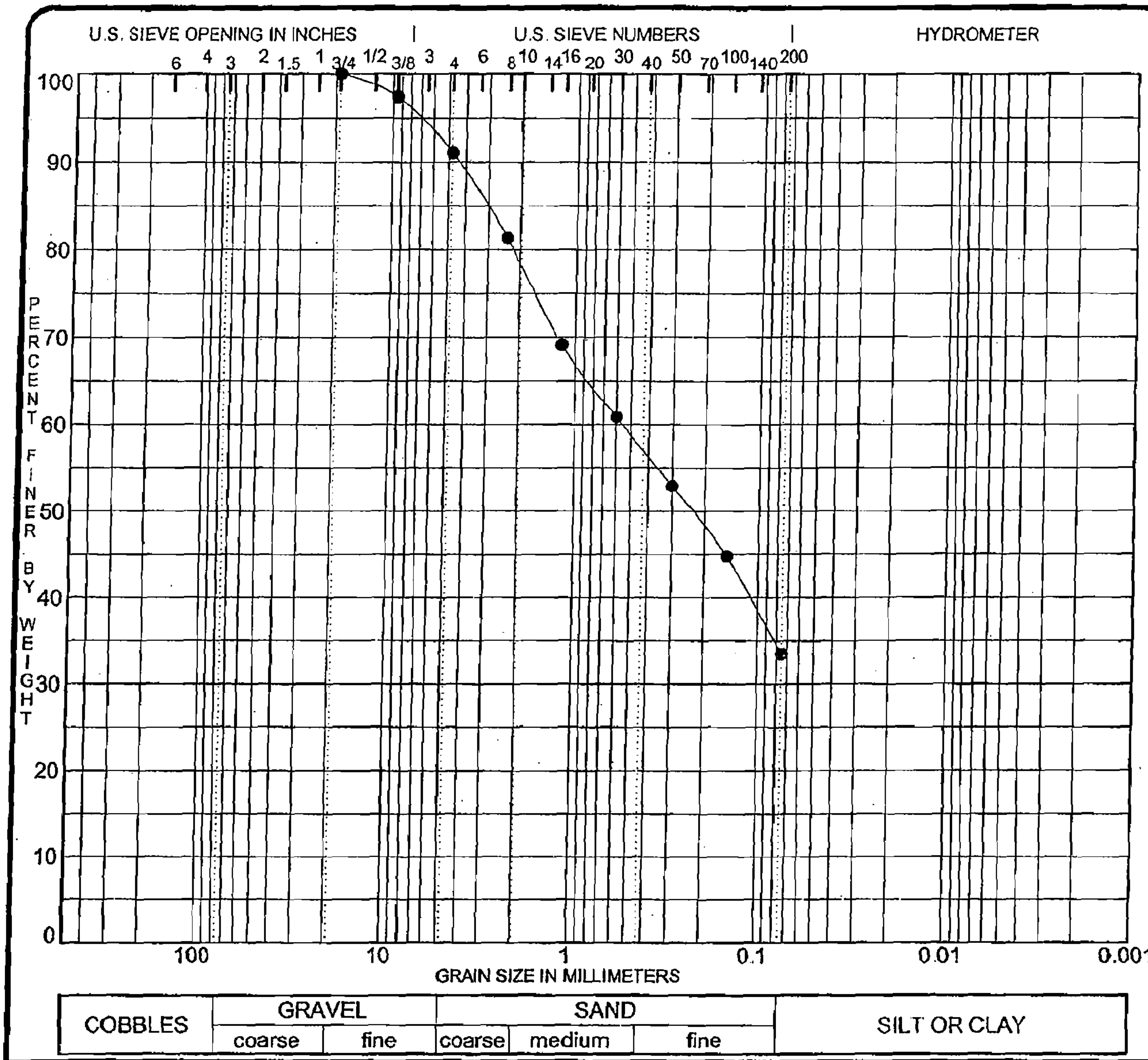
4001 BIXBY ROAD
GROVEPORT, OHIO 43125
(614) 836-4200

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10918
Point: C

368.6	0 579	80 0	10 01%	348.6	0 579	0.04878	7.016	7 11	1 4400	2 88	9 99	1 44	8 55	4.99	3 55
386 9	0.637	79.0	11 00%	366.9	0.637	0.05365	7.095	7 39	1 2960	2 88	10.27	1.58	8 98	5 28	3 70
403.5	0 695	77.7	12 00%	383.5	0 695	0 05852	7.175	7.64	1.1088	2 88	10.52	1.77	9 41	5 59	3.82
419.6	0.753	76 9	13 01%	399 6	0 753	0.06342	7 258	7.86	0.9936	2.88	10 74	1 89	9.75	5 82	3.93
434.5	0.810	75 6	14 00%	414 5	0 810	0.06828	7.342	8.06	0 8064	2 88	10 94	2 07	10 13	6 10	4.03
448 9	0 869	74 2	15.01%	428 9	0.869	0 07318	7.429	8.24	0 6048	2 88	11 12	2 28	10.52	6.40	4 12
461 8	0 926	73.1	16.01%	441.8	0 926	0.07805	7 518	8.38	0 4464	2 88	11 26	2.43	10 82	6 63	4 19
474 4	0 984	72 2	17 01%	454.4	0.984	0 08293	7 608	8.52	0 3168	2 88	11 40	2.56	11.08	6.82	4 26
486 1	1 042	71.1	18.01%	466.1	1.042	0 08779	7 701	8 63	0 1584	2 88	11.51	2.72	11.35	7 04	4 31
497 3	1 100	70.5	19.01%	477 3	1.100	0 09269	7 796	8.72	0 0720	2.88	11.60	2.81	11 53	7 17	4.36
508.3	1 158	69 3	20.01%	488.3	1.158	0 09756	7 894	8 81	-0 1008	2 88	11.69	2.98	11 79	7 39	4.41

Report Date: Friday, August 14, 2009



Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
● PZ-0903	23.5			NP	NP	NP	
		SILTY SAND SM					
		Ash Mixture - Samples10,11,12,13 Combined					

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%< 002
● PZ-0903	23.5	19.000	0.556			8.9	57.5	33.5	

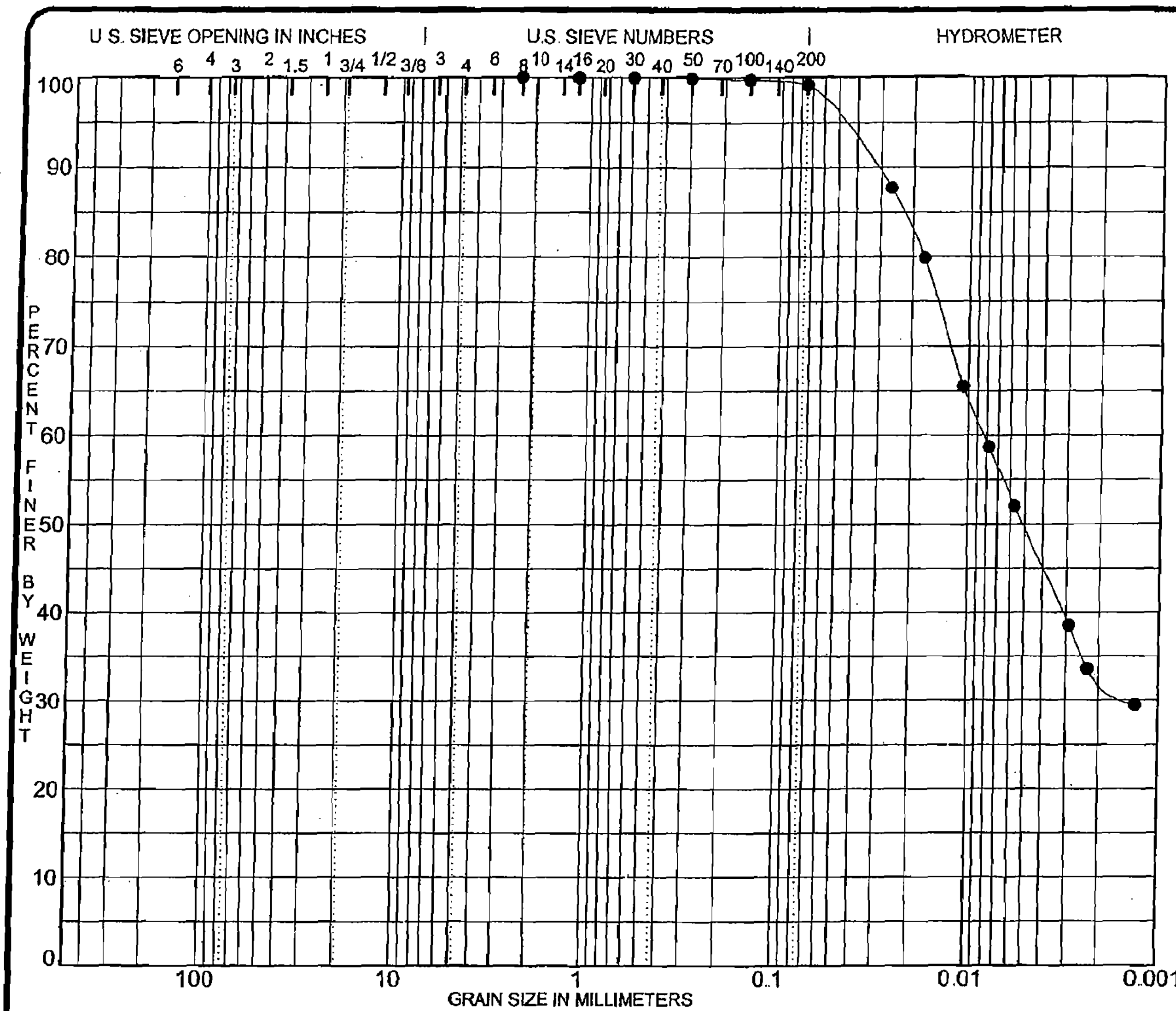
PROJECT **SPORN PLANT - FLY ASH POND DIKES - FLY ASH POND DIKES**

JOB NO.

DATE **8/14/09**

GRADATION CURVES

American Electric Power Service Corp.
Groveport, OH 43125



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.	
●	PZ-0903	46.0			45.6	24.7	20.9		
			LEAN CLAY CL						
			Shelby Tube Sample - 46' - 48'						

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	PZ-0903	46.0	2.360	0.008	0.001		0.0	0.9	99.1	32.6

PROJECT **SPORN PLANT - FLY ASH POND DIKES - FLY ASH POND DIKES**

JOB NO.

DATE **8/14/09**

GRADATION CURVES

American Electric Power Service Corp.
Groveport, OH 43125

AEP

JOB NO. ______________ DATE: Jul 31, 09

PROJECT: SPORN PLANT - FLY ASH POND DIKES

LOCATION: FLY ASH POND DIKES

SOURCE OF MATERIAL: PZ-0903 DEPTH: 46.0 ft.

DESCRIPTION OF MATERIAL: ______________

ASTM DESCRIPTION: ______________

MAX DRY DENSITY, pcf		OPTIMUM MOISTURE, %	
SPECIFIC GRAVITY	2.70		
SAMPLE HGT., mm	146 740	SAMPLE DIA., mm	71.480
CHAMBER PRESSURE, psi	70.0	BACK PRESSURE, psi	60.0
B-PARAMETER	1.00	EFFECTIVE PRESSURE, psi	10 0
INITIAL HEAD, mm	2369.2		

	BEFORE	AFTER
WATER CONTENT, %	35.4	34.3
WET DENSITY, pcf	117.0	
DRY DENSITY, pcf	86.5	
SATURATION, %	100.51	
VOID RATIO	0.9497	

PERMEABILITY COEFFICIENT K, cm/sec 1.08E-07

FLEXIBLE-MEMBRANE PERMEABILITY TEST

American Electric Power Service Corp.

Groveport, Ohio

AEPSPP004168

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AEP AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

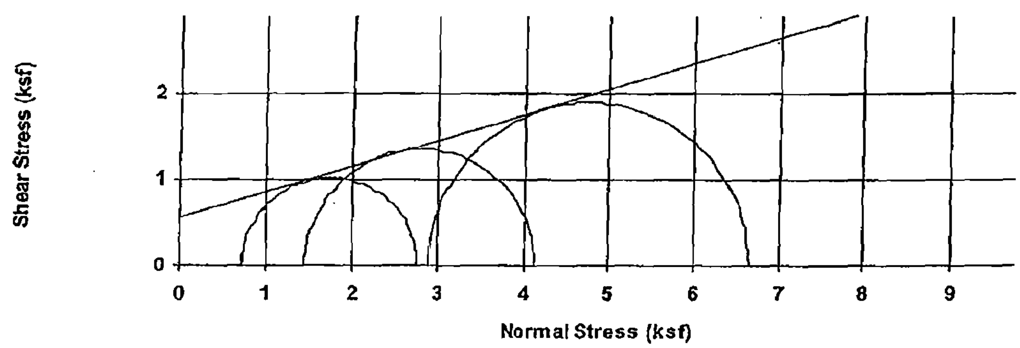
Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10922

Material Description: Boring PZ-0903, Shelby Tube - 46' - 48'; Lab # S-10922

Point Designation	Initial Conditions			Final Conditions			
	Water Content, %	Dry Density, pcf	Degree of Saturation	Water Content, %	Confining Stress, (ksf)	Deviator Stress	Induced Pore Pressure (ksf)
A	29 5%	93.1	98.3%	28 43%	0.72	2 03	0 30
B	35 4%	86 4	100 5%	34 3%	1 44	2.69	0.81
C	30 3%	92.3	99.0%	27 3%	2 88	3 77	1 92

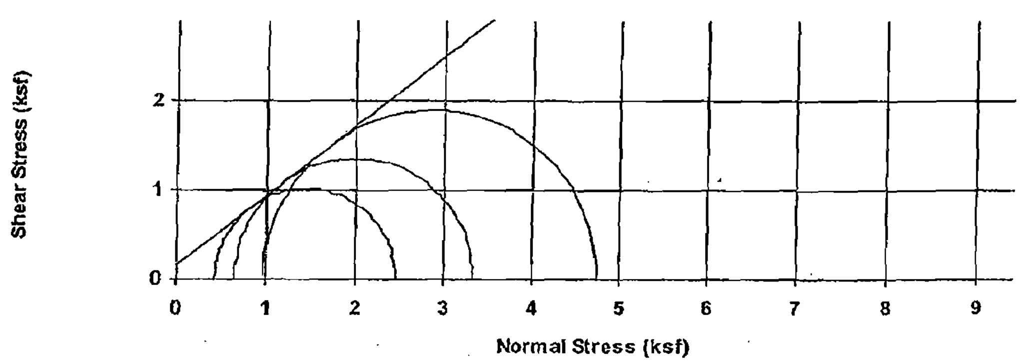
Point Designation	Axial Strain, %	q, (ksf)	Effective Stresses, (ksf)			Total Stresses, (ksf)		
			Major, (ksf)	Minor, (ksf)	p', (ksf)	Major, (ksf)	Minor, (ksf)	p, (ksf)
A	15 0%	1 01	2 45	0.42	1.43	2 75	0.72	1.73
B	13 0%	1 35	3 33	0.63	1.98	4 13	1.44	2 79
C	15.0%	1 89	4.74	0 96	2.85	6.65	2.88	4.77

Total Stress Envelope



φ: 16.6°
c: 0.55 ksf

Effective Stress Envelope



φ': 37.9°
c': 0.17 ksf

Report Date: Friday, August 14, 2009

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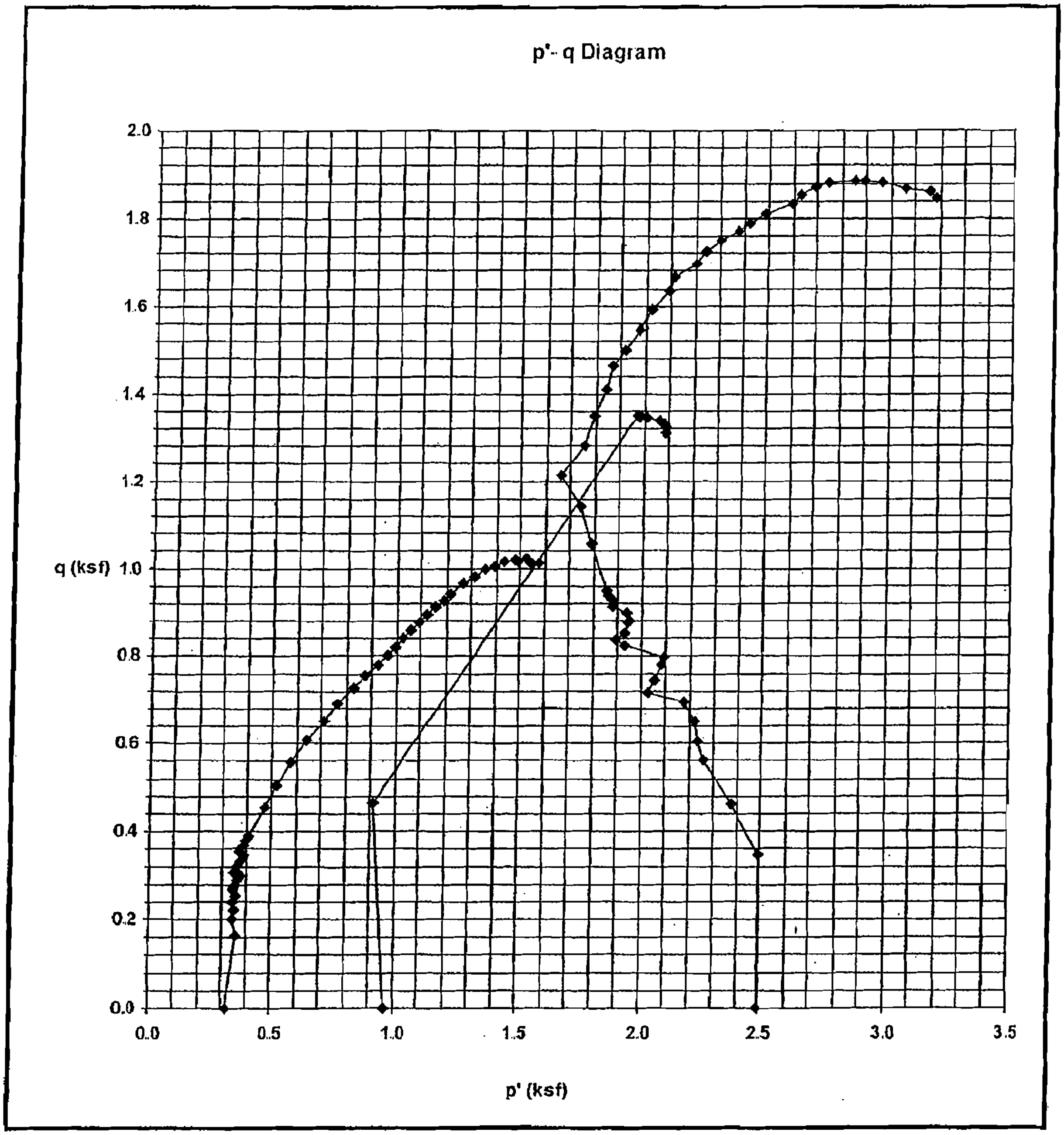
AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained
Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10922



Report Date: Friday, August 14, 2009

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CIVIL AND MINING ENGINEERING DIVISION
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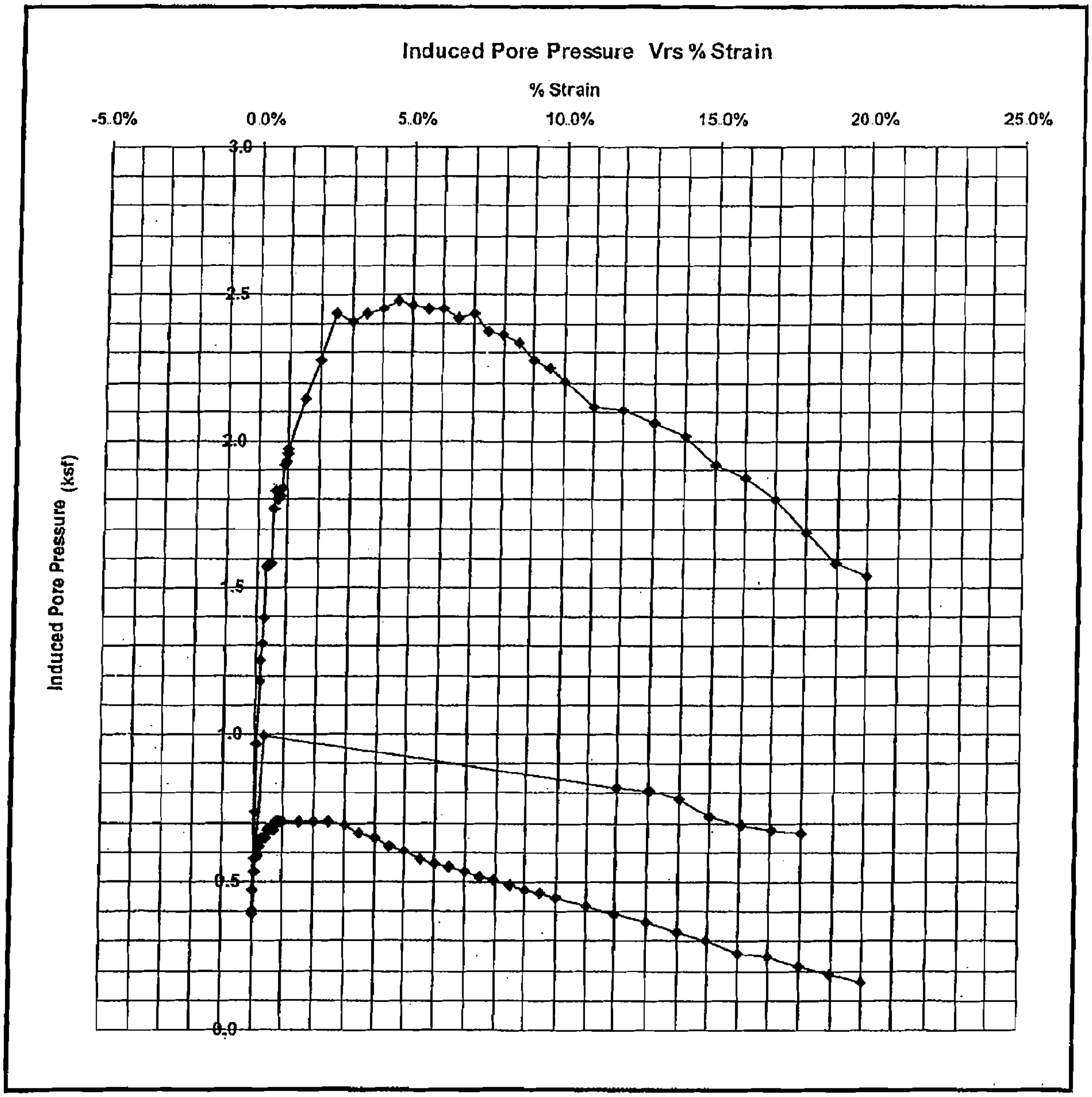
AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP

Project: SPORN ASH DISP. FACILITY

Sample No: 10922



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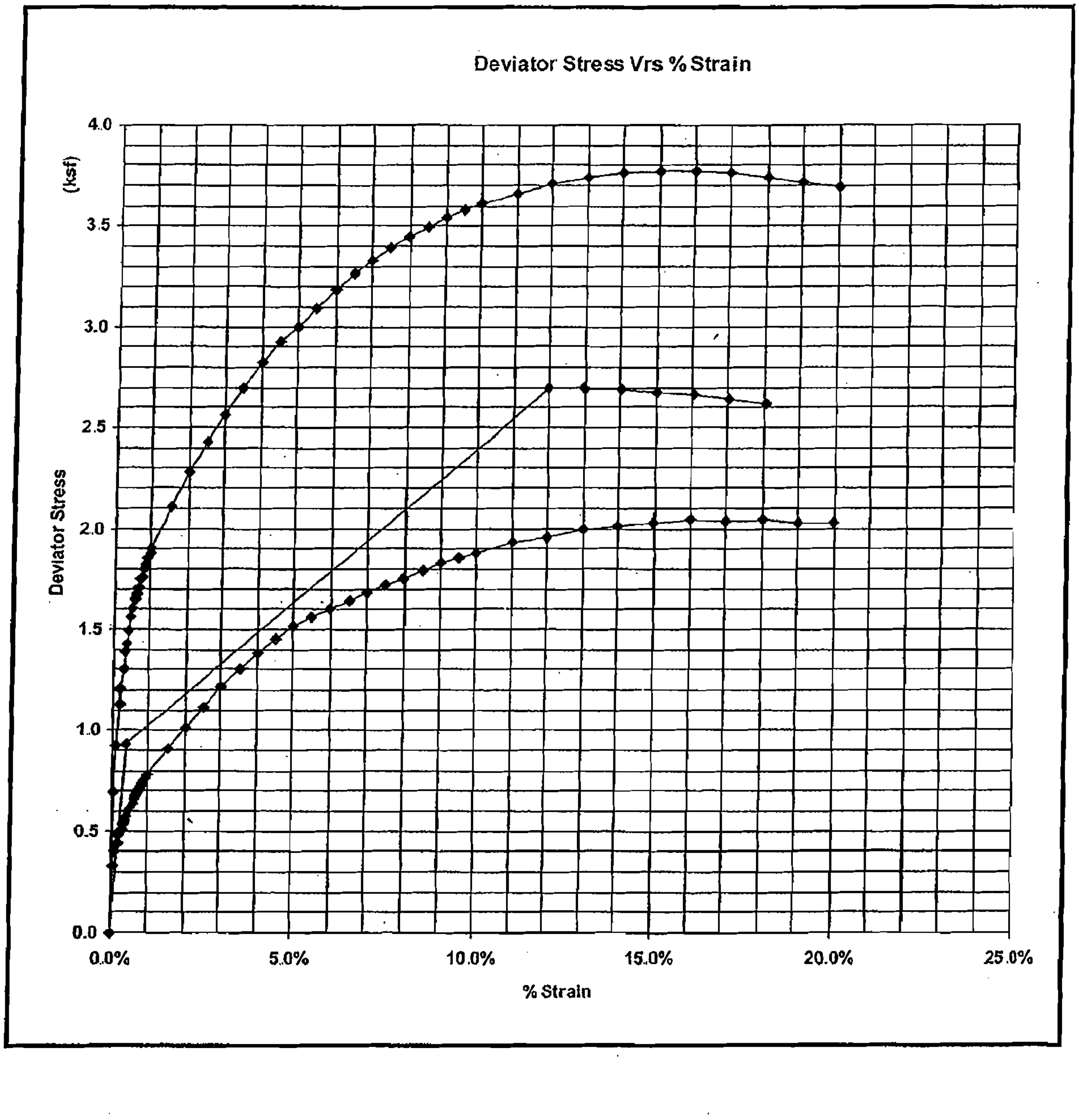
AEP AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10922



Report Date: Friday, August 14 2009

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AEP AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10922
Point: A

Material Description: Boring PZ-0903, Shelby Tube - 46' - 48'; Lab # S-10922

Moisture Determination ASTM D2216

	Before Testing	After Testing
Tare No.	TV	TV
Mass of Container and Wet Specimen (Mcws), grams	1333.67	1324.63
Mass of Container and Over Dry Specimen (Mcs), grams	1077.83	1077.83
Mass of Container (Mc), grams	209.64	209.64
Mass of Water (Mw), grams:	255.84	246.8
Mass of Solid Particles (Ms), grams:	868.19	868.19
Moisture Content (w), %	29.47%	28.43%

Initial Condition of Speciman ASTM D2435

	(1)	(2)	(3)	Average
Diameter Measurents, Inches:	2.829	2.84	2.817	2.829
Height Measurements, Inches:	5.66	5.637	5.655	5.651

Initial Volume of Specimen (Vo), In.3:	35.51
Dry Mass of Specimen After Testing, (Md), grams:	868.19
Dry Unit Weight, (γ d) pcf:	93.14
Specific Gravity of the Solids, (G):	2.70
Volume of Solids, (Vs), Cu. In.:	19.6224
Height of Solids,(Hs),In.:	3.1225
Void Ratio Before Consolidation (Eo):	0.8097
Intitail Degree of Saturation: (So)	98.27%

Saturation - ASTM D4767 Section 8.2

Dial Indicator Reading Prior to Saturation (Rb:) In.	0
Cell Pressure AfterSaturation, psi:	63.00
Back Presssure After Saturation After, psi:	60.00
Pore Pressure Paramenter B:	1
Dial Indicator Reading After Saturation, (Ra) In.:	0.021
Change in Height during Satureation, (Delta Hs) In.	0.021
Change In Volume of Specimen during Saturation (Delta Vsat), In.3:	0.396

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AEP AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10922
Point: A

Consolidation- ASTM D2435, Section 11.5:

Sample No:	T:	Burette 2:	Burette3:	Rc:
10922	0	24.1	24	0.021
10922	0.25	23.9	23.8	
10922	0.5	23.9	23.7	
10922	1	23.8	23.7	
10922	2	23.8	23.6	
10922	4	23.6	23.4	
10922	8	23.4	23.2	
10922	15	23.2	22.9	0.027
10922	30	23	22.5	0.028
10922	60	22.6	22.1	0.03
10922	120	22.3	21.6	0.032
10922	240	22.1	21.3	0.034
10922	360	22	21.2	0.036
10922	1440	21.8	21	0.037

Specimen Height After Consolidation, (Hc), In.: 5.61

Volume Change During Consolidation (Delta Vc), In.3: 0.32

Cross-Sectional Area of Specimen After Consolidation (Ac), In.2: 6.20

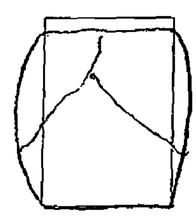
Triaxial Compression Testing ASTM D 4767

Sample Depth: 0 ft.
Cell Pressure: 65 psi
Back Pressure: 60 psi
Confining Pressure: 5 psi
Strain Rate: 0.006 in./min.

Specimen Height After Consolidation, (Hc), In.: 5.61
Correction for Vert Displacement, In.: 0
Load due to Friction and Uplift: 17.4 lbs.
Correction for Filter Paper: 0
Thickness of Membrane (tm), In.: 0.012

$\sigma1-\sigma3=$ **Deviator Stress at Failure, ksf:** 2.03
$\sigma3$ f= **Effective Consolidation Stress at Failure, ksf:** 0.72
$\sigma1=$ **Total Major Principal Stress at Failure:** 2.75
$\sigma'3f=$ $\sigma3-\Delta u=$ **Effective Minor Principal Stress at Failure,ksf:** 0.42
$\sigma'1f=$ **Effective Major Principal Stress at Failure, ksf:** 2.45
Axial Strain at Failure: 14.99%

Failure Sketch



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Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP

Project: SPORN ASH DISP. FACILITY

Sample No: 10922

Point: A

Pa: Applied Force	Vertical Displacement Reading In.:	Pore Pressure psi:	Axial Strain (E1):	(P) - Force Adj for U and F lbs:	Corrected Vertical Displac In.:	Correction for Membrane ksf:	(A) Area In 2:	(σ1−σ3) Deviator Stress ksf:	[Δu] Induced Pore Water Pressure ksf:	σ3 Effective Consolidation Stress ksf	σ1 Total Major Principal Stress ksf	σ3 Effective Minor Principal Stress ksf	σ1' Effective Major Principal Stress ksf	p'	q
17.4	0.000	62.8	0.00%	0.0	0.000	-0.00002	6.197	0.00	0.4032	0.72	0.72	0.32	0.32	0.32	0.00
31.6	0.003	63.7	0.05%	14.2	0.003	0.00025	6.201	0.33	0.5328	0.72	1.05	0.19	0.52	0.35	0.16
34.7	0.005	64.0	0.10%	17.3	0.005	0.00047	6.203	0.40	0.5760	0.72	1.12	0.14	0.55	0.34	0.20
36.6	0.009	64.1	0.16%	19.2	0.009	0.00077	6.207	0.44	0.5904	0.72	1.16	0.13	0.57	0.35	0.22
38.1	0.011	64.3	0.20%	20.7	0.011	0.00098	6.210	0.48	0.6192	0.72	1.20	0.10	0.58	0.34	0.24
39.3	0.014	64.3	0.25%	21.9	0.014	0.00124	6.213	0.51	0.6192	0.72	1.23	0.10	0.61	0.35	0.25
40.6	0.017	64.5	0.31%	23.2	0.017	0.00153	6.217	0.54	0.6480	0.72	1.26	0.07	0.61	0.34	0.27
41.3	0.019	64.5	0.35%	23.9	0.019	0.00170	6.219	0.55	0.6480	0.72	1.27	0.07	0.62	0.35	0.28
42.4	0.022	64.5	0.40%	25.0	0.022	0.00196	6.222	0.58	0.6480	0.72	1.30	0.07	0.65	0.36	0.29
43.5	0.026	64.5	0.46%	26.1	0.026	0.00224	6.226	0.60	0.6480	0.72	1.32	0.07	0.67	0.37	0.30
44.2	0.028	64.7	0.50%	26.8	0.028	0.00244	6.228	0.62	0.6768	0.72	1.34	0.04	0.66	0.35	0.31
45.3	0.031	64.7	0.56%	27.9	0.031	0.00275	6.232	0.64	0.6768	0.72	1.36	0.04	0.69	0.36	0.32
46.2	0.034	64.7	0.61%	28.8	0.034	0.00302	6.236	0.66	0.6768	0.72	1.38	0.04	0.71	0.37	0.33
46.8	0.036	64.7	0.65%	29.4	0.036	0.00319	6.238	0.68	0.6768	0.72	1.40	0.04	0.72	0.38	0.34
47.5	0.039	64.7	0.69%	30.1	0.039	0.00342	6.241	0.69	0.6768	0.72	1.41	0.04	0.73	0.39	0.35
48.2	0.042	64.9	0.74%	30.8	0.042	0.00366	6.244	0.71	0.7056	0.72	1.43	0.01	0.72	0.37	0.35
49.0	0.045	64.9	0.80%	31.6	0.045	0.00393	6.247	0.72	0.7056	0.72	1.44	0.01	0.74	0.38	0.36
49.7	0.048	64.9	0.85%	32.3	0.048	0.00419	6.251	0.74	0.7056	0.72	1.46	0.01	0.75	0.38	0.37
50.5	0.051	64.9	0.91%	33.1	0.051	0.00447	6.254	0.76	0.7056	0.72	1.48	0.01	0.77	0.39	0.38
50.9	0.054	64.9	0.95%	33.5	0.054	0.00470	6.257	0.77	0.7056	0.72	1.49	0.01	0.78	0.40	0.38
51.6	0.056	64.9	1.00%	34.2	0.056	0.00491	6.260	0.78	0.7056	0.72	1.50	0.01	0.80	0.41	0.39
57.4	0.084	64.9	1.50%	40.0	0.084	0.00738	6.292	0.91	0.7056	0.72	1.63	0.01	0.92	0.47	0.45
62.1	0.112	64.9	2.00%	44.7	0.112	0.00982	6.324	1.01	0.7056	0.72	1.73	0.01	1.02	0.52	0.50
67.2	0.140	64.9	2.49%	49.8	0.140	0.01227	6.356	1.12	0.7056	0.72	1.84	0.01	1.13	0.57	0.56
72.0	0.168	64.8	3.00%	54.6	0.168	0.01475	6.389	1.22	0.6912	0.72	1.94	0.03	1.24	0.64	0.61
76.2	0.196	64.6	3.50%	58.8	0.196	0.01722	6.422	1.30	0.6624	0.72	2.02	0.06	1.36	0.71	0.65
80.1	0.224	64.5	4.00%	62.7	0.224	0.01967	6.456	1.38	0.6480	0.72	2.10	0.07	1.45	0.76	0.69
83.7	0.253	64.3	4.50%	66.3	0.253	0.02214	6.490	1.45	0.6192	0.72	2.17	0.10	1.55	0.83	0.72
87.0	0.280	64.2	4.99%	69.6	0.280	0.02458	6.523	1.51	0.6048	0.72	2.23	0.12	1.63	0.87	0.76
89.8	0.308	64.0	5.49%	72.4	0.308	0.02704	6.558	1.56	0.5760	0.72	2.28	0.14	1.71	0.93	0.78
92.1	0.336	63.9	5.99%	74.7	0.336	0.02949	6.593	1.60	0.5616	0.72	2.32	0.16	1.76	0.96	0.80
94.4	0.365	63.8	6.49%	77.0	0.365	0.03196	6.628	1.64	0.5472	0.72	2.36	0.17	1.81	0.99	0.82
96.9	0.393	63.7	7.00%	79.5	0.393	0.03443	6.664	1.68	0.5328	0.72	2.40	0.19	1.87	1.03	0.84
99.1	0.421	63.6	7.49%	81.7	0.421	0.03687	6.699	1.72	0.5184	0.72	2.44	0.20	1.92	1.06	0.86
101.3	0.449	63.5	7.99%	83.9	0.449	0.03933	6.736	1.75	0.5040	0.72	2.47	0.22	1.97	1.09	0.88
103.5	0.477	63.4	8.49%	86.1	0.477	0.04178	6.773	1.79	0.4896	0.72	2.51	0.23	2.02	1.12	0.89
105.9	0.505	63.3	8.99%	88.5	0.505	0.04425	6.810	1.83	0.4752	0.72	2.55	0.24	2.07	1.16	0.91
107.8	0.533	63.2	9.49%	90.4	0.533	0.04671	6.847	1.85	0.4608	0.72	2.57	0.26	2.11	1.19	0.93

Report Date: Friday, August 14, 2009

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GROVEPORT, OHIO 43125
(614) 836-4200

AEP AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP

Project: SPORN ASH DISP. FACILITY

Sample No: 10922

Point: A

109 6	0.561	63 1	9 99%	92 2	0 561	0 04918	6.886	1.88	0.4464	0 72	2 60	0 27	2 15	1.21	0 94
113 3	0.617	62 9	10.99%	95 9	0 617	0 05411	6 963	1 93	0 4176	0.72	2.65	0.30	2 23	1 27	0.96
116.1	0.673	62 7	11 99%	98 7	0.673	0 05900	7 042	1 96	0 3888	0.72	2.68	0.33	2 29	1 31	0 98
119.2	0.729	62 5	12 99%	101 8	0.729	0.06394	7 123	1 99	0 3600	0 72	2 71	0 36	2.35	1.36	1.00
121.6	0 785	62 3	13 99%	104 2	0 785	0.06885	7.206	2 01	0.3312	0 72	2.73	0 39	2 40	1.40	1.01
123 9	0 841	62 1	14 99%	106 5	0 841	0.07376	7 290	2.03	0 3024	0.72	2.75	0.42	2 45	1.43	1 01
126.0	0 897	61 8	15 99%	108 6	0 897	0.07867	7 377	2.04	0 2592	0.72	2 76	0 46	2.50	1 48	1 02
127 2	0.954	61 7	16 99%	109.8	0.954	0 08361	7 466	2 03	0 2448	0.72	2 75	0 48	2 51	1.49	1.02
129 3	1.010	61.5	17 98%	111.9	1.010	0 08851	7 557	2 04	0 2160	0 72	2.76	0.50	2 55	1.53	1.02
130 0	1.066	61 3	18 99%	112 6	1.066	0 09343	7.650	2 03	0.1872	0 72	2.75	0.53	2 56	1.55	1 01
131 6	1.122	61.1	19 98%	114 2	1.122	0 09834	7.745	2.02	0 1584	0 72	2.74	0 56	2 59	1.57	1 01

Report Date: Friday August 14, 2009

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AEP AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP

Project: SPORN ASH DISP. FACILITY

Sample No: 10922

Point: B

Material Description: Boring PZ-0903, Shelby Tube - 46' - 48'; Lab # S-10922

Moisture Determination ASTM D2216

	Before Testing	After Testing
Tare No.	Q	Q
Mass of Container and Wet Specimen (Mcws), grams	1309 98	1301.68
Mass of Containel and Over Dry Specimen (Mcs), grams	1021 69	1021.69
Mass of Container (Mc), grams	206.24	206 24
Mass of Water (Mw), grams:	288.29	279 99
Mass of Solid Particles (Ms), grams:	815.45	815.45
Moisture Content (w), %	35.35%	34 34%

Initial Condition of Speciman ASTM D2435

	(1)	(2)	(3)	Average
Diameter Measurents, Inches:	2.826	2 812	2.805	2.814
Height Measurements, Inches:	5.775	5 776	5.779	5.777

Initial Volume of Specimen (Vo), In.3:	35 94
Dry Mass of Specimen After Testing, (Md), grams:	815.45
Dry Unit Weight, (γ d) pcf:	86 45
Specific Gravity of the Solids, (G):	2.70
Volume of Solids, (Vs), Cu. In.:	18.4304
Height of Solids,(Hs),In.:	2.9627
Void Ratio Before Consolidation (Eo):	0 9498
Initall Degree of Saturation: (So)	100.50%

Saturation - ASTM D4767 Section 8.2

Dial Indicator Reading Prior to Saturation (Rb:) In.	0
Cell Pressure AfterSaturation, psi:	65.00
Back Presssure After Saturation After, psi:	60.00
Pore Pressure Paramenter B:	1
Dial Indicator Reading After Saturation, (Ra) In.:	0.03
Change in Height during Satureation, (Delta Hs) In.	0.03
Change In Volume of Specimen during Saturation (Delta Vsat), In.3:	0 560

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AEP AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10922
Point: B

Consolidation- ASTM D2435, Section 11.5:

Sample No:	T:	Burette 2:	Burette3:	Rc:
10922	0	23.9	23.7	0.03
10922	0.25	23.8	23.5	
10922	0.5	23.7	23.5	
10922	1	23.7	23.5	
10922	2	23.7	23.4	
10922	4	23.6	23.3	
10922	8	23.5	23.2	
10922	15	23.4	23.1	0.036
10922	30	23.1	22.9	0.036
10922	60	22.8	22.5	0.039
10922	120	22.5	22.2	0.042
10922	240	22.1	21.8	0.042
10922	360	21.9	21.6	0.046
10922	1440	21.6	21.3	0.048

Specimen Height After Consolidation, (Hc), In.: 5.73

Volume Change During Consolidation (Delta Vc), In 3: 0.29

Cross-Sectional Area of Specimen After Consolidation (Ac), In 2: 6.13

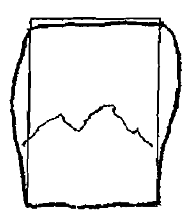
Triaxial Compression Testing ASTM D 4767

Sample Depth: 46 ft.
Cell Pressure: 70 psi
Back Pressure: 60 psi
Confining Pressure: 10 psi
Strain Rate: 0.006 In/min.

Specimen Height After Consolidation, (Hc), In.: 5.73
Correction for Vert Displacement, In.: 0
Load due to Friction and Uplift: 17.9 lbs.
Correction for Filter Paper: 0
Thickness of Membrane (tm), In.: 0.012

σ1−σ3= Deviator Stress at Failure, ksf: 2.69
σ3 f= Effective Consolidation Stress at Failure, ksf: 1.44
σ1= Total Major Principal Stress at Failure: 4.13
σ '3f= σ3− Δ υ= Effective Minor Principal Stress at Failure,ksf: 0.63
σ '1f= Effective Major Principal Stress at Failure, ksf: 3.33
Axial Strain at Failure: 13.02%

Failure Sketch



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Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10922
Point: B

Pa: Applied Force	Vertical Displacement Reading In.:	Pore Pressure psi:	Axial Strain (E1):	(P) - Force Adj for U and F lbs:	Corrected Vertical Displac In.:	Correction for Membrane ksf:	(A) Area in 2:	(σ1−σ3) Deviator Stress ksf:	[Δu] Induced Pore Water Pressure ksf:	σ3 Effective Consolidation Stress ksf	σ1 Total Major Principal Stress ksf	σ3 Effective Minor Principal Stress ksf	σ1' Effective Major Principal Stress ksf	p'	q
17 9	0.000	63.3	0.00%	0.0	0 000	0.00000	6.125	0 00	0 4752	1.44	1 44	0 96	0.96	0.96	0 00
57 6	0.020	66.9	0.35%	39.7	0 020	0.00173	6.147	0.93	0 9936	1 44	2 37	0 45	1.37	0 91	0.46
151.0	0 686	65 7	11 97%	133.1	0 686	0 05928	6.958	2.70	0 8208	1 44	4.14	0.62	3 31	1 97	1.35
152.8	0 744	65 6	12 99%	134.9	0 744	0 06429	7 039	2 70	0.8064	1 44	4.14	0.63	3 33	1 98	1.35
152 8	0 746	65 6	13 02%	134.9	0.746	0 06446	7 042	2 69	0.8064	1.44	4.13	0 63	3.33	1.98	1 35
154.4	0.803	65 4	14 02%	136 5	0.803	0 06942	7 124	2 69	0 7776	1.44	4 13	0 66	3.35	2 01	1 34
155 5	0.861	65 0	15 03%	137 6	0.861	0.07438	7.208	2.67	0 7200	1 44	4.11	0 72	3.39	2.06	1.34
156 8	0.918	64 8	16.03%	138 9	0 918	0.07934	7 294	2.66	0 6912	1 44	4.10	0 75	3 41	2.08	1.33
157 8	0.976	64 7	17.03%	139 9	0.976	0.08432	7.383	2.64	0.6768	1 44	4 08	0 76	3.41	2.09	1 32
158 6	1.033	64 6	18.03%	140 7	1.033	0.08926	7.472	2.62	0 6624	1.44	4 06	0 78	3.40	2.09	1 31

Report Date: Friday, August 14, 2009

FOSSIL AND HYDRO GENERATION
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(614) 836-4200

AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10922
Point: C

Material Description: Boring PZ-0903, Shelby Tube - 46' - 48'; Lab # S-10922

Moisture Determination ASTM D2216

	Before Testing	After Testing
Tare No.	Y	Y
Mass of Container and Wet Specimen (Mcws), grams	1361 13	1334.81
Mass of Container and Over Dry Specimen (Mcs), grams	1093 60	1093.60
Mass of Container (Mc), grams	210.21	210.21
Mass of Water (Mw), grams:	267.53	241.21
Mass of Solid Particles (Ms), grams:	883 39	883.39
Moisture Content (w), %	30.28%	27.31%

Initial Condition of Speciman ASTM D2435

	(1)	(2)	(3)	Average
Diameter Measurents, Inches:	2.807	2 825	2.827	2.820
Height Measurements, Inches:	5.841	5 841	5.835	5 839
Initial Volume of Specimen (Vo), In.3:	36.46			
Dry Mass of Specimen After Testing, (Md), grams:	883.39			
Dry Unit Weight, (γd) pcf:	92.30			
Specific Gravity of the Solids, (G):	2.70			
Volume of Solids, (Vs), Cu. In.:	19 9659			
Height of Solids,(Hs),In.:	3.1974			
Void Ratio Before Consolidation (Eo):	0.8261			
Initail Degree of Saturation: (So)	98.98%			

Saturation - ASTM D4767 Section 8.2

Dial Indicator Reading Prior to Saturation (Rb:) In.	0
Cell Pressure AfterSaturation, psi:	65.00
Back Presssure After Saturation After, psi:	60.00
Pore Pressure Paramenter B:	1
Dial Indicator Reading After Saturation, (Ra) In.:	0.031
Change in Height during Satureation, (Delta Hs) In.	0 031
Change In Volume of Specimen during Saturation (Delta Vsat), In.3:	0.581

Report Date: Friday, August 14 2009

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(614) 836-4200

AEP AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP
Project: SPORN ASH DISP. FACILITY
Sample No: 10922
Point: C

Consolidation- ASTM D2435, Section 11.5:

Sample No:	T:	Burette 2:	Burette3:	Rc:
10922	0	23.4	23.8	0.031
10922	0.25	23.1	23.5	
10922	0.5	23	23.5	
10922	1	22.9	23.4	
10922	2	22.8	23.3	
10922	4	22.5	23.1	
10922	8	22.2	22.7	
10922	15	21.8	22.3	0.046
10922	30	21.1	21.6	0.051
10922	60	19.9	20.5	0.058
10922	120	18.2	19.1	0.068
10922	240	16.2	17.4	0.08
10922	360	15	16.4	0.086
10922	1440	13.1	14.7	0.098

Specimen Height After Consolidation, (Hc), In.: 5.74

Volume Change During Consolidation (Delta Vc), In.3: 1.18

Cross-Sectional Area of Specimen After Consolidation (Ac), In.2: 6.04

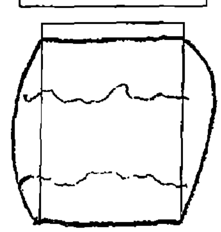
Triaxial Compression Testing
ASTM D 4767

Sample Depth: 46 ft.
Cell Pressure: 80 psi
Back Pressure: 60 psi
Confining Pressure: 20 psi
Strain Rate: 0.006 In/min.

Specimen Height After Consolidation, (Hc), In.: 5.74
Correction for Vert Displacement, In.: 0
Load due to Friction and Uplift: 22.5 lbs.
Correction for Filter Paper: 0
Thickness of Membrane (tm), In.: 0.012

$\sigma 1-\sigma 3=$ Deviator Stress at Failure, ksf: 3.77
$\sigma 3$ f= Effective Consolidation Stress at Failure, ksf: 2.88
$\sigma 1=$ Total Major Principal Stress at Failure: 6.65
$\sigma '3f=$ $\sigma 3-\Delta u=$ Effective Minor Principal Stress at Failure, ksf: 0.96
$\sigma '1f=$ Effective Major Principal Stress at Failure, ksf: 4.74
Axial Strain at Failure: 15.00%

Failure Sketch



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AMERICAN ELECTRIC POWER

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP

Project: SPORN ASH DISP. FACILITY

Sample No: 10922

Point: C

Pa: Applied Force	Vertical Displacement Reading In.:	Pore Pressure psi:	Axial Strain (Et):	(P) - Force Adj for U and F lbs:	Corrected Vertical Displac In.:	Correction for Membrane ksf:	(A) Area In 2:	(σ1−σ3) Deviator Stress ksf:	[Δu] Induced Pore Water Pressure ksf:	σ3 Effective Consolidation Stress ksf	σ1 Total Major Principal Stress ksf	σ3 Effective Minor Principal Stress ksf	σ1' Effective Major Principal Stress ksf	p'	q
22.5	0 000	62.7	0 00%	0.0	0.000	0.00002	6 044	0.00	0.3888	2.88	2.88	2 49	2.49	2.49	0 00
51.7	0.003	65 1	0 05%	29.2	0 003	0.00024	6 046	0.70	0.7344	2.88	3 58	2 15	2 84	2.49	0 35
61 2	0.006	66 7	0.10%	38.7	0 006	0 00049	6 049	0.92	0.9648	2 88	3.80	1.92	2 84	2 38	0.46
69.8	0.009	68 2	0 16%	47 3	0 009	0 00080	6 053	1 12	1.1808	2 88	4 00	1 70	2.82	2 26	0 56
73 4	0 011	68.7	0 20%	50.9	0 011	0 00099	6.056	1 21	1.2528	2.88	4 09	1 63	2 84	2 23	0 60
77 2	0.014	69.1	0 25%	54.7	0 014	0 00123	6.059	1 30	1 3104	2.88	4.18	1 57	2.87	2.22	0 65
81.0	0 018	69.7	0 31%	58.5	0 018	0 00155	6.062	1 39	1 3968	2.88	4.27	1 48	2 87	2 18	0.69
82 8	0 020	70 9	0 35%	60 3	0 020	0 00174	6.065	1.43	1 5696	2 88	4 31	1 31	2 74	2 03	0.72
85 3	0 023	70.9	0 40%	62.8	0 023	0 00198	6.068	1.49	1.5696	2 88	4 37	1 31	2.80	2 05	0 74
88 5	0 026	71 0	0 46%	66 0	0 026	0 00229	6.071	1.56	1.5840	2 88	4.44	1 30	2.86	2 08	0.78
90 0	0 029	71.0	0 50%	67 5	0.029	0.00250	6.074	1.60	1.5840	2 88	4.48	1 30	2 89	2.09	0.80
92 1	0.032	72 3	0 56%	69.6	0 032	0.00280	6 078	1 65	1 7712	2.88	4 53	1 11	2.76	1.93	0 82
93 4	0 035	72 7	0 61%	70 9	0.035	0.00302	6 080	1 68	1 8288	2 88	4 56	1 05	2.73	1 89	0 84
94 7	0 037	72 5	0.65%	72 2	0.037	0.00325	6 083	1 71	1 8000	2 88	4 59	1.08	2 79	1 93	0 85
96 7	0 040	72 6	0.70%	74 2	0.040	0.00349	6 086	1 75	1 8144	2 88	4.63	1.07	2 82	1.94	0 88
97 2	0 043	72 6	0 75%	74 7	0.043	0.00372	6 089	1 76	1 8144	2 88	4.64	1.07	2 83	1 95	0 88
98 8	0 046	72.8	0 80%	76 3	0 046	0.00399	6.092	1 80	1 8432	2 88	4 68	1 04	2.84	1.94	0 90
99.9	0 049	73 3	0 85%	77 4	0.049	0.00422	6 095	1.82	1 9152	2.88	4 70	0 96	2 79	1 88	0.91
101 1	0 052	73.4	0 91%	78 6	0.052	0 00451	6.099	1 85	1 9296	2 88	4.73	0 95	2 80	1 88	0.93
102 3	0.055	73.6	0 96%	79 8	0.055	0 00481	6.102	1.88	1 9584	2 88	4.76	0.92	2 80	1 86	0.94
103 2	0.057	73.7	1 00%	80 7	0.057	0.00498	6.105	1.90	1 9728	2 88	4.78	0.91	2 81	1 86	0 95
112 7	0.086	74.9	1 50%	90 2	0 086	0.00748	6.136	2.11	2.1456	2 88	4 99	0.73	2.84	1.79	1 05
120 7	0 115	75 8	2 00%	98.2	0.115	0 00997	6.167	2.28	2.2752	2.88	5 16	0 60	2.89	1.75	1 14
127 6	0 143	76.9	2 50%	105.1	0.143	0 01245	6.198	2.43	2.4336	2.88	5 31	0 45	2 88	1 66	1 21
134.1	0 172	76.7	3 00%	111.6	0.172	0 01493	6.230	2.56	2.4048	2.88	5 44	0 48	3 04	1 76	1 28
140 6	0 201	76 9	3 50%	118 1	0 201	0 01743	6.263	2 70	2.4336	2.88	5.58	0.45	3.14	1.80	1.35
146.7	0 229	77 0	4 00%	124 2	0 229	0 01991	6.295	2 82	2.4480	2.88	5.70	0.43	3 25	1 84	1.41
152.0	0 258	77 2	4.50%	129 5	0 258	0.02241	6.328	2 92	2.4768	2.88	5.80	0.40	3 33	1 87	1.46
156 2	0 287	77 1	5 00%	133 7	0 287	0.02490	6.361	3.00	2.4624	2.88	5.88	0 42	3.42	1 92	1 50
161.1	0 316	77 0	5 50%	138 6	0 316	0.02741	6.395	3.09	2.4480	2 88	5 97	0.43	3 53	1 98	1 55
166.0	0 344	77 0	6 00%	143 5	0 344	0.02990	6.429	3.18	2.4480	2 88	6 06	0 43	3 62	2.02	1 59
170 7	0 373	76 8	6 50%	148 2	0 373	0.03240	6.464	3.27	2.4192	2 88	6.15	0.46	3.73	2.10	1.63
174.4	0 402	76 9	7.00%	151 9	0 402	0.03486	6.498	3 33	2.4336	2.88	6.21	0.45	3 78	2 11	1 67
178.1	0.430	76 5	7.50%	155.6	0.430	0.03736	6.533	3 39	2 3760	2 88	6.27	0.50	3.90	2 20	1.70
181.6	0.459	76 4	8.00%	159 1	0.459	0.03984	6.569	3.45	2 3616	2.88	6.33	0.52	3.97	2 24	1.72
184 9	0.488	76 2	8.50%	162 4	0 488	0.04236	6.605	3 50	2 3328	2.88	6.38	0.55	4 05	2 30	1.75
188 0	0.517	75.8	9.00%	165 5	0 517	0.04484	6.641	3.54	2.2752	2.88	6 42	0 60	4 15	2 38	1.77
190 7	0.545	75 6	9.50%	168 2	0 545	0.04733	6.678	3 58	2 2464	2.88	6 46	0 63	4 21	2.42	1.79

Report Date: Friday, August 14, 2009

FOSSIL AND HYDRO GENERATION
CIVIL AND MINING ENGINEERING DIVISION
CIVIL LABORATORY SECTION
AMERICAN ELECTRIC POWER SERVICE CORPORATION
4001 BIXBY ROAD
GROVEPORT, OHIO 43125
(614) 836-4200

Test Report for Consolidated-Undrained Triaxial Compresion Test - ASTM D 4767

Company: AEP

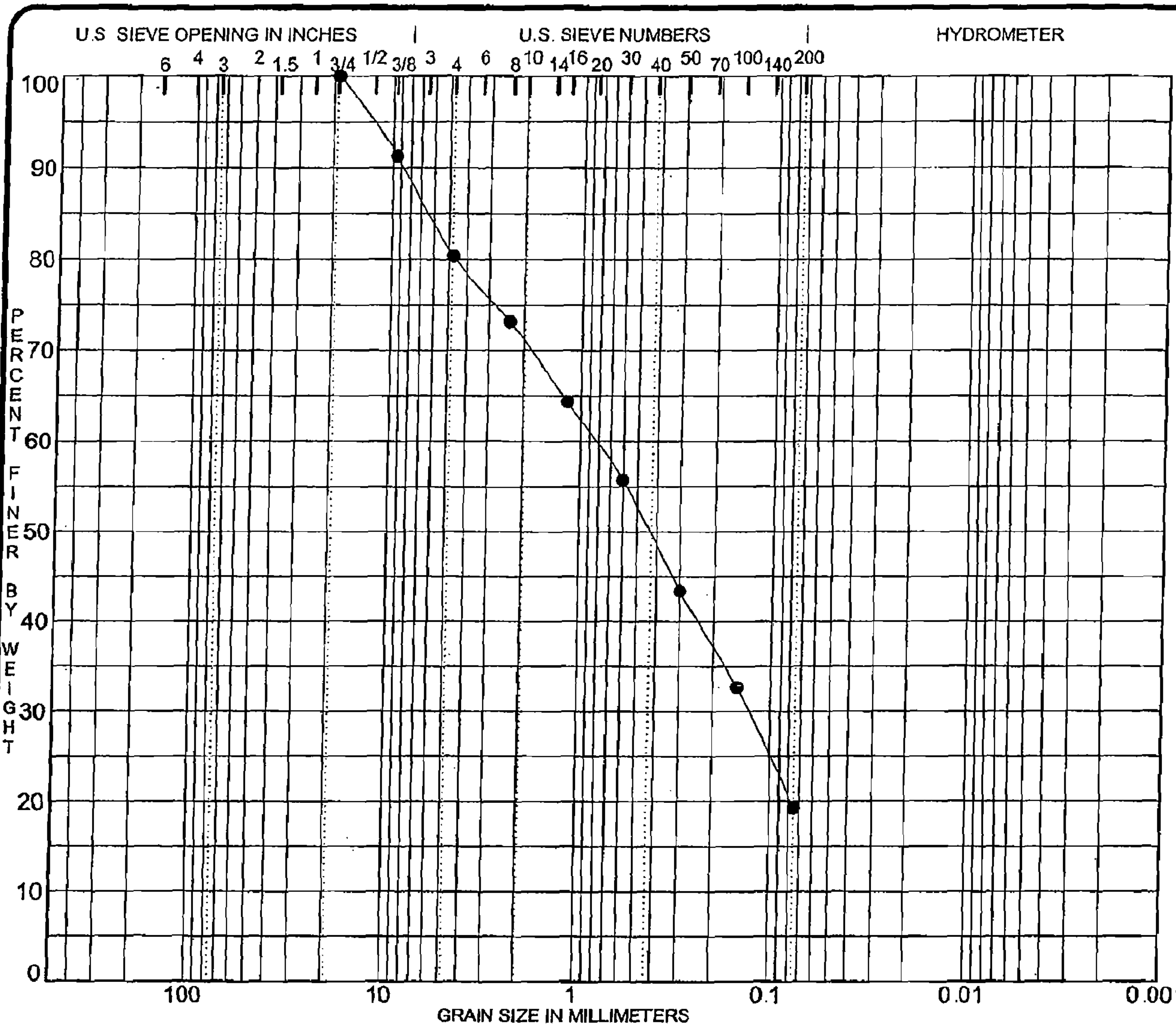
Project: SPORN ASH DISP. FACILITY

Sample No: 10922

Point: C

193.5	0.574	75 3	10 00%	171 0	0 574	0 04983	6.715	3 62	2.2032	2 88	6.50	0 68	4.29	2.49	1.81
197.7	0 632	74.7	11 00%	175 2	0 632	0 05483	6.791	3 66	2.1168	2.88	6 54	0 76	4 42	2 59	1 83
202.2	0 689	74.6	11.99%	179 7	0 689	0.05977	6.867	3.71	2 1024	2.88	6.59	0.78	4 49	2.63	1 85
206.2	0.746	74.3	13 00%	183 7	0.746	0.06477	6.946	3 74	2 0592	2.88	6.62	0.82	4.56	2 69	1 87
209.6	0 803	74.0	13.99%	187.1	0 803	0 06974	7 027	3.76	2.0160	2 88	6.64	0 86	4.63	2.75	1.88
212.5	0 861	73 3	15.00%	190 0	0.861	0.07476	7 110	3.77	1.9152	2 88	6.65	0 96	4 74	2.85	1.89
215.0	0 919	73 0	16 00%	192 5	0.919	0.07974	7 195	3.77	1 8720	2 88	6.65	1 01	4 78	2.89	1.89
217.0	0 976	72 5	16 99%	194.5	0.976	0.08469	7 281	3.76	1.8000	2 88	6 64	1 08	4.84	2.96	1 88
218.3	1 033	71 7	18 00%	195 8	1.033	0 08969	7 370	3 74	1.6848	2 88	6 62	1 20	4.93	3 06	1 87
220 1	1.090	71 0	18 99%	197.6	1 090	0.09465	7 461	3 72	1 5840	2.88	6 60	1.30	5.02	3 16	1 86
221 5	1.148	70 7	20.00%	199.0	1.148	0 09965	7 554	3 69	1 5408	2.88	6.57	1 34	5.03	3 19	1.85

Report Date: Friday, August 14 2009



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
●	PZ-0905	11.0			NP	NP	NP	
			SILTY SAND with GRAVEL SM					
			Ash Mixture - Samples 5,6,7,8 Combined					

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
●	PZ-0905	11.0	19.000	0.836	0.130		19.6	61.2	19.2	

PROJECT **SPORN PLANT - FLY ASH POND DIKES - FLY ASH POND DIKES**

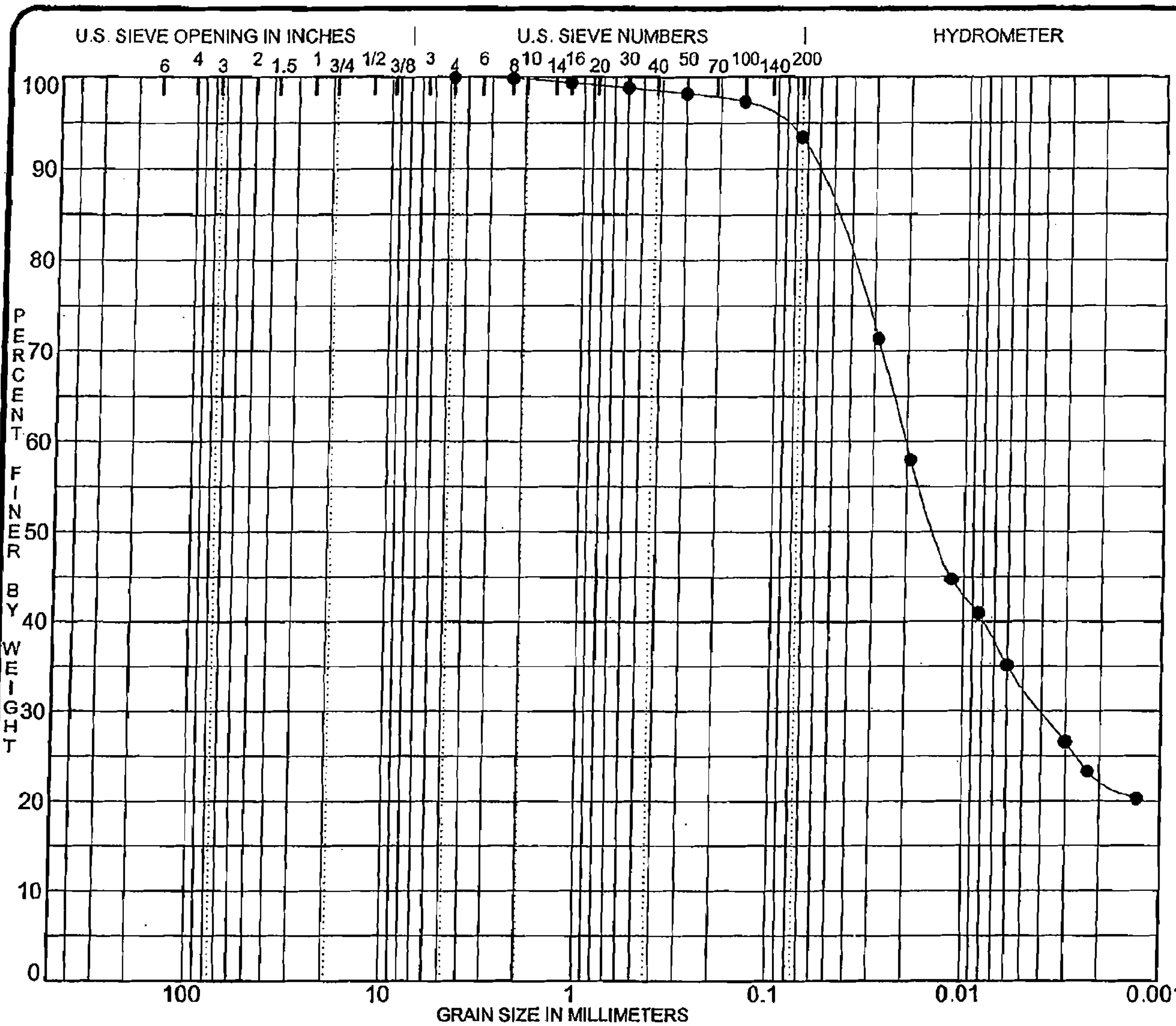
JOB NO.

DATE 8/14/09

GRADATION CURVES

American Electric Power Service Corp.
Groveport, OH 43125

AEP



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	MC%	LL	PL	PI	Sp.Gr.
● PZ-0905	38.0		25.3	31.2	19.1	12.0	
		LEAN CLAY CL					
		Shelby Tube Sample - 38' - 40'					

Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Fines	%<.002
● PZ-0905	38.0	4.750	0.020	0.004		0.0	6.5	93.5	22.6

PROJECT **SPORN PLANT - FLY ASH POND DIKES - FLY ASH POND DIKES**

JOB NO.

DATE 8/14/09

GRADATION CURVES

American Electric Power Service Corp.
Groveport, OH 43125

AEP

LABORATORY DATA DEVELOPED BY: GEO/ENVIRONMENTAL ASSOCIATES, INC.

DATED: DECEMBER 2009 & JANUARY 2010

SUMMARY OF LABORATORY TEST RESULTS

						ATTERBERG LIMITS				Project: Philip Sporn Plant Project Number: 09-387 Date: January 18, 2010
Boring	Sample No.	Sample Type*	Depth (ft)	Natural Moisture (%)	Dry Density (pcf)	Liquid Limit (%)	Plasticity Index (%)	USCS	Other Test **	Soil Description
GA-1A	ST-1	ST	26.5-27.2	26.8	80.6	--	--	SM	S	Ash mix, clay, sandy, dark brown & light brown
GA-1A	ST-2	ST	28.5-31.0	53.3	61.3	46	np	ML	S	Fly Ash, gray
GA-1A	ST-3	ST	32.5-35.0	58.5	61.0	--	--	ML	S	Fly Ash, dark gray, dark brown
GA-1A	ST-4	ST	36.5-39.0	33.0	--	--	--	ML	S	Fly Ash, dark gray
GA-1A	ST-5	ST	40.5-43.0	46.6	69.3	37	np	ML	S	Fly Ash, dark gray, dark brown
GA-1A	ST-6	ST	44.5-47.0	44.6	71.9	44	np	ML	S,T	Fly Ash, dark gray
GA-1A	ST-7	ST	48.5-51.0	37.2	--	--	--	ML	S	Fly Ash, dark gray
GA-1A	ST-8	ST	52.5-55.0	53.3	65.7	44	np	ML	S	Fly Ash, gray
GA-1A	ST-9	ST	56.5-59.0	51.5	66.5	45	np	ML	S	Fly Ash, dark gray
GA-1A	ST-10	ST	60.5-63.0	53.7	63.5	44	np	ML	S	Fly Ash, dark gray, dark brown
GA-1C	ST-2	ST	69.0-71.5	28.2	95.1	35	16	CL	S,T	Clay, silty, brown
GA-2	ST-2	ST	59.0-61.5	20.3	--	20	4	CL/ML	S	Clay, silty, brown
GA-2	ST-3	ST	69.0-71.5	20.8	--	23	6	CL/ML	S	Clay, silty, light brown
GA-3	ST-3	ST	79.0-81.5	24.4	--	32	12	CL	S	Clay, silty, light brown

*ST-SHELBY TUBE SAMPLE, SS-SPLIT SPOON SAMPLE, B-BAG SAMPLE, J-JAR SAMPLE

**TEST RESULTS REPORTED ON OTHER SHEETS:

T-TRIAXIAL
S-SIEVE OR GRAIN SIZE ANALYSIS
U-UNCONFINED COMPRESSION
P-PROCTOR TEST
K-PERMEABILITY
C-CONSOLIDATION

Geo/Environmental Associates

DATA CHECKED BY __________

LABORATORY DENSITY CALCULATIONS

Project : Philip Sporn Plant

Date : January 07, 2010

Project No. : 09-387

Boring	Sample No.	Ht	Dia	Wt(gm)	Wt(lbs)	Moisture Data (w/tare)				Area	Volume	Wet Density	Dry Density
						wet wt	dry wt	tare wt	Moist				
GA-1A	ST-1	3.77	2.84	640.9	1.413	878.4	718.8	123.2	26.8	0.0440	0.0138	102.2	80.6
GA-1A	ST-2	5.98	2.86	947.8	2.090	833.5	584.7	117.9	53.3	0.0446	0.0222	94.0	61.3
GA-1A	ST-3	7.19	2.87	1180	2.601	606.9	426.1	117.1	58.5	0.0449	0.0269	96.6	61.0
GA-1A	ST-4	3.46	2.84	650	1.433	1035.2	844.6	266.6	33.0	0.0440	0.0127	113.0	85.0
GA-1A	ST-5	7.78	2.87	1343.8	2.963	748.1	548.7	123.1	46.9	0.0449	0.0291	101.7	69.3
GA-1A	ST-6	5.55	2.83	952.9	2.101	952.9	659.0	0.0	44.6	0.0437	0.0202	104.0	71.9
GA-1A	ST-7	3.78	2.85	672.3	1.482	954.8	768.6	267.7	37.2	0.0443	0.0140	106.2	77.4
GA-1A	ST-8	8.33	2.86	1414.2	3.118	889.8	621.5	118.2	53.3	0.0446	0.0310	100.7	65.7
GA-1A	ST-9	6.02	2.83	1000.6	2.206	895.3	632.6	122.1	51.5	0.0437	0.0219	100.7	66.5
GA-1A	ST-10	8.56	2.86	1409.3	3.107	663.1	474.3	122.4	53.7	0.0446	0.0318	97.6	63.5
GA-1C	ST-2	5.88	2.87	1217.6	2.684	1217.6	950.1	0.0	28.2	0.0449	0.0220	121.9	95.1

Laboratory Void Ratio Work Sheet

Project : Philip Sporn Plant

Project No. : 09-387

Samples : Boring Ga-1A

Boring	GA-1A	GA-1A	GA-1A	GA-1A	GA-1A	GA-1A	GA-1A	GA-1A	GA-1A	GA-1A	GA-1C
Sample No.	ST-1	ST-2	ST-3	ST-4	ST-5	ST-6	ST-7	ST-8	ST-9	ST-10	ST-2
Depth	26.5-27.2	28.5-31.0	32.5-35.0	36.5-39.0	40.5-43.0	44.5-47.0	48.5-51.0	52.8-55.0	56.5-59.0	60.5-63.0	69.0-71.5
Moist(+1)	1.268	1.533	1.585	1.33	1.466	1.446	1.372	1.533	1.515	1.537	1.282
Wet Density	102.2	94.0	96.6	113.0	101.7	104.0	106.2	100.7	100.7	97.6	121.9
Dry Density	80.6	61.3	61.0	85.0	69.3	71.9	77.4	65.7	66.5	63.5	95.1
Wet wt	1.413	2.090	2.601	1.433	2.963	2.101	1.482	3.118	2.206	3.107	2.684
Dry wt	1.114	1.363	1.641	1.077	2.021	1.453	1.080	2.034	1.456	2.021	2.094
Water wt	0.299	0.727	0.960	0.356	0.942	0.648	0.402	1.084	0.750	1.086	0.590
Volume	0.0138	0.0222	0.0269	0.0127	0.0291	0.0202	0.0140	0.0310	0.0219	0.0318	0.0220
Spec. Grav.	2.36	2.21	2.32	2.49	2.36	2.43	2.43	2.44	2.40	2.30	2.71
Vol. Solids	0.0076	0.0099	0.0113	0.0069	0.0137	0.0096	0.0071	0.0134	0.0097	0.0141	0.0124
Vol. Water	0.0048	0.0116	0.0154	0.0057	0.0151	0.0104	0.0064	0.0174	0.0120	0.0174	0.0095
Vol. Air	0.0014	0.0007	0.0002	0.0001	0.0003	0.0002	0.0004	0.0003	0.0002	0.0003	0.0002
Porosity	0.4517	0.5547	0.5786	0.4540	0.5284	0.5256	0.4912	0.5691	0.5560	0.5571	0.4372
Void Ratio	0.8237	1.2456	1.3731	0.8314	1.1203	1.1081	0.9653	1.3206	1.2524	1.2577	0.7770

GA-1A	Fly Ash Pond East Dike - Section K-K									
	Sample	**ST-2**	**ST-3**	**ST-4**	**ST-5**	**ST-6**	**ST-7**	**ST-8**	**ST-9**	**ST-10**
	Sample Depth (ft)	**28.5-31.0**	**32.5-35.0**	**36.5-39.0**	**40.5-43.0**	**44.5-47.0**	**48.5-51.0**	**52.5-55.0**	**56.5-59.0**	**60.5-63.0**
DENSITY	Tube Weight (g)	2672	2658	2676	2673	2675	2657	2683	2671	2508
	Tube & Sample Weight (g)	7826	8022	8234	8080	8065	7930	7975	7820	8186
	Sample Weight (g)	5154	5364	5558	5407	5390	5273	5292	5149	5678
	Sample Weight (lbs)	11.36	11.83	12.25	11.92	11.88	11.62	11.67	11.35	12.52
	Recovery Length (ft)	2.66	2.5	2.6	2.55	2.55	2.41	2.55	2.37	2.49
	Sample Volume (ft^3)	0.120	0.113	0.117	0.115	0.115	0.109	0.115	0.107	0.112
	Density (lbs/ft^3)	**94.8**	**104.9**	**104.5**	**103.7**	**103.4**	**107.0**	**101.5**	**106.2**	**111.5**
MOISTURE	Moist Sample Weight (g)	103.54	79.83	100.6	84.72	85.84	84.61	90.97	91.42	90.5
	Dry Sample Weight (g)	75.49	53.78	66.03	58.14	52.71	51.65	59.67	54.03	72.94
	Moisture Content (%)	**37.2**	**48.4**	**52.4**	**45.7**	**62.9**	**63.8**	**52.5**	**69.2**	**24.1**
SPECIFIC GRAVITY	Sample Weight (g)	74.36	47.6	48.95	56.49	40.09	44.73	47.85	38.43	69.41
	Flask & Water (g)	673.32	680.56	673.32	680.56	673.23	680.48	673.06	680.52	673.02
	Flask, Water, and Sample (g)	719.23	708.49	702.72	710.64	695.29	705.24	701.01	702.66	716.77
	Specific Gravity of Solids	**2.61**	**2.42**	**2.50**	**2.14**	**2.22**	**2.24**	**2.40**	**2.36**	**2.70**
VOID RATIO	Volume of Sample (cm^3)	3395.7	3191.4	3319.1	3255.3	3255.3	3076.6	3255.3	3025.5	3178.7
	Weight of Solids (g)	3757.7	3613.6	3648.1	3710.6	3309.7	3218.9	3471.2	3043.1	4576.3
	Volume of Solids (cm^3)	1437.7	1493.3	1457.0	1734.8	1488.5	1437.1	1443.6	1289.9	1691.8
	Void Ratio	**1.36**	**1.14**	**1.28**	**0.88**	**1.19**	**1.14**	**1.25**	**1.35**	**0.88**

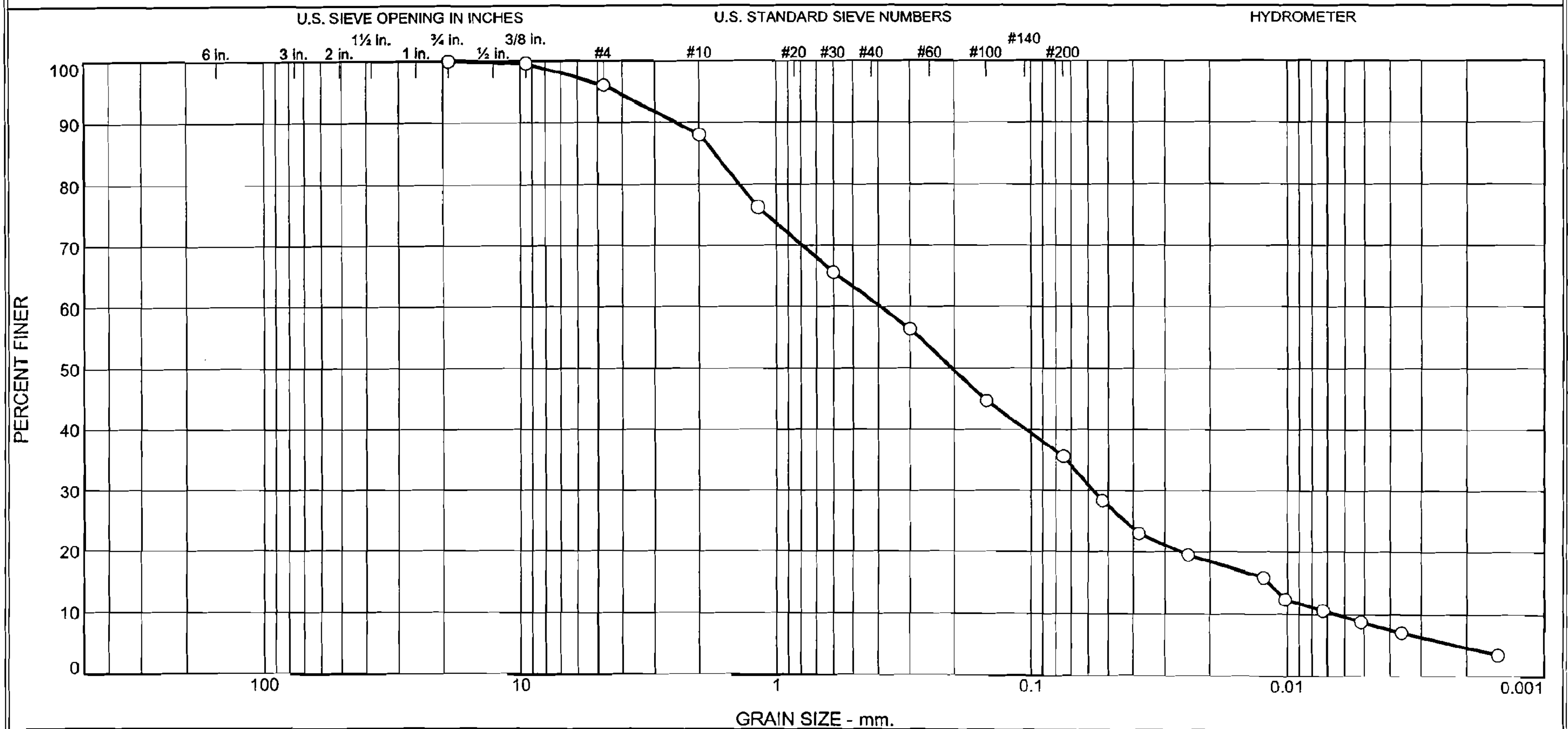
GA-1C	Fly Ash Pond East Dike - Section K-K		
	Sample	ST-1	ST-2
	Sample Depth (ft)	39.0-41.5	69.0-71.5
DENSITY	Tube Weight (g)	2667	2667
	Tube & Sample Weight (g)	5095	8663
	Sample Weight (g)	2428	5996
	Sample Weight (lbs)	5.35	13.22
	Recovery Length (ft)	0.98	2.58
	Sample Volume (ft^3)	0.044	0.116
	Density (lbs/ft^3)	**121.2**	**113.7**
MOISTURE	Moist Sample Weight (g)	75.15	84.75
	Dry Sample Weight (g)	46.08	65.06
	Moisture Content (%)	**63.1**	**30.3**
SPECIFIC GRAVITY	Sample Weight (g)	43.65	57.43
	Flask & Water (g)	673.41	680.85
	Flask, Water, and Sample (g)	696.56	717.27
	Specific Gravity of Solids	**2.13**	**2.73**
VOID RATIO	Volume of Sample (cm^3)	1251.0	3293.6
	Weight of Solids (g)	1488.8	4602.9
	Volume of Solids (cm^3)	699.2	1683.9
	Void Ratio	**0.79**	**0.96**

GA-1D	Fly Ash Pond East Dike - Section K-K			
	Sample	ST-1	ST-2	ST-3
	Sample Depth (ft)	29.0-31.5	39.0-41.5	59.0-61.5
DENSITY	Tube Weight (g)	2668	2665	2673
	Tube & Sample Weight (g)	5014	7952	7533
	Sample Weight (g)	2346	5287	4860
	Sample Weight (lbs)	5.17	11.66	10.71
	Recovery Length (ft)	1.17	2.48	2.36
	Sample Volume (ft^3)	0.053	0.112	0.106
	Density (lbs/ft^3)	**98.1**	**104.3**	**100.7**
MOISTURE	Moist Sample Weight (g)	80.9	84.89	84.19
	Dry Sample Weight (g)	52.33	57.14	59.66
	Moisture Content (%)	**54.6**	**48.6**	**41.1**
SPECIFIC GRAVITY	Sample Weight (g)	47.49	44.37	46.25
	Flask & Water (g)	673.36	680.53	673.19
	Flask, Water, and Sample (g)	698.44	705.66	700.87
	Specific Gravity of Solids	**2.12**	**2.31**	**2.49**
VOID RATIO	Volume of Sample (cm^3)	1493.6	3165.9	3012.7
	Weight of Solids (g)	1517.5	3558.7	3444.0
	Volume of Solids (cm^3)	716.1	1543.2	1382.8
	Void Ratio	**1.09**	**1.05**	**1.18**

GA-2	Fly Ash Pond East Dike - Section M-M			
	Sample	ST-1	ST-2	ST-3
	Sample Depth (ft)	39.0-41.5	59.0-61.5	69.0-70.5
DENSITY	Tube Weight (g)	2669	2657	2659
	Tube & Sample Weight (g)	4859	8808	6679
	Sample Weight (g)	2190	6151	4020
	Sample Weight (lbs)	4.83	13.56	8.86
	Recovery Length (ft)	1.10	2.50	1.70
	Sample Volume (ft^3)	0.050	0.113	0.077
	Density (lbs/ft^3)	**97.4**	**120.3**	**115.6**
MOISTURE	Moist Sample Weight (g)	62.21	73.94	96.65
	Dry Sample Weight (g)	34.09	59.79	79.79
	Moisture Content (%)	**82.5**	**23.7**	**21.1**
SPECIFIC GRAVITY	Sample Weight (g)	32.52	51.63	55.71
	Flask & Water (g)	686.86	673.69	681.01
	Flask, Water, and Sample (g)	704.09	706.28	714.17
	Specific Gravity of Solids	**2.13**	**2.71**	**2.47**
VOID RATIO	Volume of Sample (cm^3)	1404.2	3191.4	2170.2
	Weight of Solids (g)	1200.1	4973.9	3318.7
	Volume of Solids (cm^3)	564.2	1834.3	1343.3
	Void Ratio	**1.49**	**0.74**	**0.62**

GA-3	Fly Ash Pond East Dike - Section L-L			
	Sample	ST-1	ST-2	ST-3
	Sample Depth (ft)	**29.0-31.5**	**49.0-51.5**	**79.0-81.5**
DENSITY	Tube Weight (g)	2655	2653	2659
	Tube & Sample Weight (g)	5565	7463	8276
	Sample Weight (g)	2910	4810	5617
	Sample Weight (lbs)	6.42	10.60	12.38
	Recovery Length (ft)	1.51	2.34	2.27
	Sample Volume (ft^3)	0.068	0.105	0.102
	Density (lbs/ft^3)	**94.2**	**100.5**	**121.0**
MOISTURE	Moist Sample Weight (g)	54.9	84.35	93.18
	Dry Sample Weight (g)	40.85	53.78	66.03
	Moisture Content (%)	**34.4**	**56.8**	**41.1**
SPECIFIC GRAVITY	Sample Weight (g)	37.96	43.22	65.77
	Flask & Water (g)	680.82	673.27	680.82
	Flask, Water, and Sample (g)	700.62	697.43	721.95
	Specific Gravity of Solids	**2.09**	**2.27**	**2.67**
VOID RATIO	Volume of Sample (cm^3)	1927.6	2987.2	2897.8
	Weight of Solids (g)	2165.3	3066.8	3980.4
	Volume of Solids (cm^3)	1035.9	1352.4	1491.2
	Void Ratio	**0.86**	**1.21**	**0.94**

Particle Size Distribution Report



	% +3"	% Gravel Coarse	% Gravel Fine	% Sand Coarse	% Sand Medium	% Sand Fine	% Fines Silt	% Fines Clay
○	0.0	0.0	4.0	8.0	27.0	25.5	26.9	8.6

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○		GA-1A ST1	26.5'-27.2'		SM	Ash mix, clay, sandy, dark brown & light brown	26.8	nv	np

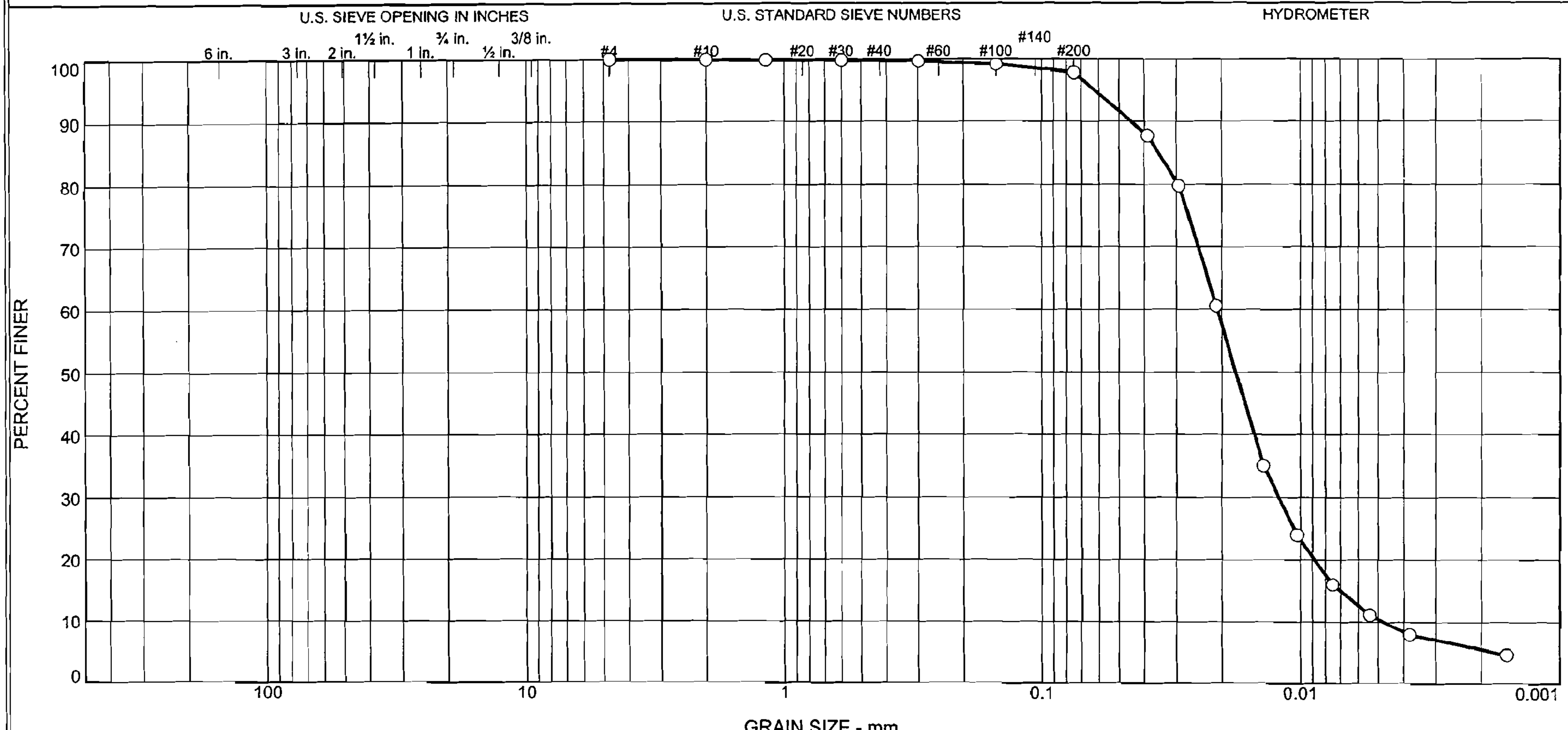
Client American Electric Power

Project Philip Sporn Plant

Project No. 09-387 Figure

Geo/Environmental Associates, Inc.
Knoxville, Tennessee

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.1	0.2	1.9	87.4	10.4

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○		GA-1A ST2	28.5'-31.0'		ML	Fly Ash, gray	53.3	46	np

Client American Electric Power

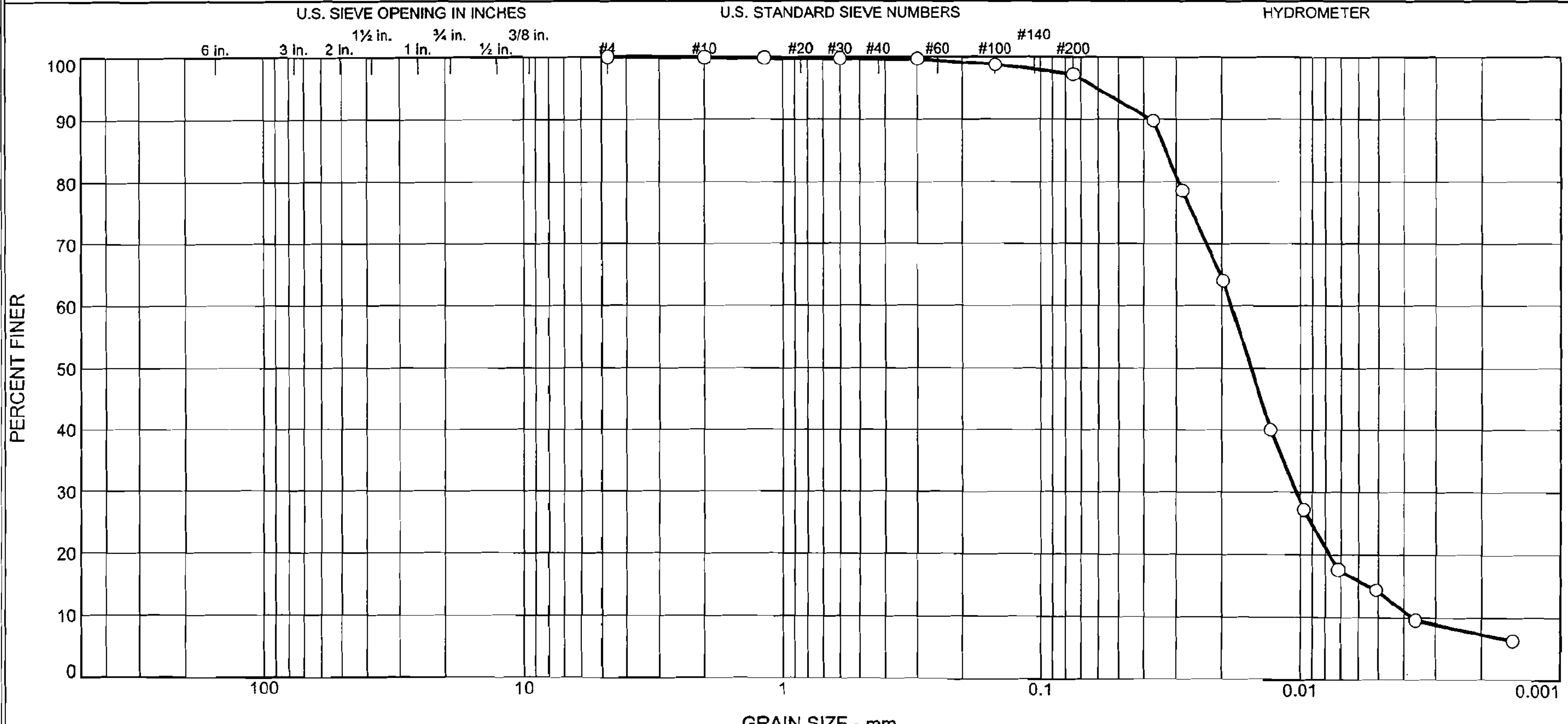
Project Philip Sporn Plant

Project No. 09-387 Figure

Geo/Environmental Associates, Inc.
Knoxville, Tennessee

AEPSPP004196

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.1	0.2	2.6	83.1	14.0

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○		GA-1A ST3	32.5'-35.0'		ML	Fly Ash, dark gray, dark brown	58.5	nv	np

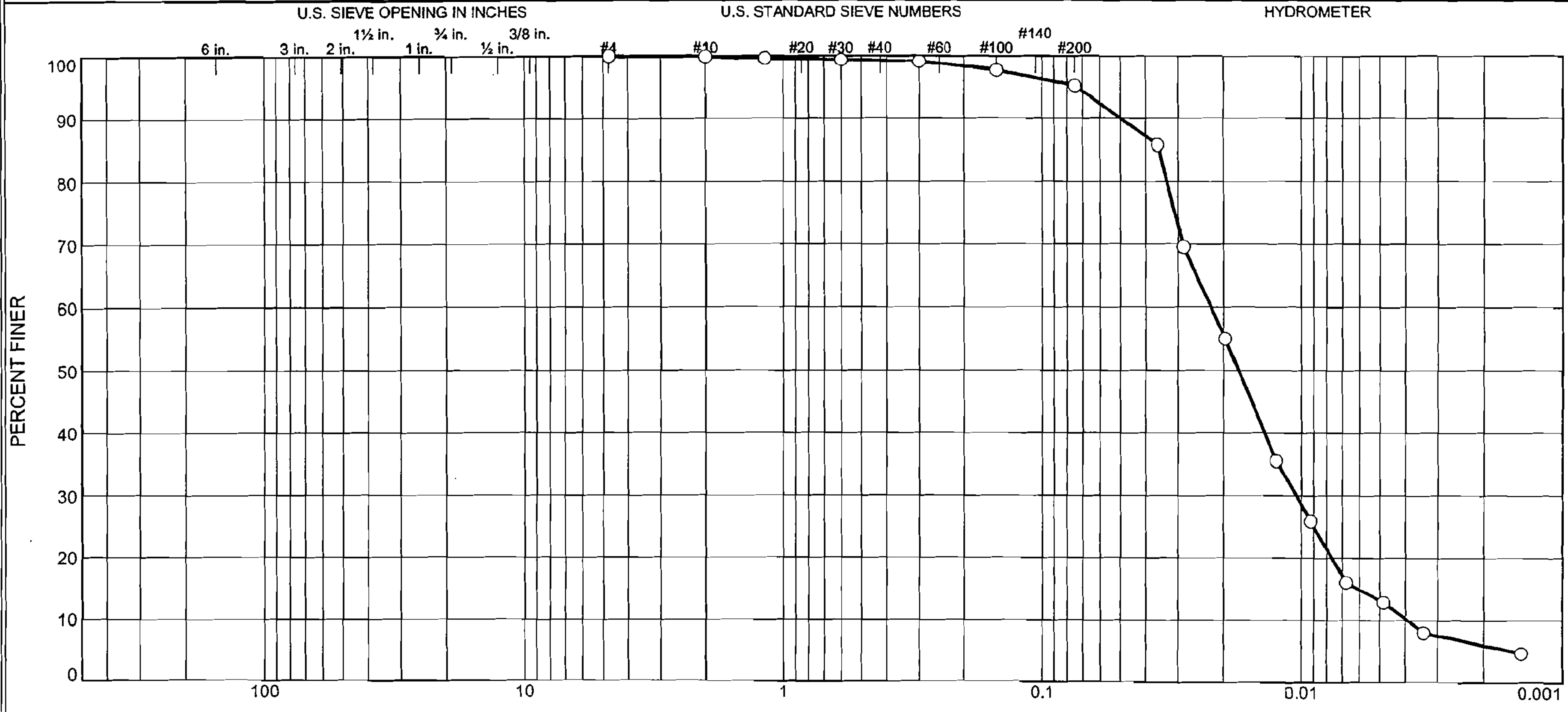
Client American Electric Power

Project Philip Sporn Plant

Project No. 09-387 Figure

**Geo/Environmental Associates, Inc.
Knoxville, Tennessee**

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.1	0.7	4.0	82.0	13.2

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○		GA-1A ST4	36.5'-39.0'		ML	Fly Ash, dark gray	33.0	nv	np

Client American Electric Power

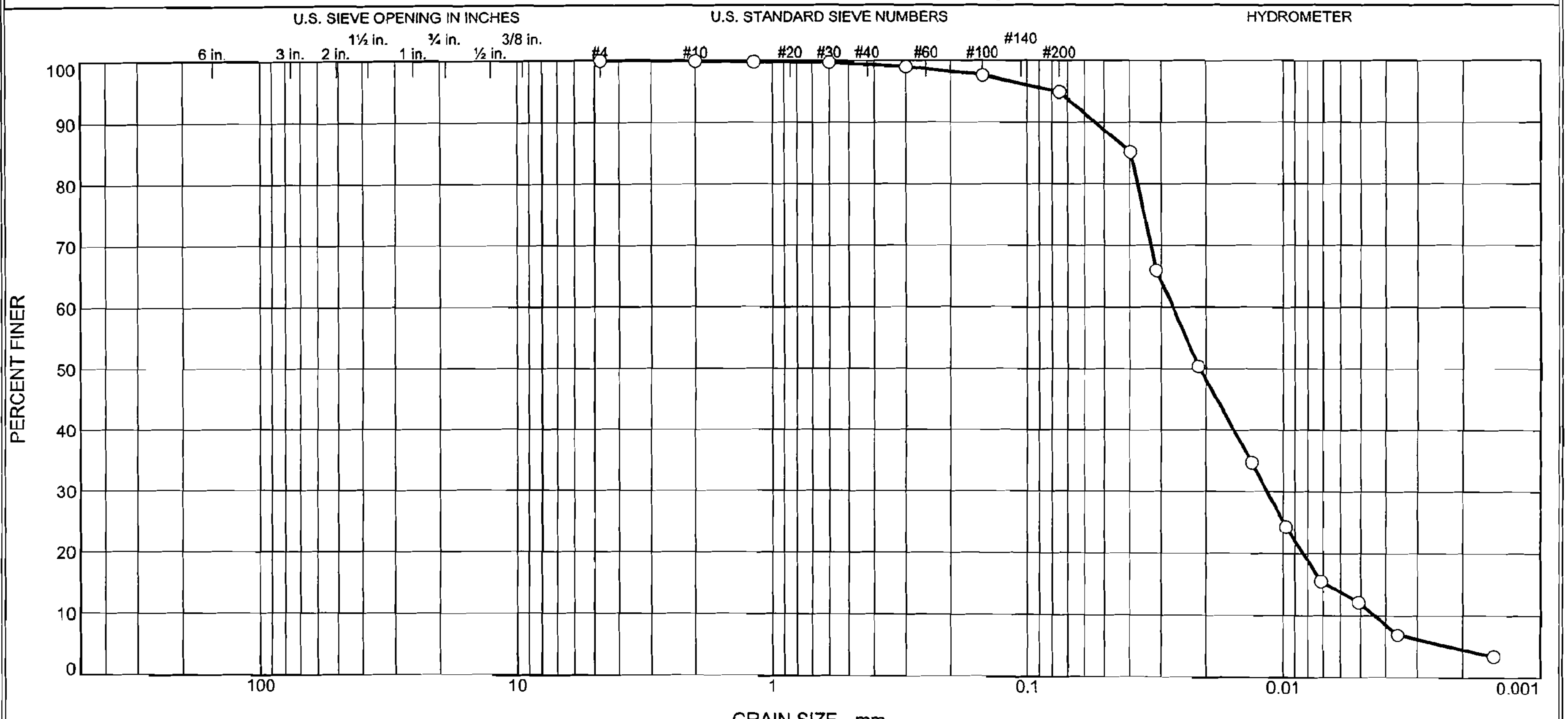
Project Philip Sporn Plant

Project No. 09-387 Figure

Geo/Environmental Associates, Inc. Knoxville, Tennessee

AEPSPP004198

Particle Size Distribution Report



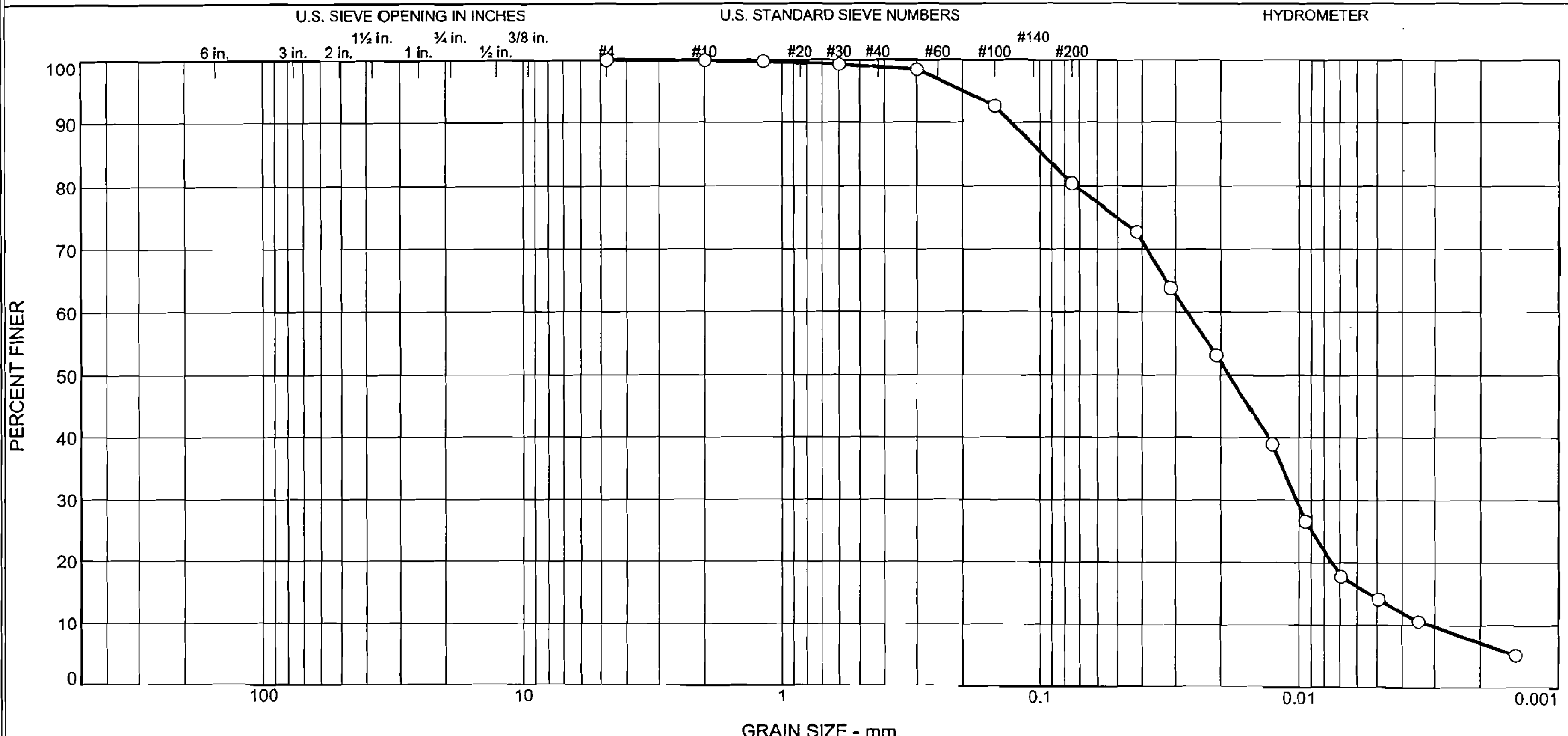
	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.1	0.6	4.5	83.0	11.8

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○		GA-1A ST5	40.5'-43.0'		ML	Fly Ash, dark gray, dark brown	46.6	37	np

Client American Electric Power	**Geo/Environmental Associates, Inc. Knoxville, Tennessee**
Project Philip Sporn Plant	
Project No. 09-387 Figure	

AEPSPP004199

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.1	1.1	18.5	66.1	14.2

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○		GA-1A ST6	44.5'-47.0'	12/18/09	ML	Fly Ash, dark gray	44.6	44	np

Client American Electric Power

Project Philip Sporn Plant

Project No. 09-387 Figure

Geo/Environmental Associates, Inc. Knoxville, Tennessee

CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Philip Sporn Plant **PROJECT NUMBER** : 09-387

CLIENT : AEP **DATE** : December 18, 2009

SAMPLE LOCATION AND CONDITIONS

Sample Id.: GA-1A ST-6 - 20 psi **Depth of Tested Sample** : 44.5' - 47.0'

Remolded: No **Sample Type** : Shelby Tube

Sample Description : Fly Ash, dark gray - 20 psi triaxial specimen

INITIAL SPECIMEN PROPERTIES

Length (in.):	5.55	**Volume (ft^3):**	0.0202	**Wet Density (PCF):**	104.0
Diameter (in.):	2.83	**Weight (lbs):**	2.10	**Dry Density (PCF):**	71.9
Area (ft^2):	0.0437	**Moisture (%):**	44.6		

Chamber Pressure (psi):	10	**Change in Pore Pressure (psi):**	2.0
Influent Pressure (psi):	8	**Change in Chamber Pressure (psi):**	2.0
Back Pressure (psi):	5	**"B" Factor:**	1.0

PERMEABILITY CALCULATIONS

k = Hydraulic Conductivity, (cm/sec)

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2)

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm)

$$k = \frac{QL}{Ath} \text{ cm/sec}$$

$$k = \frac{(600.0)(14.10)}{(40.58)(14{,}506)(211.01)}$$

$$k = \frac{8{,}460.00}{124{,}211{,}770.81}$$

$$k = 6.81 \times 10^{-5} \text{ cm/sec}$$

CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Philip Sporn Plant

PROJECT NUMBER : 09-387

CLIENT : AEP

DATE : December 18, 2009

SAMPLE LOCATION AND CONDITIONS

Sample Id.: GA-1A ST-6 - 40 psi

Depth of Tested Sample : 44.5' - 47.0'

Remolded: No

Sample Type : Shelby Tube

Sample Description : Fly Ash, dark gray - 40 psi triaxial specimen

INITIAL SPECIMEN PROPERTIES

Length (in.): 5.58

Volume (ft^3): 0.0206

Wet Density (PCF): 103.8

Diameter (in.): 2.85

Weight (lbs): 2.14

Dry Density (PCF): 71.5

Area (ft^2): 0.0443

Moisture (%): 45.2

Chamber Pressure (psi): 10

Change in Pore Pressure (psi): 2.0

Influent Pressure (psi): 8

Change in Chamber Pressure (psi): 2.0

Back Pressure (psi): 5

"B" Factor: 1.0

PERMEABILITY CALCULATIONS

k = Hydraulic Conductivity, (cm/sec)

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2)

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm)

$$k = \frac{QL}{Ath} \text{ cm/sec}$$

$$k = \frac{(600.0)(14.17)}{(41.16)(8,599)(211.01)}$$

$$k = \frac{8,502.00}{74,683,790.59}$$

$$k = 1.14 \times 10^{-4} \text{ cm/sec}$$

CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Philip Sporn Plant

PROJECT NUMBER : 09-387

CLIENT : AEP

DATE : December 18, 2009

SAMPLE LOCATION AND CONDITIONS

Sample Id.: GA-1A ST-6 - 60 psi

Depth of Tested Sample : 44.5' - 47.0'

Remolded: No

Sample Type : Shelby Tube

Sample Description : Fly Ash, dark gray - 60 psi triaxial specimen

INITIAL SPECIMEN PROPERTIES

Length (in.):	5.44	**Volume (ft^3):**	0.0202	**Wet Density (PCF):**	104.0
Diameter (in.):	2.86	**Weight (lbs):**	2.10	**Dry Density (PCF):**	73.5
Area (ft^2):	0.0446	**Moisture (%):**	41.6		

Chamber Pressure (psi):	10	**Change in Pore Pressure (psi):**	2.0
Influent Pressure (psi):	8	**Change in Chamber Pressure (psi):**	2.0
Back Pressure (psi):	5	**"B" Factor:**	1.0

PERMEABILITY CALCULATIONS

k = Hydraulic Conductivity, (cm/sec)

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2)

t = Interval of time, over which the flow Q occurs, (sec)

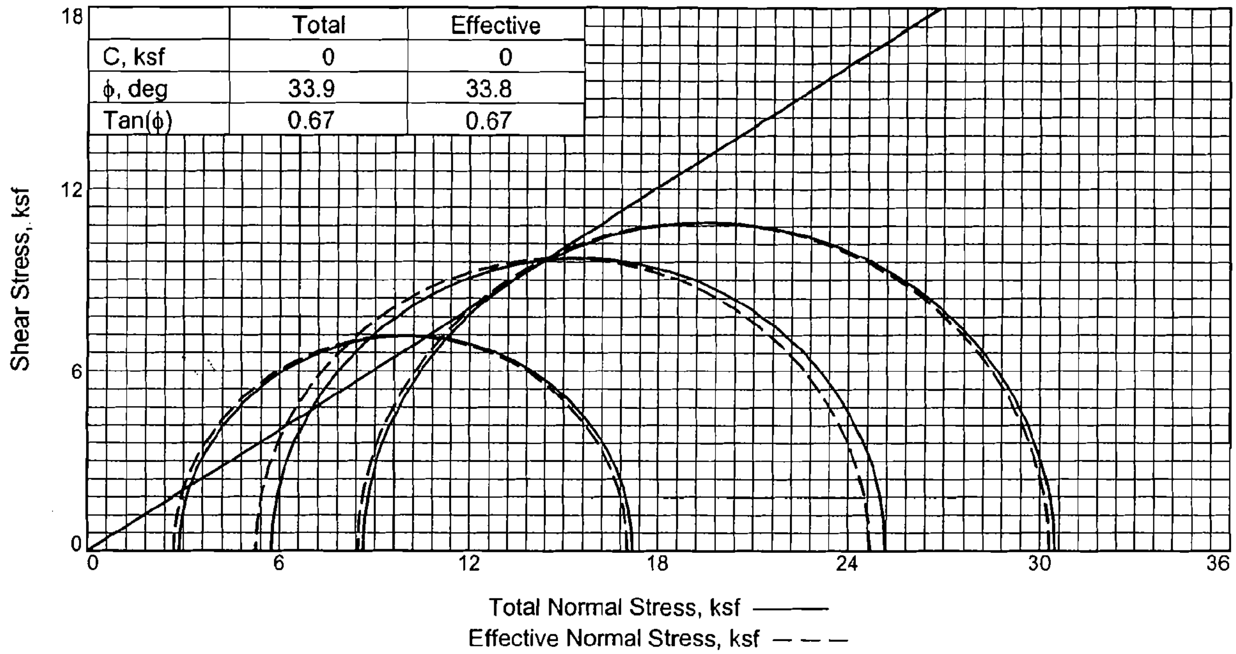
h = Difference in hydraulic head across specimen, (cm)

$$k = \frac{QL}{Ath} \text{ cm/sec}$$

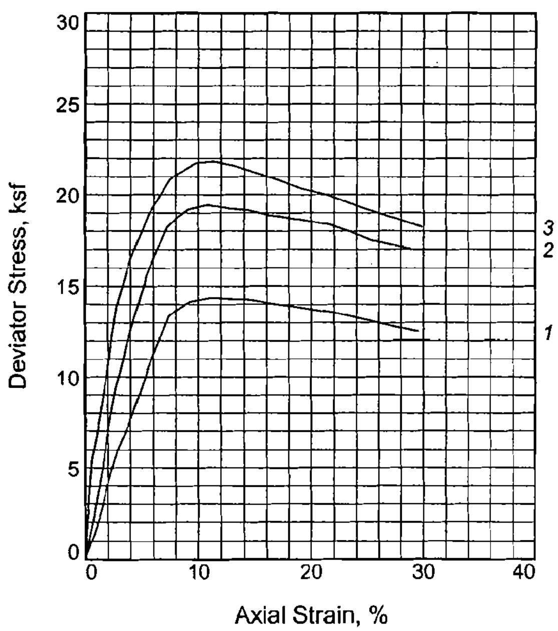
$$k = \frac{(600.0)(13.82)}{(41.45)(9{,}531)(211.01)}$$

$$k = \frac{8{,}292.00}{83{,}361{,}600.05}$$

$$k = 9.95 \times 10^{-5} \text{ cm/sec}$$



	Total	Effective
C, ksf	0	0
ϕ, deg	33.9	33.8
Tan(ϕ)	0.67	0.67



	Sample No.	1	2	3
Initial	Water Content, %	44.6	45.2	41.6
	Dry Density, pcf	71.9	71.5	73.5
	Saturation, %	97.7	98.0	94.8
	Void Ratio	1.1095	1.1210	1.0651
	Diameter, in.	2.83	2.85	2.86
	Height, in.	5.55	5.58	5.44
At Test	Water Content, %	40.1	44.4	40.7
	Dry Density, pcf	76.8	73.0	76.3
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.9746	1.0779	0.9883
	Diameter, in.	2.77	2.83	2.82
	Height, in.	5.43	5.54	5.37
	Strain rate, in./min.	0.00	0.00	0.00
	Back Pressure, psi	30.00	30.00	30.00
	Cell Pressure, psi	50.00	70.00	90.00
	Fail. Stress, ksf	14.3	19.4	21.8
	Total Pore Pr., ksf	4.5	4.8	4.5
	Ult. Stress, ksf			
	Total Pore Pr., ksf			
	$\bar{\sigma}_1$ Failure, ksf	17.0	24.7	30.3
	$\bar{\sigma}_3$ Failure, ksf	2.7	5.3	8.5

Type of Test:
CU with Pore Pressures

Sample Type: Shelby Tube

Description: Fly Ash, dark gray

LL= 44

Specific Gravity= 2.43

Remarks:

Figure 1

Client: American Electric Power

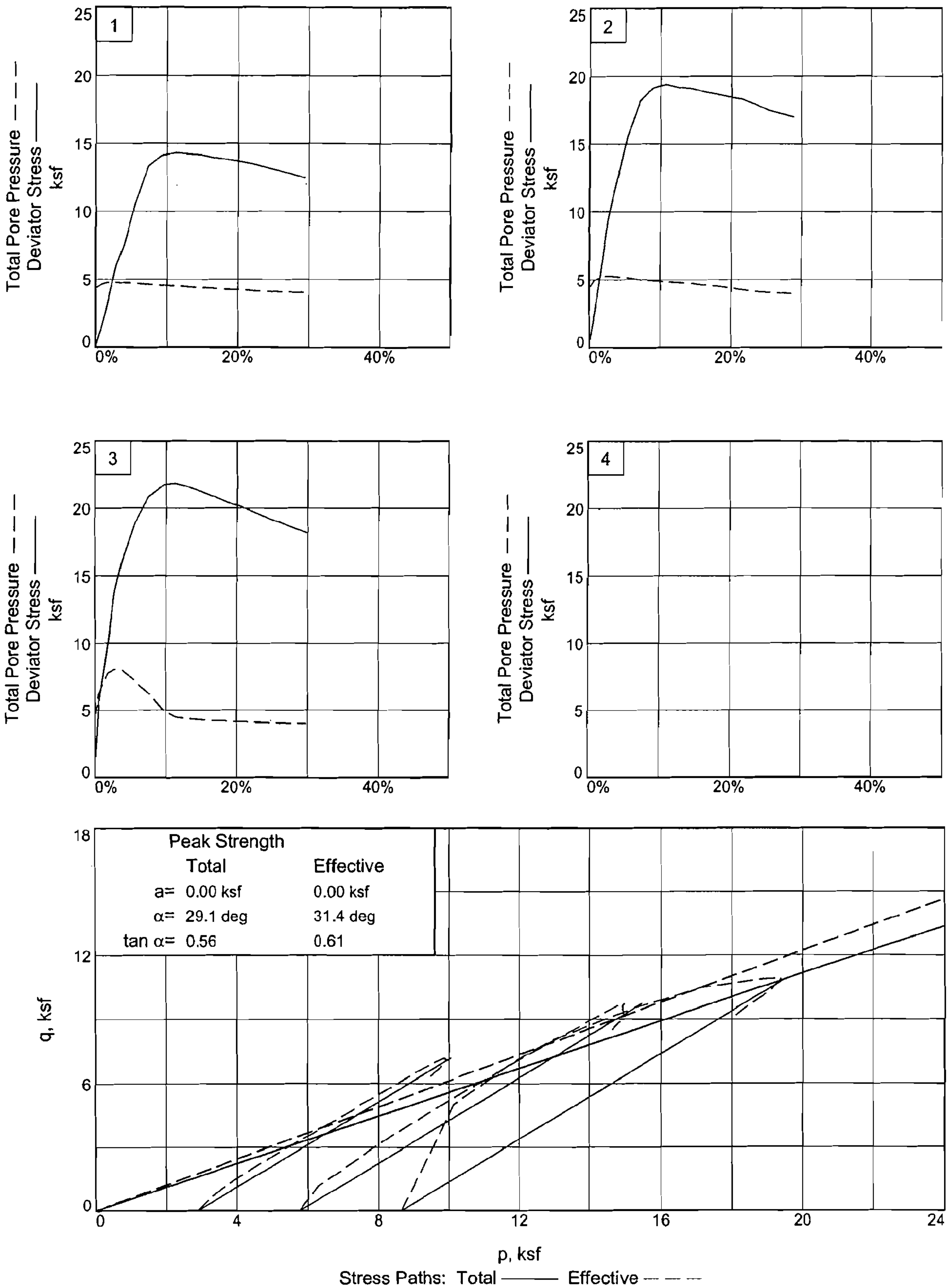
Project: Philip Sporn Plant

Sample Number: GA-1A ST6 **Depth:** 44.5'-47.0'

Proj. No.: 09-387 **Date Sampled:** 12/18/09

TRIAXIAL SHEAR TEST REPORT

Geo/Environmental Associates, Inc.



Client: American Electric Power

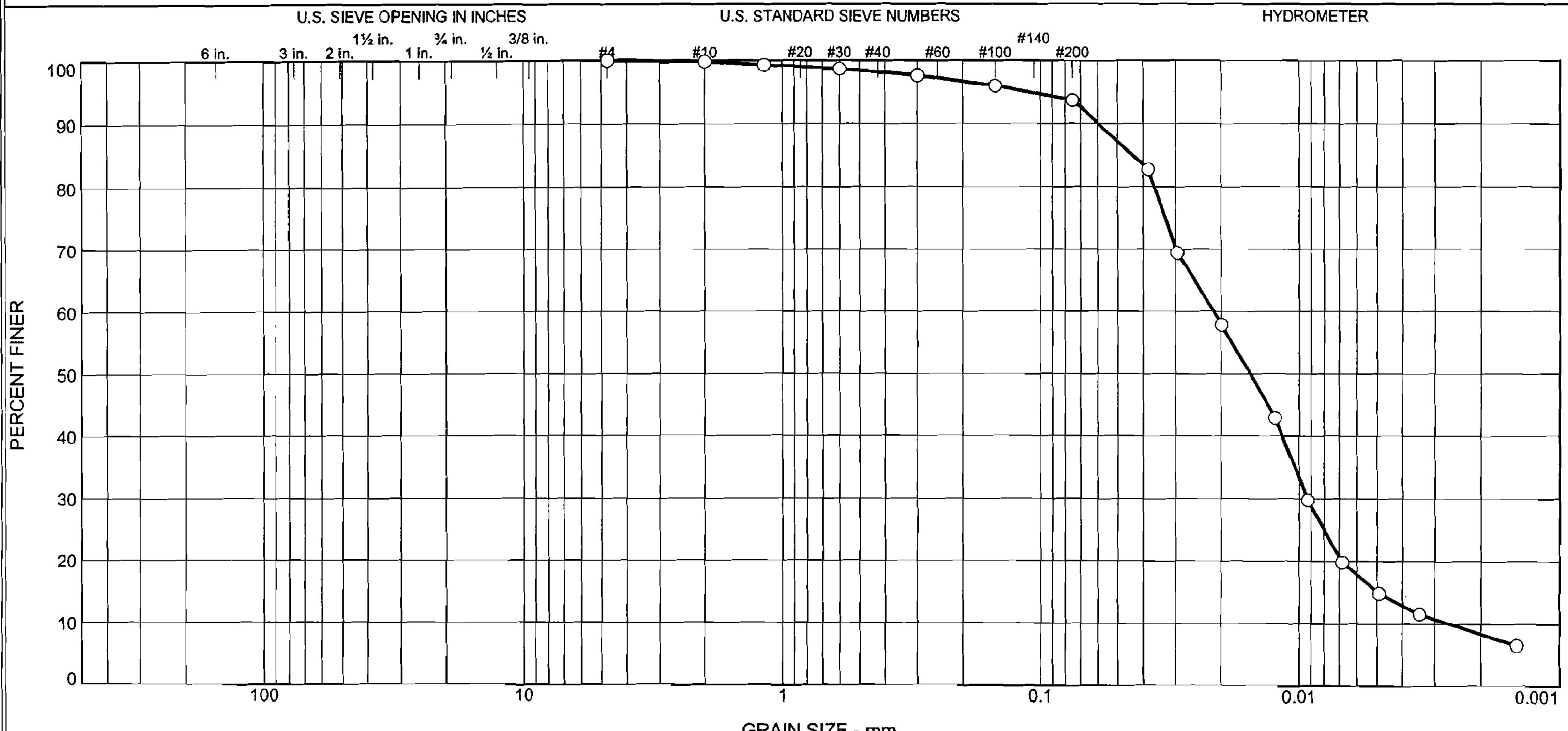
Project: Philip Sporn Plant

Depth: 44.5'-47.0' **Sample Number:** GA-1A ST6

Project No.: 09-387 **Figure** 2

Geo/Environmental Associates, Inc.

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.2	1.7	4.4	78.6	15.1

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○		GA-1A ST7	48.5'-51.0'		ML	Fly Ash, dark gray	37.2	nv	np

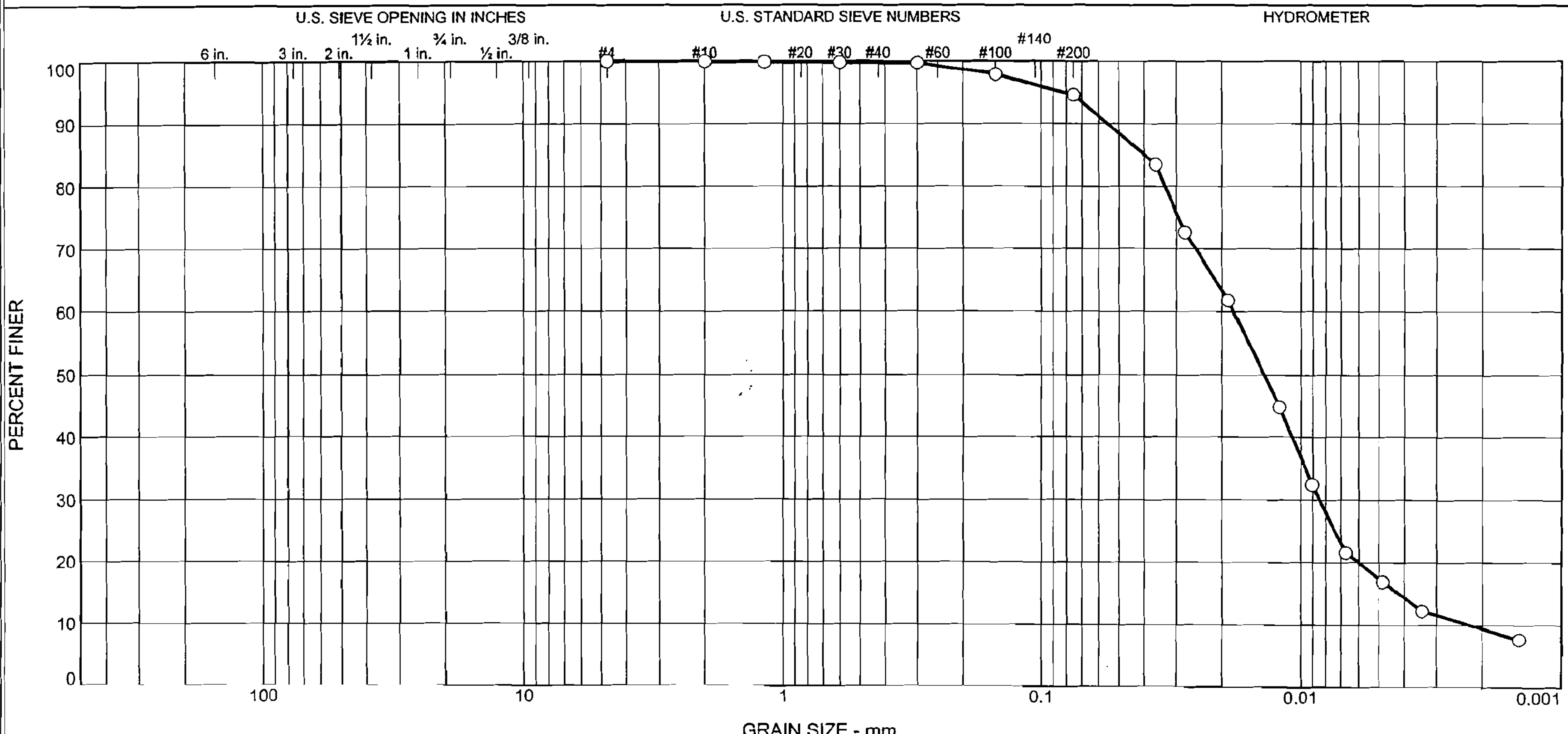
Client American Electric Power

Project Philip Sporn Plant

Project No. 09-387 Figure

Geo/Environmental Associates, Inc. Knoxville, Tennessee

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.0	0.3	5.2	77.1	17.4

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○		GA-1A ST8	52.5'-55.0'		ML	Fly Ash, gray	53.3	44	np

Client American Electric Power

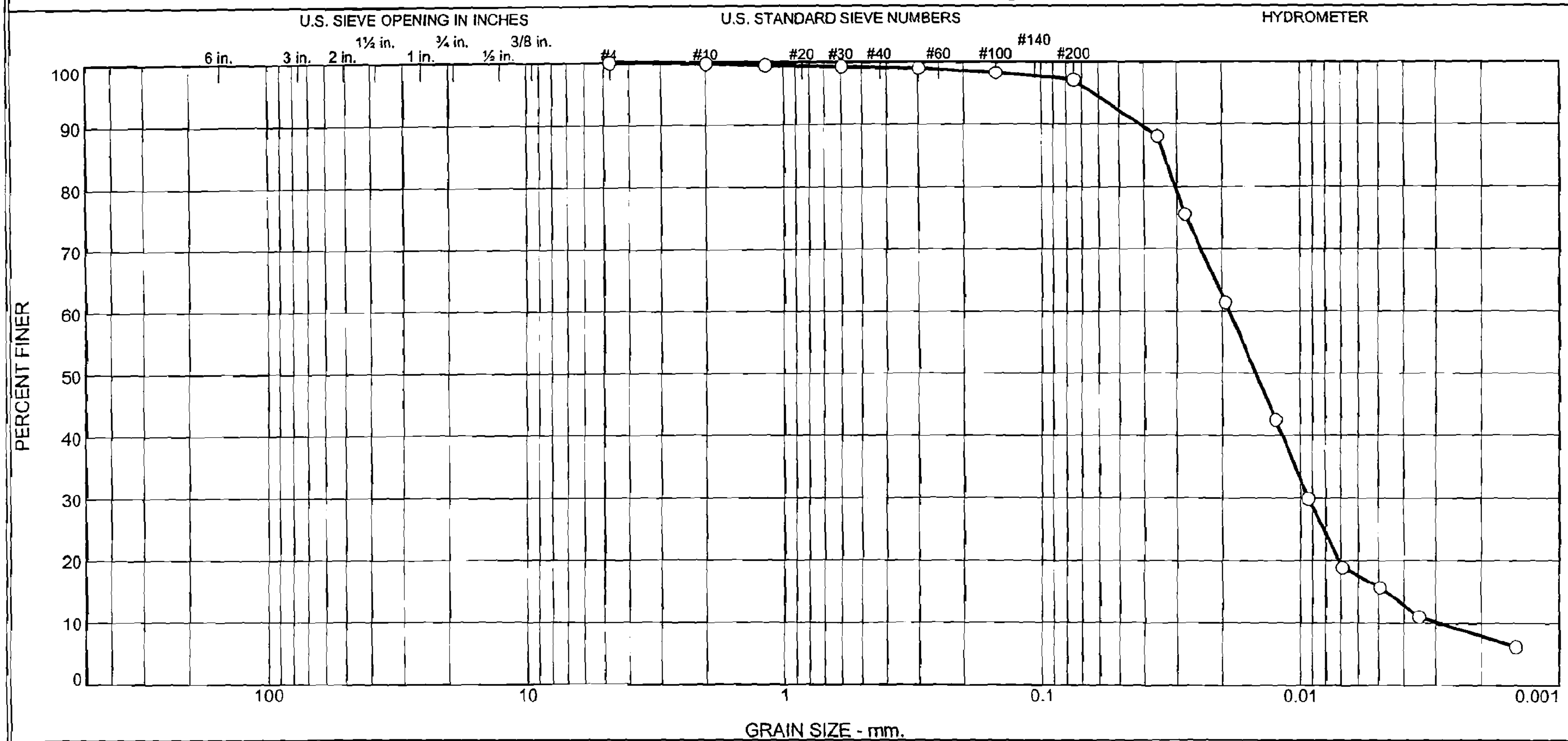
Project Philip Sporn Plant

Project No. 09-387

Figure

Geo/Environmental Associates, Inc.
Knoxville, Tennessee

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.2	0.6	2.1	81.3	15.8

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○		GA-1A ST9	56.5'-59.0'		ML	Fly Ash, dark gray	51.5	45	np

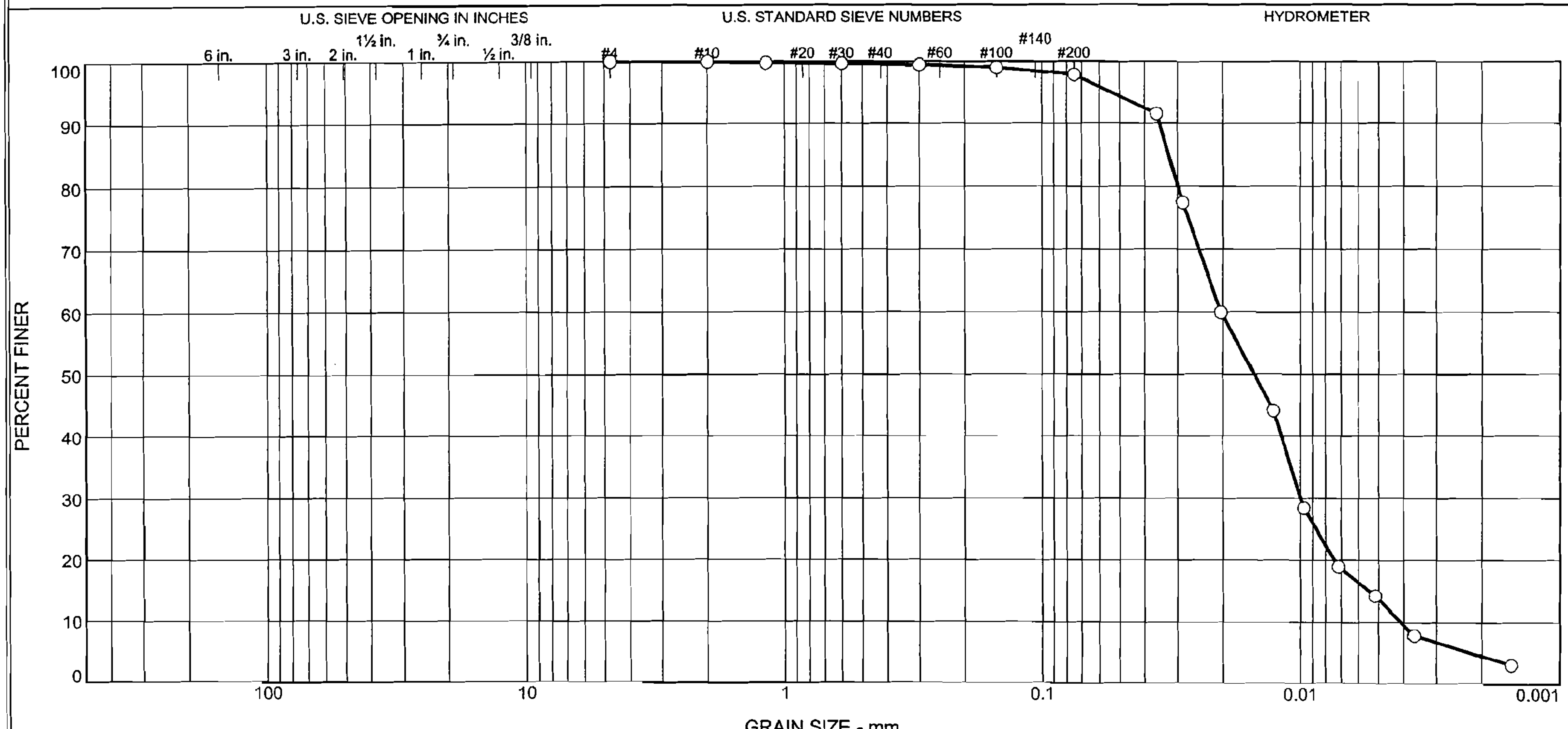
Client American Electric Power

Project Philip Sporn Plant

Project No. 09-387 Figure

Geo/Environmental Associates, Inc. Knoxville, Tennessee

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.1	0.4	1.7	84.2	13.6

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○		GA1A ST10	60.5'-63.0'		ML	Fly Ash, dark gray, dark brown	53.7	44	np

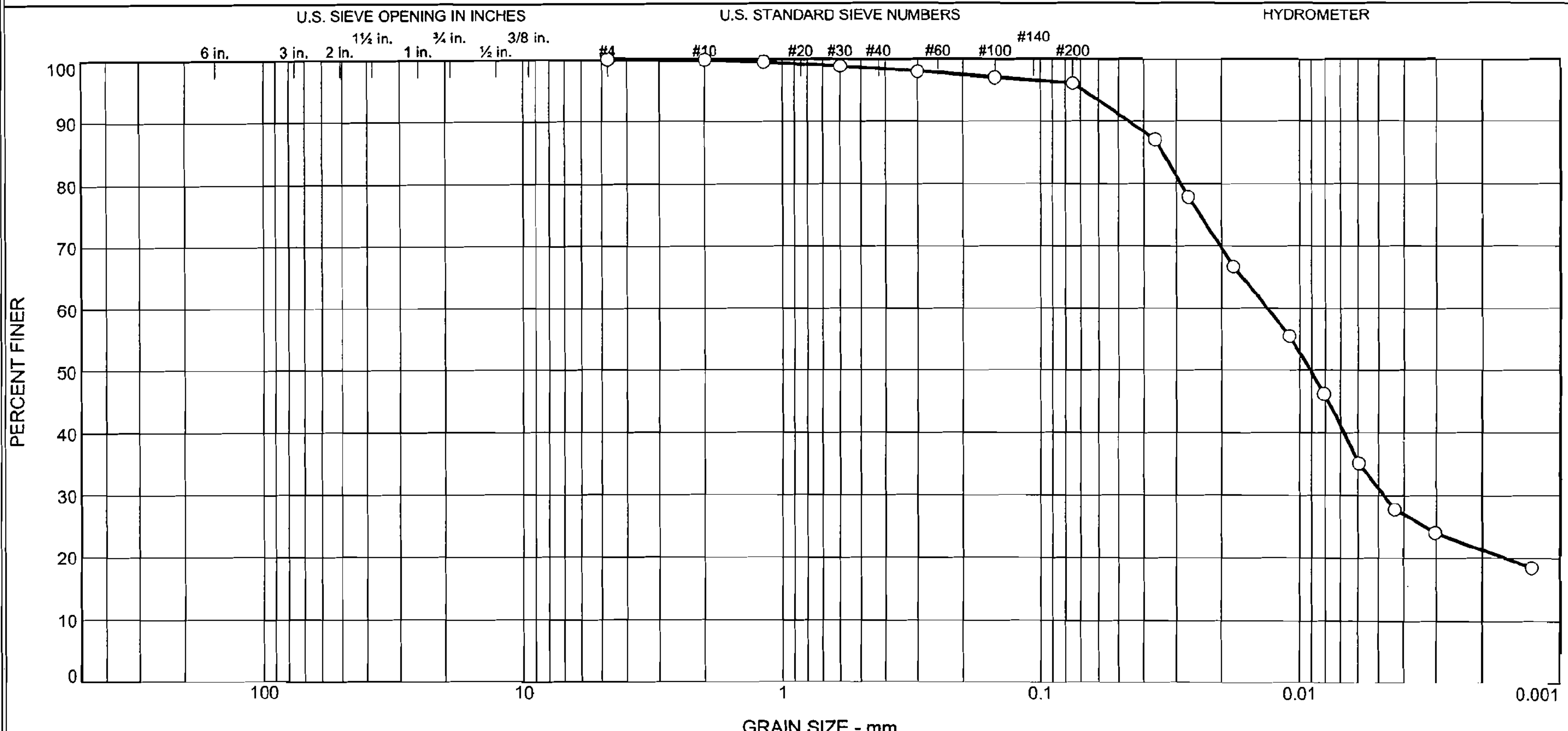
Client American Electric Power

Project Philip Sporn Plant

Project No. 09-387 Figure

Geo/Environmental Associates, Inc. Knoxville, Tennessee

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.1	1.5	2.3	65.0	31.1

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○		GA-1C ST2	69.0'-71.5'		CL	Clay, silty, brown	27.2	35	19

Client American Electric Power

Project Philip Sporn Plant

Project No. 09-387 Figure

Geo/Environmental Associates, Inc.
Knoxville, Tennessee

AEPSPP004210

Particle Size Distribution Report

	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	11.3	0.4	1.1	11.5	58.9	16.8

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○		GA-2 ST2	59.0'-61.5'		CL-ML	Clay, silty, brown	20.3	20	16

Client American Electric Power
Project Philip Sporn Plant

Project No. 09-387 Figure

Geo/Environmental Associates, Inc.
Knoxville, Tennessee

CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Philip Sporn Plant **PROJECT NUMBER** : 09-387

CLIENT : AEP **DATE** : December 29, 2009

SAMPLE LOCATION AND CONDITIONS

Sample Id.: GA-1C ST-2 - 20 psi **Depth of Tested Sample** : 69.0' - 71.5'

Remolded: No **Sample Type** : Shelby Tube

Sample Description : Clay, silty brown - 20 psi triaxial specimen

INITIAL SPECIMEN PROPERTIES

Length (in.):	5.15	**Volume (ft^3):**	0.0190	**Wet Density (PCF):**	122.7
Diameter (in.):	2.85	**Weight (lbs):**	2.33	**Dry Density (PCF):**	96.3
Area (ft^2):	0.0443	**Moisture (%):**	27.4		

Chamber Pressure (psi):	10	**Change in Pore Pressure (psi):**	2.0
Influent Pressure (psi):	8	**Change in Chamber Pressure (psi):**	2.0
Back Pressure (psi):	5	**"B" Factor:**	1.0

PERMEABILITY CALCULATIONS

k = Hydraulic Conductivity, (cm/sec)

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2)

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm)

$$k = \frac{QL}{Ath} \text{ cm/sec}$$

$$k = \frac{(16.8)(13.08)}{(41.16)(63{,}300)(211.01)}$$

$$k = \frac{219.74}{549{,}771{,}362.28}$$

$$k = 4.00 \times 10^{-7} \text{ cm/sec}$$

CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Philip Sporn Plant | **PROJECT NUMBER** : 09-387

CLIENT : AEP | **DATE** : December 29, 2009

SAMPLE LOCATION AND CONDITIONS

Sample Id.: GA-1C ST-2 - 40 psi | **Depth of Tested Sample** : 69.0' - 71.5'

Remolded: No | **Sample Type** : Shelby Tube

Sample Description : Clay, silty brown - 40 psi triaxial specimen

INITIAL SPECIMEN PROPERTIES

Length (in.):	5.97	**Volume (ft^3):**	0.0224	**Wet Density (PCF):**	121.7
Diameter (in.):	2.87	**Weight (lbs):**	2.72	**Dry Density (PCF):**	94.9
Area (ft^2):	0.0449	**Moisture (%):**	28.2		

Chamber Pressure (psi):	10	**Change in Pore Pressure (psi):**	2.0
Influent Pressure (psi):	8	**Change in Chamber Pressure (psi):**	2.0
Back Pressure (psi):	5	**"B" Factor:**	1.0

PERMEABILITY CALCULATIONS

k = Hydraulic Conductivity, (cm/sec)

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2)

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm)

$$k = \frac{QL}{Ath} \text{ cm/sec}$$

$$k = \frac{(16.8)(15.16)}{(41.74)(63{,}300)(211.01)}$$

$$k = \frac{254.69}{557{,}518{,}383.42}$$

$$k = 4.57 \times 10^{-7} \text{ cm/sec}$$

CONSTANT HEAD PERMEABILITY TESTING
ASTM D5084-90/EPA 9100 Method 2.8

PROJECT NAME : Philip Sporn Plant

PROJECT NUMBER : 09-387

CLIENT : AEP

DATE : December 29, 2009

SAMPLE LOCATION AND CONDITIONS

Sample Id.: GA-1C ST-2 - 60 psi

Depth of Tested Sample : 69.0' - 71.5'

Remolded: No

Sample Type : Shelby Tube

Sample Description : Clay, silty brown - 60 psi triaxial specimen

INITIAL SPECIMEN PROPERTIES

Length (in.):	5.88	**Volume (ft^3):**	0.0220	**Wet Density (PCF):**	121.9
Diameter (in.):	2.87	**Weight (lbs):**	2.68	**Dry Density (PCF):**	95.1
Area (ft^2):	0.0449	**Moisture (%):**	28.2		

Chamber Pressure (psi):	10	**Change in Pore Pressure (psi):**	2.0
Influent Pressure (psi):	8	**Change in Chamber Pressure (psi):**	2.0
Back Pressure (psi):	5	**"B" Factor:**	1.0

PERMEABILITY CALCULATIONS

k = Hydraulic Conductivity, (cm/sec)

L = Length of Sample, along path of flow, (cm)

Q = Quantity of flow, taken as the average of inflow and outflow, (cm^3)

A = Cross-sectional area of specimen, (cm^2)

t = Interval of time, over which the flow Q occurs, (sec)

h = Difference in hydraulic head across specimen, (cm)

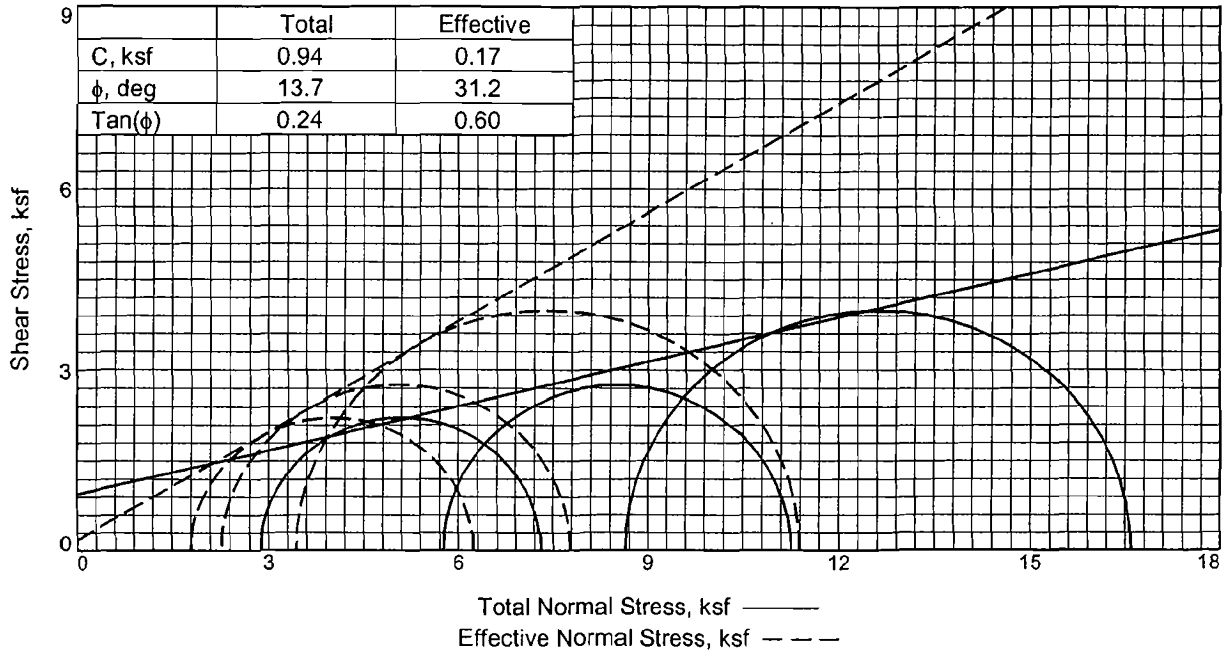
$$k = \frac{QL}{Ath} \text{ cm/sec}$$

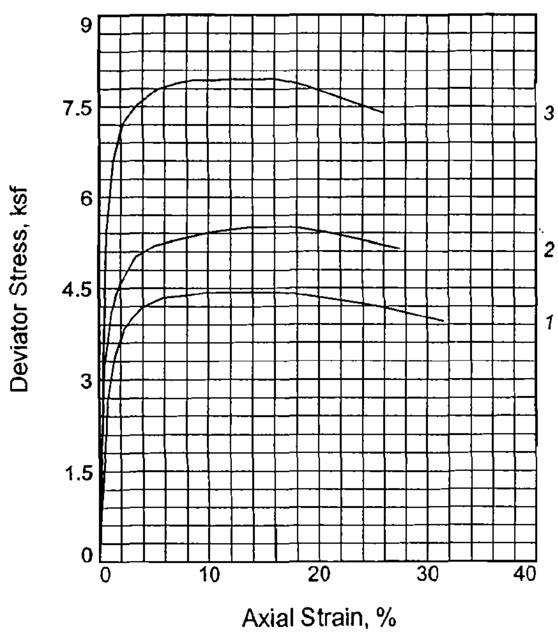
$$k = \frac{(23.0)(14.94)}{(41.74)(69{,}600)(211.01)}$$

$$k = \frac{343.62}{613{,}005{,}995.04}$$

$$k = 5.61 \times 10^{-7} \text{ cm/sec}$$

	Total	Effective
C, ksf	0.94	0.17
ϕ, deg	13.7	31.2
Tan(ϕ)	0.24	0.60





Sample No.		1	2	3
Initial	Water Content, %	27.4	28.2	28.2
	Dry Density, pcf	96.3	94.9	95.1
	Saturation, %	98.1	97.8	98.1
	Void Ratio	0.7572	0.7825	0.7782
	Diameter, in.	2.85	2.87	2.87
	Height, in.	5.15	5.97	5.88
At Test	Water Content, %	25.1	24.1	25.2
	Dry Density, pcf	100.6	102.3	100.6
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.6812	0.6539	0.6823
	Diameter, in.	2.81	2.80	2.82
	Height, in.	5.08	5.82	5.77
Strain rate, in./min.		0.00	0.00	0.00
Back Pressure, psi		30.00	30.00	30.00
Cell Pressure, psi		50.00	70.00	90.00
Fail. Stress, ksf		4.4	5.5	8.0
Total Pore Pr., ksf		5.4	7.8	9.5
Ult. Stress, ksf				
Total Pore Pr., ksf				
$\bar{\sigma}_1$ Failure, ksf		6.2	7.8	11.4
$\bar{\sigma}_3$ Failure, ksf		1.8	2.3	3.4

Type of Test:
CU with Pore Pressures

Sample Type: Shelby Tube

Description: Clay, silty, brown

LL= 35 **PL=** 19 **PI=** 16

Specific Gravity= 2.71

Remarks:

Client: American Electric Power

Project: Philip Sporn Plant

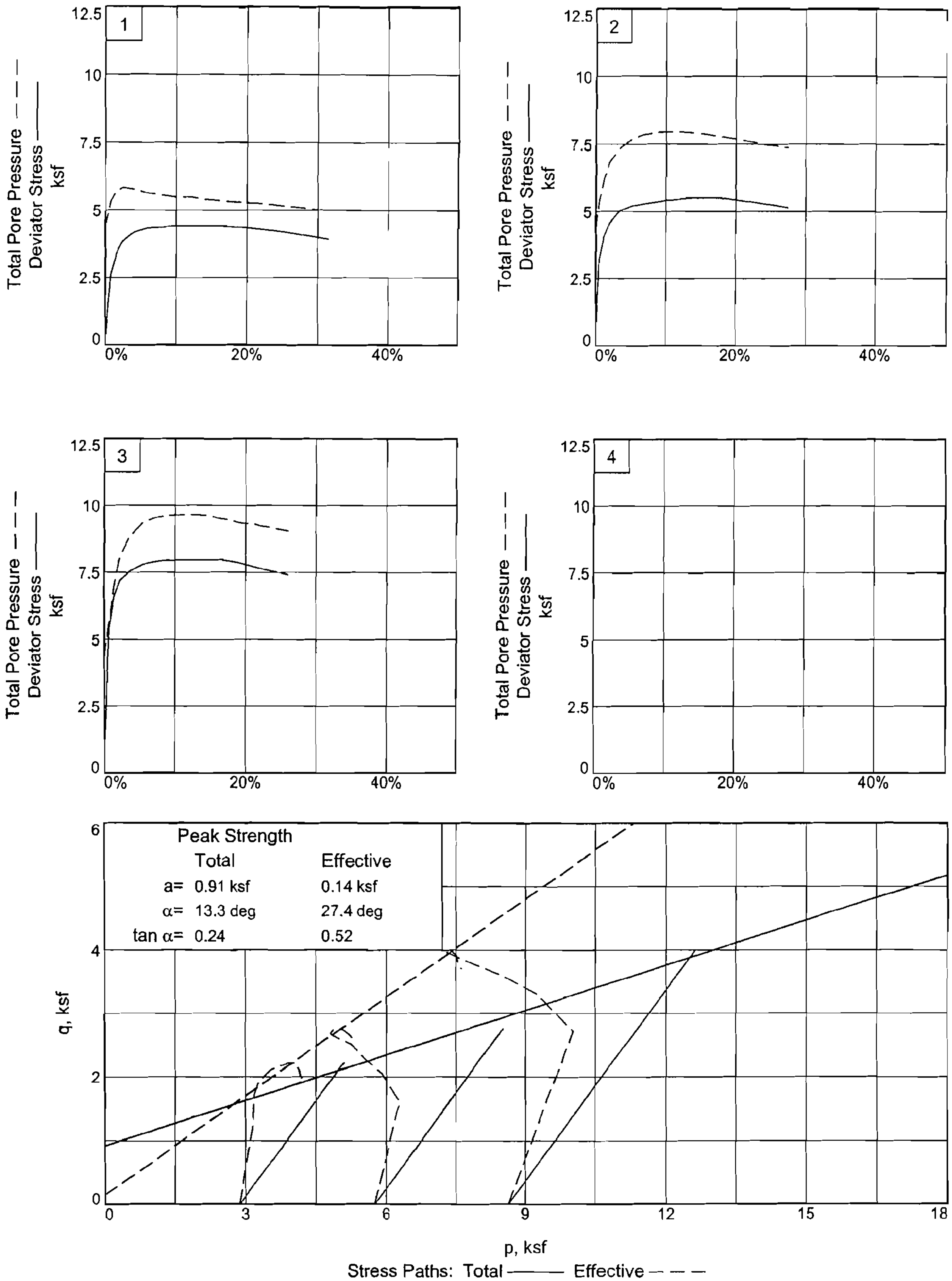
Sample Number: GA-1C ST2 **Depth:** 69.0'-71.5'

Proj. No.: 09-387 **Date Sampled:**

TRIAXIAL SHEAR TEST REPORT

Geo/Environmental Associates, Inc.

Figure 1



Client: American Electric Power

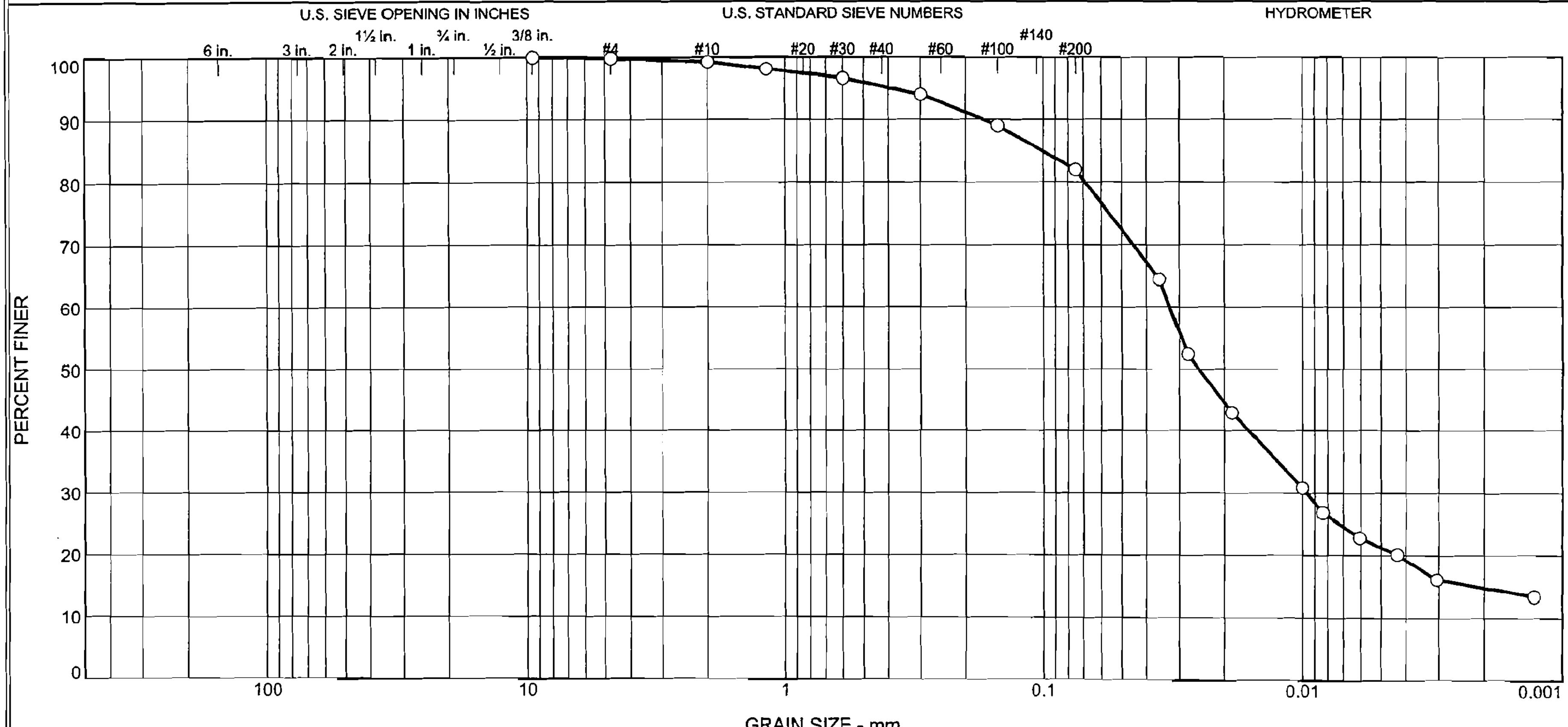
Project: Philip Sporn Plant

Depth: 69.0'-71.5' **Sample Number:** GA-1C ST2

Project No.: 09-387 **Figure** 2

Geo/Environmental Associates, Inc.

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.2	0.6	3.9	13.3	60.7	21.3

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○		GA-2 ST3	69.0'-71.5'		CL-ML	Clay, silty, light brown	20.8	23	17

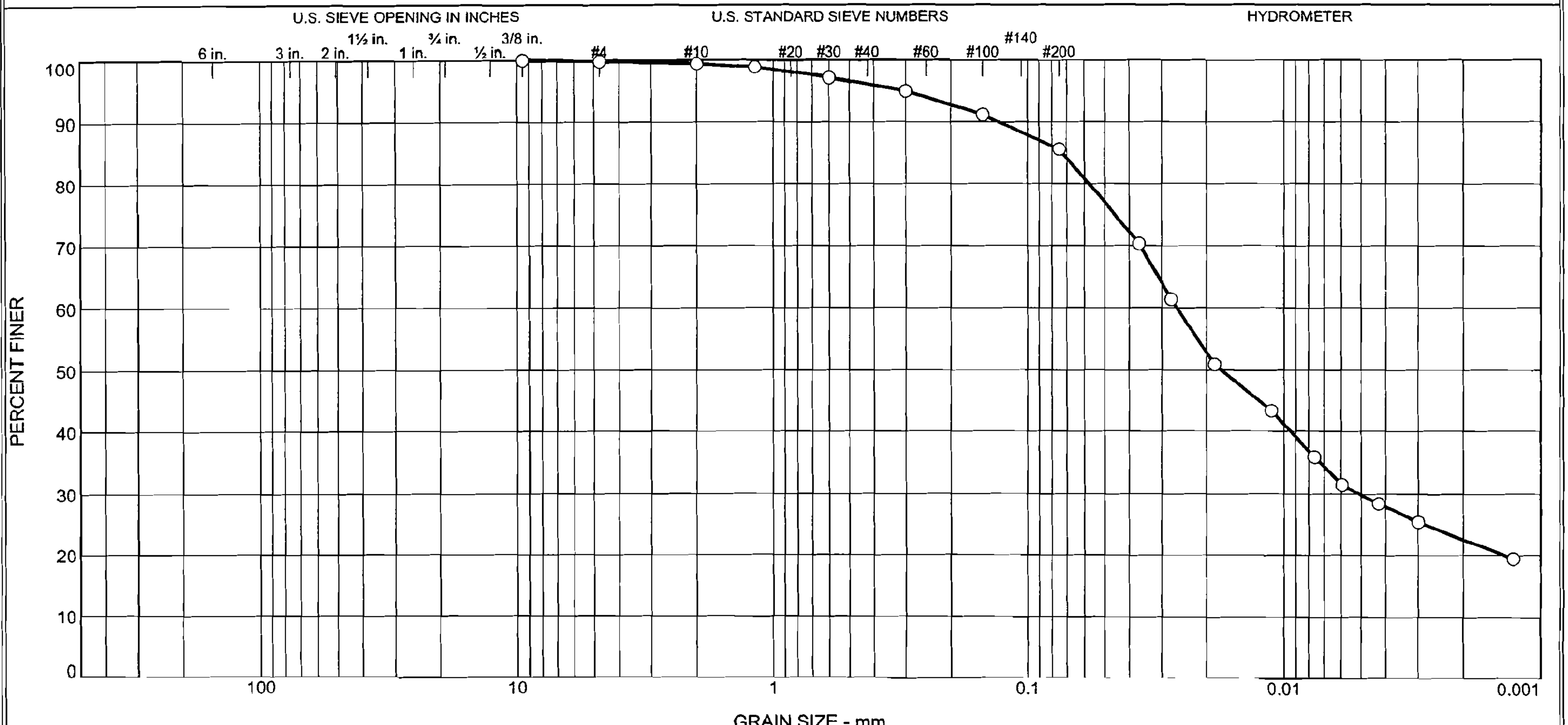
Client American Electric Power

Project Philip Sporn Plant

Project No. 09-387 | Figure

Geo/Environmental Associates, Inc. Knoxville, Tennessee

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.2	0.4	3.4	10.5	55.7	29.8

	Source	Sample #	Depth/Elev.	Date Sampled	USCS	Material Description	NM %	LL	PL
○		GA-3 ST3	79.0'-81.5'		CL	Clay, silty, light brown	24.4	32	20

Client American Electric Power

Project Philip Sporn Plant

Project No. 09-387 Figure

Geo/Environmental Associates, Inc. Knoxville, Tennessee

AEPSPP004218

GA

Geo/Environmental Associates, Inc.

Job Name: AEP Philip Sporn
Job Number: 09-387
Title: G_{max} Calcs for Section K-K
Computed By: SWF Checked by:
Date: 6/8/10 Sheet: 1 Of: 2

Small Strain Shear Modulus $[G_{max} (lbs/ft^2)] = \frac{\gamma \cdot V_v^2}{g}$

where: γ = unit weight (lbs/ft^3)
V_v = shear wave velocity (ft/s)
g = gravitational acceleration ($32.2\ ft/s^2$)

Silty Clay (1) $\frac{125(978.7)^2}{32.2}$ = 3718376 lbs/ft^2

Gravelly Silty Sand (2) $\frac{108(978.7)^2}{32.2}$ = 3212677 lbs/ft^2

Sand and Gravel (3) $\frac{114(978.7)^2}{32.2}$ = 3391159 lbs/ft^2

Bottom Ash (4) $\frac{100(978.7)^2}{32.2}$ = 2974701 lbs/ft^2

Gravelly Silty Sand (5) $\frac{110(978.7)^2}{32.2}$ = 3272171 lbs/ft^2

Silty Clay (6) $\frac{128(694)^2}{32.2}$ = 1914578 lbs/ft^2

Bottom Ash 65 (7) $\frac{90(694)^2}{32.2}$ = 1346188 lbs/ft^2

Fly Ash (8) $\frac{98(476.25)^2}{32.2}$ = 690304 lbs/ft^2

Geo/Environmental Associates, Inc.

Job Name: AEP Philip Sporn
Job Number: 09-387
Title: G_{max} Calcs for Section K-K
Computed By: SWF Checked by:
Date: 6/8/10 Sheet: 2 Of: 2

Sandy Silt	(9)	$\frac{100(978.7)^2}{32.2}$ =	2974701 lbs/ft²
Clay Foundation	(10)	$\frac{125(694)^2}{32.2}$ =	1869705 lbs/ft²
Clay Foundation	(11)	$\frac{130(694)^2}{32.2}$ =	1944493 lbs/ft²
Silty Clay Foundation	(12)	$\frac{125(694)^2}{32.2}$ =	1869705 lbs/ft²
Original Dike	(13)	$\frac{130(978.7)^2}{32.2}$ =	3867111 lbs/ft²
Foundation Soil	(14)	$\frac{130(694)^2}{32.2}$ =	1944493 lbs/ft²

Geo/Environmental Associates, Inc.

Job Name: AEP Philip Sporn
Job Number: 09-387
Title: Gmax Calcs for Section L-L
Computed By: SWF   Checked by:
Date: 6/15/10   Sheet: 1   Of: 2

Small Strain Shear Modulus $\left[G_{max}\,(lbs/ft^2)\right] = \frac{\gamma \cdot V_s^2}{g}$

where: γ = unit weight (lbs/ft^3)
V_s = shear wave velocity (ft/s)
g = gravitational acceleration ($32.2\ ft/s^2$)

Sandy Silty Clay (1) $\frac{130(978.7)^2}{32.2} = 3867112\ lbs/ft^2$

Road Fill (2) $\frac{110(978.7)^2}{32.2} = 3272171\ lbs/ft^2$

Gravelly Silty Sand (3) $\frac{110(978.7)^2}{32.2} = 3272171\ lbs/ft^2$

Gravelly Silty Sand (4) $\frac{100(978.7)^2}{32.2} = 2974701\ lbs/ft^2$

Bottom Ash (5) $\frac{65(978.7)^2}{32.2} = 1933556\ lbs/ft^2$

Silty Sand and Gravel (6) $\frac{115(978.7)^2}{32.2} = 3420906\ lbs/ft^2$

Silty Sandy Clay (7) $\frac{130(978.7)^2}{32.2} = 3867112\ lbs/ft^2$

Silty Clay (8) $\frac{130(978.7)^2}{32.2} = 3867112\ lbs/ft^2$

Geo/Environmental
Associates, Inc.

Job Name: AEP Philip Sporn
Job Number: 09 - 387
Title: Gmax Calcs for Section L-L
Computed By: SWF Checked by:
Date: 6/15/10 Sheet: 2 Of: 2

Fly Ash (9) $\frac{110(476.25)^2}{32.2}$ 774831 lbs/ft²

Clay Foundation (10) $\frac{125(694)^2}{32.2}$ = 1869705 lbs/ft²

Clay Foundation (11) $\frac{125(694)^2}{32.2}$ = 1869705 lbs/ft²

Silty Clay Foundation (12) $\frac{130(694)^2}{32.2}$ = 1944493 lbs/ft²

Geo/Environmental Associates, Inc.

Job Name: AEP Philip Sporn
Job Number: 09-387
Title: Gmax Calcs for Section M-M
Computed By: SWF Checked by:
Date: 6/17/10 Sheet: 1 Of: 2

Small Strain Shear Modulus $\left[G_{max}\left(lbs/ft^2\right)\right] = \frac{\gamma \cdot V_v^2}{g}$

where: γ = unit weight (lbs/ft^3)
V_v = Shear wave velocity (ft/s)
g = gravitational acceleration ($32.2\ ft/s^2$)

Sandy Silty Clay (1) $\frac{125(978.7)^2}{32.2} = 3718376\ lbs/ft^2$

Gravelly Silty Sand (2) $\frac{125(978.7)^2}{32.2} = 3718376\ lbs/ft^2$

Bottom Ash (3) $\frac{65(978.7)^2}{32.2} = 1933556\ lbs/ft^2$

Silty Sand and Gravel (4) $\frac{115(978.7)^2}{32.2} = 3420906\ lbs/ft^2$

Sandy Silt (5) $\frac{130(978.7)^2}{32.2} = 3867112\ lbs/ft^2$

Silty Clay (6) $\frac{130(978.7)^2}{32.2} = 3867112\ lbs/ft^2$

Fly Ash (7) $\frac{110(476.25)^2}{32.2} = 774831\ lbs/ft^2$

Brown Clay (8) $\frac{125(694)^2}{32.2} = 1869705\ lbs/ft^2$

GA

Geo/Environmental Associates, Inc.

Job Name: AEP Philip Sporn
Job Number: 09-387
Title: Gmax Calcs for Section M-M
Computed By: SWF   Checked by:
Date: 6/17/10   Sheet: 2   Of: 2

Silty Clay (9) $\frac{126(694)^2}{32.2} = 1884663$ lbs/ft²

Bottom Ash 2 (11) $\frac{90(978.7)^2}{32.2} = 2677231$ lbs/ft²

MISCELLANEOUS REFERENCES

DAMPING RATIO OF DIFFERENT TYPES OF SOILS (KOKUSHO)
SEED-IDRISS DAMPING VALUES FROM SHAKE91

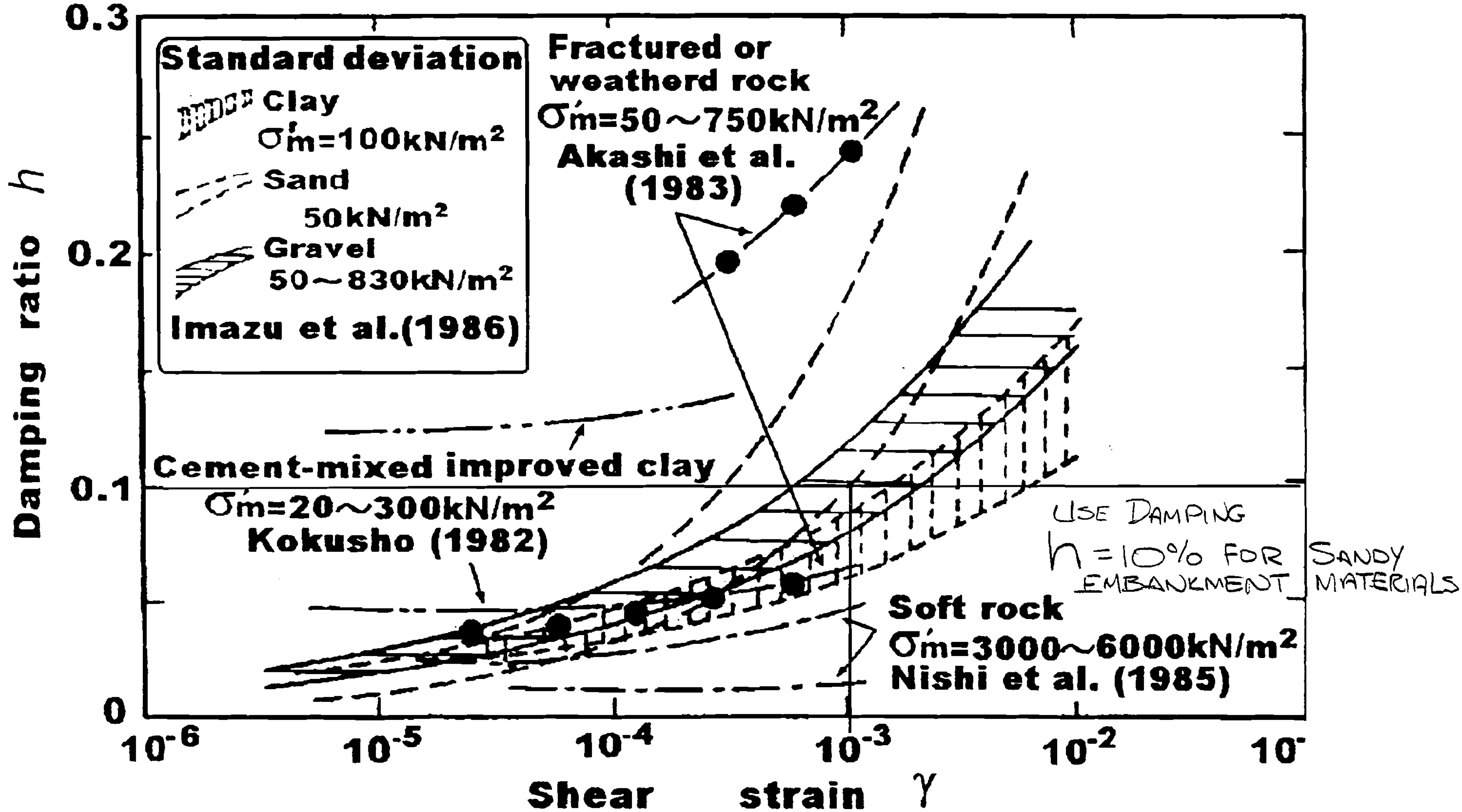


Fig. 10.20 Damping ratio of different types of soils (Kokusho, 1987)

FROM GEOTECHNICAL EARTHQUAKE ENGINEERING BY IKUO TOWHATA 2008

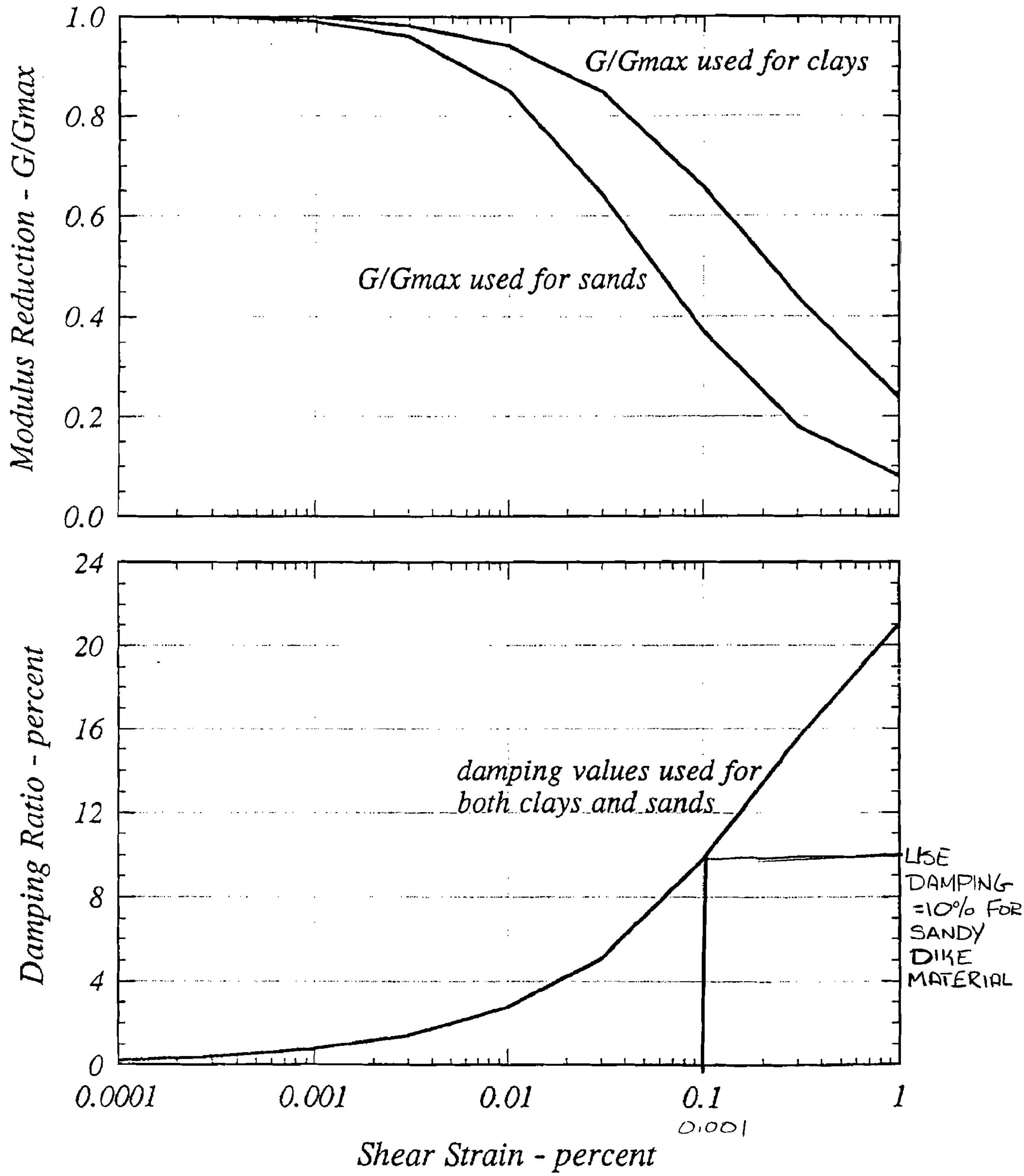


Fig. B-2 Modulus Reduction and Damping Values Used for Sample Problem

FROM SHAKE91 USERS MANUAL (SEED IDRISS)

LABORATORY DATA FROM:

EVALUATION OF LIQUEFACTION POTENTIAL OF IMPOUNDED FLY ASH*: *PHILIP SPORN POWER PLANT

PREPARED/COMPILED BY:
THE OHIO STATE UNIVERSITY

Evaluation of Liquefaction Potential of Impounded Fly Ash:

Philip Sporn Power Plant

Final Report

The Ohio State University Research Project # 60024835

December 2009 – April 2010

Submitted to: American Electric Power

Department of Civil and Environmental Engineering and Geodetic Science

The Ohio State University

470 Hitchcock Hall, 2070 Neil Avenue

Columbus, Ohio 43210

July 30, 2010

APPENDIX III

SEEPAGE ANALYSES

SEEPAGE ANALYSIS SUMMARY
EASTERN DIKE LIQUEFACTION ASSESSMENT
FLY ASH DISPOSAL FACILITY
PHILIP SPORN PLANT
NEW HAVEN, MASON COUNTY, WEST VIRGINIA
GA FILE NO. 09-387

GENERAL

Geo/Environmental Associates, Inc. (GA) has prepared steady-state seepage analyses to develop initial embankment pore pressure conditions to use in the *QUAKE/W* finite element stress analyses of the Fly Ash Disposal Facility – Eastern Dike. Specifically, GA evaluated three critical sections (i.e., Section K-K, Section L-L, and Section M-M) through the Eastern Dike using the finite element analysis computer program, *SEEP/W*. *SEEP/W* is developed by GEO-SLOPE International, Ltd. of Calgary, Alberta, Canada.

Given material permeability values and embankment geometry and using a value of total head at an inlet condition (i.e., the normal operating pool level of 605 feet) and review nodes on the downstream face (i.e., boundary conditions), the *SEEP/W* program adjusts the total head and the amount of flow at each of the nodal points within the finite element mesh until equilibrium is achieved. Equilibrium conditions are then shown as a final zero-pressure (phreatic) surface. The approximated steady-state phreatic surface for each critical section is displayed on the *SEEP/W* graphical outputs provided in this appendix.

ASSUMPTIONS AND MATERIAL PARAMETERS

Material parameters used in the seepage models were based on: (1) field testing, laboratory testing, and analysis data included in the *Philip Sporn Electric Generating Plant Unit 5 Ash Facility – Engineering Report*, prepared/compiled by the Geotechnical Engineering Section of American Electric Power Service Corporation, dated July 1998; (2) field testing, laboratory testing, and analysis data included in the *Philip Sporn Power Plant – Stability Analysis*, prepared/compiled by the Geotechnical Engineering Section of American Electric Power Service Corporation, dated March 2009; and (3) geotechnical subsurface exploration and laboratory testing conducted by GA in December 2009. For the analyses, we have conservatively assumed a horizontal permeability to vertical permeability (k_h:k_v) ratio of 9 for the dike and foundation materials and a k_h:k_v ratio of 10 for the hydraulically placed fly ash material. A summary of the material permeability parameters used for each of the critical sections is provided in Tables III-1, III-2, and III-3, respectively.

TABLE III-1 SUMMARY OF PERMEABILITY PARAMETERS FOR SECTION K-K SEEPAGE ANALYSES					
Soil Layer Number	**Material Type**	**Location**	**Horizontal Permeability k_h (ft/sec)**	**Vertical Permeability k_v (ft/sec)**	**Material Parameter Source**
1	Silty Clay	1972 Embankment Extension	4.4×10^{-7}	4.92×10^{-8}	From AEP Seepage Analysis for K-K in July 1998 Report
2	Gravelly Silty Sand	1972 Embankment Extension	1.6×10^{-4}	1.77×10^{-5}	From AEP Seepage Analysis for K-K in July 1998 Report
3	Sand & Gravel	1972 Embankment Extension	1.4×10^{-3}	1.6×10^{-4}	Using Hazen Formula on GSC for B-107 (11.6')
4	Bottom Ash (68)	1968 Embankment Extension	5.7×10^{-5}	9.5×10^{-6}	Using Hazen Formula on GSC for PZ-0901 (3.5')
5	Gravelly Silty Sand	1968 Embankment Extension	1.6×10^{-4}	1.77×10^{-5}	From AEP Seepage Analysis for K-K in July 1998 Report
6	Silty Clay	1965 Embankment Extension	1.1×10^{-7}	1.2×10^{-8}	From AEP Permeability Test on PZ-0902 (26.0')
7	Bottom Ash (65)	1965 Embankment Extension	8.6×10^{-5}	9.5×10^{-6}	Using Hazen Formula on GSC for PZ-0901 (3.5')
8	Fly Ash	Fly Ash Pond	2.2×10^{-5}	2.2×10^{-6}	From GA Permeability Test on GA-1A ST-4
9	Sandy Silt	1972 Embankment Extension	1.2×10^{-5}	1.3×10^{-6}	From AEP Seepage Analysis for K-K in July 1998 Report
10	Clay Foundation	Upper Foundation Soil	3.2×10^{-8}	3.6×10^{-9}	From AEP Permeability Test on PZ-0903 (46.0')
11	Clay Foundation	Upper Foundation Soil	1.4×10^{-7}	1.6×10^{-8}	From GA Permeability Test on GA-1C ST-2
12	Silty Clay Foundation	Mid-Level Foundation Soil	3.2×10^{-8}	3.6×10^{-9}	From AEP Permeability Test on PZ-0903 (46.0')
13	Silty Clay	Original Dike	1.1×10^{-7}	1.2×10^{-8}	From AEP Permeability Test on PZ-0902 (26.0')
14	Foundation Soil	Lower Foundation Soil	3.2×10^{-8}	3.6×10^{-9}	From AEP Permeability Test on PZ-0903 (46.0')

TABLE III-2
SUMMARY OF PERMEABILITY PARAMETERS FOR SECTION L-L SEEPAGE ANALYSES

Soil Layer Number	Material Type	Location	Horizontal Permeability k_h (ft/sec)	Vertical Permeability k_v (ft/sec)	Material Parameter Source
1	Sandy Silty Clay	1972 Embankment Extension	$1.8x10^{-6}$	$2.0x10^{-7}$	From AEP Seepage Analysis for L-L in July 1998 Report
2	Road Fill	1972 Embankment Extension	$1.9x10^{-3}$	$2.1x10^{-4}$	Using Hazen Formula on GSC for B-109 (8.5')
3	Gravelly Silty Sand	1972 Embankment Extension	$1.9x10^{-3}$	$2.1x10^{-4}$	Using Hazen Formula on GSC for B-109 (8.5')
4	Gravelly Silty Sand	1972 Embankment Extension	$1.9x10^{-3}$	$2.1x10^{-4}$	Using Hazen Formula on GSC for B-109 (8.5')
5	Bottom Ash	1968 Embankment Extension	$8.6x10^{-5}$	$9.5x10^{-6}$	Using Hazen Formula on GSC for PZ-0901 (3.5')
6	Silty Sand & Gravel	1968 Embankment Extension	$5.9x10^{-4}$	$6.6x10^{-5}$	Using Hazen Formula on GSC for PZ-0902 (8.5')
7	Silty Sandy Clay	1965 Embankment Extension	$1.1x10^{-7}$	$1.2x10^{-8}$	From AEP Permeability Test on PZ-0902 (26.0')
8	Silty Clay	1965 Embankment Extension	$1.1x10^{-7}$	$1.2x10^{-8}$	From AEP Permeability Test on PZ-0902 (26.0')
9	Fly Ash	Fly Ash Pond	$2.2x10^{-5}$	$2.2x10^{-6}$	From GA Permeability Test on GA-1A ST-4
10	Clay Foundation	Upper Foundation Soil	$1.4x10^{-7}$	$1.6x10^{-8}$	From GA Permeability Test on GA-1C ST-2
11	Clay Foundation	Upper Foundation Soil	$3.2x10^{-8}$	$3.6x10^{-9}$	From AEP Permeability Test on PZ-0903 (46.0')
12	Silty Clay Foundation	Lower Foundation Soil	$3.2x10^{-8}$	$3.6x10^{-9}$	From AEP Permeability Test on PZ-0903 (46.0')

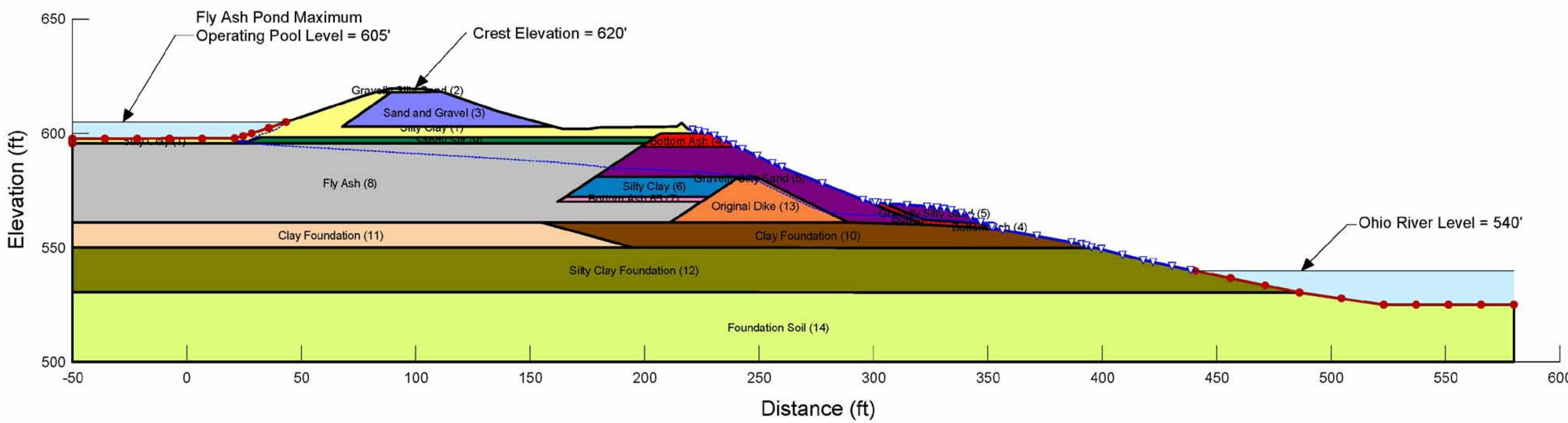
TABLE III-3 SUMMARY OF PERMEABILITY PARAMETERS FOR SECTION M-M SEEPAGE ANALYSES					
Soil Layer Number	**Material Type**	**Location**	**Horizontal Permeability k_h (ft/sec)**	**Vertical Permeability k_v (ft/sec)**	**Material Parameter Source**
1	Sandy Silty Clay	1972 Embankment Extension	$1.8x10^{-6}$	$2.0x10^{-7}$	From AEP Seepage Analysis for L-L in July 1998 Report
2	Gravelly Silty Sand	1972 Embankment Extension	$1.9x10^{-3}$	$2.1x10^{-4}$	Using Hazen Formula on GSC for B-109 (8.5')
3	Bottom Ash	1995 Embankment Modifications	$8.6x10^{-5}$	$9.5x10^{-6}$	Using Hazen Formula on GSC for PZ-0901 (3.5')
4	Silty Sand w/ Gravel	1968 Embankment Extension	$5.9x10^{-4}$	$6.6x10^{-5}$	Using Hazen Formula on GSC for PZ-0902 (8.5')
5	Sandy Silt	1965 Embankment Extension	$1.2x10^{-5}$	$1.3 x10^{-6}$	From AEP Seepage Analysis for K-K in July 1998 Report
6	Silty Clay	Original Soil Dike	$1.1x10^{-7}$	$1.2x10^{-8}$	From AEP Permeability Test on PZ-0902 (26.0')
7	Fly Ash (1)	Fly Ash Pond	$2.2x10^{-5}$	$2.2x10^{-6}$	From GA Permeability Test on GA-1A ST-4
8	Brown Clay	Upper Foundation Soil	$1.4x10^{-7}$	$1.6x10^{-8}$	From GA Permeability Test on GA-1C ST-2
9	Silty Clay	Lower Foundation Soil	$1.1x10^{-7}$	$1.2x10^{-8}$	From AEP Permeability Test on PZ-0902 (26.0')
10	Sandstone	Foundation			
11	Bottom Ash 2	1972 Embankment Extension	$8.6x10^{-5}$	$9.5x10^{-6}$	Using Hazen Formula on GSC for PZ-0901 (3.5')

SEEPAGE ANALYSIS RESULTS

Results of the *SEEP/W* finite element analyses are provided in this appendix. The approximated zero-pressure (phreatic) line is shown on the graphical output files for Sections K-K, L-L, and M-M. After compilation, the *SEEP/W* data provided herein is incorporated into *QUAKE/W* finite element stress analyses for each of the critical sections. Specifically, the pore pressure conditions are used in the initial *QUAKE/W* static analysis to determine the initial stress conditions within the embankment.

SECTION K-K

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section K-K Finite Element Seepage Analysis
File Name: FAP_K-K_Seepage.gsz
Date: 7/23/2010



AEPSPP004236

Steady-State Seepage

File Information

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section K-K Finite Element Seepage Analysis
Revision Number: 132
Last Edited By: Seth Frank
Date: 7/23/2010
Time: 10:31:02 AM
File Name: FAP_K-K_Seepage.gsz
Directory: P:\Frank\Philip Sporn\SEISMIC REPORT\Updated Analysis Files\Seepage\
Last Solved Date: 7/23/2010
Last Solved Time: 10:31:54 AM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Mass(M) Units: lbs
Mass Flux Units: lbs/sec
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Steady-State Seepage

Description: Sporn Fly Ash Pond Section K-K Seepage Analysis
Kind: SEEP/W
Method: Steady-State
Settings
- Include Air Flow: No

Control
- Apply Runoff: Yes

Convergence
- Convergence Type: Gauss Point K
- Convergence Settings
  - Maximum Number of Iterations: 500
  - Tolerance: 0.01
  - Maximum Change in K: 0.1
  - Rate of Change in K: 1.02

Minimum Change in K: 0.0001
Equation Solver: Parallel Direct
Potential Seepage Max # of Reviews: 10
Time
Starting Time: 0 sec
Duration: 0 sec
Ending Time: 0 sec

Materials

Silty Clay (1)

Model: Saturated / Unsaturated
Hydraulic
K-Function: Sandy Silty Clay
K-Ratio: 9
K-Direction: 90 °

Gravelly Silty Sand (2)

Model: Saturated / Unsaturated
Hydraulic
K-Function: Gravelly Silty Sand
K-Ratio: 9
K-Direction: 90 °

Sand and Gravel (3)

Model: Saturated / Unsaturated
Hydraulic
K-Function: Sand and Gravel
K-Ratio: 9
K-Direction: 90 °

Bottom Ash (4)

Model: Saturated / Unsaturated
Hydraulic
K-Function: Bottom Ash
K-Ratio: 9
K-Direction: 90 °

Gravelly Silty Sand (5)

Model: Saturated / Unsaturated
Hydraulic
K-Function: Gravelly Silty Sand
K-Ratio: 9
K-Direction: 90 °

Silty Clay (6)

Model: Saturated / Unsaturated
Hydraulic
K-Function: Brown Silty Clay
K-Ratio: 9
K-Direction: 90 °

Bottom Ash 65 (7)

Model: Saturated / Unsaturated
Hydraulic
K-Function: Bottom Ash
K-Ratio: 9
K-Direction: 90 °

Fly Ash (8)

Model: Saturated Only
Hydraulic
K-Sat: 2.2e-006 ft/sec
Volumetric Water Content: 0 ft^3/ft^3
Mv: 0 /psf
K-Ratio: 10
K-Direction: 90 °

Sandy Silt (9)

Model: Saturated / Unsaturated
Hydraulic
K-Function: Sandy Silt
K-Ratio: 9
K-Direction: 90 °

Clay Foundation (10)

Model: Saturated / Unsaturated
Hydraulic
K-Function: Gray Foundation Clay
K-Ratio: 9
K-Direction: 90 °

Clay Foundation (11)

Model: Saturated / Unsaturated
Hydraulic
K-Function: Brown Foundation Clay
K-Ratio: 9
K-Direction: 90 °

Silty Clay Foundation (12)

Model: Saturated / Unsaturated
Hydraulic

K-Function: Gray Foundation Clay
K-Ratio: 9
K-Direction: 90 °

Original Dike (13)

Model: Saturated / Unsaturated
Hydraulic
K-Function: Brown Silty Clay
K-Ratio: 9
K-Direction: 90 °

Foundation Soil (14)

Model: Saturated / Unsaturated
Hydraulic
K-Function: Gray Foundation Clay
K-Ratio: 9
K-Direction: 90 °

Boundary Conditions

Fly Ash Pond

Type: Head (H) 605

Potential Seepage Face

Review: true
Type: Unit Flux (q) 0

Ohio River

Type: Head (H) 539.7

K Functions

Sandy Silty Clay

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 42 %
K-Saturation: 4.92e-008
Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
Data Point: (0.05, 4.92e-008)
Data Point: (0.1, 4.92e-008)
Data Point: (0.84851, 4.92e-008)
Data Point: (7.1998, 3.1551e-008)
Data Point: (61.091, 1.145e-008)
Data Point: (410.04, 1.3566e-009)

Data Point: (4398.4, 1.9641e-012)
Data Point: (37321, 1.1509e-014)
Data Point: (316680, 1.8297e-016)
Data Point: (964730, 1.5075e-017)
Data Point: (2687000, 1.9312e-018)

Estimation Properties

Hydraulic K Sat: 0 ft/sec
Hyd. K-Function Estimation Method: Van Genuchten Function
Maximum: 1000
Minimum: 0.01
Num. Points: 20
Residual Water Content: 0 ft³/ft³

Sandy Silt

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure

Curve Fit to Data: 100 %
Segment Curvature: 42 %

K-Saturation: 1.3e-006
Data Points: Matric Suction (psf), X-Conductivity (ft/sec)

Data Point: (0.05, 1.3e-006)
Data Point: (0.1, 1.3e-006)
Data Point: (0.84851, 1.3e-006)
Data Point: (7.1998, 1.2971847e-006)
Data Point: (61.087, 9.5007643e-007)
Data Point: (518.37, 5.7439299e-008)
Data Point: (4398.4, 4.9929936e-011)
Data Point: (25333, 6.0648726e-013)
Data Point: (37321, 2.1972484e-013)
Data Point: (316680, 1.6731911e-015)
Data Point: (2415100, 1.9197771e-017)
Data Point: (2687000, 1.5238153e-017)

Estimation Properties

Hydraulic K Sat: 0 ft/sec
Hyd. K-Function Estimation Method: Van Genuchten Function
Maximum: 1000
Minimum: 0.01
Num. Points: 20
Residual Water Content: 0 ft³/ft³

Gravelly Silty Sand

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure

Curve Fit to Data: 100 %
Segment Curvature: 42 %

K-Saturation: 1.77e-005
Data Points: Matric Suction (psf), X-Conductivity (ft/sec)

Data Point: (0.05, 1.77e-005)

Data Point: (0.1, 1.77e-005)
Data Point: (0.84851, 1.77e-005)
Data Point: (7.1998, 1.77e-005)
Data Point: (61.087, 1.2238e-005)
Data Point: (518.37, 2.3267e-008)
Data Point: (4398.4, 9.9011e-012)
Data Point: (25333, 6.387e-014)
Data Point: (37321, 2.8017e-014)
Data Point: (316680, 2.8391e-016)
Data Point: (2415100, 2.4418e-018)
Data Point: (2687000, 1.8986e-018)

Estimation Properties

Hydraulic K Sat: 0 ft/sec
Hyd. K-Function Estimation Method: Van Genuchten Function
Maximum: 1000
Minimum: 0.01
Num. Points: 20
Residual Water Content: 0 ft³/ft³

Sand and Gravel

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
K-Saturation: 0.00016
Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
Data Point: (0.05, 0.00016)
Data Point: (0.1, 0.00016)
Data Point: (0.84851, 0.00016)
Data Point: (7.1998, 0.00016)
Data Point: (61.087, 0.00011062599)
Data Point: (518.37, 2.1032316e-007)
Data Point: (4398.4, 8.9501469e-011)
Data Point: (25333, 5.7735593e-013)
Data Point: (37321, 2.5326102e-013)
Data Point: (316680, 2.5664181e-015)
Data Point: (2415100, 2.2072768e-017)
Data Point: (2687000, 1.7162486e-017)

Estimation Properties

Hydraulic K Sat: 0 ft/sec
Hyd. K-Function Estimation Method: Van Genuchten Function
Maximum: 1000
Minimum: 0.01
Num. Points: 20
Residual Water Content: 0 ft³/ft³

Bottom Ash

Model: Data Point Function

Function: X-Conductivity vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 42 %
K-Saturation: 9.5e-006
Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
Data Point: (0.05, 9.5e-006)
Data Point: (0.1, 9.5e-006)
Data Point: (0.84851, 9.5e-006)
Data Point: (7.1998, 8.4395035e-006)
Data Point: (61.091, 6.323766e-006)
Data Point: (518.37, 1.5704645e-008)
Data Point: (4398.4, 4.416422e-011)
Data Point: (25333, 2.5678972e-012)
Data Point: (37321, 1.4526241e-012)
Data Point: (316680, 4.5725993e-014)
Data Point: (2415100, 8.0258156e-016)
Data Point: (2687000, 6.4188333e-016)
Data Point: (4804900, 1.8231915e-016)
Estimation Properties
Hydraulic K Sat: 0 ft/sec
Hyd. K-Function Estimation Method: Van Genuchten Function
Maximum: 1000
Minimum: 0.01
Num. Points: 20
Residual Water Content: 0 ft^3/ft^3

Gray Foundation Clay

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 40 %
K-Saturation: 3.6e-009
Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
Data Point: (0.05, 3.6e-009)
Data Point: (0.1, 3.6e-009)
Data Point: (0.39536, 3.5907652e-009)
Data Point: (1.5631, 3.5683826e-009)
Data Point: (6.18, 3.5150087e-009)
Data Point: (24.433, 3.387913e-009)
Data Point: (96.6, 3.0914609e-009)
Data Point: (381.92, 2.4337565e-009)
Data Point: (1510, 1.2219183e-009)
Data Point: (5969.8, 1.569913e-010)
Data Point: (16286, 9.4554783e-012)
Data Point: (23603, 2.7879652e-012)
Data Point: (93315, 2.2589217e-014)
Data Point: (368930, 1.6295478e-016)
Data Point: (1458600, 1.160687e-018)

Data Point: (1585500, 8.5974261e-019)
Data Point: (3154800, 7.2333391e-020)
Data Point: (4724000, 1.6921565e-020)
Data Point: (5766900, 8.2558957e-021)
Data Point: (6293300, 6.0292174e-021)
Data Point: (7862500, 2.7064174e-021)
Data Point: (9431800, 1.4061443e-021)
Data Point: (11001000, 8.082313e-022)
Data Point: (12570000, 5.0022783e-022)
Data Point: (14139000, 3.276e-022)
Data Point: (15709000, 2.2432696e-022)
Data Point: (17278000, 1.5926087e-022)
Data Point: (18847000, 1.1648191e-022)
Data Point: (20416000, 8.7354783e-023)
Data Point: (21986000, 6.6922435e-023)
Data Point: (22800000, 5.8714435e-023)

Estimation Properties

Hydraulic K Sat: 0 ft/sec
Hyd. K-Function Estimation Method: Van Genuchten Function
Maximum: 1000
Minimum: 0.01
Num. Points: 20
Residual Water Content: 0 ft^3/ft^3

Brown Foundation Clay

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 40 %
K-Saturation: 1.6e-008
Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
Data Point: (0.05, 1.6e-008)
Data Point: (0.1, 1.6e-008)
Data Point: (0.84851, 1.6e-008)
Data Point: (61.091, 9.0158049e-009)
Data Point: (518.37, 1.391122e-009)
Data Point: (4398.4, 3.163122e-011)
Data Point: (25333, 6.9640976e-013)
Data Point: (37321, 3.3350244e-013)
Data Point: (316680, 5.5125854e-015)
Data Point: (2415100, 7.6470244e-017)
Data Point: (2687000, 6.0554146e-017)
Data Point: (4804900, 1.6557073e-017)
Data Point: (7194700, 6.4148293e-018)

Estimation Properties

Hydraulic K Sat: 0 ft/sec
Hyd. K-Function Estimation Method: Van Genuchten Function
Maximum: 1000

Minimum: 0.01
Num. Points: 20
Residual Water Content: 0 ft^3/ft^3

Brown Silty Clay

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 40 %
K-Saturation: 1.2e-008
Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
Data Point: (0.05, 1.2e-008)
Data Point: (0.1, 1.2e-008)
Data Point: (0.84851, 1.2e-008)
Data Point: (61.091, 6.7618537e-009)
Data Point: (518.37, 1.0433415e-009)
Data Point: (4398.4, 2.3723415e-011)
Data Point: (25333, 5.2230732e-013)
Data Point: (37321, 2.5012683e-013)
Data Point: (316680, 4.134439e-015)
Data Point: (2415100, 5.7352683e-017)
Data Point: (2687000, 4.541561e-017)
Data Point: (4804900, 1.2417805e-017)
Data Point: (7194700, 4.811122e-018)
Estimation Properties
Hydraulic K Sat: 0 ft/sec
Hyd. K-Function Estimation Method: Van Genuchten Function
Maximum: 1000
Minimum: 0.01
Num. Points: 20
Residual Water Content: 0 ft^3/ft^3

Regions

	Material	Points	Area (ft^2)
Region 1	Silty Clay (1)	2,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24	1176.9706
Region 2	Gravelly Silty Sand (2)	9,25,26,27,10	33.408658
Region 3	Sand and Gravel (3)	10,11,12,28,29,27	841.1626
Region 4	Sandy Silt (9)	3,30,21,22,23,24	427.5068

Region 5	Bottom Ash (4)	30,21,20,19,31,32,33	190.90717
Region 6	Silty Clay (6)	34,36,37,38,39,35	554.67017
Region 7	Bottom Ash 65 (7)	36,40,41,37	147.83552
Region 8	Original Dike (13)	41,37,38,39,42,43	841.25177
Region 9	Fly Ash (8)	44,61,43,41,40,36,34,33,30,3,1	8367.6141
Region 10	Gravelly Silty Sand (5)	32,31,45,46,64,42,39,35,34,33	1406.9906
Region 11	Silty Clay Foundation (12)	51,54,55,56,57,52,62	9525.1236
Region 12	Foundation Soil (14)	55,58,69,70,59,60,54	18789.697
Region 13	Clay Foundation (11)	44,61,62,51	2466.4545
Region 14	Clay Foundation (10)	61,43,42,64,50,68,49,53,52,62	2091.4421
Region 15	Bottom Ash (4)	46,65,66,67,68,50,64	102.11485
Region 16	Gravelly Silty Sand (5)	65,47,48,67,66	161.58666
Region 17	Bottom Ash (4)	67,68,49	5.722693
Region 18	Silty Clay (1)	2,24,3,1,63	139.92875

Lines

	Start Point	End Point	Hydraulic Boundary
Line 1	2	24	
Line 2	24	3	

Line 3	2	4	Fly Ash Pond
Line 4	4	5	Fly Ash Pond
Line 5	5	6	
Line 6	6	7	
Line 7	7	8	
Line 8	8	9	
Line 9	9	10	
Line 10	10	11	
Line 11	11	12	
Line 12	12	13	
Line 13	13	14	
Line 14	14	15	
Line 15	15	16	
Line 16	16	17	
Line 17	17	18	
Line 18	18	19	Potential Seepage Face
Line 19	19	20	
Line 20	20	21	
Line 21	21	22	
Line 22	22	23	
Line 23	23	24	
Line 24	9	25	
Line 25	25	26	
Line 26	26	27	
Line 27	27	10	
Line 28	12	28	
Line 29	28	29	
Line 30	29	27	
Line 31	3	30	
Line 32	30	21	
Line 33	19	31	Potential Seepage Face
Line 34	31	32	
Line 35	32	33	
Line 36	33	30	
Line 37	33	34	
Line 38	34	35	

Line 39	34	36	
Line 40	36	37	
Line 41	37	38	
Line 42	38	39	
Line 43	39	35	
Line 44	36	40	
Line 45	40	41	
Line 46	41	37	
Line 47	39	42	
Line 48	42	43	
Line 49	43	41	
Line 50	31	45	Potential Seepage Face
Line 51	45	46	Potential Seepage Face
Line 52	51	54	
Line 53	54	55	
Line 54	55	56	Ohio River
Line 55	56	57	Potential Seepage Face
Line 56	57	52	Potential Seepage Face
Line 57	55	58	Ohio River
Line 58	59	60	
Line 59	60	54	
Line 60	44	61	
Line 61	61	43	
Line 62	51	62	
Line 63	62	52	
Line 64	61	62	
Line 65	51	44	
Line 66	49	53	Potential Seepage Face
Line 67	53	52	Potential Seepage Face
Line 68	3	1	
Line 69	50	64	
Line 70	64	42	
Line 71	46	64	
Line 72	49	68	
Line 73	68	50	
Line 74	46	65	Potential Seepage Face

Line 75	65	66	
Line 76	66	67	
Line 77	67	68	
Line 78	65	47	Potential Seepage Face
Line 79	47	48	Potential Seepage Face
Line 80	48	67	Potential Seepage Face
Line 81	49	67	Potential Seepage Face
Line 82	58	69	Ohio River
Line 83	69	70	
Line 84	70	59	
Line 85	44	1	
Line 86	1	63	Fly Ash Pond
Line 87	63	2	Fly Ash Pond

Points

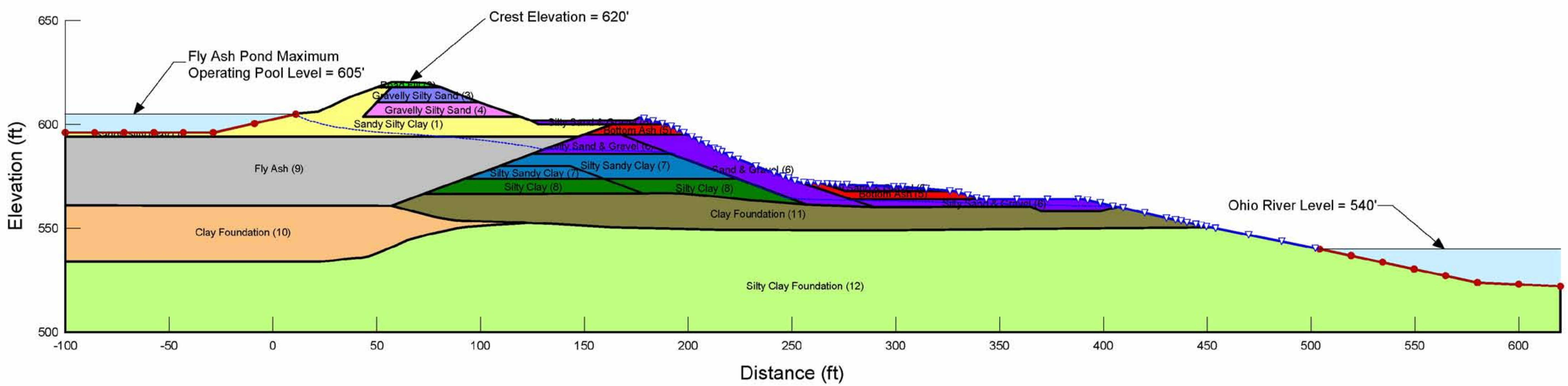
	X (ft)	Y (ft)
Point 1	-50	595.75
Point 2	20.85	597.75
Point 3	20.85	595.7
Point 4	28.29932	599.9386
Point 5	43.4	605
Point 6	66.4449	612.83618
Point 7	71.00682	614.37347
Point 8	75.83799	615.92596
Point 9	83.12625	618.01207
Point 10	89.16676	618.0063
Point 11	67.99514	603.00606
Point 12	160.50996	603.01085
Point 13	164.36012	602.00265
Point 14	175.56909	602.00354
Point 15	179.88561	602.4977
Point 16	214.07092	602.96698
Point 17	216.26115	604.4504
Point 18	218.92113	601.99621
Point 19	228.49429	599.98195

Point 20	207.18559	599.99735
Point 21	204.40592	598.13958
Point 22	32.02668	598.14303
Point 23	26.54626	596.50886
Point 24	20.85	596.5
Point 25	89.27093	619.72571
Point 26	103.77188	619.42032
Point 27	111.47933	618.0121
Point 28	135.19671	609.9055
Point 29	123.47463	613.96956
Point 30	200.77083	595.72596
Point 31	240.76421	594.01059
Point 32	222.79049	594.01222
Point 33	198.17913	594.01083
Point 34	178.5748	580.99902
Point 35	248.77756	581.00098
Point 36	165.52362	572.33858
Point 37	228.39764	572.33563
Point 38	239.8063	579.91496
Point 39	250.94764	579.91496
Point 40	161.97373	569.98666
Point 41	224.86913	569.98596
Point 42	288.91143	560.96382
Point 43	211.29094	560.95827
Point 44	-50	561
Point 45	257.89685	585.94071
Point 46	297.73567	569.9851
Point 47	325.50196	568.0018
Point 48	336.18826	565.99579
Point 49	354.42618	558.00394
Point 50	328.18785	559.80842
Point 51	-50	550.07288
Point 52	397.53591	549.83795
Point 53	388.85171	551.97178
Point 54	-50	530.60542
Point 55	486.17654	530.37993

Point 56	440.71606	539.69843
Point 57	420.04463	544.03139
Point 58	523	525
Point 59	523	500.03246
Point 60	-50	499.97967
Point 61	154.97895	560.96884
Point 62	194.99536	549.95765
Point 63	-50	597.65
Point 64	321.98827	559.99079
Point 65	304.18497	569.49578
Point 66	322.21879	562.20928
Point 67	349.0118	560.43036
Point 68	348.85409	558.38715
Point 69	580	525
Point 70	580	500

SECTION L-L

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section L-L Seepage Analysis
File Name: FAP_L-L_Seepage.gsz
Date: 7/22/2010



Steady-State Seepage

File Information

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section L-L Seepage Analysis
Revision Number: 70
Last Edited By: Seth Frank
Date: 7/22/2010
Time: 3:21:13 PM
File Name: FAP_L-L_Seepage.gsz
Directory: P:\Frank\Philip Sporn\SEISMIC REPORT\Updated Analysis Files\Seepage\
Last Solved Date: 7/22/2010
Last Solved Time: 3:22:54 PM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Mass(M) Units: lbs
Mass Flux Units: lbs/sec
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Steady-State Seepage

Kind: SEEP/W
Method: Steady-State
Settings
  Include Air Flow: No
Control
  Apply Runoff: Yes
Convergence
  Convergence Type: Gauss Point K
  Convergence Settings
    Maximum Number of Iterations: 500
    Tolerance: 0.01
    Maximum Change in K: 0.1
    Rate of Change in K: 1.02
    Minimum Change in K: 0.0001

Equation Solver: Parallel Direct
Potential Seepage Max # of Reviews: 10
Time
Starting Time: 0 sec
Duration: 0 sec
Ending Time: 0 sec

Materials

Sandy Silty Clay (1)
Model: Saturated / Unsaturated
Hydraulic
K-Function: Sandy Silty Clay
K-Ratio: 9
K-Direction: 90 °

Road Fill (2)
Model: Saturated / Unsaturated
Hydraulic
K-Function: Gravelly Silty Sand
K-Ratio: 9
K-Direction: 90 °

Gravelly Silty Sand (3)
Model: Saturated / Unsaturated
Hydraulic
K-Function: Gravelly Silty Sand
K-Ratio: 9
K-Direction: 90 °

Gravelly Silty Sand (4)
Model: Saturated / Unsaturated
Hydraulic
K-Function: Gravelly Silty Sand
K-Ratio: 9
K-Direction: 90 °

Bottom Ash (5)
Model: Saturated / Unsaturated
Hydraulic
K-Function: Bottom Ash
K-Ratio: 9
K-Direction: 90 °

Silty Sand & Gravel (6)
Model: Saturated / Unsaturated

Hydraulic

K-Function: Silty Sand with Gravel

K-Ratio: 9

K-Direction: 90 °

Silty Sandy Clay (7)

Model: Saturated / Unsaturated

Hydraulic

K-Function: Silty Sandy Clay

K-Ratio: 9

K-Direction: 90 °

Silty Clay (8)

Model: Saturated / Unsaturated

Hydraulic

K-Function: Silty Clay

K-Ratio: 9

K-Direction: 90 °

Fly Ash (9)

Model: Saturated / Unsaturated

Hydraulic

K-Function: Fly Ash

K-Ratio: 10

K-Direction: 90 °

Clay Foundation (10)

Model: Saturated / Unsaturated

Hydraulic

K-Function: Brown Foundation Clay

K-Ratio: 9

K-Direction: 90 °

Clay Foundation (11)

Model: Saturated / Unsaturated

Hydraulic

K-Function: Gray Foundation Clay

K-Ratio: 9

K-Direction: 90 °

Silty Clay Foundation (12)

Model: Saturated / Unsaturated

Hydraulic

K-Function: Gray Foundation Clay

K-Ratio: 9

K-Direction: 90 °

Boundary Conditions

Fly Ash Pond

Type: Head (H) 605

Potential Seepage Face

Review: true

Type: Unit Flux (q) 0

Ohio River

Type: Head (H) 540

K Functions

Sandy Silty Clay

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
- Curve Fit to Data: 100 %
- Segment Curvature: 42 %

K-Saturation: 2e-007
Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
- Data Point: (0.05, 2e-007)
- Data Point: (0.1, 2e-007)
- Data Point: (0.84851, 2e-007)
- Data Point: (7.1998, 1.282561e-007)
- Data Point: (61.091, 4.6544715e-008)
- Data Point: (410.04, 5.5146341e-009)
- Data Point: (4398.4, 7.9841463e-012)
- Data Point: (37321, 4.6784553e-014)
- Data Point: (316680, 7.4378049e-016)
- Data Point: (964730, 6.1280488e-017)
- Data Point: (2687000, 7.8504065e-018)

Estimation Properties
- Hydraulic K Sat: 0 ft/sec
- Hyd. K-Function Estimation Method: Van Genuchten Function
- Maximum: 1000
- Minimum: 0.01
- Num. Points: 20
- Residual Water Content: 0 ft^3/ft^3

Fly Ash

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
- Curve Fit to Data: 100 %
- Segment Curvature: 42 %

K-Saturation: 2.2e-006

Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
- Data Point: (0.05, 2.2e-006)
- Data Point: (0.1, 2.2e-006)
- Data Point: (0.84851, 2.2e-006)
- Data Point: (7.1998, 1.7835427e-006)
- Data Point: (61.091, 1.2705671e-006)
- Data Point: (518.37, 2.2124756e-007)
- Data Point: (4398.4, 5.3366768e-010)
- Data Point: (25333, 5.5729756e-013)
- Data Point: (37321, 2.0299695e-013)
- Data Point: (316680, 4.4452744e-016)
- Data Point: (2415100, 2.5504573e-018)
- Data Point: (2687000, 1.9977073e-018)

Estimation Properties
- Hydraulic K Sat: 0 ft/sec
- Hyd. K-Function Estimation Method: Van Genuchten Function
- Maximum: 1000
- Minimum: 0.01
- Num. Points: 20
- Residual Water Content: 0 ft^3/ft^3

Bottom Ash

Model: Data Point Function

Function: X-Conductivity vs. Pore-Water Pressure
- Curve Fit to Data: 100 %
- Segment Curvature: 42 %

K-Saturation: 9.5e-006

Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
- Data Point: (0.05, 9.5e-006)
- Data Point: (0.1, 9.5e-006)
- Data Point: (0.84851, 9.5e-006)
- Data Point: (7.1998, 8.4395035e-006)
- Data Point: (61.091, 6.323766e-006)
- Data Point: (518.37, 1.5704645e-008)
- Data Point: (4398.4, 4.416422e-011)
- Data Point: (25333, 2.5678972e-012)
- Data Point: (37321, 1.4526241e-012)
- Data Point: (316680, 4.5725993e-014)
- Data Point: (2415100, 8.0258156e-016)
- Data Point: (2687000, 6.4188333e-016)
- Data Point: (4804900, 1.8231915e-016)

Estimation Properties
- Hydraulic K Sat: 0 ft/sec
- Hyd. K-Function Estimation Method: Van Genuchten Function
- Maximum: 1000
- Minimum: 0.01
- Num. Points: 20
- Residual Water Content: 0 ft^3/ft^3

Gray Foundation Clay

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
  Curve Fit to Data: 100 %
  Segment Curvature: 40 %
K-Saturation: 3.6e-009
Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
  Data Point: (0.05, 3.6e-009)
  Data Point: (0.1, 3.6e-009)
  Data Point: (0.39536, 3.5907652e-009)
  Data Point: (1.5631, 3.5683826e-009)
  Data Point: (6.18, 3.5150087e-009)
  Data Point: (24.433, 3.387913e-009)
  Data Point: (96.6, 3.0914609e-009)
  Data Point: (381.92, 2.4337565e-009)
  Data Point: (1510, 1.2219183e-009)
  Data Point: (5969.8, 1.569913e-010)
  Data Point: (16286, 9.4554783e-012)
  Data Point: (23603, 2.7879652e-012)
  Data Point: (93315, 2.2589217e-014)
  Data Point: (368930, 1.6295478e-016)
  Data Point: (1458600, 1.160687e-018)
  Data Point: (1585500, 8.5974261e-019)
  Data Point: (3154800, 7.2333391e-020)
  Data Point: (4724000, 1.6921565e-020)
  Data Point: (5766900, 8.2558957e-021)
  Data Point: (6293300, 6.0292174e-021)
  Data Point: (7862500, 2.7064174e-021)
  Data Point: (9431800, 1.4061443e-021)
  Data Point: (11001000, 8.082313e-022)
  Data Point: (12570000, 5.0022783e-022)
  Data Point: (14139000, 3.276e-022)
  Data Point: (15709000, 2.2432696e-022)
  Data Point: (17278000, 1.5926087e-022)
  Data Point: (18847000, 1.1648191e-022)
  Data Point: (20416000, 8.7354783e-023)
  Data Point: (21986000, 6.6922435e-023)
  Data Point: (22800000, 5.8714435e-023)
Estimation Properties
  Hydraulic K Sat: 0 ft/sec
  Hyd. K-Function Estimation Method: Van Genuchten Function
  Maximum: 1000
  Minimum: 0.01
  Num. Points: 20
  Residual Water Content: 0 ft^3/ft^3

Brown Foundation Clay

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
  Curve Fit to Data: 100 %
  Segment Curvature: 40 %
K-Saturation: 1.6e-008
Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
  Data Point: (0.05, 1.6e-008)
  Data Point: (0.1, 1.6e-008)
  Data Point: (0.84851, 1.6e-008)
  Data Point: (61.091, 9.0158049e-009)
  Data Point: (518.37, 1.391122e-009)
  Data Point: (4398.4, 3.163122e-011)
  Data Point: (25333, 6.9640976e-013)
  Data Point: (37321, 3.3350244e-013)
  Data Point: (316680, 5.5125854e-015)
  Data Point: (2415100, 7.6470244e-017)
  Data Point: (2687000, 6.0554146e-017)
  Data Point: (4804900, 1.6557073e-017)
  Data Point: (7194700, 6.4148293e-018)
Estimation Properties
  Hydraulic K Sat: 0 ft/sec
  Hyd. K-Function Estimation Method: Van Genuchten Function
  Maximum: 1000
  Minimum: 0.01
  Num. Points: 20
  Residual Water Content: 0 ft^3/ft^3

Silty Clay

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
  Curve Fit to Data: 100 %
  Segment Curvature: 40 %
K-Saturation: 1.2e-008
Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
  Data Point: (0.05, 1.2e-008)
  Data Point: (0.1, 1.2e-008)
  Data Point: (0.84851, 1.2e-008)
  Data Point: (61.091, 6.7618537e-009)
  Data Point: (518.37, 1.0433415e-009)
  Data Point: (4398.4, 2.3723415e-011)
  Data Point: (25333, 5.2230732e-013)
  Data Point: (37321, 2.5012683e-013)
  Data Point: (316680, 4.134439e-015)
  Data Point: (2415100, 5.7352683e-017)
  Data Point: (2687000, 4.541561e-017)
  Data Point: (4804900, 1.2417805e-017)

Data Point: (7194700, 4.811122e-018)
Estimation Properties
Hydraulic K Sat: 0 ft/sec
Hyd. K-Function Estimation Method: Van Genuchten Function
Maximum: 1000
Minimum: 0.01
Num. Points: 20
Residual Water Content: 0 ft³/ft³

Silty Sandy Clay

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 40 %
K-Saturation: 1.2e-008
Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
Data Point: (0.05, 1.2e-008)
Data Point: (0.1, 1.2e-008)
Data Point: (0.84851, 1.2e-008)
Data Point: (61.091, 6.7618537e-009)
Data Point: (518.37, 1.0433415e-009)
Data Point: (4398.4, 2.3723415e-011)
Data Point: (25333, 5.2230732e-013)
Data Point: (37321, 2.5012683e-013)
Data Point: (316680, 4.134439e-015)
Data Point: (2415100, 5.7352683e-017)
Data Point: (2687000, 4.541561e-017)
Data Point: (4804900, 1.2417805e-017)
Data Point: (7194700, 4.811122e-018)
Estimation Properties
Hydraulic K Sat: 0 ft/sec
Hyd. K-Function Estimation Method: Van Genuchten Function
Maximum: 1000
Minimum: 0.01
Num. Points: 20
Residual Water Content: 0 ft³/ft³

Gravelly Silty Sand

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 42 %
K-Saturation: 0.00021
Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
Data Point: (0.05, 0.00021)
Data Point: (0.1, 0.00021)
Data Point: (0.84851, 0.00021)
Data Point: (7.1998, 0.00021)

Data Point: (61.087, 0.00014519661)
Data Point: (518.37, 2.7604915e-007)
Data Point: (4398.4, 1.1747068e-010)
Data Point: (25333, 7.5777966e-013)
Data Point: (37321, 3.3240508e-013)
Data Point: (316680, 3.3684237e-015)
Data Point: (2415100, 2.8970508e-017)
Data Point: (2687000, 2.2525763e-017)

Estimation Properties

Hydraulic K Sat: 0 ft/sec
Hyd. K-Function Estimation Method: Van Genuchten Function
Maximum: 1000
Minimum: 0.01
Num. Points: 20
Residual Water Content: 0 ft^3/ft^3

Silty Sand with Gravel

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 40 %
K-Saturation: 6.6e-005
Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
Data Point: (0.05, 6.6e-005)
Data Point: (0.1, 6.6e-005)
Data Point: (0.84851, 6.6e-005)
Data Point: (7.1998, 4.9767745e-005)
Data Point: (61.091, 2.0882213e-006)
Data Point: (518.37, 6.4129532e-009)
Data Point: (4398.4, 2.6239915e-011)
Data Point: (25333, 2.8829362e-013)
Data Point: (37321, 1.2569021e-013)
Data Point: (316680, 1.4333702e-015)

Estimation Properties

Hydraulic K Sat: 0 ft/sec
Hyd. K-Function Estimation Method: Van Genuchten Function
Maximum: 1000
Minimum: 0.01
Num. Points: 20
Residual Water Content: 0 ft^3/ft^3

Regions

	Materia l	Points	Area (ft^2)
Regi	Sandy	1,2,3,104	141.0609

on 1	Silty Clay (1)		3
Region 2	Sandy Silty Clay (1)	2,4,5,6,7,8,9,10,11,98,12,13,14,15,16,17,18,3	1797.2287
Region 3	Road Fill (2)	10,19,20,21,11	50.839704
Region 4	Silty Sand & Gravel (6)	14,23,24,25,26,16,15	116.203
Region 5	Bottom Ash (5)	16,26,27,28,17	191.73337
Region 6	Silty Sand & Gravel (6)	18,17,28,29,30	391.82116
Region 7	Silty Sand & Gravel (6)	28,27,31,32,33,34,35,101,100,36,37,99,29	923.61928
Region 8	Silty Sandy Clay (7)	38,48,40,39	312.45828
Region 9	Silty Clay (8)	48,49,41,40	623.99905
Region 10	Fly Ash (9)	49,50,51,104,3,18,30,38,48	6697.8698
Region 11	Clay Foundation (10)	51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,50	4580.0299
Region 12	Clay Foundation (11)	50,49,41,42,43,44,45,46,47,37,36,75,76,77,78,79,80,81,82,83,84,85,86,87,88,68,69,70,71,72,73,74	4582.5269
Region	Silty Sand &	102,89,90,91,103	107.81573

13	Gravel (6)		
Region 14	Silty Clay Foundation (12)	52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,88,87,86,85,84,83,82,94,95,105,106,96,97	30694.491
Region 15	Gravelly Silty Sand (3)	11,21,22,98	270.1759
Region 16	Gravelly Silty Sand (4)	22,13,12,98	428.27559
Region 17	Silty Clay (8)	99,37,47,46,45,44,43,42,41,40	583.66388
Region 18	Silty Sandy Clay (7)	99,40,39,38,30,29	875.82886
Region 19	Bottom Ash (5)	102,103,91,92,100,101,35	285.90427
Region 20	Silty Sand & Gravel (6)	100,92,93,78,77,76,75,36	493.02893

Lines

	Start Point	End Point	Hydraulic Boundary
Line 1	2	3	
Line 2	2	4	Fly Ash Pond
Line 3	4	5	
Line 4	5	6	
Line 5	6	7	
Line 6	7	8	
Line 7	8	9	

Line 8	9	10	
Line 9	10	11	
Line 10	12	13	
Line 11	13	14	
Line 12	14	15	
Line 13	15	16	
Line 14	16	17	
Line 15	17	18	
Line 16	18	3	
Line 17	10	19	
Line 18	19	20	
Line 19	20	21	
Line 20	21	11	
Line 21	14	23	
Line 22	23	24	
Line 23	24	25	
Line 24	25	26	Potential Seepage Face
Line 25	26	16	
Line 26	26	27	Potential Seepage Face
Line 27	27	28	
Line 28	28	17	
Line 29	28	29	
Line 30	29	30	
Line 31	30	18	
Line 32	27	31	Potential Seepage Face
Line 33	31	32	Potential Seepage Face
Line 34	32	33	Potential Seepage Face
Line 35	33	34	Potential Seepage Face
Line 36	34	35	Potential Seepage Face
Line 37	36	37	
Line 38	30	38	
Line 39	38	39	
Line 40	39	40	
Line 41	40	41	
Line 42	41	42	
Line 43	42	43	

Line 44	43	44	
Line 45	44	45	
Line 46	45	46	
Line 47	46	47	
Line 48	47	37	
Line 49	38	48	
Line 50	48	40	
Line 51	48	49	
Line 52	49	41	
Line 53	49	50	
Line 54	50	51	
Line 55	51	52	
Line 56	52	53	
Line 57	53	54	
Line 58	54	55	
Line 59	55	56	
Line 60	56	57	
Line 61	57	58	
Line 62	58	59	
Line 63	59	60	
Line 64	60	61	
Line 65	61	62	
Line 66	62	63	
Line 67	63	64	
Line 68	64	65	
Line 69	65	66	
Line 70	66	67	
Line 71	67	68	
Line 72	68	69	
Line 73	69	70	
Line 74	70	71	
Line 75	71	72	
Line 76	72	73	
Line 77	73	74	
Line 78	74	50	
Line 79	36	75	

Line 80	75	76	
Line 81	76	77	
Line 82	77	78	
Line 83	78	79	
Line 84	79	80	Potential Seepage Face
Line 85	80	81	Potential Seepage Face
Line 86	81	82	Potential Seepage Face
Line 87	82	83	
Line 88	83	84	
Line 89	84	85	
Line 90	85	86	
Line 91	86	87	
Line 92	87	88	
Line 93	88	68	
Line 94	89	90	Potential Seepage Face
Line 95	90	91	Potential Seepage Face
Line 96	82	94	Potential Seepage Face
Line 97	94	95	Ohio River
Line 98	96	97	
Line 99	97	52	
Line 100	11	98	
Line 101	98	12	
Line 102	21	22	
Line 103	22	98	
Line 104	22	13	
Line 105	37	99	
Line 106	99	29	
Line 107	40	99	
Line 108	100	36	
Line 109	35	101	
Line 110	101	100	
Line 111	102	89	Potential Seepage Face
Line 112	91	103	
Line 113	103	102	
Line 114	91	92	Potential Seepage Face
Line 115	92	100	

Line 116	35	102	Potential Seepage Face
Line 117	92	93	Potential Seepage Face
Line 118	93	78	Potential Seepage Face
Line 119	3	104	
Line 120	95	105	Ohio River
Line 121	105	106	
Line 122	106	96	
Line 123	104	51	
Line 124	1	104	
Line 125	1	2	Fly Ash Pond

Points

	X (ft)	Y (ft)
Point 1	-100	596.07556
Point 2	-28.73928	596.09012
Point 3	-28.7343	594.10387
Point 4	10.87106	605.00492
Point 5	12.47008	605.36299
Point 6	21.58957	606.0128
Point 7	27.88941	608.93894
Point 8	34.84064	612.1236
Point 9	39.1222	614.02931
Point 10	50.19567	618.00197
Point 11	57.04232	618.00197
Point 12	43.46173	603.74724
Point 13	118.92142	603.75291
Point 14	123.93504	601.99213
Point 15	127.87795	600.00591
Point 16	163.14756	600.01118
Point 17	149.56535	595.01063
Point 18	147.06988	594.09744
Point 19	57.38569	620.4397
Point 20	72.81546	619.98477
Point 21	80.84007	617.99987
Point 22	99.3055	610.6283

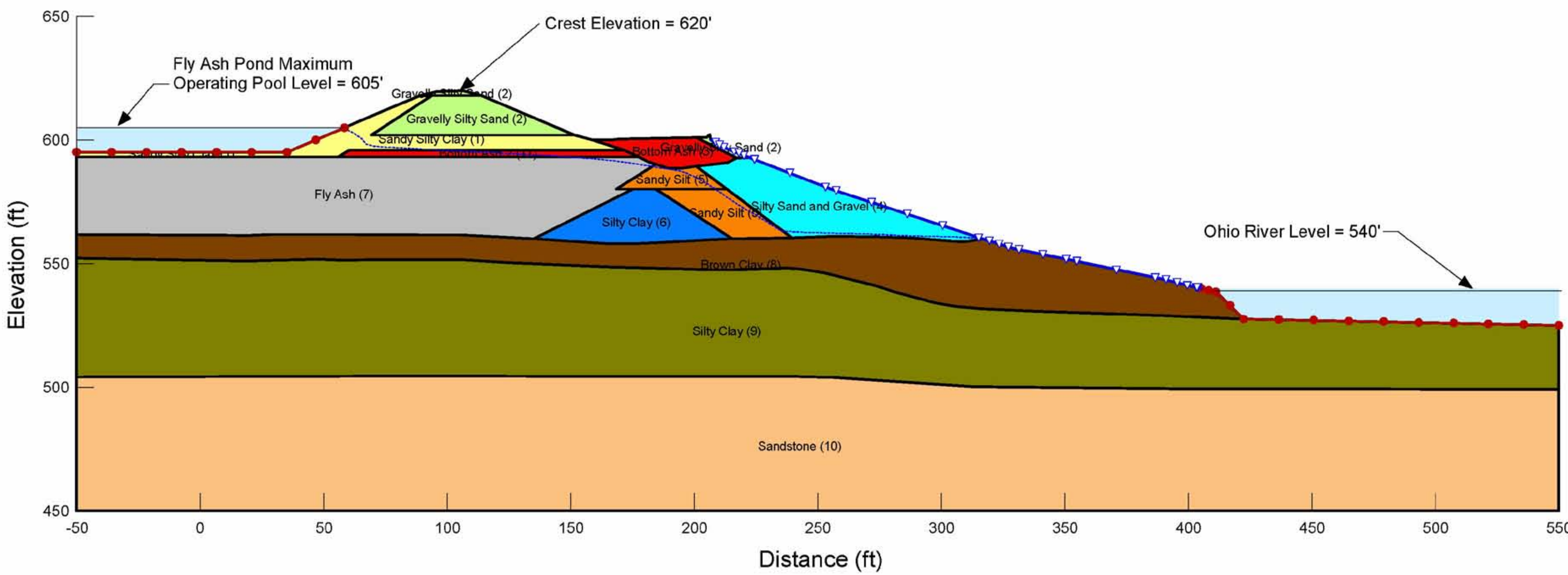
Point 23	139.17652	601.67587
Point 24	173.72543	602.00845
Point 25	176.45339	603.29228
Point 26	189.71063	600.00886
Point 27	199.68996	595.00886
Point 28	167.47087	595.01
Point 29	191.72441	585.79626
Point 30	124.59213	585.79827
Point 31	210.5102	589.59755
Point 32	218.12189	585.75717
Point 33	221.75303	584.00508
Point 34	243.39222	575.85019
Point 35	253.50591	571.98819
Point 36	289.84961	560.28268
Point 37	256.97717	561.34945
Point 38	108.92713	580.01604
Point 39	142.96147	580.0084
Point 40	159.35433	573.84449
Point 41	178.27362	566.74311
Point 42	185.14195	566.8803
Point 43	197.25818	566.77308
Point 44	199.06388	566.49447
Point 45	214.43065	565.09473
Point 46	230.53524	563.39632
Point 47	234.91774	563.19918
Point 48	92.17246	573.83178
Point 49	72.44646	566.50502
Point 50	57.05752	560.85717
Point 51	-100	561.11382
Point 52	-100	533.82575
Point 53	21.33315	533.86583
Point 54	28.78186	534.53132
Point 55	34.71071	535.25795
Point 56	39.46011	535.53175
Point 57	42.85104	535.87926
Point 58	45.71543	536.46899

Point 59	49.77857	537.76077
Point 60	59.1159	541.81514
Point 61	64.62858	544.24532
Point 62	75.01429	546.95559
Point 63	83.26625	548.88905
Point 64	88.53588	549.98847
Point 65	93.23684	550.64559
Point 66	106.0002	551.53018
Point 67	116.47627	552.07357
Point 68	122.52939	552.65487
Point 69	120.68438	552.98343
Point 70	113.2235	552.91166
Point 71	98.93865	553.2756
Point 72	88.31144	553.78513
Point 73	81.74223	554.71319
Point 74	77.73883	555.51387
Point 75	364.93178	560.3689
Point 76	369.84787	558.28744
Point 77	398.62803	558.25568
Point 78	406.56907	560.14614
Point 79	407.16945	560.17165
Point 80	432.46006	554.51883
Point 81	442.14574	552.40143
Point 82	451.7179	550.43805
Point 83	378.61552	549.7332
Point 84	292.87496	549.02254
Point 85	215.96602	549.23217
Point 86	183.76122	549.91347
Point 87	163.4328	550.32461
Point 88	134.5598	552.09884
Point 89	274.22203	571.1344
Point 90	301.03752	569.99889
Point 91	328.15873	568.01175
Point 92	341.0609	563.99026
Point 93	390.16826	564.00289
Point 94	504	540

Point 95	580	523.86886
Point 96	580	500.03246
Point 97	-100	499.99472
Point 98	49.98781	610.59727
Point 99	223.72901	573.80581
Point 100	278.12773	564.05804
Point 101	265.81244	568.02452
Point 102	264.70006	571.52684
Point 103	275.69963	568.00897
Point 104	-99.99966	594.10293
Point 105	620	522
Point 106	620	500

SECTION M-M

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section M-M Finite Element Seepage Analysis
File Name: FAP_M-M_Seepage.gsz
Date: 7/23/2010



AEPSPP004273

Steady-State Seepage

File Information

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section M-M FESM Seepage Analysis
Revision Number: 91
Last Edited By: Seth Frank
Date: 7/22/2010
Time: 3:10:43 PM
File Name: FAP_M-M_Seepage.gsz
Directory: P:\Frank\Philip Sporn\SEISMIC REPORT\Updated Analysis Files\Seepage\
Last Solved Date: 7/22/2010
Last Solved Time: 3:12:10 PM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Mass(M) Units: lbs
Mass Flux Units: lbs/sec
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Steady-State Seepage

Description: Sporn Fly Ash Pond Section M-M Seepage
Kind: SEEP/W
Method: Steady-State
Settings
- Include Air Flow: No

Control
- Apply Runoff: Yes

Convergence
- Convergence Type: Gauss Point K
- Convergence Settings
  - Maximum Number of Iterations: 500
  - Tolerance: 0.01
  - Maximum Change in K: 0.1
  - Rate of Change in K: 1.02

Minimum Change in K: 0.0001
Equation Solver: Parallel Direct
Potential Seepage Max # of Reviews: 10
Time
Starting Time: 0 sec
Duration: 0 sec
Ending Time: 0 sec

Materials

Sandy Silty Clay (1)
Model: Saturated / Unsaturated
Hydraulic
K-Function: Sandy Silty Clay
K-Ratio: 9
K-Direction: 90 °

Gravelly Silty Sand (2)
Model: Saturated / Unsaturated
Hydraulic
K-Function: Gravelly Silty Sand
K-Ratio: 9
K-Direction: 90 °

Bottom Ash (3)
Model: Saturated / Unsaturated
Hydraulic
K-Function: Bottom Ash
K-Ratio: 9
K-Direction: 90 °

Silty Sand and Gravel (4)
Model: Saturated / Unsaturated
Hydraulic
K-Function: Silty Sand with Gravel
K-Ratio: 9
K-Direction: 90 °

Sandy Silt (5)
Model: Saturated / Unsaturated
Hydraulic
K-Function: Sandy Silt
K-Ratio: 9
K-Direction: 90 °

Silty Clay (6)

Model: Saturated / Unsaturated
Hydraulic
K-Function: Silty Clay
K-Ratio: 9
K-Direction: 90 °

Fly Ash (7)

Model: Saturated / Unsaturated
Hydraulic
K-Function: Fly Ash
K-Ratio: 10
K-Direction: 90 °

Brown Clay (8)

Model: Saturated / Unsaturated
Hydraulic
K-Function: Brown Foundation Clay
K-Ratio: 9
K-Direction: 90 °

Silty Clay (9)

Model: Saturated / Unsaturated
Hydraulic
K-Function: Silty Clay
K-Ratio: 9
K-Direction: 90 °

Sandstone (10)

Model: Saturated Only
Hydraulic
K-Sat: 1e-008 ft/sec
Volumetric Water Content: 0 ft^3/ft^3
Mv: 0 /psf
K-Ratio: 9
K-Direction: 90 °

Bottom Ash 2 (11)

Model: Saturated / Unsaturated
Hydraulic
K-Function: Bottom Ash
K-Ratio: 9
K-Direction: 90 °

Boundary Conditions

Ohio River

Type: Head (H) 540

Potential Seepage Face

Review: true
Type: Unit Flux (q) 0

Fly Ash Pond

Type: Head (H) 605

K Functions

Sandy Silty Clay

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
- Curve Fit to Data: 100 %
- Segment Curvature: 42 %

K-Saturation: 2e-007
Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
- Data Point: (0.05, 2e-007)
- Data Point: (0.1, 2e-007)
- Data Point: (0.84851, 2e-007)
- Data Point: (7.1998, 1.282561e-007)
- Data Point: (61.091, 4.6544715e-008)
- Data Point: (410.04, 5.5146341e-009)
- Data Point: (4398.4, 7.9841463e-012)
- Data Point: (37321, 4.6784553e-014)
- Data Point: (316680, 7.4378049e-016)
- Data Point: (964730, 6.1280488e-017)
- Data Point: (2687000, 7.8504065e-018)

Estimation Properties
- Hydraulic K Sat: 0 ft/sec
- Hyd. K-Function Estimation Method: Van Genuchten Function
- Maximum: 1000
- Minimum: 0.01
- Num. Points: 20
- Residual Water Content: 0 ft^3/ft^3

Fly Ash

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
- Curve Fit to Data: 100 %
- Segment Curvature: 42 %

K-Saturation: 2.2e-006

Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
Data Point: (0.05, 2.2e-006)
Data Point: (0.1, 2.2e-006)
Data Point: (0.84851, 2.2e-006)
Data Point: (7.1998, 1.7835427e-006)
Data Point: (61.091, 1.2705671e-006)
Data Point: (518.37, 2.2124756e-007)
Data Point: (4398.4, 5.3366768e-010)
Data Point: (25333, 5.5729756e-013)
Data Point: (37321, 2.0299695e-013)
Data Point: (316680, 4.4452744e-016)
Data Point: (2415100, 2.5504573e-018)
Data Point: (2687000, 1.9977073e-018)
Estimation Properties
Hydraulic K Sat: 0 ft/sec
Hyd. K-Function Estimation Method: Van Genuchten Function
Maximum: 1000
Minimum: 0.01
Num. Points: 20
Residual Water Content: 0 ft^3/ft^3

Bottom Ash

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 42 %
K-Saturation: 9.5e-006
Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
Data Point: (0.05, 9.5e-006)
Data Point: (0.1, 9.5e-006)
Data Point: (0.84851, 9.5e-006)
Data Point: (7.1998, 8.4395035e-006)
Data Point: (61.091, 6.323766e-006)
Data Point: (518.37, 1.5704645e-008)
Data Point: (4398.4, 4.416422e-011)
Data Point: (25333, 2.5678972e-012)
Data Point: (37321, 1.4526241e-012)
Data Point: (316680, 4.5725993e-014)
Data Point: (2415100, 8.0258156e-016)
Data Point: (2687000, 6.4188333e-016)
Data Point: (4804900, 1.8231915e-016)
Estimation Properties
Hydraulic K Sat: 0 ft/sec
Hyd. K-Function Estimation Method: Van Genuchten Function
Maximum: 1000
Minimum: 0.01
Num. Points: 20
Residual Water Content: 0 ft^3/ft^3

Brown Foundation Clay

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 40 %
K-Saturation: 1.6e-008
Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
Data Point: (0.05, 1.6e-008)
Data Point: (0.1, 1.6e-008)
Data Point: (0.84851, 1.6e-008)
Data Point: (61.091, 9.0158049e-009)
Data Point: (518.37, 1.391122e-009)
Data Point: (4398.4, 3.163122e-011)
Data Point: (25333, 6.9640976e-013)
Data Point: (37321, 3.3350244e-013)
Data Point: (316680, 5.5125854e-015)
Data Point: (2415100, 7.6470244e-017)
Data Point: (2687000, 6.0554146e-017)
Data Point: (4804900, 1.6557073e-017)
Data Point: (7194700, 6.4148293e-018)
Estimation Properties
Hydraulic K Sat: 0 ft/sec
Hyd. K-Function Estimation Method: Van Genuchten Function
Maximum: 1000
Minimum: 0.01
Num. Points: 20
Residual Water Content: 0 ft^3/ft^3

Silty Clay

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 40 %
K-Saturation: 1.2e-008
Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
Data Point: (0.05, 1.2e-008)
Data Point: (0.1, 1.2e-008)
Data Point: (0.84851, 1.2e-008)
Data Point: (61.091, 6.7618537e-009)
Data Point: (518.37, 1.0433415e-009)
Data Point: (4398.4, 2.3723415e-011)
Data Point: (25333, 5.2230732e-013)
Data Point: (37321, 2.5012683e-013)
Data Point: (316680, 4.134439e-015)
Data Point: (2415100, 5.7352683e-017)
Data Point: (2687000, 4.541561e-017)
Data Point: (4804900, 1.2417805e-017)

Data Point: (7194700, 4.811122e-018)

Estimation Properties

Hydraulic K Sat: 0 ft/sec

Hyd. K-Function Estimation Method: Van Genuchten Function

Maximum: 1000

Minimum: 0.01

Num. Points: 20

Residual Water Content: 0 ft^3/ft^3

Gravelly Silty Sand

Model: Data Point Function

Function: X-Conductivity vs. Pore-Water Pressure

Curve Fit to Data: 100 %

Segment Curvature: 42 %

K-Saturation: 0.00021

Data Points: Matric Suction (psf), X-Conductivity (ft/sec)

Data Point: (0.05, 0.00021)

Data Point: (0.1, 0.00021)

Data Point: (0.84851, 0.00021)

Data Point: (7.1998, 0.00021)

Data Point: (61.087, 0.00014519661)

Data Point: (518.37, 2.7604915e-007)

Data Point: (4398.4, 1.1747068e-010)

Data Point: (25333, 7.5777966e-013)

Data Point: (37321, 3.3240508e-013)

Data Point: (316680, 3.3684237e-015)

Data Point: (2415100, 2.8970508e-017)

Data Point: (2687000, 2.2525763e-017)

Estimation Properties

Hydraulic K Sat: 0 ft/sec

Hyd. K-Function Estimation Method: Van Genuchten Function

Maximum: 1000

Minimum: 0.01

Num. Points: 20

Residual Water Content: 0 ft^3/ft^3

Silty Sand with Gravel

Model: Data Point Function

Function: X-Conductivity vs. Pore-Water Pressure

Curve Fit to Data: 100 %

Segment Curvature: 40 %

K-Saturation: 6.6e-005

Data Points: Matric Suction (psf), X-Conductivity (ft/sec)

Data Point: (0.05, 6.6e-005)

Data Point: (0.1, 6.6e-005)

Data Point: (0.84851, 6.6e-005)

Data Point: (7.1998, 4.9767745e-005)

Data Point: (61.091, 2.0882213e-006)

Data Point: (518.37, 6.4129532e-009)
Data Point: (4398.4, 2.6239915e-011)
Data Point: (25333, 2.8829362e-013)
Data Point: (37321, 1.2569021e-013)
Data Point: (316680, 1.4333702e-015)

Estimation Properties

Hydraulic K Sat: 0 ft/sec
Hyd. K-Function Estimation Method: Van Genuchten Function
Maximum: 1000
Minimum: 0.01
Num. Points: 20
Residual Water Content: 0 ft³/ft³

Sandy Silt

Model: Data Point Function
Function: X-Conductivity vs. Pore-Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 42 %
K-Saturation: 1.3e-006
Data Points: Matric Suction (psf), X-Conductivity (ft/sec)
Data Point: (0.05, 1.3e-006)
Data Point: (0.1, 1.3e-006)
Data Point: (0.84851, 1.3e-006)
Data Point: (7.1998, 1.2971847e-006)
Data Point: (61.087, 9.5007643e-007)
Data Point: (518.37, 5.7439299e-008)
Data Point: (4398.4, 4.9929936e-011)
Data Point: (25333, 6.0648726e-013)
Data Point: (37321, 2.1972484e-013)
Data Point: (316680, 1.6731911e-015)
Data Point: (2415100, 1.9197771e-017)
Data Point: (2687000, 1.5238153e-017)

Estimation Properties

Hydraulic K Sat: 0 ft/sec
Hyd. K-Function Estimation Method: Van Genuchten Function
Maximum: 1000
Minimum: 0.01
Num. Points: 20
Residual Water Content: 0 ft³/ft³

Regions

	Material	Points	Area (ft²)
Regio	Sandy	106,1,2,107	171.07972

n 1	Silty Clay (1)		
Region 2	Sandy Silty Clay (1)	1,108,3,4,5,6,7,8,9,10,11,12,2	962.07207
Region 3	Gravelly Silty Sand (2)	5,13,14,15,6	31.119887
Region 4	Gravelly Silty Sand (2)	7,8,15,6	819.48221
Region 5	Bottom Ash (3)	9,16,17,18,19,20,21,22,23,24,25,26,10	423.64067
Region 6	Gravelly Silty Sand (2)	18,27,28,29,30,31,19	32.648671
Region 7	Sandy Silt (5)	24,32,33,34,35,21,22,23	282.19505
Region 8	Silty Sand and Gravel (4)	21,20,19,31,36,37,38,39,40,41,42,43,44,45,35	1565.2892
Regio	Sandy	34,35,45,46	531.21818

n 9	Silt (5)		
Region 10	Silty Clay (6)	34,46,47,48,49,50,51,52,53,33	989.52619
Region 11	Fly Ash (7)	54,55,56,57,58,59,60,53,33,32,24,25,26,12,2,107	6796.2214
Region 12	Brown Clay (8)	54,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,109,91,92,93,94,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,60,59,58,57,56,55	6482.6655
Region 13	Silty Clay (9)	89,95,96,97,98,99,100,101,102,103,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88	22793.126
Region 14	Sandstone (10)	103,104,105,96,97,98,99,100,101,102	31301.229
Region 15	Bottom Ash 2 (11)	10,26,12,11	324.85555

Lines

	Start Point	End Point	Hydraulic Boundary
Line 1	1	2	
Line 2	3	4	
Line 3	4	5	
Line 4	5	6	
Line 5	6	7	
Line 6	7	8	
Line 7	8	9	
Line 8	9	10	

Line 9	10	11	
Line 10	11	12	
Line 11	12	2	
Line 12	5	13	
Line 13	13	14	
Line 14	14	15	
Line 15	15	6	
Line 16	8	15	
Line 17	9	16	
Line 18	16	17	
Line 19	17	18	
Line 20	18	19	
Line 21	19	20	
Line 22	20	21	
Line 23	21	22	
Line 24	22	23	
Line 25	23	24	
Line 26	24	25	
Line 27	25	26	
Line 28	26	12	
Line 29	18	27	
Line 30	27	28	
Line 31	28	29	
Line 32	29	30	Potential Seepage Face
Line 33	30	31	Potential Seepage Face
Line 34	31	19	
Line 35	24	32	
Line 36	32	33	
Line 37	33	34	
Line 38	34	35	
Line 39	35	21	
Line 40	31	36	Potential Seepage Face
Line 41	36	37	Potential Seepage Face
Line 42	37	38	
Line 43	38	39	
Line 44	39	40	

Line 45	40	41	
Line 46	41	42	
Line 47	42	43	
Line 48	43	44	
Line 49	44	45	
Line 50	45	35	
Line 51	45	46	
Line 52	46	34	
Line 53	46	47	
Line 54	47	48	
Line 55	48	49	
Line 56	49	50	
Line 57	50	51	
Line 58	51	52	
Line 59	52	53	
Line 60	53	33	
Line 61	54	55	
Line 62	55	56	
Line 63	56	57	
Line 64	57	58	
Line 65	58	59	
Line 66	59	60	
Line 67	60	53	
Line 68	54	61	
Line 69	61	62	
Line 70	62	63	
Line 71	63	64	
Line 72	64	65	
Line 73	65	66	
Line 74	66	67	
Line 75	67	68	
Line 76	68	69	
Line 77	69	70	
Line 78	70	71	
Line 79	71	72	
Line 80	72	73	

Line 81	73	74	
Line 82	74	75	
Line 83	75	76	
Line 84	76	77	
Line 85	77	78	
Line 86	78	79	
Line 87	79	80	
Line 88	80	81	
Line 89	81	82	
Line 90	82	83	
Line 91	83	84	
Line 92	84	85	
Line 93	85	86	
Line 94	86	87	
Line 95	87	88	
Line 96	88	89	
Line 97	89	90	Ohio River
Line 98	91	92	Potential Seepage Face
Line 99	92	93	Potential Seepage Face
Line 100	93	94	Potential Seepage Face
Line 101	94	37	Potential Seepage Face
Line 102	89	95	Ohio River
Line 103	95	96	
Line 104	96	97	
Line 105	97	98	
Line 106	98	99	
Line 107	99	100	
Line 108	100	101	
Line 109	101	102	
Line 110	102	103	
Line 111	103	61	
Line 112	103	104	
Line 113	104	105	
Line 114	105	96	
Line 115	106	1	Fly Ash Pond
Line 116	2	107	

Line 117	107	106	
Line 118	1	108	Fly Ash Pond
Line 119	108	3	
Line 120	90	109	Ohio River
Line 121	109	91	Potential Seepage Face
Line 122	26	10	
Line 123	54	107	

Points

	X (ft)	Y (ft)
Point 1	35.36015	595.10746
Point 2	35.37077	593.10938
Point 3	60.72629	605.9827
Point 4	74.8905	612.04606
Point 5	89.08286	617.98267
Point 6	93.72016	617.98376
Point 7	69.42633	602.00461
Point 8	151.61692	602.00605
Point 9	158.87128	599.99208
Point 10	171.82425	595.91741
Point 11	60.47732	595.91216
Point 12	56.0411	593.12487
Point 13	95.74708	619.48275
Point 14	106.57718	619.95406
Point 15	114.07579	617.99114
Point 16	166.70528	600.0213
Point 17	169.58045	600.43082
Point 18	200.94364	600.90024
Point 19	217.30273	592.80917
Point 20	213.38189	590.83858
Point 21	200.88583	589.29528
Point 22	195.25394	588.59744
Point 23	189.42126	588.62008
Point 24	184.5	590.20374
Point 25	181.51772	591.16693

Point 26	177.65846	593.12697
Point 27	204.98541	600.97594
Point 28	206.35442	602.21331
Point 29	206.71422	599.99306
Point 30	214.00828	595.98847
Point 31	222.27612	592.82454
Point 32	168.66722	580.09858
Point 33	175.21974	580.09858
Point 34	184.51087	580.09817
Point 35	213.24737	580.09272
Point 36	255.42934	580.07172
Point 37	317.48058	559.92079
Point 38	315.59736	559.88781
Point 39	309.9739	558.80103
Point 40	307.4465	558.76312
Point 41	287.58173	560.34006
Point 42	273.69358	560.81173
Point 43	259.80542	560.94275
Point 44	255.45555	560.94275
Point 45	239.61428	560.44981
Point 46	215.41971	560.03735
Point 47	206.90911	559.67804
Point 48	185.33019	558.38907
Point 49	177.08328	558.01754
Point 50	173.62075	558.106
Point 51	169.80438	558.01754
Point 52	164.66112	558.14391
Point 53	135.13429	560.09691
Point 54	-50	561.74545
Point 55	20.16974	561.49271
Point 56	28.34588	561.72018
Point 57	50.65765	561.88173
Point 58	61.94724	561.81622
Point 59	89.85457	561.6852
Point 60	105.36228	561.59785
Point 61	-50	552.17166

Point 62	19.23461	550.94335
Point 63	32.24565	551.32246
Point 64	41.85988	551.67124
Point 65	47.10676	551.74706
Point 66	56.64516	551.4741
Point 67	78.08761	551.61058
Point 68	95.40534	551.48927
Point 69	105.51999	551.66113
Point 70	114.75208	551.07983
Point 71	124.43302	550.29735
Point 72	142.61209	549.56582
Point 73	165.69351	548.62684
Point 74	187.96697	548.08092
Point 75	205.85125	547.44765
Point 76	216.92246	547.535
Point 77	233.69307	548.10276
Point 78	236.99041	548.14643
Point 79	242.18755	547.92806
Point 80	246.77327	547.31663
Point 81	252.65171	546.21606
Point 82	273.24811	541.09055
Point 83	281.07788	538.66929
Point 84	297.9009	534.10978
Point 85	305.69923	532.66332
Point 86	316.39049	531.68853
Point 87	338.77924	530.77663
Point 88	389.87718	528.88993
Point 89	422.60496	527.57608
Point 90	411.3282	538.58079
Point 91	401.8504	540.81657
Point 92	388.80805	543.92059
Point 93	352.80366	551.31013
Point 94	329.44346	556.01129
Point 95	550	524.91002
Point 96	550	499.15439
Point 97	396.01919	499.3174

Point 98	313.20998	500.09985
Point 99	256.3846	503.93603
Point 100	240.95296	504.37072
Point 101	191.37067	504.40695
Point 102	86.37793	504.45549
Point 103	-50	504.13087
Point 104	-50	449.97963
Point 105	550	450.03403
Point 106	-49.97813	595.11744
Point 107	-49.97513	593.10625
Point 108	58.47531	605
Point 109	405.33383	539.99484

APPENDIX IV

DYNAMIC FINITE ELEMENT STRESS ANALYSES

**DYNAMIC FINITE ELEMENT STRESS ANALYSIS SUMMARY
EASTERN DIKE LIQUEFACTION ASSESSMENT
FLY ASH DISPOSAL FACILITY
PHILIP SPORN PLANT
NEW HAVEN, MASON COUNTY, WEST VIRGINIA
GA FILE NO. 09-387**

GENERAL

Geo/Environmental Associates, Inc. (GA) has prepared dynamic finite element stress analyses for the Eastern Dike of the Fly Ash Disposal Facility at the Philip Sporn Plant. Specifically, GA has evaluated Section K-K, Section L-L, and Section M-M of the Fly Ash Disposal Facility - Eastern Dike. The dynamic finite element stress analyses were conducted using the computer program *QUAKE/W*. *QUAKE/W* is developed by GEO-SLOPE International, Ltd. of Calgary, Alberta, Canada. A general discussion of the methodology used for the *QUAKE/W* analyses is provided in the reference *Procedures and Methods for a Liquefaction Assessment using GeoStudio 2007*, published by GEO-SLOPE International, Ltd. (Note that GeoStudio includes the *SEEP/W*, *QUAKE/W*, and *SLOPE/W* computer programs).

The *QUAKE/W* finite element program was used to model stresses in the embankment under static and dynamic conditions. Specifically, the linear-elastic constitutive model with two-dimensional plane strain conditions was used in the finite element analyses. The initial static analyses use pore pressure conditions imported from *SEEP/W* and specified material parameters to determine initial stress conditions. The dynamic conditions were modeled using earthquake time-acceleration data for an earthquake centered in the Giles County, Virginia, area. The earthquake was scaled to the earthquake ground acceleration value of 0.06g, as specified in the USEPA request for information. The Giles County earthquake was chosen because of its proximity to the Philip Sporn Power Plant (i.e., approximately 130 miles southeast of the site), the area's history of producing measurable earthquakes, and the availability of time-acceleration data for the area. The time-acceleration data for the Giles County earthquake used in the analyses was provided in *Research Report KTC-96-4 Source Zones, Recurrence Rates, and Time Histories for Earthquakes Affecting Kentucky*. The *QUAKE/W* dynamic analyses were used to calculate the stress conditions at specified time steps throughout the earthquake event.

MATERIAL PARAMETERS

Material parameters for the various embankment and foundation materials used in the finite element liquefaction assessment for critical Sections K-K, L-L, and M-M are provided in Tables IV-1.1, IV-1.2, IV-2, and IV-3 respectively. In general, parameters were based on site specific data and from accepted reference materials in relation to the site specific soils/conditions. Material parameters required for the finite element stress analysis include the unit weight, damping ratio, small strain shear modulus, cyclic number function (CNF), Poisson's ratio, and effective angle of internal friction. The damping ratios for the fly ash and foundation materials were determined by free-free resonant column testing performed by Dr. Michael Kalinski at the University of Kentucky. The damping ratios for the remaining embankment materials were conservatively estimated based on published data, as related to site specific materials. Small strain shear modulus (G_{max}) values were calculated from shear wave velocity data that was obtained by Dr. Kalinski using cross borehole seismic testing performed in the eastern dike. Hand calculations of G_{max} values are included in Appendix II. Poisson's ratio was also provided by Dr. Kalinski from the cross borehole seismic testing in the eastern dike. Unit weights were determined from in situ and laboratory testing performed by AEP and GA. The Cyclic Stress Ratio (CSR) curve for fly ash was provided by Ohio State University. Specifically, cyclic triaxial testing was conducted by Ohio State University using fly ash bulk samples obtained from the site. For the cyclic triaxial testing, the fly ash materials were reconstituted to an initial minimum density of 62 pounds per cubic foot, as measured for the minimum in-place density during on-site laboratory testing of undisturbed fly ash piston tube samples. The Cyclic Stress Ratio (CSR) graph developed during the cyclic triaxial strength testing of the fly ash material is provided in Appendix II.

TABLE IV.1.1. QUAKE/W MATERIAL PARAMETERS FOR SECTION K-K FINITE ELEMENT/LIQUEFACTION ANALYSIS

	Silty Clay (1)	Gravelly Silty Sand (2)	Sand and Gravel (3)	Bottom Ash (4)	Gravelly Silty Sand (5)	Silty Clay (6)	Bottom Ash 65 (7)	Fly Ash (8)	Sandy Silt (9)	Clay Foundation (10)	Clay Foundation (11)	Silty Clay Foundation (12)
Unit Weight γ (pcf)	125	108	114	100	110	128	90	98	100	125	130	125
Source	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)
Damping Ratio λ (%)	10	10	10	10	10	10	10	4.5	10	7	7	7
Source(5)	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Kalinski Report	Seed-Idriss, Kokusho	Kalinski Report	Kalinski Report	Kalinski Report
Small Strain Shear Modulus G_{max} (psf)	3,718,376	3,212,677	3,391,159	2,974,701	3,272,171	1,914,578	1,246,188	690,304	2,974,701	1,869,705	1,944,493	1,869,705
Source(3)	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report
Poisson's Ratio ν	.45	0.352	0.352	0.352	0.352	0.45	0.45	0.495	0.352	0.45	0.45	0.45
Source	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report
Cyclic Number Function(4)	None	None	None	None	None	None	None	OSU	None	None	None	None

Notes:

(1) AEP Philip Sporn Electric Generating Plant Bottom Ash Facility - Engineering Report, 1996

(2) AEP Philip Sporn Power Plant Bottom Ash Disposal Facility - Stability Analysis, 2009

(3) G_{max} derived from shear wave velocities from cross hole measurements

(4) Cyclic Number Function for fly ash based on cyclic triaxial testing data prepared by Ohio State University (OSU)

(5) Damping Ratios From:
- Kalinski Report – for fly ash and foundation soil
- Seed Idriss (SHAKE91 Users Manual)
- Kokusho (Geotchnical Earthquake Engineering by Kuo Towhata)

TABLE IV.1.2. QUAKE/W MATERIAL PARAMETERS FOR SECTION K-K FINITE ELEMENT/LIQUEFACTION ANALYSIS

	Original Dike (13)	**Foundation Soil (14)**
Unit Weight γ (pcf)	130	130
Source	AEP(1,2)	AEP(1,2)
Damping Ratio λ (%)	10	7
Source(5)	Seed-Idriss, Kokusho	Kalinski Report
Small Strain Shear Modulus G_{max} (psf)	3,867,111	1,944,493
Source(3)	Kalinski Report	Kalinski Report
Poisson's Ratio ν	0.45	0.45
Source	Kalinski Report	Kalinski Report
Cyclic Number Function(4)	None	None

Notes:

(1) AEP Philip Sporn Electric Generating Plant Bottom Ash Facility - Engineering Report, 1996
(2) AEP Philip Sporn Power Plant Bottom Ash Disposal Facility - Stability Analysis, 2009
(3) G_{max} derived from shear wave velocities from cross hole measurements
(4) Cyclic Number Function for fly ash based on cyclic triaxial testing data prepared by Ohio State University (OSU)
(5) Damping Ratios From:
- Kalinski Report – for fly ash and foundation soil
- Seed Idriss (SHAKE91 Users Manual)
- Kokusho (Geotchnical Earthquake Engineering by Kuo Towhata)

TABLE IV.2. QUAKE/W MATERIAL PARAMETERS FOR SECTION L-L FINITE ELEMENT/LIQUEFACTION ANALYSIS

	Sandy Silty Clay (1)	Road Fill (2)	Gravelly Silty Sand (3)	Gravelly Silty Sand (4)	Bottom Ash (5)	Silty Sand and Gravel (6)	Silty Sandy Clay (7)	Silty Clay (8)	Fly Ash (9)	Clay Foundation (10)	Clay Foundation (11)	Silty Clay Foundation (12)
Unit Weight γ (pcf)	130	110	110	100	65	115	130	130	110	125	125	130
Source	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]
Damping Ratio λ (%)	10	10	10	10	10	10	10	10	4.5	7	7	7
Source[5]	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report
Small Strain Shear Modulus G_{max} (psf)	3,867,112	3,272,171	3,272,171	2,974,701	1,933,556	3,420,906	3,867,112	3,867,112	774,831	1,869,705	1,869,705	1,944,493
Source[3]	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report
Poisson's Ratio v	0.45	0.352	0.352	0.352	0.352	0.352	0.45	0.45	0.495	0.45	0.45	0.45
Source	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report
Cyclic Number Function[4]	None	None	None	None	None	None	None	None	OSU	None	None	None

Notes:

(1) AEP Philip Sporn Electric Generating Plant Fly Ash Facility - Engineering Report, 1998
(2) AEP Philip Sporn Power Plant Fly Ash Disposal Facility - Stability Analysis, 2009
(3) G_{max} derived from shear wave velocities from cross hole measurements
(4) Cyclic Number Function for fly ash based on cyclic triaxial testing data prepared by Ohio State University (OSU)
(5) Damping Ratios From:
- Kalinski Report – for fly ash and foundation soil
- Seed Idriss (SHAKE91 Users Manual)
- Kokusho (Geotchnical Earthquake Engineering by Kuo Towhata)

TABLE IV.3. QUAKE/W MATERIAL PARAMETERS FOR SECTION M-M FINITE ELEMENT/LIQUEFACTION ANALYSIS

	Sandy Silty Clay (1)	Gravelly Silty Sand (2)	Bottom Ash (3)	Silty Sand and Gravel (4)	Sandy Silt (5)	Silty Clay (6)	Fly Ash (7)	Brown Clay (8)	Silty Clay (9)	Sandstone (10)	Bottom Ash 2 (11)
Unit Weight γ (pcf)	125	125	65	115	115	130	110	125	126	140	90
Source	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	-	AEP(1,2)
Damping Ratio λ (%)	10	10	10	10	10	10	4.5	7	7	1	10
Source(5)	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Seed-Idriss, Kokusho	Kalinski Report	Kalinski Report	Kalinski Report	-	Seed-Idriss, Kokusho
Small Strain Shear Modulus G_{max} (psf)	3,718,376	3,718,376	1,933,556	3,420,906	3,867,112	3,867,112	774,831	1,869,705	1,884,663	78,000,000	2,677,231
Source(3)	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Bowles	Kalinski Report
Poisson's Ratio ν	0.45	0.352	0.352	0.352	0.45	0.45	0.495	0.45	0.45	0.2	0.45
Source	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Kalinski Report	Bowles	Kalinski Report
Cyclic Number Function(4)	None	None	None	None	None	None	OSU	None	None	None	None

Notes:

(1) AEP Philip Sporn Electric Generating Plant Fly Ash Facility - Engineering Report, 1998
(2) AEP Philip Sporn Power Plant Fly Ash Disposal Facility - Stability Analysis, 2009
(3) G_{max} derived from shear wave velocities from cross hole measurements or referenced value
(4) Cyclic Number Function for fly ash based on cyclic triaxial testing data prepared by Ohio State University (OSU)
(5) Damping Ratios From:
- Kalinski Report – for fly ash and foundation soils 8 and 9
- Seed Idriss (SHAKE91 Users Manual)
- Kokusho (Geotchnical Earthquake Engineering by Kuo Towhata)

QUAKE/W FINITE ELEMENT ANALYSIS RESULTS

Using the general methodology prescribed in the reference *Procedures and Methods for a Liquefaction Assessment using GeoStudio 2007*, GA used *QUAKE/W* finite element stress analyses to assess the liquefaction potential of the fly ash material beneath the Fly Ash Disposal Facility – Eastern Dike. Specifically, GA used QUAKE/W to perform dynamic finite element stress analyses for Section K-K, Section L-L, and Section M-M of the eastern dike. Given the site specific material parameters and seismic time-acceleration data scaled for site conditions (i.e., the design earthquake), *QUAKE/W* analyses were performed to delineate potential liquefaction zones within the critical sections. During an earthquake event, ground motions can cause an increase in the effective stress. If this increase in effective stress overcomes the shear strength of the soil, liquefaction can occur. In the analyses provided herein, the loading/stress conditions that could promote liquefaction is not predicted. Graphical output pages from the *QUAKE/W* finite element stress analyses are provided in this appendix. As shown in the output and in Table IV.4, no liquefaction is predicted for any of the three critical sections for the given design earthquake loading conditions. Based on the results of these analyses we believe that liquefaction of the fly ash foundation material below the upper section of the Fly Ash Disposal Facility – Eastern Dike is unlikely during the design earthquake event.

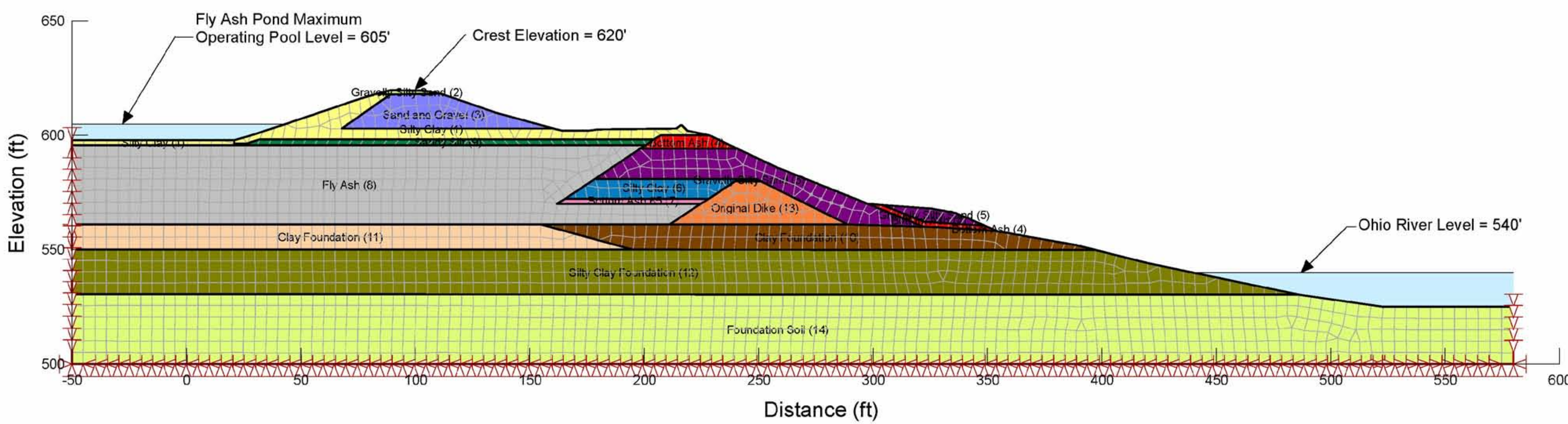
TABLE IV.4
SUMMARY FINITE ELEMENT STRESS ANALYSIS LIQUEFACTION RESULTS
BASED ON GILES COUNTY EARTHQUAKE SCALED TO 0.06g

Critical Section	Liquefaction of Fly Ash Foundation Predicted?
Section K-K	NO
Section L-L	NO
Section M-M	NO

SECTION K-K

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section K-K Finite Element Stress Analysis
File Name: FAP_K-K_QUAKE_MESH.gsz
Date: 7/23/2010

QUAKE/W MESH



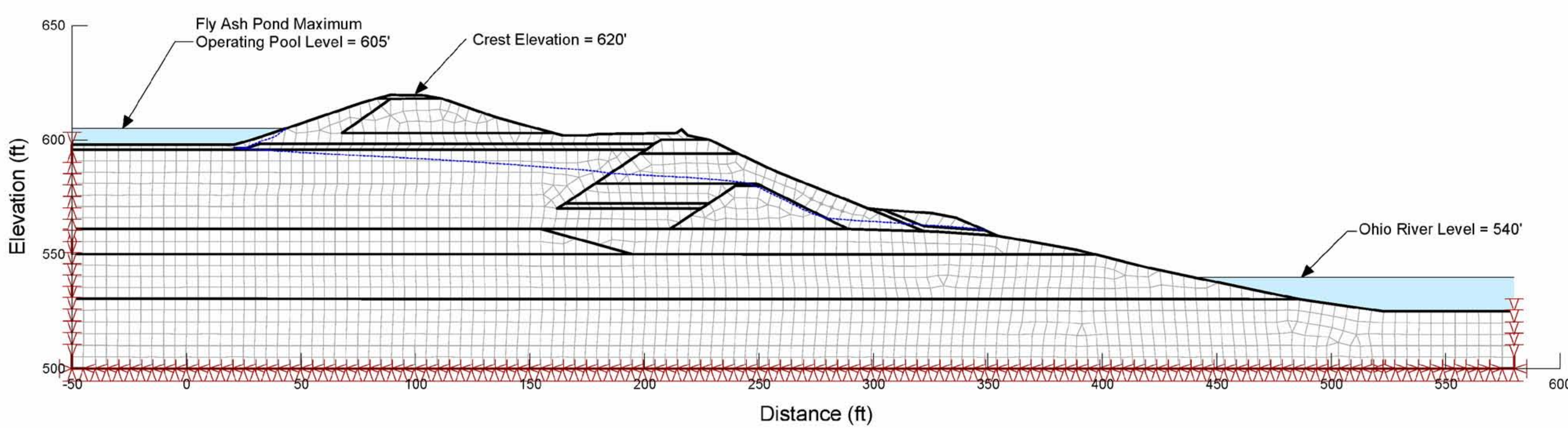
Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section K-K Finite Element Stress Analysis
File Name: FAP_K-K_QUAKE_RESULTS.gsz
Date: 7/23/2010

QUAKE/W MESH RESULTS WITH LIQUEFIED ZONES

NOTE: NO LIQUEFACTION PREDICTED

ELEMENT THAT DOES NOT LIQUEFY UNDER THE MODELED CONDITIONS →

ELEMENT THAT LIQUEFIES UNDER THE MODELED CONDITIONS →



Dynamic QUAKE/W

File Information

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section K-K Finite Element Stress Analysis
Revision Number: 132
Last Edited By: Seth Frank
Date: 7/23/2010
Time: 2:19:29 PM
File Name: FAP_K-K_QUAKE_RESULTS.gsz
Directory: P:\Frank\Philip Sporn\SEISMIC REPORT\Updated Analysis Files\
Last Solved Date: 7/23/2010
Last Solved Time: 2:26:24 PM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Stiffness Units: psf
Unit Weight of Water: 62.4 pcf
Air Pressure: 101.33 psf
View: 2D

Analysis Settings

Dynamic QUAKE/W

Kind: QUAKE/W
Parent: Initial Static
Method: Equivalent Linear Dynamic
Settings
- Initial Stress: Parent Analysis
- Initial PWP: Parent Analysis
- Exclude cumulative values: No

Control
- Coefficient of Equivalent Shear Stress: 0.65
- Coefficient of Equivalent Shear Strain: 0.5
- Equivalent Number of Cycles: 10
- Liquefaction Stress Limit: 0

Convergence

Maximum Number of Iterations: 10
Displacement Norm Tolerance: 1 %

Time

Starting Time: 0 sec
Duration: 5.125 sec
# of Steps: 1025
Save Steps Every: 10
Steps Generated via Earthquake Records: Yes

Materials

Silty Clay (1)

Model: Linear Elastic

Stress Strain

Unit Weight: 125 pcf
Poisson's Ratio: 0.45
Damping Ratio: 0.1
Pore Water Pressure Function: New Function
G Modulus: 3718376 psf

Gravelly Silty Sand (2)

Model: Linear Elastic

Stress Strain

Unit Weight: 108 pcf
Poisson's Ratio: 0.352
Damping Ratio: 0.1
Pore Water Pressure Function: New Function
G Modulus: 3212677 psf

Sand and Gravel (3)

Model: Linear Elastic

Stress Strain

Unit Weight: 114 pcf
Poisson's Ratio: 0.352
Damping Ratio: 0.1
Pore Water Pressure Function: New Function
G Modulus: 3391159 psf

Bottom Ash (4)

Model: Linear Elastic

Stress Strain

Unit Weight: 100 pcf
Poisson's Ratio: 0.352
Damping Ratio: 0.1
Pore Water Pressure Function: New Function
G Modulus: 2974701 psf

Gravelly Silty Sand (5)

Model: Linear Elastic
Stress Strain
Unit Weight: 110 pcf
Poisson's Ratio: 0.352
Damping Ratio: 0.1
Pore Water Pressure Function: New Function
G Modulus: 3272171 psf

Silty Clay (6)

Model: Linear Elastic
Stress Strain
Unit Weight: 128 pcf
Poisson's Ratio: 0.45
Damping Ratio: 0.1
Pore Water Pressure Function: New Function
G Modulus: 1914578 psf

Bottom Ash 65 (7)

Model: Linear Elastic
Stress Strain
Unit Weight: 90 pcf
Poisson's Ratio: 0.45
Damping Ratio: 0.1
Pore Water Pressure Function: New Function
G Modulus: 1246188 psf

Fly Ash (8)

Model: Linear Elastic
Stress Strain
Unit Weight: 98 pcf
Poisson's Ratio: 0.495
Damping Ratio: 0.045
Pore Water Pressure Function: New Function
Cyclic Function: Cyclic Triaxial Results for Fly Ash
G Modulus: 690304 psf

Sandy Silt (9)

Model: Linear Elastic
Stress Strain
Unit Weight: 100 pcf
Poisson's Ratio: 0.352
Damping Ratio: 0.1
Pore Water Pressure Function: New Function
G Modulus: 2974701 psf

Clay Foundation (10)

Model: Linear Elastic
Stress Strain
Unit Weight: 125 pcf
Poisson's Ratio: 0.45
Damping Ratio: 0.07
Pore Water Pressure Function: New Function
G Modulus: 1869705 psf

Clay Foundation (11)

Model: Linear Elastic
Stress Strain
Unit Weight: 130 pcf
Poisson's Ratio: 0.45
Damping Ratio: 0.07
Pore Water Pressure Function: New Function
G Modulus: 1944493 psf

Silty Clay Foundation (12)

Model: Linear Elastic
Stress Strain
Unit Weight: 125 pcf
Poisson's Ratio: 0.45
Damping Ratio: 0.07
Pore Water Pressure Function: New Function
G Modulus: 1869705 psf

Original Dike (13)

Model: Linear Elastic
Stress Strain
Unit Weight: 130 pcf
Poisson's Ratio: 0.45
Damping Ratio: 0.1
Pore Water Pressure Function: New Function
G Modulus: 3867111 psf

Foundation Soil (14)

Model: Linear Elastic
Stress Strain
Unit Weight: 130 pcf
Poisson's Ratio: 0.45
Damping Ratio: 0.07
Pore Water Pressure Function: New Function
G Modulus: 1944493 psf

Boundary Conditions

Fixed Y

X: 0
Y: Y-Displacement 0

Fixed X/Y

X: X-Displacement 0
Y: Y-Displacement 0

Earthquake Records

Horizontal Earthquake Records

Description: Giles Co
Use Baseline Correction: No
Modified Peak Acc.: 1
Modified Duration: 1

Records

	Time (sec)	Acc (ft/sec^2)
1	0.005	0.0002252
2	0.01	0.0004806
3	0.015	0.0006091
4	0.02	0.0006336
5	0.025	0.000619
6	0.03	0.0006133
7	0.035	0.0006126
8	0.04	0.0006149
9	0.045	0.0006244
10	0.05	0.0006359
11	0.055	0.0006489
12	0.06	0.0006636
13	0.065	0.0006699
14	0.07	0.0006753
15	0.075	0.0006999
16	0.08	0.0007235
17	0.085	0.0007153
18	0.09	0.0007094

19	0.095	0.0007379
20	0.1	0.0007451
21	0.105	0.0007109
22	0.11	0.0007434
23	0.115	0.0008756
24	0.12	0.0009596
25	0.125	0.0009336
26	0.13	0.0009042
27	0.135	0.0008036
28	0.14	0.000411
29	0.145	-5.14e-005
30	0.15	0.0001137
31	0.155	0.0012106
32	0.16	0.0027418
33	0.165	0.0040178
34	0.17	0.004533
35	0.175	0.0036267
36	0.18	0.0006306
37	0.185	-0.0040431
38	0.19	-0.0080566
39	0.195	-0.007726
40	0.2	-0.0004478
41	0.205	0.0120988
42	0.21	0.0236196
43	0.215	0.0281112
44	0.22	0.0251375
45	0.225	0.0183908
46	0.23	0.0103121
47	0.235	0.0019936
48	0.24	-0.0027726
49	0.245	0.0003438
50	0.25	0.0088108
51	0.255	0.0139334
52	0.26	0.0110236
53	0.265	0.0036809
54	0.27	-0.0035294

55	0.275	-0.0105479
56	0.28	-0.0175788
57	0.285	-0.0212473
58	0.29	-0.0184
59	0.295	-0.0099158
60	0.3	0.0010443
61	0.305	0.0108225
62	0.31	0.0148055
63	0.315	0.0100035
64	0.32	-0.0007076
65	0.325	-0.0107373
66	0.33	-0.0166978
67	0.335	-0.0200445
68	0.34	-0.0226399
69	0.345	-0.0245554
70	0.35	-0.0258552
71	0.355	-0.0272427
72	0.36	-0.0290774
73	0.365	-0.0313277
74	0.37	-0.0329538
75	0.375	-0.030538
76	0.38	-0.021124
77	0.385	-0.0083604
78	0.39	-0.0017502
79	0.395	-0.0064239
80	0.4	-0.0163815
81	0.405	-0.0209451
82	0.41	-0.0159514
83	0.415	-0.0060669
84	0.42	0.0021128
85	0.425	0.0061293
86	0.43	0.0071432
87	0.435	0.0065471
88	0.44	0.0056637
89	0.445	0.0079156
90	0.45	0.0172907

91	0.455	0.0324349
92	0.46	0.0451973
93	0.465	0.0481252
94	0.47	0.0412079
95	0.475	0.0288628
96	0.48	0.0144336
97	0.485	0.0016896
98	0.49	-0.0034407
99	0.495	0.000286
100	0.5	0.0040543
101	0.505	-0.0018455
102	0.51	-0.014756
103	0.515	-0.0224288
104	0.52	-0.0186531
105	0.525	-0.0099698
106	0.53	-0.0062783
107	0.535	-0.0096605
108	0.54	-0.0136626
109	0.545	-0.0103853
110	0.55	0.0027172
111	0.555	0.0208572
112	0.56	0.0353276
113	0.565	0.0394587
114	0.57	0.0326676
115	0.575	0.0206575
116	0.58	0.0121413
117	0.585	0.0124571
118	0.59	0.017735
119	0.595	0.0174082
120	0.6	0.0059386
121	0.605	-0.0091326
122	0.61	-0.0145239
123	0.615	-0.0066629
124	0.62	0.0032267
125	0.625	0.0006626
126	0.63	-0.0166168

127	0.635	-0.0353799
128	0.64	-0.0389058
129	0.645	-0.0221588
130	0.65	0.0049074
131	0.655	0.0281044
132	0.66	0.0408834
133	0.665	0.045335
134	0.67	0.0450154
135	0.675	0.0399197
136	0.68	0.0273501
137	0.685	0.0057392
138	0.69	-0.02143
139	0.695	-0.044943
140	0.7	-0.05573
141	0.705	-0.0526891
142	0.71	-0.0420862
143	0.715	-0.0287676
144	0.72	-0.0124826
145	0.725	0.0052199
146	0.73	0.0159773
147	0.735	0.0119913
148	0.74	-0.0033358
149	0.745	-0.0170346
150	0.75	-0.0197666
151	0.755	-0.0147384
152	0.76	-0.0116916
153	0.765	-0.0132587
154	0.77	-0.0107467
155	0.775	0.004124
156	0.78	0.0257997
157	0.785	0.0386819
158	0.79	0.0351386
159	0.795	0.0243038
160	0.8	0.0201176
161	0.805	0.0255344
162	0.81	0.0329668

163	0.815	0.0360837
164	0.82	0.0344654
165	0.825	0.028107
166	0.83	0.0148789
167	0.835	-0.0038921
168	0.84	-0.0199591
169	0.845	-0.0242331
170	0.85	-0.0152663
171	0.855	-0.0002955
172	0.86	0.01042
173	0.865	0.0097146
174	0.87	-0.0020464
175	0.875	-0.0154448
176	0.88	-0.018202
177	0.885	-0.0078782
178	0.89	0.0029692
179	0.895	-0.000807
180	0.9	-0.0198658
181	0.905	-0.0403203
182	0.91	-0.0502033
183	0.915	-0.0504452
184	0.92	-0.0489627
185	0.925	-0.0502036
186	0.93	-0.0534861
187	0.935	-0.0565266
188	0.94	-0.0559057
189	0.945	-0.0465097
190	0.95	-0.0251058
191	0.955	0.0050059
192	0.96	0.0345675
193	0.965	0.0541503
194	0.97	0.06
195	0.975	0.0553696
196	0.98	0.0460484
197	0.985	0.0344038
198	0.99	0.0197362

199	0.995	0.0049496
200	1	-0.002022
201	1.005	0.0023018
202	1.01	0.0098066
203	1.015	0.0092365
204	1.02	8.69e-005
205	1.025	-0.0077083
206	1.03	-0.006817
207	1.035	0.0003858
208	1.04	0.0066127
209	1.045	0.005504
210	1.05	-0.0062733
211	1.055	-0.025407
212	1.06	-0.0396539
213	1.065	-0.036286
214	1.07	-0.0155686
215	1.075	0.0087087
216	1.08	0.0234379
217	1.085	0.026477
218	1.09	0.0227851
219	1.095	0.0173007
220	1.1	0.0143316
221	1.105	0.0173657
222	1.11	0.0239464
223	1.115	0.0243109
224	1.12	0.0109262
225	1.125	-0.0112788
226	1.13	-0.0282641
227	1.135	-0.030954
228	1.14	-0.0237618
229	1.145	-0.0189783
230	1.15	-0.0243334
231	1.155	-0.0359955
232	1.16	-0.0423053
233	1.165	-0.0345325
234	1.17	-0.0154861

235	1.175	0.0024812
236	1.18	0.0092208
237	1.185	0.0061612
238	1.19	0.0028645
239	1.195	0.0059456
240	1.2	0.0142515
241	1.205	0.0232854
242	1.21	0.029106
243	1.215	0.027335
244	1.22	0.014708
245	1.225	-0.0040195
246	1.23	-0.0145743
247	1.235	-0.0046056
248	1.24	0.0227943
249	1.245	0.0498825
250	1.25	0.0593509
251	1.255	0.0478944
252	1.26	0.0260722
253	1.265	0.0074069
254	1.27	-0.0016088
255	1.275	-0.0031106
256	1.28	-0.0031803
257	1.285	-0.0069234
258	1.29	-0.0155334
259	1.295	-0.0248911
260	1.3	-0.0277331
261	1.305	-0.020496
262	1.31	-0.0084763
263	1.315	-0.0018686
264	1.32	-0.0062347
265	1.325	-0.0179731
266	1.33	-0.0279077
267	1.335	-0.0277083
268	1.34	-0.0152588
269	1.345	0.0030553
270	1.35	0.0169486

271	1.355	0.0220868
272	1.36	0.0240213
273	1.365	0.0302152
274	1.37	0.0404707
275	1.375	0.047736
276	1.38	0.0459893
277	1.385	0.0348329
278	1.39	0.0187427
279	1.395	0.0042443
280	1.4	-0.0044891
281	1.405	-0.0094875
282	1.41	-0.0163807
283	1.415	-0.0265963
284	1.42	-0.0351327
285	1.425	-0.0376928
286	1.43	-0.0363943
287	1.435	-0.0356472
288	1.44	-0.035421
289	1.445	-0.0321438
290	1.45	-0.0246377
291	1.455	-0.0158217
292	1.46	-0.0088933
293	1.465	-0.0042561
294	1.47	-0.000624
295	1.475	0.0021988
296	1.48	0.0025612
297	1.485	-0.0006468
298	1.49	-0.0049733
299	1.495	-0.0053505
300	1.5	0.0001511
301	1.505	0.0065246
302	1.51	0.0067986
303	1.515	0.0011804
304	1.52	-0.001992
305	1.525	0.0038399
306	1.53	0.0152949

307	1.535	0.0233471
308	1.54	0.0234448
309	1.545	0.0176426
310	1.55	0.0083096
311	1.555	-0.0045231
312	1.56	-0.0180061
313	1.565	-0.0240088
314	1.57	-0.0165257
315	1.575	0.0004142
316	1.58	0.0162772
317	1.585	0.0244756
318	1.59	0.0257214
319	1.595	0.0222743
320	1.6	0.0140869
321	1.605	0.0016996
322	1.61	-0.0112501
323	1.615	-0.0203543
324	1.62	-0.0229073
325	1.625	-0.0178852
326	1.63	-0.0069651
327	1.635	0.0042053
328	1.64	0.0102281
329	1.645	0.0125519
330	1.65	0.0172746
331	1.655	0.0247309
332	1.66	0.0262524
333	1.665	0.0144918
334	1.67	-0.0065738
335	1.675	-0.0249497
336	1.68	-0.0313339
337	1.685	-0.0247544
338	1.69	-0.0111742
339	1.695	0.000749
340	1.7	0.0054044
341	1.705	0.0047089
342	1.71	0.0053119

343	1.715	0.0100305
344	1.72	0.0144764
345	1.725	0.0132799
346	1.73	0.0065097
347	1.735	-0.0017627
348	1.74	-0.0081066
349	1.745	-0.010632
350	1.75	-0.008009
351	1.755	-0.0008037
352	1.76	0.0071387
353	1.765	0.011079
354	1.77	0.0094773
355	1.775	0.0050805
356	1.78	0.0021308
357	1.785	0.0025773
358	1.79	0.0045465
359	1.795	0.004546
360	1.8	0.001408
361	1.805	-0.0023775
362	1.81	-0.0033548
363	1.815	-0.0003448
364	1.82	0.0047573
365	1.825	0.0078407
366	1.83	0.0044702
367	1.835	-0.0063462
368	1.84	-0.0192476
369	1.845	-0.0257676
370	1.85	-0.022042
371	1.855	-0.0117109
372	1.86	-0.0005552
373	1.865	0.0090575
374	1.87	0.0170248
375	1.875	0.0218276
376	1.88	0.0208651
377	1.885	0.0134539
378	1.89	0.0019905

379	1.895	-0.0088456
380	1.9	-0.013602
381	1.905	-0.0091876
382	1.91	0.0018389
383	1.915	0.0126639
384	1.92	0.01832
385	1.925	0.0192963
386	1.93	0.0184552
387	1.935	0.0164237
388	1.94	0.0118745
389	1.945	0.0052038
390	1.95	-0.0004723
391	1.955	-0.0027264
392	1.96	-0.0031285
393	1.965	-0.0057585
394	1.97	-0.012054
395	1.975	-0.0181137
396	1.98	-0.0182542
397	1.985	-0.0111688
398	1.99	-0.0017544
399	1.995	0.0033205
400	2	0.001554
401	2.005	-0.0037904
402	2.01	-0.0078063
403	2.015	-0.0093261
404	2.02	-0.0111895
405	2.025	-0.014845
406	2.03	-0.0167404
407	2.035	-0.0121878
408	2.04	-0.0016862
409	2.045	0.0087666
410	2.05	0.0128625
411	2.055	0.0080069
412	2.06	-0.0037657
413	2.065	-0.0162093
414	2.07	-0.0219134

415	2.075	-0.0181145
416	2.08	-0.0089403
417	2.085	-0.000348
418	2.09	0.0054233
419	2.095	0.0091007
420	2.1	0.0112023
421	2.105	0.011998
422	2.11	0.0119496
423	2.115	0.0099294
424	2.12	0.0037218
425	2.125	-0.0055989
426	2.13	-0.0126656
427	2.135	-0.0133924
428	2.14	-0.0091604
429	2.145	-0.0040732
430	2.15	-0.000916
431	2.155	-0.0010548
432	2.16	-0.005042
433	2.165	-0.0113743
434	2.17	-0.0168366
435	2.175	-0.0194702
436	2.18	-0.0198812
437	2.185	-0.0194856
438	2.19	-0.0188451
439	2.195	-0.0171402
440	2.2	-0.0120884
441	2.205	-0.0021767
442	2.21	0.0092347
443	2.215	0.0145982
444	2.22	0.0099724
445	2.225	0.000388
446	2.23	-0.0052344
447	2.235	-0.0029222
448	2.24	0.0045585
449	2.245	0.0122482
450	2.25	0.0166438

451	2.255	0.0168919
452	2.26	0.0151228
453	2.265	0.0143918
454	2.27	0.0148135
455	2.275	0.0136973
456	2.28	0.0106437
457	2.285	0.0093281
458	2.29	0.0118562
459	2.295	0.0142919
460	2.3	0.0113772
461	2.305	0.004256
462	2.31	-9.67e-005
463	2.315	0.002778
464	2.32	0.0096234
465	2.325	0.0131973
466	2.33	0.0093584
467	2.335	-0.0003629
468	2.34	-0.0114765
469	2.345	-0.0197172
470	2.35	-0.0218815
471	2.355	-0.0161812
472	2.36	-0.0038886
473	2.365	0.0099717
474	2.37	0.0195014
475	2.375	0.0219833
476	2.38	0.018504
477	2.385	0.0114653
478	2.39	0.0033243
479	2.395	-0.002827
480	2.4	-0.0043823
481	2.405	-0.0019333
482	2.41	0.0011551
483	2.415	0.0028748
484	2.42	0.0044948
485	2.425	0.0074654
486	2.43	0.0105322

487	2.435	0.0115961
488	2.44	0.0109749
489	2.445	0.0109908
490	2.45	0.0129021
491	2.455	0.0152854
492	2.46	0.0149214
493	2.465	0.0089844
494	2.47	-0.0022438
495	2.475	-0.0139943
496	2.48	-0.0196087
497	2.485	-0.0158399
498	2.49	-0.0055279
499	2.495	0.0049029
500	2.5	0.0100502
501	2.505	0.0084877
502	2.51	0.0029948
503	2.515	-0.0019448
504	2.52	-0.0040888
505	2.525	-0.0049296
506	2.53	-0.0066018
507	2.535	-0.0083702
508	2.54	-0.0076356
509	2.545	-0.0033699
510	2.55	0.0032003
511	2.555	0.0102027
512	2.56	0.0153924
513	2.565	0.0160102
514	2.57	0.0109144
515	2.575	0.0024431
516	2.58	-0.0055647
517	2.585	-0.0106533
518	2.59	-0.011314
519	2.595	-0.0061257
520	2.6	0.0036012
521	2.605	0.0122178
522	2.61	0.0146851

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524	2.62	0.0102602
525	2.625	0.0095312
526	2.63	0.0063241
527	2.635	-0.0015781
528	2.64	-0.0110332
529	2.645	-0.0170922
530	2.65	-0.017323
531	2.655	-0.0122099
532	2.66	-0.0043669
533	2.665	0.0018599
534	2.67	0.0029528
535	2.675	-0.0001793
536	2.68	-0.0030558
537	2.685	-0.0029114
538	2.69	-0.0012138
539	2.695	-0.0002659
540	2.7	0.0002188
541	2.705	0.001481
542	2.71	0.0025918
543	2.715	0.0014833
544	2.72	-0.0013902
545	2.725	-0.0027052
546	2.73	-0.0002649
547	2.735	0.0039824
548	2.74	0.0058118
549	2.745	0.0029144
550	2.75	-0.003444
551	2.755	-0.0100608
552	2.76	-0.0139199
553	2.765	-0.0133676
554	2.77	-0.0090521
555	2.775	-0.0040756
556	2.78	-0.0017762
557	2.785	-0.0025965
558	2.79	-0.0038552

559	2.795	-0.0027704
560	2.8	0.0011816
561	2.805	0.0065897
562	2.81	0.0110342
563	2.815	0.0115667
564	2.82	0.0065596
565	2.825	-0.0016298
566	2.83	-0.0073853
567	2.835	-0.0068234
568	2.84	-0.0015038
569	2.845	0.0036951
570	2.85	0.0056515
571	2.855	0.0050984
572	2.86	0.0044288
573	2.865	0.0046806
574	2.87	0.0048004
575	2.875	0.0031515
576	2.88	-0.0006886
577	2.885	-0.005459
578	2.89	-0.009037
579	2.895	-0.0094558
580	2.9	-0.0056893
581	2.905	0.0015052
582	2.91	0.0093151
583	2.915	0.0143272
584	2.92	0.0148447
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587	2.935	0.0002201
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589	2.945	-0.005157
590	2.95	-0.0021426
591	2.955	0.0023865
592	2.96	0.0047576
593	2.965	0.0029991
594	2.97	-0.0017042

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599	2.995	0.0056477
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601	3.005	0.0027237
602	3.01	0.0007567
603	3.015	3.57e-005
604	3.02	0.0001142
605	3.025	0.0002354
606	3.03	-0.0007164
607	3.035	-0.003729
608	3.04	-0.008083
609	3.045	-0.0113478
610	3.05	-0.0118788
611	3.055	-0.0103347
612	3.06	-0.0080869
613	3.065	-0.0055785
614	3.07	-0.0031989
615	3.075	-0.002132
616	3.08	-0.0028412
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619	3.095	-0.004081
620	3.1	-0.004112
621	3.105	-0.0032911
622	3.11	-0.000707
623	3.115	0.0019547
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625	3.125	-0.0002978
626	3.13	-0.0022635
627	3.135	-0.0019072
628	3.14	-0.000289
629	3.145	0.0001891
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633	3.165	-0.0067891
634	3.17	-0.0033136
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637	3.185	0.0028041
638	3.19	0.0012779
639	3.195	-0.0006963
640	3.2	-0.0024537
641	3.205	-0.0033772
642	3.21	-0.0033701
643	3.215	-0.00315
644	3.22	-0.0032719
645	3.225	-0.0031753
646	3.23	-0.0019341
647	3.235	0.0002205
648	3.24	0.0017071
649	3.245	0.0009316
650	3.25	-0.0023622
651	3.255	-0.0067404
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653	3.265	-0.0094047
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663	3.315	-0.005383
664	3.32	-0.0042972
665	3.325	-0.0023641
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672	3.36	0.0005497
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675	3.375	0.0041321
676	3.38	0.0017068
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678	3.39	-0.0034268
679	3.395	-0.0023417
680	3.4	-2.8e-005
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685	3.425	0.0032155
686	3.43	0.0031368
687	3.435	0.0014192
688	3.44	-0.0020907
689	3.445	-0.0057558
690	3.45	-0.0075845
691	3.455	-0.0069029
692	3.46	-0.0043096
693	3.465	-0.0008353
694	3.47	0.0021955
695	3.475	0.0032662
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697	3.485	-0.0008977
698	3.49	-0.0023764
699	3.495	-0.0013637
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712	3.56	0.003319
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714	3.57	-0.0019727
715	3.575	-0.0025297
716	3.58	-0.002099
717	3.585	-0.0019058
718	3.59	-0.002028
719	3.595	-0.0013967
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721	3.605	0.0027553
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723	3.615	0.0046265
724	3.62	0.0040936
725	3.625	0.0029809
726	3.63	0.0017987
727	3.635	0.0012097
728	3.64	0.0015015
729	3.645	0.0023038
730	3.65	0.0029708
731	3.655	0.0031396
732	3.66	0.0029733
733	3.665	0.0029439
734	3.67	0.003202
735	3.675	0.0030943
736	3.68	0.0016232
737	3.685	-0.0014148
738	3.69	-0.0049108

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740	3.7	-0.0068651
741	3.705	-0.0041011
742	3.71	-0.0001252
743	3.715	0.0031732
744	3.72	0.0045462
745	3.725	0.0042164
746	3.73	0.0033539
747	3.735	0.0027499
748	3.74	0.0022064
749	3.745	0.0011845
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752	3.76	-0.0018288
753	3.765	-0.0015215
754	3.77	-0.0010374
755	3.775	-0.0004647
756	3.78	0.0005217
757	3.785	0.0018853
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759	3.795	0.0030692
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761	3.805	0.002898
762	3.81	0.003943
763	3.815	0.0049685
764	3.82	0.0045671
765	3.825	0.0022304
766	3.83	-0.0009636
767	3.835	-0.0031837
768	3.84	-0.0034791
769	3.845	-0.0024666
770	3.85	-0.0013267
771	3.855	-0.0004892
772	3.86	0.0002775
773	3.865	0.0008455
774	3.87	0.0006566

775	3.875	-0.0001701
776	3.88	-0.0004598
777	3.885	0.0007183
778	3.89	0.0027731
779	3.895	0.0041596
780	3.9	0.0039849
781	3.905	0.0026056
782	3.91	0.0009428
783	3.915	-0.0001617
784	3.92	-0.000141
785	3.925	0.0008832
786	3.93	0.0017772
787	3.935	0.0013082
788	3.94	-0.0002688
789	3.945	-0.0011764
790	3.95	-0.0001079
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794	3.97	0.0015809
795	3.975	-0.0008553
796	3.98	-0.0025447
797	3.985	-0.0029214
798	3.99	-0.0024464
799	3.995	-0.0021177
800	4	-0.0022849
801	4.005	-0.0022147
802	4.01	-0.00115
803	4.015	0.000518
804	4.02	0.0015665
805	4.025	0.0012957
806	4.03	0.0002428
807	4.035	-0.0004201
808	4.04	-2.96e-005
809	4.045	0.0010067
810	4.05	0.0017042

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814	4.07	-0.001991
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816	4.08	-0.003605
817	4.085	-0.0033795
818	4.09	-0.0030202
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820	4.1	-0.0036138
821	4.105	-0.003919
822	4.11	-0.0039812
823	4.115	-0.0041609
824	4.12	-0.0045813
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826	4.13	-0.0050067
827	4.135	-0.0046261
828	4.14	-0.0037815
829	4.145	-0.0025717
830	4.15	-0.0013718
831	4.155	-0.0006168
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833	4.165	-0.000704
834	4.17	-0.0011376
835	4.175	-0.0014583
836	4.18	-0.00139
837	4.185	-0.000961
838	4.19	-0.0006532
839	4.195	-0.0009423
840	4.2	-0.0016285
841	4.205	-0.0018908
842	4.21	-0.0012298
843	4.215	-0.0002178
844	4.22	2.62e-005
845	4.225	-0.0008116
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848	4.24	-0.0002092
849	4.245	0.0012626
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852	4.26	0.0016321
853	4.265	0.0016129
854	4.27	0.001996
855	4.275	0.0025068
856	4.28	0.0025295
857	4.285	0.0016544
858	4.29	0.0002633
859	4.295	-0.0007571
860	4.3	-0.0009815
861	4.305	-0.0007813
862	4.31	-0.0005894
863	4.315	-0.0002669
864	4.32	0.0004677
865	4.325	0.0012977
866	4.33	0.0015043
867	4.335	0.000906
868	4.34	0.0002016
869	4.345	0.000186
870	4.35	0.0008368
871	4.355	0.0013986
872	4.36	0.0013038
873	4.365	0.0008108
874	4.37	0.0006865
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876	4.38	0.0024425
877	4.385	0.0030859
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880	4.4	0.0001489
881	4.405	-0.0010673
882	4.41	-0.0020327

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884	4.42	-0.0027139
885	4.425	-0.0017073
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887	4.435	0.0018264
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889	4.445	0.0017672
890	4.45	0.0003404
891	4.455	-0.000895
892	4.46	-0.0013179
893	4.465	-0.0008845
894	4.47	-1.79e-005
895	4.475	0.0007875
896	4.48	0.0013682
897	4.485	0.001846
898	4.49	0.0021464
899	4.495	0.0018698
900	4.5	0.0009363
901	4.505	7.53e-005
902	4.51	0.0001319
903	4.515	0.00092
904	4.52	0.0012578
905	4.525	0.0002416
906	4.53	-0.0018505
907	4.535	-0.0039001
908	4.54	-0.0048024
909	4.545	-0.0040371
910	4.55	-0.0019435
911	4.555	0.0003772
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913	4.565	0.0018641
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915	4.575	-0.0001603
916	4.58	-0.0013634
917	4.585	-0.002196
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919	4.595	-0.001688
920	4.6	-0.0007434
921	4.605	6.63e-005
922	4.61	0.0004388
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926	4.63	0.0005397
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929	4.645	0.0018496
930	4.65	0.0008113
931	4.655	3.2e-005
932	4.66	2.1e-006
933	4.665	0.0005077
934	4.67	0.0010688
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937	4.685	0.0022804
938	4.69	0.0023316
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940	4.7	0.0013009
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942	4.71	6.08e-005
943	4.715	-0.0007077
944	4.72	-0.0013786
945	4.725	-0.0016085
946	4.73	-0.0014073
947	4.735	-0.0010939
948	4.74	-0.0008571
949	4.745	-0.0006637
950	4.75	-0.0005648
951	4.755	-0.0007731
952	4.76	-0.0013308
953	4.765	-0.0019014
954	4.77	-0.0020174

955	4.775	-0.0014972
956	4.78	-0.0006197
957	4.785	6.78e-005
958	4.79	0.0001969
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960	4.8	-0.0002576
961	4.805	-0.000126
962	4.81	2.9e-006
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966	4.83	-0.0006877
967	4.835	-0.0003351
968	4.84	-7.68e-005
969	4.845	-1.26e-005
970	4.85	-0.0002289
971	4.855	-0.0007205
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973	4.865	-0.0010182
974	4.87	-0.0002528
975	4.875	0.0006749
976	4.88	0.0012088
977	4.885	0.00118
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979	4.895	0.0002979
980	4.9	-0.000114
981	4.905	-0.000339
982	4.91	-0.0002261
983	4.915	0.0003478
984	4.92	0.0012244
985	4.925	0.0019184
986	4.93	0.0020434
987	4.935	0.0017181
988	4.94	0.0013434
989	4.945	0.0010977
990	4.95	0.0009249

991	4.955	0.0008594
992	4.96	0.0009578
993	4.965	0.0010094
994	4.97	0.0007606
995	4.975	0.0003907
996	4.98	0.0003217
997	4.985	0.0005564
998	4.99	0.00063
999	4.995	0.0002614
1000	5	-0.0003198
1001	5.005	-0.000726
1002	5.01	-0.000787
1003	5.015	-0.0005802
1004	5.02	-0.0003631
1005	5.025	-0.0004212
1006	5.03	-0.0007277
1007	5.035	-0.0008581
1008	5.04	-0.0005164
1009	5.045	-9e-006
1010	5.05	0.0001227
1011	5.055	-0.0001737
1012	5.06	-0.0004607
1013	5.065	-0.0004702
1014	5.07	-0.0003971
1015	5.075	-0.0004953
1016	5.08	-0.0007029
1017	5.085	-0.0007941
1018	5.09	-0.000699
1019	5.095	-0.0005326
1020	5.1	-0.000419
1021	5.105	-0.0003923
1022	5.11	-0.0004182
1023	5.115	-0.0004423
1024	5.12	-0.0004624
1025	5.125	-0.000467

Vertical Earthquake Records

Description: Giles Co
Use Baseline Correction: No
Modified Peak Acc.: 1
Modified Duration: 1

Records

	Time (sec)	Acc (ft/sec²)
1	0.005	-0.0007757
2	0.01	-0.0004575
3	0.015	-0.0002791
4	0.02	-0.0002467
5	0.025	-0.0002848
6	0.03	-0.0003109
7	0.035	-0.0003297
8	0.04	-0.0003586
9	0.045	-0.0003742
10	0.05	-0.0003667
11	0.055	-0.0003652
12	0.06	-0.0003801
13	0.065	-0.0003882
14	0.07	-0.0003871
15	0.075	-0.0003986
16	0.08	-0.0004171
17	0.085	-0.0004222
18	0.09	-0.0004283
19	0.095	-0.0004563
20	0.1	-0.0004821
21	0.105	-0.0004798
22	0.11	-0.0004706
23	0.115	-0.0004707
24	0.12	-0.0004571
25	0.125	-0.0004412
26	0.13	-0.0004919
27	0.135	-0.0006237
28	0.14	-0.0007423
29	0.145	-0.0007092

30	0.15	-0.0003538
31	0.155	0.0005207
32	0.16	0.0019766
33	0.165	0.0038358
34	0.17	0.0058105
35	0.175	0.0075037
36	0.18	0.0082305
37	0.185	0.0074459
38	0.19	0.0057325
39	0.195	0.0046402
40	0.2	0.0047952
41	0.205	0.0046613
42	0.21	0.0019691
43	0.215	-0.0038675
44	0.22	-0.0110746
45	0.225	-0.0165058
46	0.23	-0.0169544
47	0.235	-0.0109372
48	0.24	-0.0005993
49	0.245	0.0087755
50	0.25	0.0124105
51	0.255	0.0092398
52	0.26	0.0015381
53	0.265	-0.0073466
54	0.27	-0.0142206
55	0.275	-0.0164168
56	0.28	-0.0127034
57	0.285	-0.0043782
58	0.29	0.0045896
59	0.295	0.0091268
60	0.3	0.0064456
61	0.305	-0.0011925
62	0.31	-0.0084154
63	0.315	-0.0122682
64	0.32	-0.0138288
65	0.325	-0.0133738

66	0.33	-0.007632
67	0.335	0.0047128
68	0.34	0.01763
69	0.345	0.022851
70	0.35	0.0197122
71	0.355	0.0156418
72	0.36	0.0168477
73	0.365	0.0223162
74	0.37	0.027209
75	0.375	0.027989
76	0.38	0.022828
77	0.385	0.0110531
78	0.39	-0.0044683
79	0.395	-0.0164362
80	0.4	-0.0182084
81	0.405	-0.009931
82	0.41	0.0021238
83	0.415	0.0118541
84	0.42	0.0171438
85	0.425	0.0179936
86	0.43	0.01371
87	0.435	0.0036906
88	0.44	-0.0094001
89	0.445	-0.018535
90	0.45	-0.0164339
91	0.455	-0.0028625
92	0.46	0.0128802
93	0.465	0.0200786
94	0.47	0.017838
95	0.475	0.0147277
96	0.48	0.016246
97	0.485	0.0175025
98	0.49	0.0114384
99	0.495	-0.0003175
100	0.5	-0.0098754
101	0.505	-0.0135001

102	0.51	-0.014099
103	0.515	-0.014483
104	0.52	-0.0133132
105	0.525	-0.0082598
106	0.53	0.0003768
107	0.535	0.0100376
108	0.54	0.0177857
109	0.545	0.0215988
110	0.55	0.0215305
111	0.555	0.0198068
112	0.56	0.018547
113	0.565	0.0171471
114	0.57	0.0126234
115	0.575	0.0029093
116	0.58	-0.0101343
117	0.585	-0.0212242
118	0.59	-0.0259173
119	0.595	-0.0244445
120	0.6	-0.0202592
121	0.605	-0.0152624
122	0.61	-0.0092346
123	0.615	-0.0042719
124	0.62	-0.0051191
125	0.625	-0.0119458
126	0.63	-0.0168362
127	0.635	-0.0127595
128	0.64	-0.0040728
129	0.645	-0.0025077
130	0.65	-0.0130171
131	0.655	-0.0284823
132	0.66	-0.0386012
133	0.665	-0.0393828
134	0.67	-0.0334638
135	0.675	-0.0259537
136	0.68	-0.0213717
137	0.685	-0.0207269

138	0.69	-0.020475
139	0.695	-0.0176127
140	0.7	-0.0152173
141	0.705	-0.0179153
142	0.71	-0.0223919
143	0.715	-0.0194172
144	0.72	-0.0068633
145	0.725	0.0060994
146	0.73	0.0105141
147	0.735	0.0071751
148	0.74	0.001529
149	0.745	-0.0047258
150	0.75	-0.0122801
151	0.755	-0.0190982
152	0.76	-0.0216992
153	0.765	-0.019185
154	0.77	-0.0130878
155	0.775	-0.0060016
156	0.78	-0.0021661
157	0.785	-0.0048977
158	0.79	-0.0102242
159	0.795	-0.007623
160	0.8	0.0078856
161	0.805	0.0271104
162	0.81	0.0353655
163	0.815	0.0285505
164	0.82	0.0158729
165	0.825	0.0073745
166	0.83	0.0043628
167	0.835	0.0034149
168	0.84	0.0041653
169	0.845	0.0085871
170	0.85	0.0151051
171	0.855	0.0184244
172	0.86	0.0155927
173	0.865	0.0090157

174	0.87	0.0026754
175	0.875	-0.0019559
176	0.88	-0.0050329
177	0.885	-0.0060158
178	0.89	-0.004557
179	0.895	-0.0020434
180	0.9	0.000338
181	0.905	0.0039047
182	0.91	0.009827
183	0.915	0.014888
184	0.92	0.0138375
185	0.925	0.006736
186	0.93	9.78e-005
187	0.935	-0.0012029
188	0.94	0.0003049
189	0.945	-8.15e-005
190	0.95	-0.0011898
191	0.955	0.0025282
192	0.96	0.012309
193	0.965	0.0218621
194	0.97	0.0237417
195	0.975	0.0168785
196	0.98	0.0072722
197	0.985	0.0025579
198	0.99	0.0059073
199	0.995	0.0139534
200	1	0.0204371
201	1.005	0.0223097
202	1.01	0.0215532
203	1.015	0.0206664
204	1.02	0.0186947
205	1.025	0.0141437
206	1.03	0.0099069
207	1.035	0.0107962
208	1.04	0.0156487
209	1.045	0.0164772

210	1.05	0.0083666
211	1.055	-0.0029154
212	1.06	-0.0070803
213	1.065	-0.0014043
214	1.07	0.0072748
215	1.075	0.0114031
216	1.08	0.008983
217	1.085	0.0017462
218	1.09	-0.0071211
219	1.095	-0.0124021
220	1.1	-0.0098433
221	1.105	-0.0022554
222	1.11	0.0021984
223	1.115	0.0001681
224	1.12	-0.0035419
225	1.125	-0.005372
226	1.13	-0.0096605
227	1.135	-0.0214669
228	1.14	-0.0378696
229	1.145	-0.0515745
230	1.15	-0.059078
231	1.155	-0.06
232	1.16	-0.0520861
233	1.165	-0.0333474
234	1.17	-0.0081044
235	1.175	0.0138149
236	1.18	0.02401
237	1.185	0.0202684
238	1.19	0.0072315
239	1.195	-0.0052981
240	1.2	-0.0081342
241	1.205	-0.0007815
242	1.21	0.0075325
243	1.215	0.0072321
244	1.22	-0.0025317
245	1.225	-0.0150998

246	1.23	-0.0234891
247	1.235	-0.024271
248	1.24	-0.017419
249	1.245	-0.0057944
250	1.25	0.0064002
251	1.255	0.0172242
252	1.26	0.028359
253	1.265	0.0410727
254	1.27	0.0518651
255	1.275	0.0544442
256	1.28	0.0459717
257	1.285	0.0296466
258	1.29	0.0112684
259	1.295	-0.0045518
260	1.3	-0.0142925
261	1.305	-0.0148136
262	1.31	-0.0059883
263	1.315	0.006814
264	1.32	0.0159996
265	1.325	0.0179261
266	1.33	0.0140128
267	1.335	0.0066841
268	1.34	-0.0023408
269	1.345	-0.0099387
270	1.35	-0.0122963
271	1.355	-0.0096091
272	1.36	-0.0069076
273	1.365	-0.0083265
274	1.37	-0.01311
275	1.375	-0.0186678
276	1.38	-0.0242946
277	1.385	-0.0293266
278	1.39	-0.0303504
279	1.395	-0.0240104
280	1.4	-0.0120949
281	1.405	-0.0010266

282	1.41	0.0042552
283	1.415	0.0043643
284	1.42	0.0029825
285	1.425	0.0018265
286	1.43	-0.0003058
287	1.435	-0.0037245
288	1.44	-0.0052417
289	1.445	-0.0012076
290	1.45	0.0075266
291	1.455	0.0156863
292	1.46	0.0186931
293	1.465	0.0159343
294	1.47	0.0089939
295	1.475	-0.0005836
296	1.48	-0.0104054
297	1.485	-0.0166956
298	1.49	-0.0175183
299	1.495	-0.0156527
300	1.5	-0.0156197
301	1.505	-0.0178008
302	1.51	-0.0176864
303	1.515	-0.0116251
304	1.52	-0.0018419
305	1.525	0.0051006
306	1.53	0.0041913
307	1.535	-0.0037867
308	1.54	-0.0128049
309	1.545	-0.01597
310	1.55	-0.0106084
311	1.555	-0.0002983
312	1.56	0.0082896
313	1.565	0.01133
314	1.57	0.0105764
315	1.575	0.009842
316	1.58	0.0097377
317	1.585	0.007558

318	1.59	0.0020374
319	1.595	-0.0043192
320	1.6	-0.0086125
321	1.605	-0.0108188
322	1.61	-0.0118415
323	1.615	-0.0104832
324	1.62	-0.0049866
325	1.625	0.0038605
326	1.63	0.0135889
327	1.635	0.0223766
328	1.64	0.0280236
329	1.645	0.0270593
330	1.65	0.0188304
331	1.655	0.008783
332	1.66	0.0032116
333	1.665	0.0016948
334	1.67	-0.0009346
335	1.675	-0.0061513
336	1.68	-0.0102813
337	1.685	-0.0110097
338	1.69	-0.0097505
339	1.695	-0.0067207
340	1.7	0.0008683
341	1.705	0.0132645
342	1.71	0.0247371
343	1.715	0.0286231
344	1.72	0.0239451
345	1.725	0.015442
346	1.73	0.008807
347	1.735	0.0070765
348	1.74	0.0097615
349	1.745	0.013494
350	1.75	0.0139788
351	1.755	0.0089546
352	1.76	0.0002501
353	1.765	-0.0070704

354	1.77	-0.0085094
355	1.775	-0.0040587
356	1.78	0.0017862
357	1.785	0.0044211
358	1.79	0.0030348
359	1.795	-0.0001781
360	1.8	-0.0031496
361	1.805	-0.0049464
362	1.81	-0.0050305
363	1.815	-0.0033334
364	1.82	-0.0003736
365	1.825	0.003622
366	1.83	0.0082243
367	1.835	0.0107803
368	1.84	0.0077488
369	1.845	-0.0002042
370	1.85	-0.0073932
371	1.855	-0.0095545
372	1.86	-0.0080886
373	1.865	-0.0059361
374	1.87	-0.0034874
375	1.875	-0.0016691
376	1.88	-0.0041337
377	1.885	-0.0112743
378	1.89	-0.0159404
379	1.895	-0.0111474
380	1.9	0.0001992
381	1.905	0.0087177
382	1.91	0.0098954
383	1.915	0.006931
384	1.92	0.0038384
385	1.925	0.0010892
386	1.93	-0.0020905
387	1.935	-0.0053147
388	1.94	-0.0074692
389	1.945	-0.0074327

390	1.95	-0.0049914
391	1.955	-0.0024246
392	1.96	-0.0032819
393	1.965	-0.007659
394	1.97	-0.0106601
395	1.975	-0.0077982
396	1.98	-0.0005836
397	1.985	0.0049224
398	1.99	0.0039912
399	1.995	-0.0030963
400	2	-0.0114586
401	2.005	-0.0147814
402	2.01	-0.0098583
403	2.015	0.0006967
404	2.02	0.010681
405	2.025	0.0151192
406	2.03	0.012517
407	2.035	0.0042431
408	2.04	-0.0059347
409	2.045	-0.0127036
410	2.05	-0.0125087
411	2.055	-0.0065655
412	2.06	0.0005289
413	2.065	0.0048446
414	2.07	0.0052397
415	2.075	0.003063
416	2.08	0.001155
417	2.085	0.0018342
418	2.09	0.0046208
419	2.095	0.0070968
420	2.1	0.0083802
421	2.105	0.0094826
422	2.11	0.0097341
423	2.115	0.0062988
424	2.12	-0.0009487
425	2.125	-0.0073447

426	2.13	-0.0089159
427	2.135	-0.0073797
428	2.14	-0.0068626
429	2.145	-0.0078573
430	2.15	-0.0075485
431	2.155	-0.0045801
432	2.16	-0.0004702
433	2.165	0.0027853
434	2.17	0.0040853
435	2.175	0.0031019
436	2.18	0.0008897
437	2.185	-0.0003402
438	2.19	0.0001396
439	2.195	0.0003823
440	2.2	-0.0010785
441	2.205	-0.0025346
442	2.21	-0.0016233
443	2.215	0.0011838
444	2.22	0.0040701
445	2.225	0.0072865
446	2.23	0.0121953
447	2.235	0.0178455
448	2.24	0.0213004
449	2.245	0.0209935
450	2.25	0.0175431
451	2.255	0.0118253
452	2.26	0.0046001
453	2.265	-0.0022081
454	2.27	-0.0061192
455	2.275	-0.006378
456	2.28	-0.0044486
457	2.285	-0.0023775
458	2.29	-0.0014842
459	2.295	-0.0019384
460	2.3	-0.0026151
461	2.305	-0.002134

462	2.31	-0.0008917
463	2.315	-0.0010707
464	2.32	-0.0038269
465	2.325	-0.0076128
466	2.33	-0.0099943
467	2.335	-0.0097529
468	2.34	-0.0065551
469	2.345	-0.0004433
470	2.35	0.0070117
471	2.355	0.0124934
472	2.36	0.0133464
473	2.365	0.0095996
474	2.37	0.0032354
475	2.375	-0.0032245
476	2.38	-0.0070553
477	2.385	-0.0062798
478	2.39	-0.0017768
479	2.395	0.0024933
480	2.4	0.0026364
481	2.405	-0.0018343
482	2.41	-0.0078956
483	2.415	-0.0117804
484	2.42	-0.0119728
485	2.425	-0.0101059
486	2.43	-0.0089073
487	2.435	-0.0090842
488	2.44	-0.0088168
489	2.445	-0.0065357
490	2.45	-0.0030667
491	2.455	-0.0003441
492	2.46	0.00086
493	2.465	0.0009922
494	2.47	0.0005324
495	2.475	-0.0001889
496	2.48	-0.0007691
497	2.485	-0.0012601

498	2.49	-0.0022481
499	2.495	-0.0036757
500	2.5	-0.0044192
501	2.505	-0.0038973
502	2.51	-0.0032558
503	2.515	-0.0038014
504	2.52	-0.0047751
505	2.525	-0.0039537
506	2.53	-0.0004938
507	2.535	0.0037736
508	2.54	0.0061951
509	2.545	0.0058574
510	2.55	0.0038699
511	2.555	0.0014388
512	2.56	-0.0014876
513	2.565	-0.005096
514	2.57	-0.0077651
515	2.575	-0.0066183
516	2.58	-0.000671
517	2.585	0.0074344
518	2.59	0.0137403
519	2.595	0.0164296
520	2.6	0.0161282
521	2.605	0.0137202
522	2.61	0.0096287
523	2.615	0.005033
524	2.62	0.0017371
525	2.625	0.0001208
526	2.63	-0.0012335
527	2.635	-0.0029519
528	2.64	-0.0032495
529	2.645	-0.0002024
530	2.65	0.0051764
531	2.655	0.0094871
532	2.66	0.0103358
533	2.665	0.0082137

534	2.67	0.0051585
535	2.675	0.002469
536	2.68	1.43e-005
537	2.685	-0.0026524
538	2.69	-0.0049726
539	2.695	-0.0055645
540	2.7	-0.0039174
541	2.705	-0.0015004
542	2.71	-0.0005502
543	2.715	-0.0017617
544	2.72	-0.0035812
545	2.725	-0.0036904
546	2.73	-0.0009406
547	2.735	0.0036781
548	2.74	0.0073888
549	2.745	0.0074638
550	2.75	0.0036715
551	2.755	-0.0012257
552	2.76	-0.0041229
553	2.765	-0.0045573
554	2.77	-0.0044532
555	2.775	-0.0053335
556	2.78	-0.0067384
557	2.785	-0.0071918
558	2.79	-0.0056793
559	2.795	-0.0021298
560	2.8	0.0024695
561	2.805	0.0059743
562	2.81	0.0059627
563	2.815	0.0016706
564	2.82	-0.0048745
565	2.825	-0.010059
566	2.83	-0.0113055
567	2.835	-0.0086753
568	2.84	-0.0041468
569	2.845	0.0003055

570	2.85	0.0036383
571	2.855	0.005096
572	2.86	0.003757
573	2.865	-0.0003036
574	2.87	-0.0047337
575	2.875	-0.0061061
576	2.88	-0.0031633
577	2.885	0.0015568
578	2.89	0.0039904
579	2.895	0.0024613
580	2.9	-0.0009462
581	2.905	-0.0027934
582	2.91	-0.0015897
583	2.915	0.001426
584	2.92	0.0041203
585	2.925	0.005172
586	2.93	0.0040382
587	2.935	0.0005525
588	2.94	-0.0044034
589	2.945	-0.0083909
590	2.95	-0.0088194
591	2.955	-0.005128
592	2.96	0.000801
593	2.965	0.006148
594	2.97	0.0086801
595	2.975	0.0075493
596	2.98	0.0038349
597	2.985	0.00026
598	2.99	-0.000762
599	2.995	0.0006861
600	3	0.0021809
601	3.005	0.0014583
602	3.01	-0.0015444
603	3.015	-0.0050265
604	3.02	-0.0070757
605	3.025	-0.0068657

606	3.03	-0.0046929
607	3.035	-0.0015753
608	3.04	0.0010703
609	3.045	0.002008
610	3.05	0.0011859
611	3.055	0.0001225
612	3.06	0.0006028
613	3.065	0.0026984
614	3.07	0.0045435
615	3.075	0.0043819
616	3.08	0.002491
617	3.085	0.0008166
618	3.09	0.0009509
619	3.095	0.0025973
620	3.1	0.0038159
621	3.105	0.0028305
622	3.11	-0.0001501
623	3.115	-0.0030851
624	3.12	-0.0042646
625	3.125	-0.0037782
626	3.13	-0.0025031
627	3.135	-0.0006922
628	3.14	0.0014288
629	3.145	0.0026669
630	3.15	0.002025
631	3.155	0.0003276
632	3.16	-0.0008091
633	3.165	-0.0011813
634	3.17	-0.0016518
635	3.175	-0.0020823
636	3.18	-0.0013933
637	3.185	0.0004703
638	3.19	0.0023446
639	3.195	0.0036308
640	3.2	0.0047092
641	3.205	0.0055092

642	3.21	0.0052495
643	3.215	0.0039707
644	3.22	0.003073
645	3.225	0.0038202
646	3.23	0.0059909
647	3.235	0.0081059
648	3.24	0.008413
649	3.245	0.0059171
650	3.25	0.0012957
651	3.255	-0.0032601
652	3.26	-0.0057456
653	3.265	-0.0057827
654	3.27	-0.004094
655	3.275	-0.0012514
656	3.28	0.0022659
657	3.285	0.0053319
658	3.29	0.0065503
659	3.295	0.0053982
660	3.3	0.0025082
661	3.305	-0.0009602
662	3.31	-0.0038138
663	3.315	-0.0051375
664	3.32	-0.0048083
665	3.325	-0.0036149
666	3.33	-0.0025019
667	3.335	-0.0018734
668	3.34	-0.0018166
669	3.345	-0.0024415
670	3.35	-0.0034198
671	3.355	-0.0035672
672	3.36	-0.001718
673	3.365	0.0018027
674	3.37	0.0050003
675	3.375	0.0057861
676	3.38	0.0037355
677	3.385	0.0003534

678	3.39	-0.0022557
679	3.395	-0.0029992
680	3.4	-0.0023332
681	3.405	-0.0015015
682	3.41	-0.0013895
683	3.415	-0.001981
684	3.42	-0.0026371
685	3.425	-0.0027525
686	3.43	-0.0021977
687	3.435	-0.0011881
688	3.44	0.0001571
689	3.445	0.0018207
690	3.45	0.0033147
691	3.455	0.0035484
692	3.46	0.0018553
693	3.465	-0.0009399
694	3.47	-0.0030885
695	3.475	-0.003674
696	3.48	-0.003285
697	3.485	-0.0027772
698	3.49	-0.0020468
699	3.495	-0.000601
700	3.5	0.0011473
701	3.505	0.0020605
702	3.51	0.0017577
703	3.515	0.0011309
704	3.52	0.0011231
705	3.525	0.0016006
706	3.53	0.0018019
707	3.535	0.0013936
708	3.54	0.0006284
709	3.545	-0.0001756
710	3.55	-0.0008515
711	3.555	-0.0013176
712	3.56	-0.001635
713	3.565	-0.0018726

714	3.57	-0.0016885
715	3.575	-0.0005189
716	3.58	0.0013819
717	3.585	0.0025477
718	3.59	0.0016308
719	3.595	-0.0009747
720	3.6	-0.0033259
721	3.605	-0.0037188
722	3.61	-0.0020095
723	3.615	0.0005963
724	3.62	0.0025657
725	3.625	0.0028998
726	3.63	0.0015579
727	3.635	-0.0005706
728	3.64	-0.002193
729	3.645	-0.0024342
730	3.65	-0.0014073
731	3.655	-4.65e-005
732	3.66	0.0007329
733	3.665	0.0007943
734	3.67	0.0006702
735	3.675	0.0007639
736	3.68	0.0009012
737	3.685	0.0007395
738	3.69	0.0003093
739	3.695	-9.08e-005
740	3.7	-0.0003437
741	3.705	-0.0005959
742	3.71	-0.0009784
743	3.715	-0.0014454
744	3.72	-0.0018291
745	3.725	-0.0018801
746	3.73	-0.0012992
747	3.735	5.67e-005
748	3.74	0.0018772
749	3.745	0.0033904

750	3.75	0.00383
751	3.755	0.0030151
752	3.76	0.0014271
753	3.765	-0.0002683
754	3.77	-0.0015866
755	3.775	-0.0021153
756	3.78	-0.0015141
757	3.785	-1.82e-005
758	3.79	0.0013937
759	3.795	0.0019251
760	3.8	0.0019223
761	3.805	0.0022988
762	3.81	0.0030258
763	3.815	0.0029305
764	3.82	0.001268
765	3.825	-0.0011148
766	3.83	-0.0026856
767	3.835	-0.002934
768	3.84	-0.0025884
769	3.845	-0.0022608
770	3.85	-0.0016032
771	3.855	-0.0001539
772	3.86	0.0015031
773	3.865	0.0021402
774	3.87	0.0013965
775	3.875	0.0002282
776	3.88	-0.0003471
777	3.885	-0.0003456
778	3.89	-0.0002941
779	3.895	-0.0002143
780	3.9	0.0002208
781	3.905	0.0008811
782	3.91	0.0012712
783	3.915	0.0013024
784	3.92	0.0013032
785	3.925	0.0012675

786	3.93	0.000722
787	3.935	-0.0005054
788	3.94	-0.0018631
789	3.945	-0.0026407
790	3.95	-0.0026529
791	3.955	-0.0021934
792	3.96	-0.0015782
793	3.965	-0.0009846
794	3.97	-0.0005979
795	3.975	-0.0005888
796	3.98	-0.0008271
797	3.985	-0.0008394
798	3.99	-0.0003451
799	3.995	0.0002037
800	4	-3.42e-005
801	4.005	-0.0012746
802	4.01	-0.0027068
803	4.015	-0.0032645
804	4.02	-0.0025591
805	4.025	-0.0009355
806	4.03	0.0010077
807	4.035	0.0026435
808	4.04	0.003376
809	4.045	0.0029451
810	4.05	0.0016468
811	4.055	1.82e-005
812	4.06	-0.0015967
813	4.065	-0.0029873
814	4.07	-0.0038066
815	4.075	-0.003715
816	4.08	-0.0027778
817	4.085	-0.0015048
818	4.09	-0.0004933
819	4.095	-9.27e-005
820	4.1	-0.0002532
821	4.105	-0.0005488

822	4.11	-0.0005263
823	4.115	-0.0002155
824	4.12	-0.0001361
825	4.125	-0.0006042
826	4.13	-0.0012444
827	4.135	-0.0014557
828	4.14	-0.0011756
829	4.145	-0.0008234
830	4.15	-0.0006172
831	4.155	-0.0003786
832	4.16	-4e-005
833	4.165	0.0001005
834	4.17	-0.0001595
835	4.175	-0.0004899
836	4.18	-0.0003429
837	4.185	0.0003779
838	4.19	0.0011484
839	4.195	0.0013098
840	4.2	0.0006152
841	4.205	-0.000631
842	4.21	-0.0017987
843	4.215	-0.0022809
844	4.22	-0.0018359
845	4.225	-0.0007755
846	4.23	0.0002139
847	4.235	0.0005924
848	4.24	0.0003672
849	4.245	-3.44e-005
850	4.25	-0.0002164
851	4.255	-4.39e-005
852	4.26	0.0004498
853	4.265	0.0011139
854	4.27	0.001593
855	4.275	0.001468
856	4.28	0.0006888
857	4.285	-0.0002382

858	4.29	-0.0006491
859	4.295	-0.0002752
860	4.3	0.0006254
861	4.305	0.0015213
862	4.31	0.0019116
863	4.315	0.001577
864	4.32	0.0007328
865	4.325	-0.0001234
866	4.33	-0.0006227
867	4.335	-0.0007594
868	4.34	-0.0007385
869	4.345	-0.0007537
870	4.35	-0.000906
871	4.355	-0.0011258
872	4.36	-0.00114
873	4.365	-0.0007719
874	4.37	-0.0002995
875	4.375	-0.0002102
876	4.38	-0.0005111
877	4.385	-0.0006396
878	4.39	-0.0001986
879	4.395	0.0005504
880	4.4	0.0011122
881	4.405	0.0013227
882	4.41	0.0012481
883	4.415	0.0008349
884	4.42	1.81e-005
885	4.425	-0.0009785
886	4.43	-0.0017406
887	4.435	-0.0020169
888	4.44	-0.0018201
889	4.445	-0.001283
890	4.45	-0.0005591
891	4.455	0.0002039
892	4.46	0.0008811
893	4.465	0.0012795

894	4.47	0.0010737
895	4.475	0.0001056
896	4.48	-0.0011583
897	4.485	-0.0018004
898	4.49	-0.0013437
899	4.495	-0.0002779
900	4.5	0.0005614
901	4.505	0.0009362
902	4.51	0.001215
903	4.515	0.0016207
904	4.52	0.0019236
905	4.525	0.0018823
906	4.53	0.0015654
907	4.535	0.0011207
908	4.54	0.0005857
909	4.545	0.0001077
910	4.55	4.91e-005
911	4.555	0.0006125
912	4.56	0.0015175
913	4.565	0.0022623
914	4.57	0.0026068
915	4.575	0.0026454
916	4.58	0.0025156
917	4.585	0.0022347
918	4.59	0.001795
919	4.595	0.0012629
920	4.6	0.0007274
921	4.605	0.0002207
922	4.61	-0.0002595
923	4.615	-0.0006383
924	4.62	-0.0007202
925	4.625	-0.0003556
926	4.63	0.000277
927	4.635	0.0006469
928	4.64	0.0003009
929	4.645	-0.0006248

930	4.65	-0.0014465
931	4.655	-0.0015846
932	4.66	-0.0011136
933	4.665	-0.000563
934	4.67	-0.0002611
935	4.675	-7.39e-005
936	4.68	0.0002059
937	4.685	0.0004994
938	4.69	0.0006394
939	4.695	0.0007032
940	4.7	0.0008405
941	4.705	0.0008673
942	4.71	0.0003808
943	4.715	-0.0006396
944	4.72	-0.0016192
945	4.725	-0.0019276
946	4.73	-0.0014913
947	4.735	-0.0007625
948	4.74	-0.0002178
949	4.745	2.5e-006
950	4.75	7.9e-005
951	4.755	0.0002775
952	4.76	0.0006629
953	4.765	0.0009656
954	4.77	0.0008248
955	4.775	0.0002435
956	4.78	-0.000333
957	4.785	-0.0005147
958	4.79	-0.0004068
959	4.795	-0.0003981
960	4.8	-0.0006498
961	4.805	-0.001
962	4.81	-0.0012488
963	4.815	-0.0012802
964	4.82	-0.0009746
965	4.825	-0.0002999

966	4.83	0.0004911
967	4.835	0.0010039
968	4.84	0.0011112
969	4.845	0.0010432
970	4.85	0.0010409
971	4.855	0.0010803
972	4.86	0.0009814
973	4.865	0.0006373
974	4.87	8.24e-005
975	4.875	-0.0005471
976	4.88	-0.0010407
977	4.885	-0.0011732
978	4.89	-0.0008319
979	4.895	-0.0001163
980	4.9	0.0006993
981	4.905	0.0013271
982	4.91	0.0016206
983	4.915	0.0015809
984	4.92	0.0012627
985	4.925	0.000749
986	4.93	0.0002022
987	4.935	-0.0002006
988	4.94	-0.0004367
989	4.945	-0.0006425
990	4.95	-0.0009036
991	4.955	-0.0011511
992	4.96	-0.0012915
993	4.965	-0.0013007
994	4.97	-0.001153
995	4.975	-0.0008364
996	4.98	-0.0005083
997	4.985	-0.000454
998	4.99	-0.0007693
999	4.995	-0.0012122
1000	5	-0.0014654
1001	5.005	-0.0014194

1002	5.01	-0.0011172
1003	5.015	-0.0005791
1004	5.02	0.0001714
1005	5.025	0.0009928
1006	5.03	0.001666
1007	5.035	0.0020303
1008	5.04	0.0020313
1009	5.045	0.0017003
1010	5.05	0.001154
1011	5.055	0.0005768
1012	5.06	0.0001279
1013	5.065	-0.0001514
1014	5.07	-0.0003238
1015	5.075	-0.0004437
1016	5.08	-0.0004695
1017	5.085	-0.0003172
1018	5.09	-1.63e-005
1019	5.095	0.0002257
1020	5.1	0.0001786
1021	5.105	-0.0001842
1022	5.11	-0.000643
1023	5.115	-0.0009043
1024	5.12	-0.0010868
1025	5.125	-0.0011303

Cyclic Number Functions

Cyclic Triaxial Results for Fly Ash

Model: Spline Data Point Function
Function: Cyclic Number vs. Shear Stress Ratio
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Y-Intercept: 500
Data Points: Shear Stress Ratio, Cyclic Number
Data Point: (0.16, 500)
Data Point: (0.17, 200)
Data Point: (0.185, 100)
Data Point: (0.225, 40)

Data Point: (0.265, 20)
Data Point: (0.315, 10)
Data Point: (0.37, 5)
Data Point: (0.425, 3)
Estimation Properties
Sample Material: Loose Sand

Pore Pressure Functions

New Function

Model: Spline Data Point Function
Function: PWP Ratio vs. Cyclic Number Ratio N/NL
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Y-Intercept: 0
Data Points: Cyclic Number Ratio N/NL, PWP Ratio
Data Point: (0, 0)
Data Point: (0.05, 0.075089716)
Data Point: (0.1, 0.12368875)
Data Point: (0.15, 0.16607762)
Data Point: (0.2, 0.20519259)
Data Point: (0.25, 0.24231186)
Data Point: (0.3, 0.2781656)
Data Point: (0.35, 0.31324362)
Data Point: (0.4, 0.3479165)
Data Point: (0.45, 0.38249492)
Data Point: (0.5, 0.41726502)
Data Point: (0.55, 0.45251442)
Data Point: (0.6, 0.48855688)
Data Point: (0.65, 0.52576183)
Data Point: (0.7, 0.56459752)
Data Point: (0.75, 0.60570358)
Data Point: (0.8, 0.65003056)
Data Point: (0.85, 0.69915001)
Data Point: (0.9, 0.75610124)
Data Point: (0.95, 0.82872015)
Data Point: (1, 1)
Estimation Properties
N-Exponent: 0.7

Regions

	Material	Points	Area (ft^2)
Region 1	Silty Clay (1)	63,2,24,3,1	143.25612

Region 2	Silty Clay (1)	2,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24	1176.8788
Region 3	Gravelly Silty Sand (2)	9,25,26,27,10	33.408658
Region 4	Sand and Gravel (3)	10,11,12,28,29,27	841.1626
Region 5	Sandy Silt (9)	3,30,21,22,23,24	425.72956
Region 6	Bottom Ash (4)	30,21,20,19,31,32,33	190.90717
Region 7	Silty Clay (6)	34,36,37,38,39,35	554.67017
Region 8	Bottom Ash 65 (7)	36,40,41,37	147.83552
Region 9	Original Dike (13)	41,37,38,39,42,43	841.25177
Region 10	Fly Ash (8)	44,61,43,41,40,36,34,33,30,3,1	8369.164
Region 11	Gravelly Silty Sand (5)	32,31,45,46,64,42,39,35,34,33	1406.9906
Region 12	Silty Clay Foundation (12)	51,54,55,56,57,52,62	9525.1236
Region 13	Foundation Soil (14)	55,58,69,70,59,60,54	18789.697
Region 14	Clay Foundation (11)	44,61,62,51	2466.2444
Region 15	Clay Foundation (10)	61,43,42,64,50,68,49,53,52,62	2091.4421
Region 16	Bottom Ash (4)	46,65,66,67,68,50,64	102.11485
Region 17	Gravelly Silty Sand (5)	65,47,48,67,66	161.58666
Region	Bottom	67,68,49	5.722693

18	Ash (4)		

Lines

	Start Point	End Point	Stress/Strain Boundary
Line 1	2	24	
Line 2	24	3	
Line 3	2	4	
Line 4	4	5	
Line 5	5	6	
Line 6	6	7	
Line 7	7	8	
Line 8	8	9	
Line 9	9	10	
Line 10	10	11	
Line 11	11	12	
Line 12	12	13	
Line 13	13	14	
Line 14	14	15	
Line 15	15	16	
Line 16	16	17	
Line 17	17	18	
Line 18	18	19	
Line 19	19	20	
Line 20	20	21	
Line 21	21	22	
Line 22	22	23	
Line 23	23	24	
Line 24	9	25	
Line 25	25	26	
Line 26	26	27	
Line 27	27	10	
Line 28	12	28	
Line 29	28	29	
Line 30	29	27	
Line 31	3	30	

Line 32	30	21	
Line 33	19	31	
Line 34	31	32	
Line 35	32	33	
Line 36	33	30	
Line 37	33	34	
Line 38	34	35	
Line 39	34	36	
Line 40	36	37	
Line 41	37	38	
Line 42	38	39	
Line 43	39	35	
Line 44	36	40	
Line 45	40	41	
Line 46	41	37	
Line 47	39	42	
Line 48	42	43	
Line 49	43	41	
Line 50	31	45	
Line 51	45	46	
Line 52	51	54	Fixed Y
Line 53	54	55	
Line 54	55	56	
Line 55	56	57	
Line 56	57	52	
Line 57	55	58	
Line 58	59	60	Fixed X/Y
Line 59	60	54	Fixed Y
Line 60	44	61	
Line 61	61	43	
Line 62	51	62	
Line 63	62	52	
Line 64	61	62	
Line 65	51	44	Fixed Y
Line 66	49	53	
Line 67	53	52	

Line 68	3	1	
Line 69	63	2	
Line 70	1	63	Fixed Y
Line 71	50	64	
Line 72	64	42	
Line 73	46	64	
Line 74	49	68	
Line 75	68	50	
Line 76	46	65	
Line 77	65	66	
Line 78	66	67	
Line 79	67	68	
Line 80	65	47	
Line 81	47	48	
Line 82	48	67	
Line 83	49	67	
Line 84	58	69	
Line 85	69	70	Fixed Y
Line 86	70	59	Fixed X/Y
Line 87	44	1	Fixed Y

Points

	X (ft)	Y (ft)
Point 1	-50.00109	595.71827
Point 2	20.87006	597.74003
Point 3	20.88514	595.7195
Point 4	28.29932	599.9386
Point 5	43.4	605
Point 6	66.4449	612.83618
Point 7	71.00682	614.37347
Point 8	75.83799	615.92596
Point 9	83.12625	618.01207
Point 10	89.16676	618.0063
Point 11	67.99514	603.00606
Point 12	160.50996	603.01085

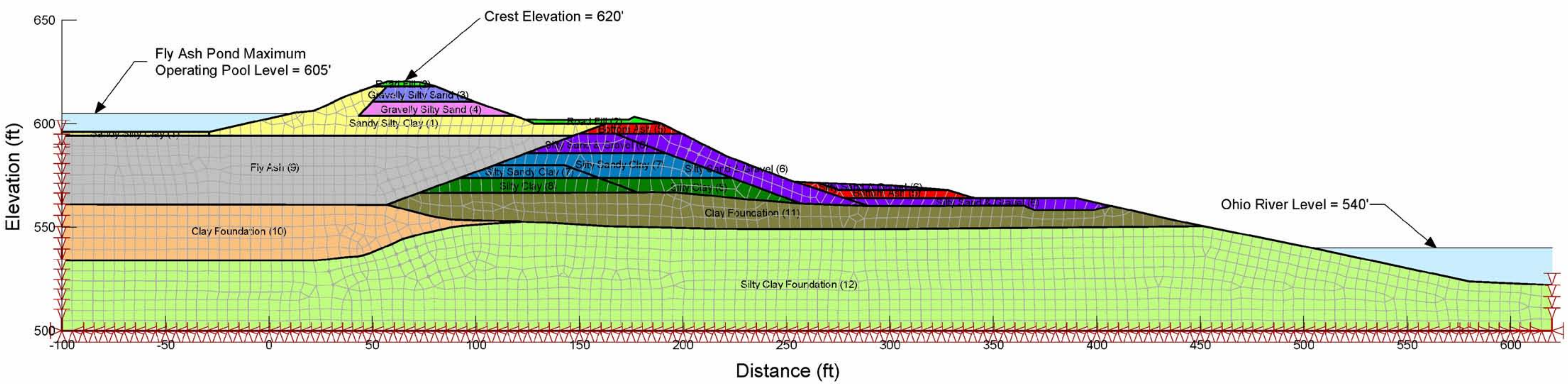
Point 13	164.36012	602.00265
Point 14	175.56909	602.00354
Point 15	179.88561	602.4977
Point 16	214.07092	602.96698
Point 17	216.26115	604.4504
Point 18	218.92113	601.99621
Point 19	228.49429	599.98195
Point 20	207.18559	599.99735
Point 21	204.40592	598.13958
Point 22	32.02668	598.14303
Point 23	26.54626	596.50886
Point 24	20.87931	596.50076
Point 25	89.27093	619.72571
Point 26	103.77188	619.42032
Point 27	111.47933	618.0121
Point 28	135.19671	609.9055
Point 29	123.47463	613.96956
Point 30	200.77083	595.72596
Point 31	240.76421	594.01059
Point 32	222.79049	594.01222
Point 33	198.17913	594.01083
Point 34	178.5748	580.99902
Point 35	248.77756	581.00098
Point 36	165.52362	572.33858
Point 37	228.39764	572.33563
Point 38	239.8063	579.91496
Point 39	250.94764	579.91496
Point 40	161.97373	569.98666
Point 41	224.86913	569.98596
Point 42	288.91143	560.96382
Point 43	211.29094	560.95827
Point 44	-50	560.99795
Point 45	257.89685	585.94071
Point 46	297.73567	569.9851
Point 47	325.50196	568.0018
Point 48	336.18826	565.99579

Point 49	354.42618	558.00394
Point 50	328.18785	559.80842
Point 51	-50	550.07288
Point 52	397.53591	549.83795
Point 53	388.85171	551.97178
Point 54	-50	530.60542
Point 55	486.17654	530.37993
Point 56	440.71606	539.69843
Point 57	420.04463	544.03139
Point 58	523	525
Point 59	523	500.03246
Point 60	-50	499.97967
Point 61	154.97895	560.96884
Point 62	194.99536	549.95765
Point 63	-50.00109	597.74003
Point 64	321.98827	559.99079
Point 65	304.18497	569.49578
Point 66	322.21879	562.20928
Point 67	349.0118	560.43036
Point 68	348.85409	558.38715
Point 69	580	525
Point 70	580	500

SECTION L-L

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section L-L Finite Element Stress Analysis
File Name: FAP_L-L_QUAKE_MESH.gsz
Date: 7/22/2010

QUAKE/W MESH

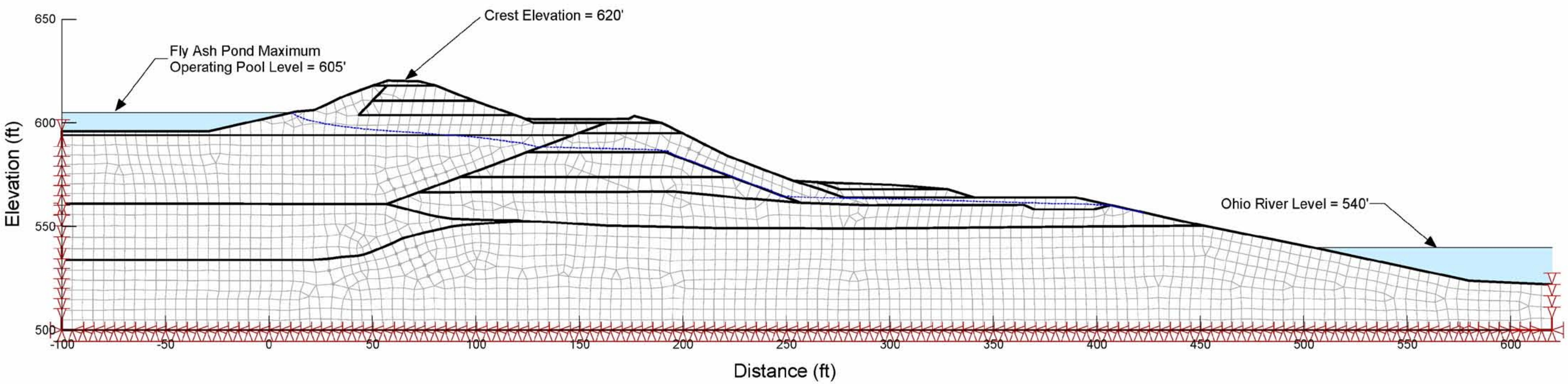


Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section L-L Finite Element Stress Analysis
File Name: FAP_L-L_QUAKE_RESULTS.gsz
Date: 7/22/2010

QUAKE/W MESH WITH LIQUEFIED ZONES
NOTE: NO LIQUEFACTION PREDICTED

ELEMENT THAT DOES NOT LIQUEFY UNDER THE MODELED CONDITIONS

ELEMENT THAT LIQUEFIES UNDER THE MODELED CONDITIONS



Dynamic QUAKE/W

File Information

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section L-L Finite Element Stress Analysis
Revision Number: 73
Last Edited By: Seth Frank
Date: 7/22/2010
Time: 2:29:42 PM
File Name: FAP_L-L_QUAKE_MESH.gsz
Directory: P:\Frank\Philip Sporn\SEISMIC REPORT\Updated Analysis Files\
Last Solved Date: 7/22/2010
Last Solved Time: 2:40:16 PM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Stiffness Units: psf
Unit Weight of Water: 62.4 pcf
Air Pressure: 101.33 psf
View: 2D

Analysis Settings

Dynamic QUAKE/W

Kind: QUAKE/W
Parent: Initial Static
Method: Equivalent Linear Dynamic
Settings
- Initial Stress: Parent Analysis
- Initial PWP: Parent Analysis
- Exclude cumulative values: No

Control
- Coefficient of Equivalent Shear Stress: 0.65
- Coefficient of Equivalent Shear Strain: 0.5
- Equivalent Number of Cycles: 10
- Liquefaction Stress Limit: 0

Convergence

Maximum Number of Iterations: 10
Displacement Norm Tolerance: 1 %

Time

Starting Time: 0 sec
Duration: 5.125 sec
# of Steps: 1025
Save Steps Every: 10
Steps Generated via Earthquake Records: Yes

Materials

Sandy Silty Clay (1)

Model: Linear Elastic

Stress Strain

Unit Weight: 130 pcf
Poisson's Ratio: 0.45
Damping Ratio: 0.1
Pore Water Pressure Function: New Function
G Modulus: 3867112 psf

Road Fill (2)

Model: Linear Elastic

Stress Strain

Unit Weight: 110 pcf
Poisson's Ratio: 0.352
Damping Ratio: 0.1
Pore Water Pressure Function: New Function
G Modulus: 3272171 psf

Gravelly Silty Sand (3)

Model: Linear Elastic

Stress Strain

Unit Weight: 110 pcf
Poisson's Ratio: 0.352
Damping Ratio: 0.1
Pore Water Pressure Function: New Function
G Modulus: 3272171 psf

Gravelly Silty Sand (4)

Model: Linear Elastic

Stress Strain

Unit Weight: 100 pcf
Poisson's Ratio: 0.352
Damping Ratio: 0.1
Pore Water Pressure Function: New Function
G Modulus: 2974701 psf

Bottom Ash (5)

Model: Linear Elastic

Stress Strain

Unit Weight: 65 pcf

Poisson's Ratio: 0.352

Damping Ratio: 0.1

Pore Water Pressure Function: New Function

G Modulus: 1933556 psf

Silty Sand & Gravel (6)

Model: Linear Elastic

Stress Strain

Unit Weight: 115 pcf

Poisson's Ratio: 0.352

Damping Ratio: 0.1

Pore Water Pressure Function: New Function

G Modulus: 3420906 psf

Silty Sandy Clay (7)

Model: Linear Elastic

Stress Strain

Unit Weight: 130 pcf

Poisson's Ratio: 0.45

Damping Ratio: 0.1

Pore Water Pressure Function: New Function

G Modulus: 3867112 psf

Silty Clay (8)

Model: Linear Elastic

Stress Strain

Unit Weight: 130 pcf

Poisson's Ratio: 0.45

Damping Ratio: 0.1

Pore Water Pressure Function: New Function

G Modulus: 3867112 psf

Fly Ash (9)

Model: Linear Elastic

Stress Strain

Unit Weight: 110 pcf

Poisson's Ratio: 0.495

Damping Ratio: 0.045

Pore Water Pressure Function: New Function

Cyclic Function: Cyclic Triaxial Results for Fly Ash

G Modulus: 774831 psf

Clay Foundation (10)

Model: Linear Elastic
Stress Strain
Unit Weight: 125 pcf
Poisson's Ratio: 0.45
Damping Ratio: 0.07
Pore Water Pressure Function: New Function
G Modulus: 1869705 psf

Clay Foundation (11)

Model: Linear Elastic
Stress Strain
Unit Weight: 125 pcf
Poisson's Ratio: 0.45
Damping Ratio: 0.07
Pore Water Pressure Function: New Function
G Modulus: 1869705 psf

Silty Clay Foundation (12)

Model: Linear Elastic
Stress Strain
Unit Weight: 130 pcf
Poisson's Ratio: 0.45
Damping Ratio: 0.07
Pore Water Pressure Function: New Function
G Modulus: 1944493 psf

Boundary Conditions

Fixed Y

X: 0
Y: Y-Displacement 0

Fixed X/Y

X: X-Displacement 0
Y: Y-Displacement 0

Earthquake Records

Horizontal Earthquake Records

Description: Giles Co
Use Baseline Correction: No
Modified Peak Acc.: 0.30340468
Modified Duration: 1

Records

	Time (sec)	Acc (ft/sec²)
1	0.005	0.00074237381
2	0.01	0.0015841338
3	0.015	0.0020074131
4	0.02	0.0020881411
5	0.025	0.0020403079
6	0.03	0.0020214541
7	0.035	0.0020190272
8	0.04	0.0020266646
9	0.045	0.0020580096
10	0.05	0.0020958295
11	0.055	0.0021387682
12	0.06	0.0021873254
13	0.065	0.0022080249
14	0.07	0.0022257673
15	0.075	0.0023068013
16	0.08	0.0023844499
17	0.085	0.0023576833
18	0.09	0.002338085
19	0.095	0.0024320485
20	0.1	0.0024556847
21	0.105	0.0023430917
22	0.11	0.0024501479
23	0.115	0.0028857959
24	0.12	0.0031628123
25	0.125	0.0030771286
26	0.13	0.0029803406
27	0.135	0.0026485572
28	0.14	0.0013546956
29	0.145	-0.00016941878
30	0.15	0.00037487815
31	0.155	0.0039899358
32	0.16	0.0090366473
33	0.165	0.013242276

34	0.17	0.014940349
35	0.175	0.011953197
36	0.18	0.002078342
37	0.185	-0.01332589
38	0.19	-0.02655389
39	0.195	-0.02546426
40	0.2	-0.0014758234
41	0.205	0.039876925
42	0.21	0.077848578
43	0.215	0.092652493
44	0.22	0.082851331
45	0.225	0.060614765
46	0.23	0.033987866
47	0.235	0.0065708474
48	0.24	-0.0091383094
49	0.245	0.0011332212
50	0.25	0.029039869
51	0.255	0.045923524
52	0.26	0.036332925
53	0.265	0.012131845
54	0.27	-0.011632813
55	0.275	-0.034764964
56	0.28	-0.057938513
57	0.285	-0.070029673
58	0.29	-0.060645151
59	0.295	-0.03268186
60	0.3	0.0034418884
61	0.305	0.035670338
62	0.31	0.048797899
63	0.315	0.032970837
64	0.32	-0.0023321811
65	0.325	-0.035389416
66	0.33	-0.055034873
67	0.335	-0.066065361
68	0.34	-0.074619354
69	0.345	-0.080932803

70	0.35	-0.085216886
71	0.355	-0.089790048
72	0.36	-0.095836953
73	0.365	-0.1032538
74	0.37	-0.10861324
75	0.375	-0.10065117
76	0.38	-0.069623228
77	0.385	-0.027555318
78	0.39	-0.005768655
79	0.395	-0.021172836
80	0.4	-0.053992148
81	0.405	-0.069033445
82	0.41	-0.052574794
83	0.415	-0.019996125
84	0.42	0.0069637504
85	0.425	0.020201897
86	0.43	0.023543387
87	0.435	0.021578872
88	0.44	0.018667075
89	0.445	0.026089324
90	0.45	0.056988784
91	0.455	0.10690323
92	0.46	0.14896706
93	0.465	0.15861731
94	0.47	0.13581829
95	0.475	0.095129805
96	0.48	0.04757204
97	0.485	0.0055686958
98	0.49	-0.011340369
99	0.495	0.00094269399
100	0.5	0.013362802
101	0.505	-0.0060825125
102	0.51	-0.048634649
103	0.515	-0.073923728
104	0.52	-0.061479148
105	0.525	-0.032859692

106	0.53	-0.020692872
107	0.535	-0.031840318
108	0.54	-0.045030794
109	0.545	-0.034229224
110	0.55	0.0089556949
111	0.555	0.068743856
112	0.56	0.11643724
113	0.565	0.13005302
114	0.57	0.10767003
115	0.575	0.068085653
116	0.58	0.040016825
117	0.585	0.041057612
118	0.59	0.058453146
119	0.595	0.057376262
120	0.6	0.01957306
121	0.605	-0.030100235
122	0.61	-0.047869583
123	0.615	-0.021960436
124	0.62	0.010634853
125	0.625	0.0021839095
126	0.63	-0.054767717
127	0.635	-0.11660956
128	0.64	-0.12823086
129	0.645	-0.073033751
130	0.65	0.016174569
131	0.655	0.092629958
132	0.66	0.13474865
133	0.665	0.14942082
134	0.67	0.14836749
135	0.675	0.13157235
136	0.68	0.090144081
137	0.685	0.018915876
138	0.69	-0.070631794
139	0.695	-0.14812889
140	0.7	-0.18368206
141	0.705	-0.17365963

142	0.71	-0.13871316
143	0.715	-0.094815948
144	0.72	-0.041141837
145	0.725	0.017204548
146	0.73	0.052659937
147	0.735	0.039522484
148	0.74	-0.010994494
149	0.745	-0.056144897
150	0.75	-0.065149383
151	0.755	-0.048576833
152	0.76	-0.038534822
153	0.765	-0.043699806
154	0.77	-0.03542021
155	0.775	0.013592332
156	0.78	0.085033955
157	0.785	0.12749261
158	0.79	0.11581421
159	0.795	0.080103498
160	0.8	0.06630621
161	0.805	0.08415958
162	0.81	0.10865606
163	0.815	0.11892934
164	0.82	0.11359539
165	0.825	0.092638727
166	0.83	0.049039869
167	0.835	-0.012828082
168	0.84	-0.065783624
169	0.845	-0.079870603
170	0.85	-0.050316509
171	0.855	-0.00097395534
172	0.86	0.03434353
173	0.865	0.03201866
174	0.87	-0.0067449271
175	0.875	-0.050904966
176	0.88	-0.059992556
177	0.885	-0.025965841

178	0.89	0.009786112
179	0.895	-0.0026597634
180	0.9	-0.065476089
181	0.905	-0.13289283
182	0.91	-0.1654665
183	0.915	-0.16626389
184	0.92	-0.16137759
185	0.925	-0.16546752
186	0.93	-0.17628633
187	0.935	-0.18630774
188	0.94	-0.18426124
189	0.945	-0.15329255
190	0.95	-0.082747017
191	0.955	0.016499133
192	0.96	0.11393189
193	0.965	0.17847558
194	0.97	0.19775568
195	0.975	0.18249414
196	0.98	0.1517722
197	0.985	0.11339247
198	0.99	0.065048945
199	0.995	0.01631345
200	1	-0.0066645049
201	1.005	0.0075865504
202	1.01	0.032321811
203	1.015	0.030442847
204	1.02	0.00028647701
205	1.025	-0.025406138
206	1.03	-0.022468339
207	1.035	0.0012715917
208	1.04	0.021795146
209	1.045	0.01814092
210	1.05	-0.020676456
211	1.055	-0.083739676
212	1.06	-0.13069644
213	1.065	-0.11959621

214	1.07	-0.051312838
215	1.075	0.028703375
216	1.08	0.077249618
217	1.085	0.087266442
218	1.09	0.075098195
219	1.095	0.057022025
220	1.1	0.047235954
221	1.105	0.05723626
222	1.11	0.078925461
223	1.115	0.08012695
224	1.12	0.03601193
225	1.125	-0.037174059
226	1.13	-0.093156521
227	1.135	-0.10202203
228	1.14	-0.078317324
229	1.145	-0.062551035
230	1.15	-0.080201081
231	1.155	-0.11863873
232	1.16	-0.1394351
233	1.165	-0.11381666
234	1.17	-0.051040991
235	1.175	0.0081778628
236	1.18	0.030390945
237	1.185	0.020307026
238	1.19	0.0094410319
239	1.195	0.019596411
240	1.2	0.046971959
241	1.205	0.076747119
242	1.21	0.095931376
243	1.215	0.090094218
244	1.22	0.048476598
245	1.225	-0.013247986
246	1.23	-0.048035689
247	1.235	-0.015179668
248	1.24	0.07512848
249	1.245	0.1644091

250	1.25	0.1956164
251	1.255	0.15785663
252	1.26	0.085932191
253	1.265	0.024412664
254	1.27	-0.0053024166
255	1.275	-0.010252167
256	1.28	-0.010482105
257	1.285	-0.022819007
258	1.29	-0.051197002
259	1.295	-0.082039156
260	1.3	-0.09140624
261	1.305	-0.067553482
262	1.31	-0.027937392
263	1.315	-0.0061588865
264	1.32	-0.020548996
265	1.325	-0.059238095
266	1.33	-0.09198185
267	1.335	-0.091324462
268	1.34	-0.050291934
269	1.345	0.010070011
270	1.35	0.055861324
271	1.355	0.072796472
272	1.36	0.079172326
273	1.365	0.09958703
274	1.37	0.1333884
275	1.375	0.15733456
276	1.38	0.15157744
277	1.385	0.11480677
278	1.39	0.061774549
279	1.395	0.013988987
280	1.4	-0.014795758
281	1.405	-0.031270113
282	1.41	-0.053989599
283	1.415	-0.087659529
284	1.42	-0.11579484
285	1.425	-0.12423269

286	1.43	-0.11995309
287	1.435	-0.11749057
288	1.44	-0.11674518
289	1.445	-0.10594371
290	1.45	-0.081204038
291	1.455	-0.052147242
292	1.46	-0.029311614
293	1.465	-0.014027837
294	1.47	-0.0020567248
295	1.475	0.0072472418
296	1.48	0.0084415418
297	1.485	-0.0021317528
298	1.49	-0.016391557
299	1.495	-0.017634853
300	1.5	0.00049808708
301	1.505	0.021504538
302	1.51	0.022407668
303	1.515	0.0038906393
304	1.52	-0.0065656164
305	1.525	0.012656164
306	1.53	0.050410931
307	1.535	0.07695024
308	1.54	0.077272255
309	1.545	0.058148669
310	1.55	0.027387784
311	1.555	-0.014907821
312	1.56	-0.059346793
313	1.565	-0.079131335
314	1.57	-0.054467625
315	1.575	0.0013653207
316	1.58	0.053648618
317	1.585	0.08066993
318	1.59	0.084775772
319	1.595	0.073414398
320	1.6	0.046429285
321	1.605	0.0056018762

322	1.61	-0.037079433
323	1.615	-0.067086265
324	1.62	-0.075500867
325	1.625	-0.0589482
326	1.63	-0.02295646
327	1.635	0.013860508
328	1.64	0.033711227
329	1.645	0.041370042
330	1.65	0.056935964
331	1.655	0.081511165
332	1.66	0.086525951
333	1.665	0.047764046
334	1.67	-0.021666667
335	1.675	-0.082232385
336	1.68	-0.10327419
337	1.685	-0.081588661
338	1.69	-0.036829204
339	1.695	0.0024685327
340	1.7	0.017812379
341	1.705	0.015520241
342	1.71	0.017507801
343	1.715	0.033059753
344	1.72	0.047713266
345	1.725	0.043769756
346	1.73	0.021455593
347	1.735	-0.0058096054
348	1.74	-0.026718874
349	1.745	-0.035042215
350	1.75	-0.026397063
351	1.755	-0.0026489752
352	1.76	0.023528806
353	1.765	0.036515652
354	1.77	0.031236566
355	1.775	0.01674508
356	1.78	0.0070231263
357	1.785	0.0084944427

358	1.79	0.014984807
359	1.795	0.014983379
360	1.8	0.0046407566
361	1.805	-0.0078359335
362	1.81	-0.011057102
363	1.815	-0.0011364739
364	1.82	0.015679617
365	1.825	0.025842256
366	1.83	0.014733354
367	1.835	-0.020916692
368	1.84	-0.063438768
369	1.845	-0.084928011
370	1.85	-0.072648822
371	1.855	-0.038598246
372	1.86	-0.0018299684
373	1.865	0.02985286
374	1.87	0.056112573
375	1.875	0.071942286
376	1.88	0.068769756
377	1.885	0.044343122
378	1.89	0.0065606302
379	1.895	-0.02915438
380	1.9	-0.044831141
381	1.905	-0.030281534
382	1.91	0.0060609361
383	1.915	0.04173937
384	1.92	0.060381462
385	1.925	0.063599266
386	1.93	0.060827164
387	1.935	0.054131437
388	1.94	0.039137555
389	1.945	0.017151422
390	1.95	-0.0015565209
391	1.955	-0.0089859182
392	1.96	-0.01031141
393	1.965	-0.018979504

394	1.97	-0.039729173
395	1.975	-0.059701336
396	1.98	-0.060164576
397	1.985	-0.036811563
398	1.99	-0.0057823799
399	1.995	0.01094402
400	2	0.0051219639
401	2.005	-0.012492811
402	2.01	-0.025728867
403	2.015	-0.030738044
404	2.02	-0.036879678
405	2.025	-0.048927909
406	2.03	-0.055175181
407	2.035	-0.040170185
408	2.04	-0.0055574386
409	2.045	0.028893953
410	2.05	0.042394004
411	2.055	0.026390129
412	2.06	-0.012411339
413	2.065	-0.053424595
414	2.07	-0.072224941
415	2.075	-0.059704191
416	2.08	-0.029466707
417	2.085	-0.0011468645
418	2.09	0.017874783
419	2.095	0.029995309
420	2.1	0.036921893
421	2.105	0.039544611
422	2.11	0.039385031
423	2.115	0.032726522
424	2.12	0.01226685
425	2.125	-0.018453656
426	2.13	-0.041744978
427	2.135	-0.044140512
428	2.14	-0.030192006
429	2.145	-0.013425105

430	2.15	-0.003019119
431	2.155	-0.0034765882
432	2.16	-0.016618232
433	2.165	-0.037488835
434	2.17	-0.055492301
435	2.175	-0.06417253
436	2.18	-0.065526971
437	2.185	-0.064223106
438	2.19	-0.062111961
439	2.195	-0.056492709
440	2.2	-0.039842459
441	2.205	-0.0071743551
442	2.21	0.030437035
443	2.215	0.04811451
444	2.22	0.032868461
445	2.225	0.0012788314
446	2.23	-0.017252167
447	2.235	-0.0096314673
448	2.24	0.01502437
449	2.245	0.040369226
450	2.25	0.054856735
451	2.255	0.05567462
452	2.26	0.049843581
453	2.265	0.047434384
454	2.27	0.048824309
455	2.275	0.045145304
456	2.28	0.035080861
457	2.285	0.030744774
458	2.29	0.039077292
459	2.295	0.047105129
460	2.3	0.037498521
461	2.305	0.014027531
462	2.31	-0.00031881207
463	2.315	0.0091559498
464	2.32	0.031718059
465	2.325	0.0434974

466	2.33	0.030844703
467	2.335	-0.0011959519
468	2.34	-0.037825737
469	2.345	-0.06498654
470	2.35	-0.072119812
471	2.355	-0.053332008
472	2.36	-0.012816662
473	2.365	0.032866116
474	2.37	0.06427511
475	2.375	0.072455491
476	2.38	0.060987968
477	2.385	0.037788824
478	2.39	0.010956664
479	2.395	-0.0093176303
480	2.4	-0.014443765
481	2.405	-0.0063721627
482	2.41	0.0038070256
483	2.415	0.0094749771
484	2.42	0.014814622
485	2.425	0.024605384
486	2.43	0.034713368
487	2.435	0.038219945
488	2.44	0.036172428
489	2.445	0.036225043
490	2.45	0.042524421
491	2.455	0.050379525
492	2.46	0.049179973
493	2.465	0.02961191
494	2.47	-0.0073953605
495	2.475	-0.046124095
496	2.48	-0.064628939
497	2.485	-0.052207301
498	2.49	-0.018219639
499	2.495	0.01615958
500	2.5	0.033124809
501	2.505	0.027974712

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507	2.535	-0.02758754
508	2.54	-0.02516631
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510	2.55	0.010547976
511	2.555	0.033627205
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516	2.58	-0.018340777
517	2.585	-0.035112675
518	2.59	-0.037290099
519	2.595	-0.020189762
520	2.6	0.011869379
521	2.605	0.04026889
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523	2.615	0.040701132
524	2.62	0.033816967
525	2.625	0.03141399
526	2.63	0.020843683
527	2.635	-0.0052012032
528	2.64	-0.036364638
529	2.645	-0.056334659
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531	2.655	-0.040242888
532	2.66	-0.014392883
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535	2.675	-0.00059091975
536	2.68	-0.010071755
537	2.685	-0.0095956052

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539	2.695	-0.00087639033
540	2.7	0.00072098603
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543	2.715	0.0048888243
544	2.72	-0.0045819211
545	2.725	-0.0089163047
546	2.73	-0.00087293158
547	2.735	0.013125625
548	2.74	0.019155399
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550	2.75	-0.01135128
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552	2.76	-0.045879066
553	2.765	-0.04405853
554	2.77	-0.029835118
555	2.775	-0.013432854
556	2.78	-0.0058543591
557	2.785	-0.0085577547
558	2.79	-0.012706434
559	2.795	-0.0091310391
560	2.8	0.0038944224
561	2.805	0.02171918
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563	2.815	0.038122973
564	2.82	0.021620067
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566	2.83	-0.024341491
567	2.835	-0.022489344
568	2.84	-0.0049562557
569	2.845	0.012178852
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571	2.855	0.01680412
572	2.86	0.014597023
573	2.865	0.015426838

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575	2.875	0.010386968
576	2.88	-0.0022694402
577	2.885	-0.017992556
578	2.89	-0.029785357
579	2.895	-0.0311658
580	2.9	-0.018751402
581	2.905	0.0049609769
582	2.91	0.030701744
583	2.915	0.047221576
584	2.92	0.048927093
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588	2.94	-0.013951973
589	2.945	-0.016997145
590	2.95	-0.0070618232
591	2.955	0.0078656368
592	2.96	0.015680738
593	2.965	0.0098848476
594	2.97	-0.0056169267
595	2.975	-0.019613133
596	2.98	-0.021452534
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598	2.99	0.0083652493
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601	3.005	0.0089770368
602	3.01	0.0024941776
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604	3.02	0.00037634139
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606	3.03	-0.002361089
607	3.035	-0.012290609
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617	3.085	-0.013110023
618	3.09	-0.013974916
619	3.095	-0.013450597
620	3.1	-0.01355287
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622	3.11	-0.0023302641
623	3.115	0.0064424595
624	3.12	0.0067798613
625	3.125	-0.00098164168
626	3.13	-0.0074602427
627	3.135	-0.0062861426
628	3.14	-0.00095259509
629	3.145	0.00062338126
630	3.15	-0.0055271235
631	3.155	-0.016411135
632	3.16	-0.02429846
633	3.165	-0.022376364
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655	3.275	-0.00064559498
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664	3.32	-0.014163149
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681	3.405	0.0059729989

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683	3.415	0.0091910574
684	3.42	0.0094899562
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687	3.435	0.0046776996
688	3.44	-0.0068909248
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692	3.46	-0.01420414
693	3.465	-0.0027530437
694	3.47	0.0072362292
695	3.475	0.010765168
696	3.48	0.0058869685
697	3.485	-0.0029588967
698	3.49	-0.0078323952
699	3.495	-0.0044945141
700	3.5	0.0042182625
701	3.505	0.012380748
702	3.51	0.016772305
703	3.515	0.017709289
704	3.52	0.015967268
705	3.525	0.011878964
706	3.53	0.0075477312
707	3.535	0.0068246661
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723	3.615	0.015248598
724	3.62	0.013492097
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726	3.63	0.0059284797
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729	3.645	0.0075931172
730	3.65	0.0097914347
731	3.655	0.010348017
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733	3.665	0.0097029571
734	3.67	0.010553584
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739	3.695	-0.02351504
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742	3.71	-0.00041275212
743	3.715	0.01045855
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757	3.785	0.0062138574
758	3.79	0.0096357398
759	3.795	0.010115825
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761	3.805	0.009551555
762	3.81	0.012995921
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766	3.83	-0.0031760069
767	3.835	-0.010493219
768	3.84	-0.011466707
769	3.845	-0.008129897
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773	3.865	0.002786632
774	3.87	0.0021639645
775	3.875	-0.00056059141
776	3.88	-0.001515336
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784	3.92	-0.00046480575
785	3.925	0.0029108188
786	3.93	0.0058575201
787	3.935	0.0043118079
788	3.94	-0.0008858703
789	3.945	-0.0038772407

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792	3.96	0.012665035
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794	3.97	0.0052106251
795	3.975	-0.0028191088
796	3.98	-0.008387254
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798	3.99	-0.0080630978
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801	4.005	-0.007299429
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804	4.02	0.0051631488
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853	4.265	0.0053158458
854	4.27	0.0065786071
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859	4.295	-0.0024954522
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863	4.315	-0.00087984399
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865	4.325	0.0042771388
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871	4.355	0.0046095442
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881	4.405	-0.0035178342
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884	4.42	-0.0089448149
885	4.425	-0.0056272153
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892	4.46	-0.0043438258
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896	4.48	0.0045093913
897	4.485	0.0060841644

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899	4.495	0.0061626593
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908	4.54	-0.015828388
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923	4.615	0.00093873968
924	4.62	-0.00041802488
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927	4.635	0.005473733
928	4.64	0.0074803814
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937	4.685	0.0075159274
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939	4.695	0.0063567554
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941	4.705	0.0022978383
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943	4.715	-0.0023324462
944	4.72	-0.004543836
945	4.725	-0.0053014581
946	4.73	-0.0046383909
947	4.735	-0.0036053227
948	4.74	-0.0028248802
949	4.745	-0.0021873866
950	4.75	-0.0018614765
951	4.755	-0.0025480575
952	4.76	-0.0043861527
953	4.765	-0.0062669624
954	4.77	-0.0066491894
955	4.775	-0.0049345366
956	4.78	-0.0020423677
957	4.785	0.00022348934
958	4.79	0.00064881207
959	4.795	-0.00025208015
960	4.8	-0.00084905884
961	4.805	-0.00041532885
962	4.81	9.3948812e-006
963	4.815	-0.00075777404
964	4.82	-0.0022286326
965	4.825	-0.0029061997
966	4.83	-0.0022666871
967	4.835	-0.001104354
968	4.84	-0.00025318446
969	4.845	-4.1540532e-005

970	4.85	-0.00075436423
971	4.855	-0.0023745896
972	4.86	-0.0037787397
973	4.865	-0.0033557969
974	4.87	-0.00083311614
975	4.875	0.0022244723
976	4.88	0.0039842052
977	4.885	0.0038892832
978	4.89	0.0025904966
979	4.895	0.00098172632
980	4.9	-0.00037558683
981	4.905	-0.0011173448
982	4.91	-0.00074520547
983	4.915	0.0011464668
984	4.92	0.0040353727
985	4.925	0.0063228918
986	4.93	0.0067348017
987	4.935	0.0056626287
988	4.94	0.0044278169
989	4.945	0.0036179464
990	4.95	0.0030484348
991	4.955	0.002832589
992	4.96	0.003156786
993	4.965	0.0033269807
994	4.97	0.0025068217
995	4.975	0.0012876007
996	4.98	0.0010604568
997	4.985	0.0018338942
998	4.99	0.002076578
999	4.995	0.00086157337
1000	5	-0.0010539717
1001	5.005	-0.0023928928
1002	5.01	-0.0025940247
1003	5.015	-0.0019123381
1004	5.02	-0.0011967472
1005	5.025	-0.0013882431

1006	5.03	-0.0023985724
1007	5.035	-0.0028282757
1008	5.04	-0.0017019578
1009	5.045	-2.9691445e-005
1010	5.05	0.00040450189
1011	5.055	-0.00057246763
1012	5.06	-0.001518395
1013	5.065	-0.0015497808
1014	5.07	-0.0013087183
1015	5.075	-0.0016324666
1016	5.08	-0.0023166718
1017	5.085	-0.0026173448
1018	5.09	-0.0023037728
1019	5.095	-0.0017553584
1020	5.1	-0.0013810543
1021	5.105	-0.0012929132
1022	5.11	-0.0013784032
1023	5.115	-0.0014576629
1024	5.12	-0.0015240339
1025	5.125	-0.0015391353

Vertical Earthquake Records

Description: Giles Co
Use Baseline Correction: No
Modified Peak Acc.: 0.48380254
Modified Duration: 1

Records

	Time (sec)	Acc (ft/sec²)
1	0.005	-0.0016033751
2	0.01	-0.00094558377
3	0.015	-0.00057697767
4	0.02	-0.0005099847
5	0.025	-0.00058870195
6	0.03	-0.00064258387
7	0.035	-0.00068153972
8	0.04	-0.00074123687

9	0.045	-0.00077343428
10	0.05	-0.00075803406
11	0.055	-0.00075484246
12	0.06	-0.00078559702
13	0.065	-0.00080241052
14	0.07	-0.00080017844
15	0.075	-0.00082386663
16	0.08	-0.00086219537
17	0.085	-0.00087266646
18	0.09	-0.00088534924
19	0.095	-0.00094309065
20	0.1	-0.00099650964
21	0.105	-0.00099179872
22	0.11	-0.00097262568
23	0.115	-0.00097294891
24	0.12	-0.00094472418
25	0.125	-0.00091186805
26	0.13	-0.0010167401
27	0.135	-0.0012892628
28	0.14	-0.001534404
29	0.145	-0.0014658509
30	0.15	-0.00073137555
31	0.155	0.0010761905
32	0.16	0.0040854798
33	0.165	0.0079283573
34	0.17	0.012009993
35	0.175	0.015509942
36	0.18	0.017012134
37	0.185	0.015390435
38	0.19	0.011848883
39	0.195	0.0095911594
40	0.2	0.009911502
41	0.205	0.0096348119
42	0.21	0.0040700112
43	0.215	-0.0079938717
44	0.22	-0.02289069

45	0.225	-0.034116753
46	0.23	-0.03504405
47	0.235	-0.022606709
48	0.24	-0.0012386765
49	0.245	0.018138676
50	0.25	0.025651983
51	0.255	0.019098195
52	0.26	0.0031792801
53	0.265	-0.015185072
54	0.27	-0.029393392
55	0.275	-0.033932803
56	0.28	-0.026257367
57	0.285	-0.0090495666
58	0.29	0.0094864383
59	0.295	0.01886479
60	0.3	0.013322831
61	0.305	-0.0024649332
62	0.31	-0.017394208
63	0.315	-0.025357908
64	0.32	-0.028583563
65	0.325	-0.02764301
66	0.33	-0.015775059
67	0.335	0.0097410625
68	0.34	0.036440502
69	0.345	0.047232181
70	0.35	0.040744264
71	0.355	0.032330988
72	0.36	0.034823493
73	0.365	0.046126746
74	0.37	0.056239931
75	0.375	0.057852044
76	0.38	0.04718446
77	0.385	0.022846232
78	0.39	-0.0092357908
79	0.395	-0.033972978
80	0.4	-0.037635974

81	0.405	-0.020527072
82	0.41	0.0043897114
83	0.415	0.024501988
84	0.42	0.035435505
85	0.425	0.037192108
86	0.43	0.028338024
87	0.435	0.0076283369
88	0.44	-0.019429693
89	0.445	-0.038311104
90	0.45	-0.033968186
91	0.455	-0.0059167533
92	0.46	0.02662282
93	0.465	0.041501682
94	0.47	0.036870399
95	0.475	0.030441623
96	0.48	0.033579892
97	0.485	0.036176914
98	0.49	0.023642704
99	0.495	-0.00065627205
100	0.5	-0.020411951
101	0.505	-0.027904252
102	0.51	-0.029142143
103	0.515	-0.02993576
104	0.52	-0.027517895
105	0.525	-0.017072601
106	0.53	0.0007787407
107	0.535	0.020747221
108	0.54	0.036762415
109	0.545	0.044643826
110	0.55	0.0445026
111	0.555	0.040939941
112	0.56	0.038335985
113	0.565	0.035442439
114	0.57	0.026091975
115	0.575	0.0060133884
116	0.58	-0.020947283

117	0.585	-0.043869583
118	0.59	-0.053570001
119	0.595	-0.050525849
120	0.6	-0.041874885
121	0.605	-0.031546854
122	0.61	-0.019087489
123	0.615	-0.0088298154
124	0.62	-0.010580912
125	0.625	-0.024691547
126	0.63	-0.034799837
127	0.635	-0.026373305
128	0.64	-0.0084183338
129	0.645	-0.0051833996
130	0.65	-0.026905884
131	0.655	-0.058871826
132	0.66	-0.079787193
133	0.665	-0.081402672
134	0.67	-0.069168247
135	0.675	-0.053645151
136	0.68	-0.044174467
137	0.685	-0.042841644
138	0.69	-0.042320893
139	0.695	-0.036404813
140	0.7	-0.031453554
141	0.705	-0.037030284
142	0.71	-0.046283063
143	0.715	-0.040134598
144	0.72	-0.014186092
145	0.725	0.012607219
146	0.73	0.02173213
147	0.735	0.014830733
148	0.74	0.003160467
149	0.745	-0.0097679719
150	0.75	-0.02538238
151	0.755	-0.039475171
152	0.76	-0.044851433

153	0.765	-0.039654532
154	0.77	-0.027052004
155	0.775	-0.012405119
156	0.78	-0.0044773121
157	0.785	-0.0101233
158	0.79	-0.021133068
159	0.795	-0.015756398
160	0.8	0.016299174
161	0.805	0.056035995
162	0.81	0.073099011
163	0.815	0.059012746
164	0.82	0.032808606
165	0.825	0.015242888
166	0.83	0.0090177118
167	0.835	0.0070583767
168	0.84	0.0086094116
169	0.845	0.017749261
170	0.85	0.031221678
171	0.855	0.038082492
172	0.86	0.03222953
173	0.865	0.018635057
174	0.87	0.0055299888
175	0.875	-0.004042745
176	0.88	-0.010402875
177	0.885	-0.012434486
178	0.89	-0.00941917
179	0.895	-0.0042236362
180	0.9	0.00069856225
181	0.905	0.0080708576
182	0.91	0.02031192
183	0.915	0.030772917
184	0.92	0.028601611
185	0.925	0.013923014
186	0.93	0.00020212909
187	0.935	-0.0024862751
188	0.94	0.00063029061

189	0.945	-0.00016843377
190	0.95	-0.0024592434
191	0.955	0.0052257571
192	0.96	0.025442133
193	0.965	0.045188029
194	0.97	0.049073213
195	0.975	0.034887121
196	0.98	0.015031406
197	0.985	0.005287152
198	0.99	0.012210156
199	0.995	0.028841134
200	1	0.042242582
201	1.005	0.046113286
202	1.01	0.044549505
203	1.015	0.042716631
204	1.02	0.038641277
205	1.025	0.029234526
206	1.03	0.020477108
207	1.035	0.022315285
208	1.04	0.032345162
209	1.045	0.034057612
210	1.05	0.017293464
211	1.055	-0.0060261038
212	1.06	-0.014634751
213	1.065	-0.0029027123
214	1.07	0.01503681
215	1.075	0.023569797
216	1.08	0.018567554
217	1.085	0.0036093709
218	1.09	-0.014718976
219	1.095	-0.025634547
220	1.1	-0.020345671
221	1.105	-0.0046617314
222	1.11	0.0045439788
223	1.115	0.00034749465
224	1.12	-0.007320985

225	1.125	-0.011103701
226	1.13	-0.019967778
227	1.135	-0.044371163
228	1.14	-0.078274906
229	1.145	-0.10660243
230	1.15	-0.12211176
231	1.155	-0.12401754
232	1.16	-0.10765983
233	1.165	-0.068927705
234	1.17	-0.016751504
235	1.175	0.02855491
236	1.18	0.049627715
237	1.185	0.041893953
238	1.19	0.014947283
239	1.195	-0.010951055
240	1.2	-0.016813093
241	1.205	-0.0016153462
242	1.21	0.015569287
243	1.215	0.014948404
244	1.22	-0.0052328235
245	1.225	-0.031210666
246	1.23	-0.048551035
247	1.235	-0.050167126
248	1.24	-0.036004283
249	1.245	-0.011976751
250	1.25	0.01322902
251	1.255	0.035601815
252	1.26	0.058616804
253	1.265	0.084895687
254	1.27	0.10720302
255	1.275	0.1125339
256	1.28	0.095021515
257	1.285	0.061278271
258	1.29	0.023291221
259	1.295	-0.0094083614
260	1.3	-0.02954196

261	1.305	-0.03061915
262	1.31	-0.012377485
263	1.315	0.014084328
264	1.32	0.03307046
265	1.325	0.037052615
266	1.33	0.028963801
267	1.335	0.013815846
268	1.34	-0.0048384011
269	1.345	-0.02054298
270	1.35	-0.025416029
271	1.355	-0.019861629
272	1.36	-0.014277761
273	1.365	-0.017210564
274	1.37	-0.027097889
275	1.375	-0.0385855
276	1.38	-0.050215866
277	1.385	-0.060616906
278	1.39	-0.062732946
279	1.395	-0.049628531
280	1.4	-0.024999694
281	1.405	-0.0021220251
282	1.41	0.0087952279
283	1.415	0.0090209034
284	1.42	0.0061647191
285	1.425	0.0037753849
286	1.43	-0.00063200979
287	1.435	-0.0076984705
288	1.44	-0.010834302
289	1.445	-0.0024959723
290	1.45	0.015557153
291	1.455	0.032422963
292	1.46	0.03863781
293	1.465	0.032935454
294	1.47	0.018590089
295	1.475	-0.0012063526
296	1.48	-0.021507597

297	1.485	-0.034509126
298	1.49	-0.036209646
299	1.495	-0.032353421
300	1.5	-0.032285204
301	1.505	-0.036793515
302	1.51	-0.036557051
303	1.515	-0.024028551
304	1.52	-0.0038070562
305	1.525	0.010542674
306	1.53	0.0086631998
307	1.535	-0.0078270215
308	1.54	-0.026467217
309	1.545	-0.033009279
310	1.55	-0.021927195
311	1.555	-0.00061657184
312	1.56	0.017134292
313	1.565	0.023418681
314	1.57	0.021861018
315	1.575	0.02034302
316	1.58	0.02012746
317	1.585	0.015622107
318	1.59	0.0042112165
319	1.595	-0.0089275925
320	1.6	-0.017801672
321	1.605	-0.022362088
322	1.61	-0.024475885
323	1.615	-0.021668298
324	1.62	-0.010307026
325	1.625	0.0079795248
326	1.63	0.028087794
327	1.635	0.046251453
328	1.64	0.057923728
329	1.645	0.05593056
330	1.65	0.038921689
331	1.655	0.018154074
332	1.66	0.0066382176

333	1.665	0.0035030896
334	1.67	-0.0019317426
335	1.675	-0.01271449
336	1.68	-0.021251045
337	1.685	-0.022756602
338	1.69	-0.02015387
339	1.695	-0.013891506
340	1.7	0.001794769
341	1.705	0.027417151
342	1.71	0.051130621
343	1.715	0.059162741
344	1.72	0.049493627
345	1.725	0.031918018
346	1.73	0.018203732
347	1.735	0.014626797
348	1.74	0.020176711
349	1.745	0.027891506
350	1.75	0.028893647
351	1.755	0.018508718
352	1.76	0.00051698685
353	1.765	-0.014614153
354	1.77	-0.017588559
355	1.775	-0.0083891404
356	1.78	0.0036919445
357	1.785	0.0091381768
358	1.79	0.0062728153
359	1.795	-0.00036818497
360	1.8	-0.0065100133
361	1.805	-0.010223922
362	1.81	-0.010397777
363	1.815	-0.0068900683
364	1.82	-0.00077220149
365	1.825	0.0074865504
366	1.83	0.016999286
367	1.835	0.022282349
368	1.84	0.016016417

369	1.845	-0.00042199449
370	1.85	-0.015281534
371	1.855	-0.019748751
372	1.86	-0.016718874
373	1.865	-0.012269603
374	1.87	-0.0072082186
375	1.875	-0.0034499643
376	1.88	-0.0085441215
377	1.885	-0.023303559
378	1.89	-0.0329482
379	1.895	-0.023041297
380	1.9	0.00041172428
381	1.905	0.018019068
382	1.91	0.02045335
383	1.915	0.014326094
384	1.92	0.0079338534
385	1.925	0.0022514327
386	1.93	-0.004320985
387	1.935	-0.010985215
388	1.94	-0.015438462
389	1.945	-0.015363108
390	1.95	-0.01031712
391	1.955	-0.0050115632
392	1.96	-0.006783471
393	1.965	-0.015830835
394	1.97	-0.022033955
395	1.975	-0.016118487
396	1.98	-0.0012062812
397	1.985	0.010174324
398	1.99	0.0082496992
399	1.995	-0.006399898
400	2	-0.023684409
401	2.005	-0.030552463
402	2.01	-0.02037667
403	2.015	0.0014400428
404	2.02	0.022077088

405	2.025	0.031250739
406	2.03	0.02587203
407	2.035	0.0087702865
408	2.04	-0.012266748
409	2.045	-0.026257775
410	2.05	-0.025855002
411	2.055	-0.013570613
412	2.06	0.0010933109
413	2.065	0.010013674
414	2.07	0.010830223
415	2.075	0.0063311614
416	2.08	0.002387254
417	2.085	0.0037912613
418	2.09	0.0095510758
419	2.095	0.014668706
420	2.1	0.017321607
421	2.105	0.019600082
422	2.11	0.020119914
423	2.115	0.013019374
424	2.12	-0.0019608239
425	2.125	-0.015181095
426	2.13	-0.018428877
427	2.135	-0.015253492
428	2.14	-0.014184766
429	2.145	-0.016240644
430	2.15	-0.015602529
431	2.155	-0.0094669114
432	2.16	-0.00097193127
433	2.165	0.0057571836
434	2.17	0.0084442235
435	2.175	0.0064114204
436	2.18	0.0018389824
437	2.185	-0.00070314673
438	2.19	0.00028855103
439	2.195	0.00079023962
440	2.2	-0.0022292036

441	2.205	-0.0052388294
442	2.21	-0.003355287
443	2.215	0.0024467931
444	2.22	0.0084127256
445	2.225	0.015060875
446	2.23	0.025207097
447	2.235	0.036886
448	2.24	0.044027022
449	2.245	0.043392679
450	2.25	0.036260936
451	2.255	0.024442439
452	2.26	0.0095081778
453	2.265	-0.0045641073
454	2.27	-0.01264821
455	2.275	-0.013183033
456	2.28	-0.0091950036
457	2.285	-0.0049141022
458	2.29	-0.0030678597
459	2.295	-0.0040066891
460	2.3	-0.0054053431
461	2.305	-0.0044108494
462	2.31	-0.0018430611
463	2.315	-0.0022130723
464	2.32	-0.0079100235
465	2.325	-0.015735291
466	2.33	-0.020657897
467	2.335	-0.020158866
468	2.34	-0.013549098
469	2.345	-0.00091620373
470	2.35	0.014492811
471	2.355	0.025823289
472	2.36	0.02758652
473	2.365	0.019842052
474	2.37	0.0066874273
475	2.375	-0.006664821
476	2.38	-0.014583053

477	2.385	-0.012980014
478	2.39	-0.0036724992
479	2.395	0.0051536352
480	2.4	0.0054494035
481	2.405	-0.0037914857
482	2.41	-0.016319874
483	2.415	-0.024349546
484	2.42	-0.024747221
485	2.425	-0.020888549
486	2.43	-0.018411033
487	2.435	-0.018776588
488	2.44	-0.018224024
489	2.445	-0.013509024
490	2.45	-0.0063387988
491	2.455	-0.00071131131
492	2.46	0.0017775874
493	2.465	0.0020507903
494	2.47	0.0011003773
495	2.475	-0.00039051902
496	2.48	-0.0015896502
497	2.485	-0.002604609
498	2.49	-0.0046466911
499	2.495	-0.0075974202
500	2.5	-0.009134353
501	2.505	-0.0080555929
502	2.51	-0.0067297033
503	2.515	-0.007857255
504	2.52	-0.0098698481
505	2.525	-0.0081721322
506	2.53	-0.0010205873
507	2.535	0.0077999388
508	2.54	0.012805037
509	2.545	0.012107066
510	2.55	0.0079988987
511	2.555	0.0029740186
512	2.56	-0.0030748955

513	2.565	-0.010533191
514	2.57	-0.016050168
515	2.575	-0.013679821
516	2.58	-0.0013869787
517	2.585	0.015366575
518	2.59	0.028400734
519	2.595	0.033959213
520	2.6	0.033336392
521	2.605	0.028359131
522	2.61	0.019902111
523	2.615	0.010403079
524	2.62	0.0035905986
525	2.625	0.0002497308
526	2.63	-0.0025496176
527	2.635	-0.0061014276
528	2.64	-0.006716631
529	2.645	-0.00041832773
530	2.65	0.010699398
531	2.655	0.019609463
532	2.66	0.02136372
533	2.665	0.016977465
534	2.67	0.010662384
535	2.675	0.0051034057
536	2.68	2.9539411e-005
537	2.685	-0.0054824819
538	2.69	-0.010278067
539	2.695	-0.011501682
540	2.7	-0.0080971755
541	2.705	-0.0031013256
542	2.71	-0.0011373101
543	2.715	-0.0036413582
544	2.72	-0.0074021515
545	2.725	-0.0076278271
546	2.73	-0.0019442847
547	2.735	0.007602437
548	2.74	0.015272255

549	2.745	0.01542745
550	2.75	0.0075887937
551	2.755	-0.0025335475
552	2.76	-0.008521811
553	2.765	-0.009419741
554	2.77	-0.0092045478
555	2.775	-0.011024166
556	2.78	-0.013928011
557	2.785	-0.014865198
558	2.79	-0.011738962
559	2.795	-0.0044022739
560	2.8	0.005104354
561	2.805	0.012348629
562	2.81	0.012324666
563	2.815	0.0034531355
564	2.82	-0.010075334
565	2.825	-0.020791577
566	2.83	-0.023368002
567	2.835	-0.017931478
568	2.84	-0.0085712042
569	2.845	0.00063141837
570	2.85	0.0075201387
571	2.855	0.010533191
572	2.86	0.0077655552
573	2.865	-0.00062746915
574	2.87	-0.0097844091
575	2.875	-0.012620985
576	2.88	-0.0065383706
577	2.885	0.0032178546
578	2.89	0.0082479657
579	2.895	0.0050875089
580	2.9	-0.0019557867
581	2.905	-0.0057739166
582	2.91	-0.0032859284
583	2.915	0.0029474661
584	2.92	0.0085165086

585	2.925	0.010690221
586	2.93	0.0083468441
587	2.935	0.0011419292
588	2.94	-0.0091016213
589	2.945	-0.017343734
590	2.95	-0.018229428
591	2.955	-0.010599266
592	2.96	0.0016556133
593	2.965	0.01270776
594	2.97	0.01794147
595	2.975	0.015604058
596	2.98	0.007926634
597	2.985	0.00053732946
598	2.99	-0.0015749771
599	2.995	0.0014181707
600	3	0.0045079331
601	3.005	0.0030143163
602	3.01	-0.0031921893
603	3.015	-0.010389518
604	3.02	-0.014625268
605	3.025	-0.014191088
606	3.03	-0.0097
607	3.035	-0.0032560416
608	3.04	0.0022122464
609	3.045	0.0041504945
610	3.05	0.0024513001
611	3.055	0.0002532538
612	3.06	0.0012460385
613	3.065	0.0055774039
614	3.07	0.009391241
615	3.075	0.0090571836
616	3.08	0.0051487611
617	3.085	0.0016878964
618	3.09	0.0019655246
619	3.095	0.0053684817
620	3.1	0.007887356

621	3.105	0.0058504945
622	3.11	-0.00031022229
623	3.115	-0.0063767819
624	3.12	-0.0088146936
625	3.125	-0.007809432
626	3.13	-0.005173886
627	3.135	-0.0014306516
628	3.14	0.0029533293
629	3.145	0.0055122871
630	3.15	0.0041855715
631	3.155	0.00067713572
632	3.16	-0.0016722851
633	3.165	-0.0024417559
634	3.17	-0.0034141939
635	3.175	-0.0043039462
636	3.18	-0.0028799633
637	3.185	0.00097214235
638	3.19	0.0048462119
639	3.195	0.0075047007
640	3.2	0.0097338024
641	3.205	0.011387376
642	3.21	0.010850515
643	3.215	0.0082072193
644	3.22	0.0063517182
645	3.225	0.007896166
646	3.23	0.01238289
647	3.235	0.016754563
648	3.24	0.017389416
649	3.245	0.012230448
650	3.25	0.0026781483
651	3.255	-0.0067384827
652	3.26	-0.011875905
653	3.265	-0.011952687
654	3.27	-0.0084620271
655	3.275	-0.002586683
656	3.28	0.0046835118

657	3.285	0.011020903
658	3.29	0.013539105
659	3.295	0.011157948
660	3.3	0.0051842765
661	3.305	-0.0019846742
662	3.31	-0.0078828898
663	3.315	-0.010618946
664	3.32	-0.0099386357
665	3.325	-0.0074718772
666	3.33	-0.0051713062
667	3.335	-0.0038723361
668	3.34	-0.0037548996
669	3.345	-0.0050464464
670	3.35	-0.0070686143
671	3.355	-0.007373315
672	3.36	-0.0035511165
673	3.365	0.0037260732
674	3.37	0.010335373
675	3.375	0.011959723
676	3.38	0.0077211889
677	3.385	0.00073050678
678	3.39	-0.004662486
679	3.395	-0.0061991537
680	3.4	-0.0048226165
681	3.405	-0.0031034975
682	3.41	-0.0028719792
683	3.415	-0.0040945957
684	3.42	-0.0054507903
685	3.425	-0.0056893341
686	3.43	-0.004542643
687	3.435	-0.0024557459
688	3.44	0.00032469257
689	3.445	0.0037633119
690	3.45	0.0068513919
691	3.455	0.007334302
692	3.46	0.0038347915

693	3.465	-0.001942694
694	3.47	-0.0063838381
695	3.475	-0.0075939431
696	3.48	-0.0067899562
697	3.485	-0.0057404099
698	3.49	-0.0042306414
699	3.495	-0.0012422555
700	3.5	0.0023713776
701	3.505	0.0042589987
702	3.51	0.003633007
703	3.515	0.0023376058
704	3.52	0.0023214031
705	3.525	0.0033083614
706	3.53	0.0037244417
707	3.535	0.0028804629
708	3.54	0.0012989395
709	3.545	-0.00036302845
710	3.55	-0.001759947
711	3.555	-0.0027234322
712	3.56	-0.0033794127
713	3.565	-0.0038705414
714	3.57	-0.0034899969
715	3.575	-0.0010725298
716	3.58	0.0028563883
717	3.585	0.0052659529
718	3.59	0.0033707148
719	3.595	-0.0020147344
720	3.6	-0.0068745998
721	3.605	-0.0076866626
722	3.61	-0.0041535536
723	3.615	0.0012324768
724	3.62	0.0053030998
725	3.625	0.00599378
726	3.63	0.0032201795
727	3.635	-0.0011793923
728	3.64	-0.0045328643

729	3.645	-0.0050314265
730	3.65	-0.0029088508
731	3.655	-9.6209952e-005
732	3.66	0.0015149383
733	3.665	0.0016416845
734	3.67	0.0013853472
735	3.675	0.001578913
736	3.68	0.0018626695
737	3.685	0.0015286122
738	3.69	0.00063927807
739	3.695	-0.00018777506
740	3.7	-0.00071035791
741	3.705	-0.0012316407
742	3.71	-0.002022382
743	3.715	-0.0029876415
744	3.72	-0.0037805955
745	3.725	-0.003886061
746	3.73	-0.0026852962
747	3.735	0.00011716529
748	3.74	0.0038800857
749	3.745	0.0070077904
750	3.75	0.0079163761
751	3.755	0.0062320383
752	3.76	0.0029496686
753	3.765	-0.00055450495
754	3.77	-0.0032793617
755	3.775	-0.0043722851
756	3.78	-0.0031296625
757	3.785	-3.7695422e-005
758	3.79	0.0028807484
759	3.795	0.0039790966
760	3.8	0.0039734169
761	3.805	0.0047515346
762	3.81	0.0062541348
763	3.815	0.0060571938
764	3.82	0.0026209646

765	3.825	-0.002304303
766	3.83	-0.0055510044
767	3.835	-0.0060643622
768	3.84	-0.0053501377
769	3.845	-0.0046730397
770	3.85	-0.0033136637
771	3.855	-0.00031816967
772	3.86	0.0031068319
773	3.865	0.0044236566
774	3.87	0.0028865912
775	3.875	0.00047163455
776	3.88	-0.00071745386
777	3.885	-0.00071426838
778	3.89	-0.00060792495
779	3.895	-0.00044288162
780	3.9	0.0004564301
781	3.905	0.0018211278
782	3.91	0.0026275721
783	3.915	0.0026920363
784	3.92	0.0026935862
785	3.925	0.002619792
786	3.93	0.0014923116
787	3.935	-0.0010447028
788	3.94	-0.0038509126
789	3.945	-0.0054581217
790	3.95	-0.0054834914
791	3.955	-0.0045337106
792	3.96	-0.0032619761
793	3.965	-0.0020351382
794	3.97	-0.0012359131
795	3.975	-0.0012171102
796	3.98	-0.0017096666
797	3.985	-0.001734975
798	3.99	-0.00071328235
799	3.995	0.00042100948
800	4	-7.0639951e-005

801	4.005	-0.0026344754
802	4.01	-0.0055947486
803	4.015	-0.0067476089
804	4.02	-0.0052894667
805	4.025	-0.0019337004
806	4.03	0.0020829204
807	4.035	0.0054640359
808	4.04	0.0069779545
809	4.045	0.0060873356
810	4.05	0.003403783
811	4.055	3.7616396e-005
812	4.06	-0.0033002651
813	4.065	-0.006174559
814	4.07	-0.0078681656
815	4.075	-0.0076786581
816	4.08	-0.0057416233
817	4.085	-0.0031103803
818	4.09	-0.001019635
819	4.095	-0.00019166004
820	4.1	-0.00052335781
821	4.105	-0.0011344244
822	4.11	-0.0010877944
823	4.115	-0.00044539003
824	4.12	-0.00028135312
825	4.125	-0.0012489344
826	4.13	-0.0025721016
827	4.135	-0.0030088304
828	4.14	-0.0024298868
829	4.145	-0.001701968
830	4.15	-0.0012757622
831	4.155	-0.00078257265
832	4.16	-8.2774855e-005
833	4.165	0.00020772917
834	4.17	-0.00032969716
835	4.175	-0.0010126624
836	4.18	-0.00070876925

837	4.185	0.00078114
838	4.19	0.0023736923
839	4.195	0.0027072805
840	4.2	0.0012714999
841	4.205	-0.0013042317
842	4.21	-0.0037178954
843	4.215	-0.0047145406
844	4.22	-0.0037946569
845	4.225	-0.0016028551
846	4.23	0.00044211584
847	4.235	0.0012244621
848	4.24	0.00075893953
849	4.245	-7.1053635e-005
850	4.25	-0.00044719078
851	4.255	-9.0755787e-005
852	4.26	0.00092969104
853	4.265	0.0023023045
854	4.27	0.0032927195
855	4.275	0.003034353
856	4.28	0.001423626
857	4.285	-0.00049225961
858	4.29	-0.0013416539
859	4.295	-0.0005689069
860	4.3	0.0012926277
861	4.305	0.0031444886
862	4.31	0.0039511675
863	4.315	0.0032594983
864	4.32	0.0015146834
865	4.325	-0.00025497808
866	4.33	-0.0012871928
867	4.335	-0.0015695626
868	4.34	-0.0015264097
869	4.345	-0.0015578056
870	4.35	-0.0018727338
871	4.355	-0.0023269501
872	4.36	-0.0023564189

873	4.365	-0.0015954012
874	4.37	-0.00061912206
875	4.375	-0.00043438156
876	4.38	-0.0010564189
877	4.385	-0.0013220455
878	4.39	-0.00041055369
879	4.395	0.0011376568
880	4.4	0.002298858
881	4.405	0.0027339553
882	4.41	0.0025797899
883	4.415	0.0017256246
884	4.42	3.7380545e-005
885	4.425	-0.0020226063
886	4.43	-0.0035977159
887	4.435	-0.0041688692
888	4.44	-0.0037620985
889	4.445	-0.0026519221
890	4.45	-0.0011557153
891	4.455	0.0004214041
892	4.46	0.0018211787
893	4.465	0.0026446926
894	4.47	0.0022193127
895	4.475	0.00021834914
896	4.48	-0.0023942592
897	4.485	-0.0037212807
898	4.49	-0.0027773835
899	4.495	-0.00057448557
900	4.5	0.001160365
901	4.505	0.0019351178
902	4.51	0.0025114
903	4.515	0.0033498929
904	4.52	0.0039759356
905	4.525	0.0038907005
906	4.53	0.0032356684
907	4.535	0.0023164882
908	4.54	0.0012106251

909	4.545	0.00022263587
910	4.55	0.00010145661
911	4.555	0.0012660345
912	4.56	0.0031365861
913	4.565	0.0046761599
914	4.57	0.0053881819
915	4.575	0.0054679617
916	4.58	0.0051997247
917	4.585	0.0046189762
918	4.59	0.003710156
919	4.595	0.0026102886
920	4.6	0.0015034057
921	4.605	0.00045623024
922	4.61	-0.00053635566
923	4.615	-0.0013193535
924	4.62	-0.001488651
925	4.625	-0.00073496482
926	4.63	0.0005725961
927	4.635	0.0013370858
928	4.64	0.0006219221
929	4.645	-0.0012913429
930	4.65	-0.0029899562
931	4.655	-0.0032753645
932	4.66	-0.0023017233
933	4.665	-0.0011637198
934	4.67	-0.00053975528
935	4.675	-0.00015277251
936	4.68	0.00042557153
937	4.685	0.0010322729
938	4.69	0.001321709
939	4.695	0.0014535434
940	4.7	0.0017373815
941	4.705	0.0017926175
942	4.71	0.00078699908
943	4.715	-0.0013221067
944	4.72	-0.0033468135

945	4.725	-0.003984195
946	4.73	-0.0030823595
947	4.735	-0.0015759967
948	4.74	-0.00045016417
949	4.745	5.1359641e-006
950	4.75	0.0001632589
951	4.755	0.00057358214
952	4.76	0.0013701642
953	4.765	0.0019957581
954	4.77	0.0017047313
955	4.775	0.00050323952
956	4.78	-0.00068832773
957	4.785	-0.0010638727
958	4.79	-0.00084087183
959	4.795	-0.00082283369
960	4.8	-0.0013430917
961	4.805	-0.0020668808
962	4.81	-0.0025811257
963	4.815	-0.0026462017
964	4.82	-0.0020145304
965	4.825	-0.00061988682
966	4.83	0.0010150219
967	4.835	0.0020750178
968	4.84	0.0022967676
969	4.845	0.0021562149
970	4.85	0.0021514632
971	4.855	0.0022329051
972	4.86	0.0020284797
973	4.865	0.0013171714
974	4.87	0.00017034159
975	4.875	-0.0011309269
976	4.88	-0.0021510146
977	4.885	-0.0024249822
978	4.89	-0.0017194759
979	4.895	-0.00024031814
980	4.9	0.0014453248

981	4.905	0.0027430203
982	4.91	0.0033497706
983	4.915	0.0032677577
984	4.92	0.0026100133
985	4.925	0.0015481391
986	4.93	0.00041791577
987	4.935	-0.000414663
988	4.94	-0.00090271133
989	4.945	-0.0013281126
990	4.95	-0.0018677067
991	4.955	-0.0023791883
992	4.96	-0.00266943
993	4.965	-0.0026885184
994	4.97	-0.0023832467
995	4.975	-0.0017288773
996	4.98	-0.0010505353
997	4.985	-0.00093848578
998	4.99	-0.0015901601
999	4.995	-0.0025056592
1000	5	-0.0030290099
1001	5.005	-0.0029339146
1002	5.01	-0.0023091261
1003	5.015	-0.0011969206
1004	5.02	0.00035436831
1005	5.025	0.0020520547
1006	5.03	0.0034436321
1007	5.035	0.0041964719
1008	5.04	0.0041985419
1009	5.045	0.0035143673
1010	5.05	0.0023853064
1011	5.055	0.0011922708
1012	5.06	0.0002644509
1013	5.065	-0.00031285612
1014	5.07	-0.00066928622
1015	5.075	-0.00091704701
1016	5.08	-0.00097053737

1017	5.085	-0.00065557561
1018	5.09	-3.3627511e-005
1019	5.095	0.00046641481
1020	5.1	0.00036907005
1021	5.105	-0.00038066075
1022	5.11	-0.0013290711
1023	5.115	-0.0018691343
1024	5.12	-0.0022463241
1025	5.125	-0.002336372

Cyclic Number Functions

Cyclic Triaxial Results for Fly Ash

Model: Spline Data Point Function
Function: Cyclic Number vs. Shear Stress Ratio
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Y-Intercept: 500
Data Points: Shear Stress Ratio, Cyclic Number
Data Point: (0.16, 500)
Data Point: (0.17, 200)
Data Point: (0.185, 100)
Data Point: (0.225, 40)
Data Point: (0.265, 20)
Data Point: (0.315, 10)
Data Point: (0.37, 5)
Data Point: (0.425, 3)
Estimation Properties
Sample Material: Loose Sand

Pore Pressure Functions

New Function

Model: Spline Data Point Function
Function: PWP Ratio vs. Cyclic Number Ratio N/NL
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Y-Intercept: 0
Data Points: Cyclic Number Ratio N/NL, PWP Ratio
Data Point: (0, 0)
Data Point: (0.05, 0.075089716)
Data Point: (0.1, 0.12368875)

Data Point: (0.15, 0.16607762)
Data Point: (0.2, 0.20519259)
Data Point: (0.25, 0.24231186)
Data Point: (0.3, 0.2781656)
Data Point: (0.35, 0.31324362)
Data Point: (0.4, 0.3479165)
Data Point: (0.45, 0.38249492)
Data Point: (0.5, 0.41726502)
Data Point: (0.55, 0.45251442)
Data Point: (0.6, 0.48855688)
Data Point: (0.65, 0.52576183)
Data Point: (0.7, 0.56459752)
Data Point: (0.75, 0.60570358)
Data Point: (0.8, 0.65003056)
Data Point: (0.85, 0.69915001)
Data Point: (0.9, 0.75610124)
Data Point: (0.95, 0.82872015)
Data Point: (1, 1)

Estimation Properties

N-Exponent: 0.7

Regions

	Material	Points	Area (ft²)
Region 1	Sandy Silty Clay (1)	103,1,2,104	144.86613
Region 2	Sandy Silty Clay (1)	1,3,4,5,6,7,8,9,10,97,11,12,13,14,15,16,17,2	1797.2287
Region 3	Road Fill (2)	9,18,19,20,10	50.839704
Region 4	Road Fill (2)	13,22,23,24,25,15,14	116.203
Region 5	Bottom Ash (5)	15,25,26,27,16	191.73337
Region 6	Silty Sand & Gravel (6)	17,16,27,28,29	391.82116
Region 7	Silty Sand &	27,26,30,31,32,33,34,100,99,35,36,98,28	923.61928

	Gravel (6)		
Region 8	Silty Sandy Clay (7)	37,47,39,38	312.45828
Region 9	Silty Clay (8)	47,48,40,39	623.99905
Region 10	Fly Ash (9)	48,49,50,104,2,17,29,37,47	6694.2078
Region 11	Clay Foundation (10)	50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,49	4580.0299
Region 12	Clay Foundation (11)	49,48,40,41,42,43,44,45,46,36,35,74,75,76,77,78,79,80,81,82,83,84,85,86,87,67,68,69,70,71,72,73	4582.5269
Region 13	Silty Sand & Gravel (6)	101,88,89,90,102	107.81573
Region 14	Silty Clay Foundation (12)	51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,87,86,85,84,83,82,81,93,94,105,106,95,96	30694.491
Region 15	Gravelly Silty Sand (3)	10,20,21,97	270.1759
Region 16	Gravelly Silty Sand (4)	21,12,11,97	428.27559
Region 17	Silty Clay (8)	98,36,46,45,44,43,42,41,40,39	583.66388
Regi	Silty	98,39,38,37,29,28	875.8288

on 18	Sandy Clay (7)		6
Region 19	Bottom Ash (5)	101,102,90,91,99,100,34	285.90427
Region 20	Silty Sand & Gravel (6)	99,91,92,77,76,75,74,35	493.02893

Lines

	Start Point	End Point	Stress/Strain Boundary
Line 1	1	2	
Line 2	1	3	
Line 3	3	4	
Line 4	4	5	
Line 5	5	6	
Line 6	6	7	
Line 7	7	8	
Line 8	8	9	
Line 9	9	10	
Line 10	11	12	
Line 11	12	13	
Line 12	13	14	
Line 13	14	15	
Line 14	15	16	
Line 15	16	17	
Line 16	17	2	
Line 17	9	18	
Line 18	18	19	
Line 19	19	20	
Line 20	20	10	
Line 21	13	22	
Line 22	22	23	
Line 23	23	24	
Line 24	24	25	

Line 25	25	15	
Line 26	25	26	
Line 27	26	27	
Line 28	27	16	
Line 29	27	28	
Line 30	28	29	
Line 31	29	17	
Line 32	26	30	
Line 33	30	31	
Line 34	31	32	
Line 35	32	33	
Line 36	33	34	
Line 37	35	36	
Line 38	29	37	
Line 39	37	38	
Line 40	38	39	
Line 41	39	40	
Line 42	40	41	
Line 43	41	42	
Line 44	42	43	
Line 45	43	44	
Line 46	44	45	
Line 47	45	46	
Line 48	46	36	
Line 49	37	47	
Line 50	47	39	
Line 51	47	48	
Line 52	48	40	
Line 53	48	49	
Line 54	49	50	
Line 55	50	51	Fixed Y
Line 56	51	52	
Line 57	52	53	
Line 58	53	54	
Line 59	54	55	
Line 60	55	56	

Line 61	56	57	
Line 62	57	58	
Line 63	58	59	
Line 64	59	60	
Line 65	60	61	
Line 66	61	62	
Line 67	62	63	
Line 68	63	64	
Line 69	64	65	
Line 70	65	66	
Line 71	66	67	
Line 72	67	68	
Line 73	68	69	
Line 74	69	70	
Line 75	70	71	
Line 76	71	72	
Line 77	72	73	
Line 78	73	49	
Line 79	35	74	
Line 80	74	75	
Line 81	75	76	
Line 82	76	77	
Line 83	77	78	
Line 84	78	79	
Line 85	79	80	
Line 86	80	81	
Line 87	81	82	
Line 88	82	83	
Line 89	83	84	
Line 90	84	85	
Line 91	85	86	
Line 92	86	87	
Line 93	87	67	
Line 94	88	89	
Line 95	89	90	
Line 96	81	93	

Line 97	93	94	
Line 98	95	96	Fixed X/Y
Line 99	96	51	Fixed Y
Line 100	10	97	
Line 101	97	11	
Line 102	20	21	
Line 103	21	97	
Line 104	21	12	
Line 105	36	98	
Line 106	98	28	
Line 107	39	98	
Line 108	99	35	
Line 109	34	100	
Line 110	100	99	
Line 111	101	88	
Line 112	90	102	
Line 113	102	101	
Line 114	90	91	
Line 115	91	99	
Line 116	34	101	
Line 117	91	92	
Line 118	92	77	
Line 119	103	1	
Line 120	2	104	
Line 121	104	103	Fixed Y
Line 122	94	105	
Line 123	105	106	Fixed Y
Line 124	106	95	Fixed X/Y
Line 125	104	50	Fixed Y

Points

	X (ft)	Y (ft)
Point 1	-28.73928	596.09012
Point 2	-28.7343	594.10387
Point 3	10.87106	605.00492

Point 4	12.47008	605.36299
Point 5	21.58957	606.0128
Point 6	27.88941	608.93894
Point 7	34.84064	612.1236
Point 8	39.1222	614.02931
Point 9	50.19567	618.00197
Point 10	57.04232	618.00197
Point 11	43.46173	603.74724
Point 12	118.92142	603.75291
Point 13	123.93504	601.99213
Point 14	127.87795	600.00591
Point 15	163.14756	600.01118
Point 16	149.56535	595.01063
Point 17	147.06988	594.09744
Point 18	57.38569	620.4397
Point 19	72.81546	619.98477
Point 20	80.84007	617.99987
Point 21	99.3055	610.6283
Point 22	139.17652	601.67587
Point 23	173.72543	602.00845
Point 24	176.45339	603.29228
Point 25	189.71063	600.00886
Point 26	199.68996	595.00886
Point 27	167.47087	595.01
Point 28	191.72441	585.79626
Point 29	124.59213	585.79827
Point 30	210.5102	589.59755
Point 31	218.12189	585.75717
Point 32	221.75303	584.00508
Point 33	243.39222	575.85019
Point 34	253.50591	571.98819
Point 35	289.84961	560.28268
Point 36	256.97717	561.34945
Point 37	108.92713	580.01604
Point 38	142.96147	580.0084
Point 39	159.35433	573.84449

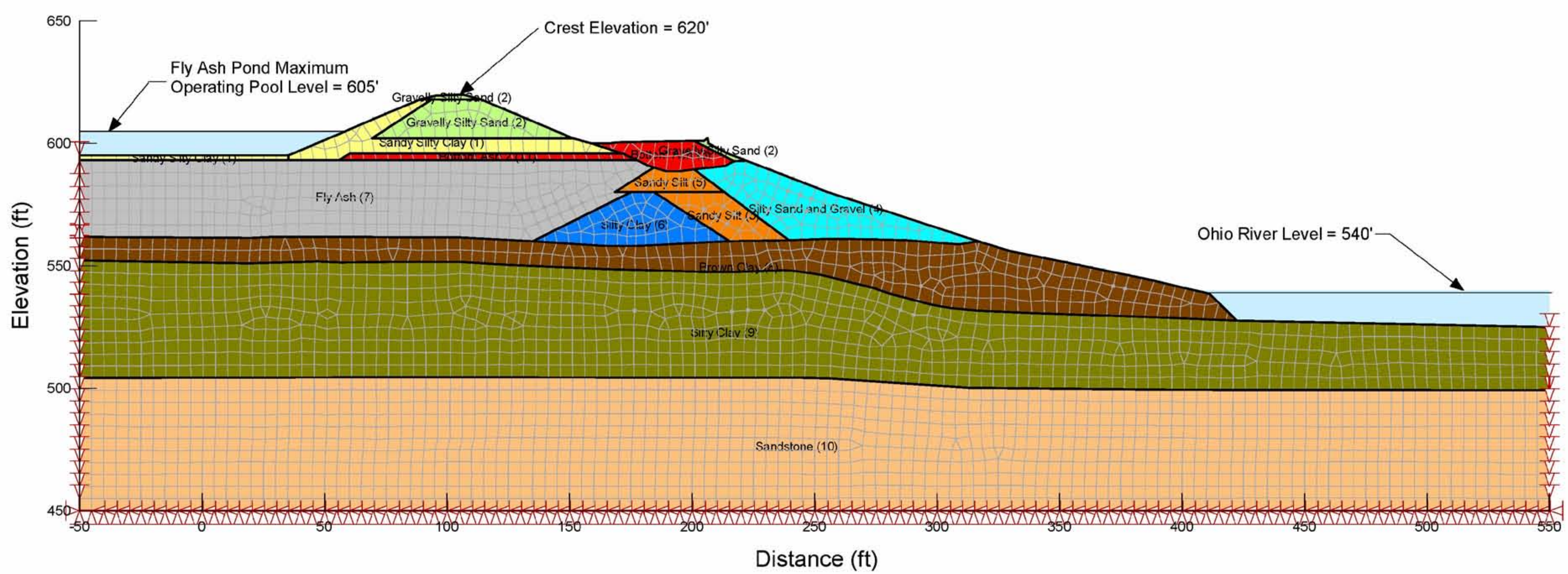
Point 40	178.27362	566.74311
Point 41	185.14195	566.8803
Point 42	197.25818	566.77308
Point 43	199.06388	566.49447
Point 44	214.43065	565.09473
Point 45	230.53524	563.39632
Point 46	234.91774	563.19918
Point 47	92.17246	573.83178
Point 48	72.44646	566.50502
Point 49	57.05752	560.85717
Point 50	-100	561.11382
Point 51	-100	533.82575
Point 52	21.33315	533.86583
Point 53	28.78186	534.53132
Point 54	34.71071	535.25795
Point 55	39.46011	535.53175
Point 56	42.85104	535.87926
Point 57	45.71543	536.46899
Point 58	49.77857	537.76077
Point 59	59.1159	541.81514
Point 60	64.62858	544.24532
Point 61	75.01429	546.95559
Point 62	83.26625	548.88905
Point 63	88.53588	549.98847
Point 64	93.23684	550.64559
Point 65	106.0002	551.53018
Point 66	116.47627	552.07357
Point 67	122.52939	552.65487
Point 68	120.68438	552.98343
Point 69	113.2235	552.91166
Point 70	98.93865	553.2756
Point 71	88.31144	553.78513
Point 72	81.74223	554.71319
Point 73	77.73883	555.51387
Point 74	364.93178	560.3689
Point 75	369.84787	558.28744

Point 76	398.62803	558.25568
Point 77	406.56907	560.14614
Point 78	407.16945	560.17165
Point 79	432.46006	554.51883
Point 80	442.14574	552.40143
Point 81	451.7179	550.43805
Point 82	378.61552	549.7332
Point 83	292.87496	549.02254
Point 84	215.96602	549.23217
Point 85	183.76122	549.91347
Point 86	163.4328	550.32461
Point 87	134.5598	552.09884
Point 88	274.22203	571.1344
Point 89	301.03752	569.99889
Point 90	328.15873	568.01175
Point 91	341.0609	563.99026
Point 92	390.16826	564.00289
Point 93	504	540
Point 94	580	523.86886
Point 95	580	500.03246
Point 96	-100	499.99472
Point 97	49.98781	610.59727
Point 98	223.72901	573.80581
Point 99	278.12773	564.05804
Point 100	265.81244	568.02452
Point 101	264.70006	571.52684
Point 102	275.69963	568.00897
Point 103	-100.04534	596.07808
Point 104	-100	594
Point 105	620	522
Point 106	620	500

SECTION M-M

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section M-M Finite Element Stress Analysis
File Name: FAP_M-M_QUAKE_MESH.gsz
Date: 7/23/2010

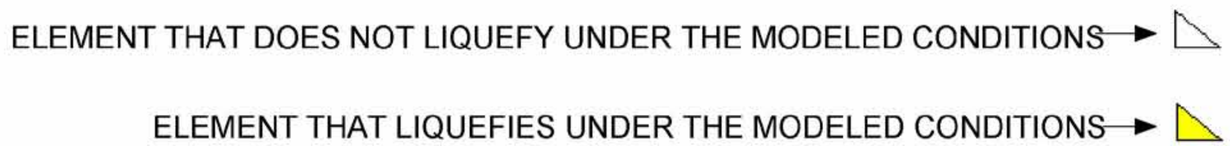
QUAKE/W MESH

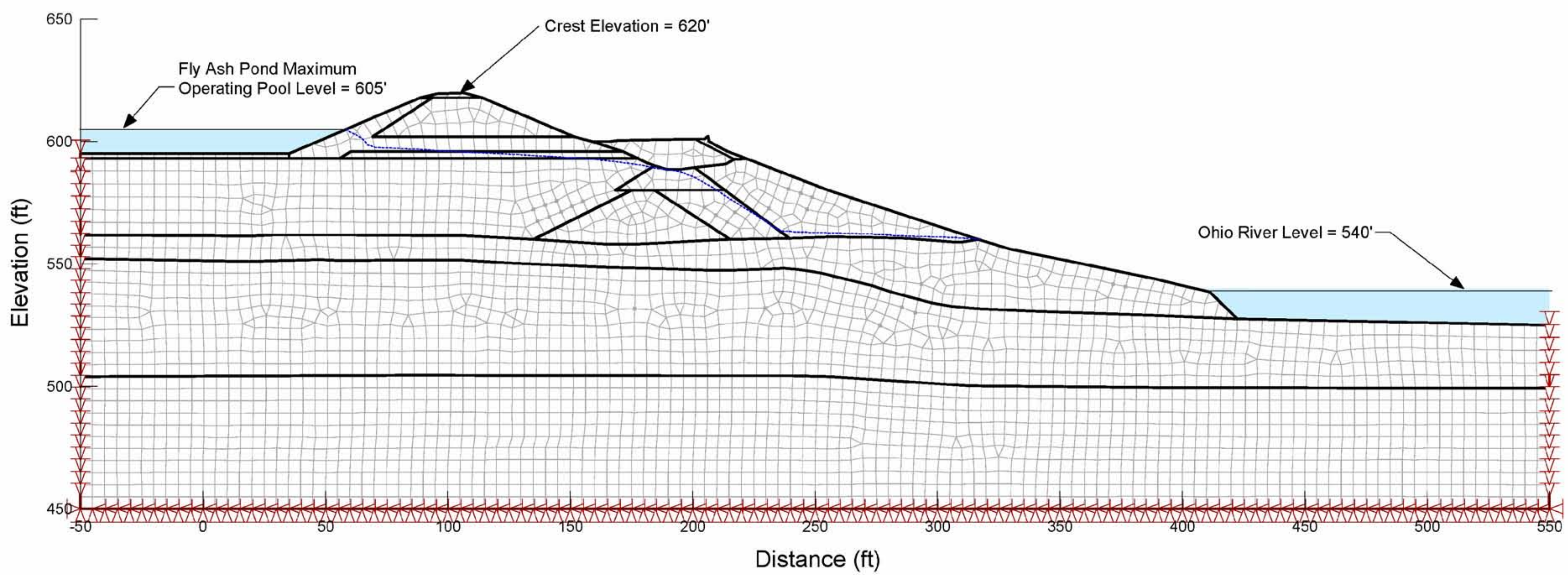


Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section M-M Finite Element Stress Analysis
File Name: FAP_M-M_QUAKE_RESULTS.gsz
Date: 7/23/2010

QUAKE/W MESH WITH LIQUEFIED ZONES

NOTE: NO LIQUEFACTION PREDICTED





AEPSPP004447

Dynamic QUAKE/W

File Information

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section M-M Finite Element Stress Analysis
Revision Number: 97
Last Edited By: Seth Frank
Date: 7/23/2010
Time: 10:42:52 AM
File Name: FAP_M-M_QUAKE_RESULTS.gsz
Directory: P:\Frank\Philip Sporn\SEISMIC REPORT\Updated Analysis Files\
Last Solved Date: 7/23/2010
Last Solved Time: 10:51:48 AM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Stiffness Units: psf
Unit Weight of Water: 62.4 pcf
Air Pressure: 101.33 psf
View: 2D

Analysis Settings

Dynamic QUAKE/W

Kind: QUAKE/W
Parent: Initial Static
Method: Equivalent Linear Dynamic
Settings
    Initial Stress: Parent Analysis
    Initial PWP: Parent Analysis
    Exclude cumulative values: No
Control
    Coefficient of Equivalent Shear Stress: 0.65
    Coefficient of Equivalent Shear Strain: 0.5
    Equivalent Number of Cycles: 10
    Liquefaction Stress Limit: 0
Convergence

Maximum Number of Iterations: 10
Displacement Norm Tolerance: 1 %

Time

Starting Time: 0 sec
Duration: 5.125 sec
# of Steps: 1025
Save Steps Every: 10
Steps Generated via Earthquake Records: Yes

Materials

Sandy Silty Clay (1)

Model: Linear Elastic

Stress Strain

Unit Weight: 125 pcf
Poisson's Ratio: 0.45
Damping Ratio: 0.1
Pore Water Pressure Function: New Function
G Modulus: 3718376 psf

Gravelly Silty Sand (2)

Model: Linear Elastic

Stress Strain

Unit Weight: 125 pcf
Poisson's Ratio: 0.352
Damping Ratio: 0.1
Pore Water Pressure Function: New Function
G Modulus: 3718376 psf

Bottom Ash (3)

Model: Linear Elastic

Stress Strain

Unit Weight: 65 pcf
Poisson's Ratio: 0.352
Damping Ratio: 0.1
Pore Water Pressure Function: New Function
G Modulus: 1933556 psf

Silty Sand and Gravel (4)

Model: Linear Elastic

Stress Strain

Unit Weight: 115 pcf
Poisson's Ratio: 0.352
Damping Ratio: 0.1
Pore Water Pressure Function: New Function
G Modulus: 3420906 psf

Sandy Silt (5)

Model: Linear Elastic
Stress Strain
Unit Weight: 115 pcf
Poisson's Ratio: 0.45
Damping Ratio: 0.1
Pore Water Pressure Function: New Function
G Modulus: 3867112 psf

Silty Clay (6)

Model: Linear Elastic
Stress Strain
Unit Weight: 130 pcf
Poisson's Ratio: 0.45
Damping Ratio: 0.1
Pore Water Pressure Function: New Function
G Modulus: 3867112 psf

Fly Ash (7)

Model: Linear Elastic
Stress Strain
Unit Weight: 110 pcf
Poisson's Ratio: 0.495
Damping Ratio: 0.045
Pore Water Pressure Function: New Function
Cyclic Function: Cyclic Triaxial Results for Fly Ash
G Modulus: 774831 psf

Brown Clay (8)

Model: Linear Elastic
Stress Strain
Unit Weight: 125 pcf
Poisson's Ratio: 0.45
Damping Ratio: 0.07
Pore Water Pressure Function: New Function
G Modulus: 1869705 psf

Silty Clay (9)

Model: Linear Elastic
Stress Strain
Unit Weight: 126 pcf
Poisson's Ratio: 0.45
Damping Ratio: 0.07
Pore Water Pressure Function: New Function
G Modulus: 1884663 psf

Sandstone (10)

Model: Linear Elastic

Stress Strain

Unit Weight: 140 pcf

Poisson's Ratio: 0.2

Damping Ratio: 0.01

G Modulus: 78000000 psf

Bottom Ash 2 (11)

Model: Linear Elastic

Stress Strain

Unit Weight: 90 pcf

Poisson's Ratio: 0.45

Damping Ratio: 0.1

Pore Water Pressure Function: New Function

G Modulus: 2677231 psf

Boundary Conditions

Fixed Y

X: 0

Y: Y-Displacement 0

Fixed X/Y

X: X-Displacement 0

Y: Y-Displacement 0

Earthquake Records

Horizontal Earthquake Records

Description: Giles County_

Use Baseline Correction: No

Modified Peak Acc.: 0.30340468

Modified Duration: 1

Records

	Time (sec)	Acc (ft/sec^2)
1	0.005	0.00074237381
2	0.01	0.0015841338
3	0.015	0.0020074131
4	0.02	0.0020881411
5	0.025	0.0020403079

6	0.03	0.0020214541
7	0.035	0.0020190272
8	0.04	0.0020266646
9	0.045	0.0020580096
10	0.05	0.0020958295
11	0.055	0.0021387682
12	0.06	0.0021873254
13	0.065	0.0022080249
14	0.07	0.0022257673
15	0.075	0.0023068013
16	0.08	0.0023844499
17	0.085	0.0023576833
18	0.09	0.002338085
19	0.095	0.0024320485
20	0.1	0.0024556847
21	0.105	0.0023430917
22	0.11	0.0024501479
23	0.115	0.0028857959
24	0.12	0.0031628123
25	0.125	0.0030771286
26	0.13	0.0029803406
27	0.135	0.0026485572
28	0.14	0.0013546956
29	0.145	-0.00016941878
30	0.15	0.00037487815
31	0.155	0.0039899358
32	0.16	0.0090366473
33	0.165	0.013242276
34	0.17	0.014940349
35	0.175	0.011953197
36	0.18	0.002078342
37	0.185	-0.01332589
38	0.19	-0.02655389
39	0.195	-0.02546426
40	0.2	-0.0014758234
41	0.205	0.039876925

42	0.21	0.077848578
43	0.215	0.092652493
44	0.22	0.082851331
45	0.225	0.060614765
46	0.23	0.033987866
47	0.235	0.0065708474
48	0.24	-0.0091383094
49	0.245	0.0011332212
50	0.25	0.029039869
51	0.255	0.045923524
52	0.26	0.036332925
53	0.265	0.012131845
54	0.27	-0.011632813
55	0.275	-0.034764964
56	0.28	-0.057938513
57	0.285	-0.070029673
58	0.29	-0.060645151
59	0.295	-0.03268186
60	0.3	0.0034418884
61	0.305	0.035670338
62	0.31	0.048797899
63	0.315	0.032970837
64	0.32	-0.0023321811
65	0.325	-0.035389416
66	0.33	-0.055034873
67	0.335	-0.066065361
68	0.34	-0.074619354
69	0.345	-0.080932803
70	0.35	-0.085216886
71	0.355	-0.089790048
72	0.36	-0.095836953
73	0.365	-0.1032538
74	0.37	-0.10861324
75	0.375	-0.10065117
76	0.38	-0.069623228
77	0.385	-0.027555318

78	0.39	-0.005768655
79	0.395	-0.021172836
80	0.4	-0.053992148
81	0.405	-0.069033445
82	0.41	-0.052574794
83	0.415	-0.019996125
84	0.42	0.0069637504
85	0.425	0.020201897
86	0.43	0.023543387
87	0.435	0.021578872
88	0.44	0.018667075
89	0.445	0.026089324
90	0.45	0.056988784
91	0.455	0.10690323
92	0.46	0.14896706
93	0.465	0.15861731
94	0.47	0.13581829
95	0.475	0.095129805
96	0.48	0.04757204
97	0.485	0.0055686958
98	0.49	-0.011340369
99	0.495	0.00094269399
100	0.5	0.013362802
101	0.505	-0.0060825125
102	0.51	-0.048634649
103	0.515	-0.073923728
104	0.52	-0.061479148
105	0.525	-0.032859692
106	0.53	-0.020692872
107	0.535	-0.031840318
108	0.54	-0.045030794
109	0.545	-0.034229224
110	0.55	0.0089556949
111	0.555	0.068743856
112	0.56	0.11643724
113	0.565	0.13005302

114	0.57	0.10767003
115	0.575	0.068085653
116	0.58	0.040016825
117	0.585	0.041057612
118	0.59	0.058453146
119	0.595	0.057376262
120	0.6	0.01957306
121	0.605	-0.030100235
122	0.61	-0.047869583
123	0.615	-0.021960436
124	0.62	0.010634853
125	0.625	0.0021839095
126	0.63	-0.054767717
127	0.635	-0.11660956
128	0.64	-0.12823086
129	0.645	-0.073033751
130	0.65	0.016174569
131	0.655	0.092629958
132	0.66	0.13474865
133	0.665	0.14942082
134	0.67	0.14836749
135	0.675	0.13157235
136	0.68	0.090144081
137	0.685	0.018915876
138	0.69	-0.070631794
139	0.695	-0.14812889
140	0.7	-0.18368206
141	0.705	-0.17365963
142	0.71	-0.13871316
143	0.715	-0.094815948
144	0.72	-0.041141837
145	0.725	0.017204548
146	0.73	0.052659937
147	0.735	0.039522484
148	0.74	-0.010994494
149	0.745	-0.056144897

150	0.75	-0.065149383
151	0.755	-0.048576833
152	0.76	-0.038534822
153	0.765	-0.043699806
154	0.77	-0.03542021
155	0.775	0.013592332
156	0.78	0.085033955
157	0.785	0.12749261
158	0.79	0.11581421
159	0.795	0.080103498
160	0.8	0.06630621
161	0.805	0.08415958
162	0.81	0.10865606
163	0.815	0.11892934
164	0.82	0.11359539
165	0.825	0.092638727
166	0.83	0.049039869
167	0.835	-0.012828082
168	0.84	-0.065783624
169	0.845	-0.079870603
170	0.85	-0.050316509
171	0.855	-0.00097395534
172	0.86	0.03434353
173	0.865	0.03201866
174	0.87	-0.0067449271
175	0.875	-0.050904966
176	0.88	-0.059992556
177	0.885	-0.025965841
178	0.89	0.009786112
179	0.895	-0.0026597634
180	0.9	-0.065476089
181	0.905	-0.13289283
182	0.91	-0.1654665
183	0.915	-0.16626389
184	0.92	-0.16137759
185	0.925	-0.16546752

186	0.93	-0.17628633
187	0.935	-0.18630774
188	0.94	-0.18426124
189	0.945	-0.15329255
190	0.95	-0.082747017
191	0.955	0.016499133
192	0.96	0.11393189
193	0.965	0.17847558
194	0.97	0.19775568
195	0.975	0.18249414
196	0.98	0.1517722
197	0.985	0.11339247
198	0.99	0.065048945
199	0.995	0.01631345
200	1	-0.0066645049
201	1.005	0.0075865504
202	1.01	0.032321811
203	1.015	0.030442847
204	1.02	0.00028647701
205	1.025	-0.025406138
206	1.03	-0.022468339
207	1.035	0.0012715917
208	1.04	0.021795146
209	1.045	0.01814092
210	1.05	-0.020676456
211	1.055	-0.083739676
212	1.06	-0.13069644
213	1.065	-0.11959621
214	1.07	-0.051312838
215	1.075	0.028703375
216	1.08	0.077249618
217	1.085	0.087266442
218	1.09	0.075098195
219	1.095	0.057022025
220	1.1	0.047235954
221	1.105	0.05723626

222	1.11	0.078925461
223	1.115	0.08012695
224	1.12	0.03601193
225	1.125	-0.037174059
226	1.13	-0.093156521
227	1.135	-0.10202203
228	1.14	-0.078317324
229	1.145	-0.062551035
230	1.15	-0.080201081
231	1.155	-0.11863873
232	1.16	-0.1394351
233	1.165	-0.11381666
234	1.17	-0.051040991
235	1.175	0.0081778628
236	1.18	0.030390945
237	1.185	0.020307026
238	1.19	0.0094410319
239	1.195	0.019596411
240	1.2	0.046971959
241	1.205	0.076747119
242	1.21	0.095931376
243	1.215	0.090094218
244	1.22	0.048476598
245	1.225	-0.013247986
246	1.23	-0.048035689
247	1.235	-0.015179668
248	1.24	0.07512848
249	1.245	0.1644091
250	1.25	0.1956164
251	1.255	0.15785663
252	1.26	0.085932191
253	1.265	0.024412664
254	1.27	-0.0053024166
255	1.275	-0.010252167
256	1.28	-0.010482105
257	1.285	-0.022819007

258	1.29	-0.051197002
259	1.295	-0.082039156
260	1.3	-0.09140624
261	1.305	-0.067553482
262	1.31	-0.027937392
263	1.315	-0.0061588865
264	1.32	-0.020548996
265	1.325	-0.059238095
266	1.33	-0.09198185
267	1.335	-0.091324462
268	1.34	-0.050291934
269	1.345	0.010070011
270	1.35	0.055861324
271	1.355	0.072796472
272	1.36	0.079172326
273	1.365	0.09958703
274	1.37	0.1333884
275	1.375	0.15733456
276	1.38	0.15157744
277	1.385	0.11480677
278	1.39	0.061774549
279	1.395	0.013988987
280	1.4	-0.014795758
281	1.405	-0.031270113
282	1.41	-0.053989599
283	1.415	-0.087659529
284	1.42	-0.11579484
285	1.425	-0.12423269
286	1.43	-0.11995309
287	1.435	-0.11749057
288	1.44	-0.11674518
289	1.445	-0.10594371
290	1.45	-0.081204038
291	1.455	-0.052147242
292	1.46	-0.029311614
293	1.465	-0.014027837

294	1.47	-0.0020567248
295	1.475	0.0072472418
296	1.48	0.0084415418
297	1.485	-0.0021317528
298	1.49	-0.016391557
299	1.495	-0.017634853
300	1.5	0.00049808708
301	1.505	0.021504538
302	1.51	0.022407668
303	1.515	0.0038906393
304	1.52	-0.0065656164
305	1.525	0.012656164
306	1.53	0.050410931
307	1.535	0.07695024
308	1.54	0.077272255
309	1.545	0.058148669
310	1.55	0.027387784
311	1.555	-0.014907821
312	1.56	-0.059346793
313	1.565	-0.079131335
314	1.57	-0.054467625
315	1.575	0.0013653207
316	1.58	0.053648618
317	1.585	0.08066993
318	1.59	0.084775772
319	1.595	0.073414398
320	1.6	0.046429285
321	1.605	0.0056018762
322	1.61	-0.037079433
323	1.615	-0.067086265
324	1.62	-0.075500867
325	1.625	-0.0589482
326	1.63	-0.02295646
327	1.635	0.013860508
328	1.64	0.033711227
329	1.645	0.041370042

330	1.65	0.056935964
331	1.655	0.081511165
332	1.66	0.086525951
333	1.665	0.047764046
334	1.67	-0.021666667
335	1.675	-0.082232385
336	1.68	-0.10327419
337	1.685	-0.081588661
338	1.69	-0.036829204
339	1.695	0.0024685327
340	1.7	0.017812379
341	1.705	0.015520241
342	1.71	0.017507801
343	1.715	0.033059753
344	1.72	0.047713266
345	1.725	0.043769756
346	1.73	0.021455593
347	1.735	-0.0058096054
348	1.74	-0.026718874
349	1.745	-0.035042215
350	1.75	-0.026397063
351	1.755	-0.0026489752
352	1.76	0.023528806
353	1.765	0.036515652
354	1.77	0.031236566
355	1.775	0.01674508
356	1.78	0.0070231263
357	1.785	0.0084944427
358	1.79	0.014984807
359	1.795	0.014983379
360	1.8	0.0046407566
361	1.805	-0.0078359335
362	1.81	-0.011057102
363	1.815	-0.0011364739
364	1.82	0.015679617
365	1.825	0.025842256

366	1.83	0.014733354
367	1.835	-0.020916692
368	1.84	-0.063438768
369	1.845	-0.084928011
370	1.85	-0.072648822
371	1.855	-0.038598246
372	1.86	-0.0018299684
373	1.865	0.02985286
374	1.87	0.056112573
375	1.875	0.071942286
376	1.88	0.068769756
377	1.885	0.044343122
378	1.89	0.0065606302
379	1.895	-0.02915438
380	1.9	-0.044831141
381	1.905	-0.030281534
382	1.91	0.0060609361
383	1.915	0.04173937
384	1.92	0.060381462
385	1.925	0.063599266
386	1.93	0.060827164
387	1.935	0.054131437
388	1.94	0.039137555
389	1.945	0.017151422
390	1.95	-0.0015565209
391	1.955	-0.0089859182
392	1.96	-0.01031141
393	1.965	-0.018979504
394	1.97	-0.039729173
395	1.975	-0.059701336
396	1.98	-0.060164576
397	1.985	-0.036811563
398	1.99	-0.0057823799
399	1.995	0.01094402
400	2	0.0051219639
401	2.005	-0.012492811

402	2.01	-0.025728867
403	2.015	-0.030738044
404	2.02	-0.036879678
405	2.025	-0.048927909
406	2.03	-0.055175181
407	2.035	-0.040170185
408	2.04	-0.0055574386
409	2.045	0.028893953
410	2.05	0.042394004
411	2.055	0.026390129
412	2.06	-0.012411339
413	2.065	-0.053424595
414	2.07	-0.072224941
415	2.075	-0.059704191
416	2.08	-0.029466707
417	2.085	-0.0011468645
418	2.09	0.017874783
419	2.095	0.029995309
420	2.1	0.036921893
421	2.105	0.039544611
422	2.11	0.039385031
423	2.115	0.032726522
424	2.12	0.01226685
425	2.125	-0.018453656
426	2.13	-0.041744978
427	2.135	-0.044140512
428	2.14	-0.030192006
429	2.145	-0.013425105
430	2.15	-0.003019119
431	2.155	-0.0034765882
432	2.16	-0.016618232
433	2.165	-0.037488835
434	2.17	-0.055492301
435	2.175	-0.06417253
436	2.18	-0.065526971
437	2.185	-0.064223106

438	2.19	-0.062111961
439	2.195	-0.056492709
440	2.2	-0.039842459
441	2.205	-0.0071743551
442	2.21	0.030437035
443	2.215	0.04811451
444	2.22	0.032868461
445	2.225	0.0012788314
446	2.23	-0.017252167
447	2.235	-0.0096314673
448	2.24	0.01502437
449	2.245	0.040369226
450	2.25	0.054856735
451	2.255	0.05567462
452	2.26	0.049843581
453	2.265	0.047434384
454	2.27	0.048824309
455	2.275	0.045145304
456	2.28	0.035080861
457	2.285	0.030744774
458	2.29	0.039077292
459	2.295	0.047105129
460	2.3	0.037498521
461	2.305	0.014027531
462	2.31	-0.00031881207
463	2.315	0.0091559498
464	2.32	0.031718059
465	2.325	0.0434974
466	2.33	0.030844703
467	2.335	-0.0011959519
468	2.34	-0.037825737
469	2.345	-0.06498654
470	2.35	-0.072119812
471	2.355	-0.053332008
472	2.36	-0.012816662
473	2.365	0.032866116

474	2.37	0.06427511
475	2.375	0.072455491
476	2.38	0.060987968
477	2.385	0.037788824
478	2.39	0.010956664
479	2.395	-0.0093176303
480	2.4	-0.014443765
481	2.405	-0.0063721627
482	2.41	0.0038070256
483	2.415	0.0094749771
484	2.42	0.014814622
485	2.425	0.024605384
486	2.43	0.034713368
487	2.435	0.038219945
488	2.44	0.036172428
489	2.445	0.036225043
490	2.45	0.042524421
491	2.455	0.050379525
492	2.46	0.049179973
493	2.465	0.02961191
494	2.47	-0.0073953605
495	2.475	-0.046124095
496	2.48	-0.064628939
497	2.485	-0.052207301
498	2.49	-0.018219639
499	2.495	0.01615958
500	2.5	0.033124809
501	2.505	0.027974712
502	2.51	0.0098705211
503	2.515	-0.0064098297
504	2.52	-0.013476394
505	2.525	-0.016247476
506	2.53	-0.02175905
507	2.535	-0.02758754
508	2.54	-0.02516631
509	2.545	-0.011106964

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511	2.555	0.033627205
512	2.56	0.05073213
513	2.565	0.052768329
514	2.57	0.03597308
515	2.575	0.0080523096
516	2.58	-0.018340777
517	2.585	-0.035112675
518	2.59	-0.037290099
519	2.595	-0.020189762
520	2.6	0.011869379
521	2.605	0.04026889
522	2.61	0.048401142
523	2.615	0.040701132
524	2.62	0.033816967
525	2.625	0.03141399
526	2.63	0.020843683
527	2.635	-0.0052012032
528	2.64	-0.036364638
529	2.645	-0.056334659
530	2.65	-0.057095238
531	2.655	-0.040242888
532	2.66	-0.014392883
533	2.665	0.0061300602
534	2.67	0.0097322321
535	2.675	-0.00059091975
536	2.68	-0.010071755
537	2.685	-0.0095956052
538	2.69	-0.0040004894
539	2.695	-0.00087639033
540	2.7	0.00072098603
541	2.705	0.0048812685
542	2.71	0.0085424493
543	2.715	0.0048888243
544	2.72	-0.0045819211
545	2.725	-0.0089163047

546	2.73	-0.00087293158
547	2.735	0.013125625
548	2.74	0.019155399
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550	2.75	-0.01135128
551	2.755	-0.033159784
552	2.76	-0.045879066
553	2.765	-0.04405853
554	2.77	-0.029835118
555	2.775	-0.013432854
556	2.78	-0.0058543591
557	2.785	-0.0085577547
558	2.79	-0.012706434
559	2.795	-0.0091310391
560	2.8	0.0038944224
561	2.805	0.02171918
562	2.81	0.0363679
563	2.815	0.038122973
564	2.82	0.021620067
565	2.825	-0.0053717345
566	2.83	-0.024341491
567	2.835	-0.022489344
568	2.84	-0.0049562557
569	2.845	0.012178852
570	2.85	0.018626899
571	2.855	0.01680412
572	2.86	0.014597023
573	2.865	0.015426838
574	2.87	0.01582176
575	2.875	0.010386968
576	2.88	-0.0022694402
577	2.885	-0.017992556
578	2.89	-0.029785357
579	2.895	-0.0311658
580	2.9	-0.018751402
581	2.905	0.0049609769

582	2.91	0.030701744
583	2.915	0.047221576
584	2.92	0.048927093
585	2.925	0.038070868
586	2.93	0.02020363
587	2.935	0.00072536657
588	2.94	-0.013951973
589	2.945	-0.016997145
590	2.95	-0.0070618232
591	2.955	0.0078656368
592	2.96	0.015680738
593	2.965	0.0098848476
594	2.97	-0.0056169267
595	2.975	-0.019613133
596	2.98	-0.021452534
597	2.985	-0.0091368512
598	2.99	0.0083652493
599	2.995	0.018614459
600	3	0.016938207
601	3.005	0.0089770368
602	3.01	0.0024941776
603	3.015	0.00011759661
604	3.02	0.00037634139
605	3.025	0.00077590701
606	3.03	-0.002361089
607	3.035	-0.012290609
608	3.04	-0.026641073
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611	3.055	-0.034062404
612	3.06	-0.026653921
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615	3.075	-0.0070269705
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617	3.085	-0.013110023

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619	3.095	-0.013450597
620	3.1	-0.01355287
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622	3.11	-0.0023302641
623	3.115	0.0064424595
624	3.12	0.0067798613
625	3.125	-0.00098164168
626	3.13	-0.0074602427
627	3.135	-0.0062861426
628	3.14	-0.00095259509
629	3.145	0.00062338126
630	3.15	-0.0055271235
631	3.155	-0.016411135
632	3.16	-0.02429846
633	3.165	-0.022376364
634	3.17	-0.010921485
635	3.175	0.0023801162
636	3.18	0.009657826
637	3.185	0.0092420822
638	3.19	0.0042117875
639	3.195	-0.002294871
640	3.2	-0.0080871622
641	3.205	-0.011131131
642	3.21	-0.011107576
643	3.215	-0.010382278
644	3.22	-0.01078393
645	3.225	-0.010465688
646	3.23	-0.0063745182
647	3.235	0.00072674926
648	3.24	0.0056263689
649	3.245	0.0030703681
650	3.25	-0.0077857857
651	3.255	-0.022215968
652	3.26	-0.032165698
653	3.265	-0.030997145

654	3.27	-0.018291526
655	3.275	-0.00064559498
656	3.28	0.012863057
657	3.285	0.016649128
658	3.29	0.011173753
659	3.295	0.0011495564
660	3.3	-0.008278964
661	3.305	-0.014524931
662	3.31	-0.017616396
663	3.315	-0.017742021
664	3.32	-0.014163149
665	3.325	-0.0077917508
666	3.33	-0.0029670643
667	3.335	-0.0033863261
668	3.34	-0.0068615581
669	3.345	-0.0077834302
670	3.35	-0.0046794738
671	3.355	-0.00100803
672	3.36	0.0018116447
673	3.365	0.0064276231
674	3.37	0.012506679
675	3.375	0.013619048
676	3.38	0.0056254206
677	3.385	-0.0058791577
678	3.39	-0.011294586
679	3.395	-0.0077182013
680	3.4	-9.221505e-005
681	3.405	0.0059729989
682	3.41	0.0086971857
683	3.415	0.0091910574
684	3.42	0.0094899562
685	3.425	0.01059794
686	3.43	0.010338534
687	3.435	0.0046776996
688	3.44	-0.0068909248
689	3.445	-0.018970735

690	3.45	-0.024997859
691	3.455	-0.0227513
692	3.46	-0.01420414
693	3.465	-0.0027530437
694	3.47	0.0072362292
695	3.475	0.010765168
696	3.48	0.0058869685
697	3.485	-0.0029588967
698	3.49	-0.0078323952
699	3.495	-0.0044945141
700	3.5	0.0042182625
701	3.505	0.012380748
702	3.51	0.016772305
703	3.515	0.017709289
704	3.52	0.015967268
705	3.525	0.011878964
706	3.53	0.0075477312
707	3.535	0.0068246661
708	3.54	0.011315693
709	3.545	0.017918833
710	3.55	0.021503824
711	3.555	0.019015397
712	3.56	0.010939227
713	3.565	0.0008028082
714	3.57	-0.0065019272
715	3.575	-0.0083377995
716	3.58	-0.0069180789
717	3.585	-0.006281452
718	3.59	-0.0066840522
719	3.595	-0.0046035485
720	3.6	0.0016081778
721	3.605	0.0090814112
722	3.61	0.014022535
723	3.615	0.015248598
724	3.62	0.013492097
725	3.625	0.0098248598

726	3.63	0.0059284797
727	3.635	0.0039869583
728	3.64	0.0049489548
729	3.645	0.0075931172
730	3.65	0.0097914347
731	3.655	0.010348017
732	3.66	0.0097996941
733	3.665	0.0097029571
734	3.67	0.010553584
735	3.675	0.010198634
736	3.68	0.0053500255
737	3.685	-0.0046631284
738	3.69	-0.016185582
739	3.695	-0.02351504
740	3.7	-0.022626797
741	3.705	-0.013516774
742	3.71	-0.00041275212
743	3.715	0.01045855
744	3.72	0.014983787
745	3.725	0.013897114
746	3.73	0.011054247
747	3.735	0.0090634241
748	3.74	0.0072722137
749	3.745	0.0039041501
750	3.75	-0.00088802794
751	3.755	-0.0048162843
752	3.76	-0.0060274396
753	3.765	-0.0050148771
754	3.77	-0.0034190374
755	3.775	-0.0015315795
756	3.78	0.0017194453
757	3.785	0.0062138574
758	3.79	0.0096357398
759	3.795	0.010115825
760	3.8	0.0089895177
761	3.805	0.009551555

762	3.81	0.012995921
763	3.815	0.016375956
764	3.82	0.015052717
765	3.825	0.007351086
766	3.83	-0.0031760069
767	3.835	-0.010493219
768	3.84	-0.011466707
769	3.845	-0.008129897
770	3.85	-0.0043727949
771	3.855	-0.0016124401
772	3.86	0.00091455593
773	3.865	0.002786632
774	3.87	0.0021639645
775	3.875	-0.00056059141
776	3.88	-0.001515336
777	3.885	0.0023673499
778	3.89	0.0091400326
779	3.895	0.013709901
780	3.9	0.013133884
781	3.905	0.0085877129
782	3.91	0.0031073621
783	3.915	-0.00053301213
784	3.92	-0.00046480575
785	3.925	0.0029108188
786	3.93	0.0058575201
787	3.935	0.0043118079
788	3.94	-0.0008858703
789	3.945	-0.0038772407
790	3.95	-0.00035550933
791	3.955	0.0072958091
792	3.96	0.012665035
793	3.965	0.011674824
794	3.97	0.0052106251
795	3.975	-0.0028191088
796	3.98	-0.008387254
797	3.985	-0.0096288875

798	3.99	-0.0080630978
799	3.995	-0.0069796676
800	4	-0.0075308861
801	4.005	-0.007299429
802	4.01	-0.003790313
803	4.015	0.0017071683
804	4.02	0.0051631488
805	4.025	0.0042706128
806	4.03	0.00080039258
807	4.035	-0.0013846742
808	4.04	-9.7456205e-005
809	4.045	0.0033180687
810	4.05	0.0056170083
811	4.055	0.0048931987
812	4.06	0.0017815642
813	4.065	-0.0022819823
814	4.07	-0.0065622515
815	4.075	-0.010244927
816	4.08	-0.011881921
817	4.085	-0.011138574
818	4.09	-0.0099542266
819	4.095	-0.010350872
820	4.1	-0.011910982
821	4.105	-0.012916794
822	4.11	-0.013121852
823	4.115	-0.01371398
824	4.12	-0.015099623
825	4.125	-0.016342001
826	4.13	-0.016501581
827	4.135	-0.015247374
828	4.14	-0.012463546
829	4.145	-0.0084761803
830	4.15	-0.004521505
831	4.155	-0.0020328643
832	4.16	-0.0014731416
833	4.165	-0.0023201897

834	4.17	-0.0037492913
835	4.175	-0.0048065973
836	4.18	-0.0045813501
837	4.185	-0.0031674722
838	4.19	-0.0021527582
839	4.195	-0.0031059141
840	4.2	-0.0053672683
841	4.205	-0.0062320281
842	4.21	-0.0040533191
843	4.215	-0.00071785255
844	4.22	8.6396655e-005
845	4.225	-0.0026748853
846	4.23	-0.0057301927
847	4.235	-0.0051236464
848	4.24	-0.0006896319
849	4.245	0.0041614255
850	4.25	0.0064868563
851	4.255	0.0062915061
852	4.26	0.0053791272
853	4.265	0.0053158458
854	4.27	0.0065786071
855	4.275	0.0082622311
856	4.28	0.0083370348
857	4.285	0.0054527684
858	4.29	0.00086791374
859	4.295	-0.0024954522
860	4.3	-0.0032348221
861	4.305	-0.0025751096
862	4.31	-0.0019427246
863	4.315	-0.00087984399
864	4.32	0.001541348
865	4.325	0.0042771388
866	4.33	0.00495803
867	4.335	0.0029861935
868	4.34	0.00066433364
869	4.345	0.00061309167

870	4.35	0.0027578872
871	4.355	0.0046095442
872	4.36	0.0042971245
873	4.365	0.0026723769
874	4.37	0.0022627817
875	4.375	0.0044771082
876	4.38	0.0080502498
877	4.385	0.01017097
878	4.39	0.0090142347
879	4.395	0.0051339757
880	4.4	0.00049087998
881	4.405	-0.0035178342
882	4.41	-0.0066997043
883	4.415	-0.0088937596
884	4.42	-0.0089448149
885	4.425	-0.0056272153
886	4.43	0.00036660651
887	4.435	0.0060197206
888	4.44	0.0081179668
889	4.445	0.0058244519
890	4.45	0.0011219537
891	4.455	-0.0029498114
892	4.46	-0.0043438258
893	4.465	-0.0029152136
894	4.47	-5.9130009e-005
895	4.475	0.0025954012
896	4.48	0.0045093913
897	4.485	0.0060841644
898	4.49	0.0070742735
899	4.495	0.0061626593
900	4.5	0.003085959
901	4.505	0.00024830529
902	4.51	0.00043487509
903	4.515	0.0030324156
904	4.52	0.0041456205
905	4.525	0.00079613541

906	4.53	-0.006099225
907	4.535	-0.012854492
908	4.54	-0.015828388
909	4.545	-0.013306006
910	4.55	-0.0064057102
911	4.555	0.0012430611
912	4.56	0.0058495157
913	4.565	0.0061438768
914	4.57	0.0034247374
915	4.575	-0.00052829713
916	4.58	-0.0044937188
917	4.585	-0.0072379423
918	4.59	-0.007595697
919	4.595	-0.0055635057
920	4.6	-0.0024502702
921	4.605	0.00021848578
922	4.61	0.0014462629
923	4.615	0.00093873968
924	4.62	-0.00041802488
925	4.625	-0.00059448863
926	4.63	0.0017789742
927	4.635	0.005473733
928	4.64	0.0074803814
929	4.645	0.0060961252
930	4.65	0.0026738248
931	4.655	0.00010531865
932	4.66	6.9722239e-006
933	4.665	0.0016732232
934	4.67	0.0035228102
935	4.675	0.0049442439
936	4.68	0.0063005098
937	4.685	0.0075159274
938	4.69	0.0076848374
939	4.695	0.0063567554
940	4.7	0.0042877842
941	4.705	0.0022978383

942	4.71	0.00020028857
943	4.715	-0.0023324462
944	4.72	-0.004543836
945	4.725	-0.0053014581
946	4.73	-0.0046383909
947	4.735	-0.0036053227
948	4.74	-0.0028248802
949	4.745	-0.0021873866
950	4.75	-0.0018614765
951	4.755	-0.0025480575
952	4.76	-0.0043861527
953	4.765	-0.0062669624
954	4.77	-0.0066491894
955	4.775	-0.0049345366
956	4.78	-0.0020423677
957	4.785	0.00022348934
958	4.79	0.00064881207
959	4.795	-0.00025208015
960	4.8	-0.00084905884
961	4.805	-0.00041532885
962	4.81	9.3948812e-006
963	4.815	-0.00075777404
964	4.82	-0.0022286326
965	4.825	-0.0029061997
966	4.83	-0.0022666871
967	4.835	-0.001104354
968	4.84	-0.00025318446
969	4.845	-4.1540532e-005
970	4.85	-0.00075436423
971	4.855	-0.0023745896
972	4.86	-0.0037787397
973	4.865	-0.0033557969
974	4.87	-0.00083311614
975	4.875	0.0022244723
976	4.88	0.0039842052
977	4.885	0.0038892832

978	4.89	0.0025904966
979	4.895	0.00098172632
980	4.9	-0.00037558683
981	4.905	-0.0011173448
982	4.91	-0.00074520547
983	4.915	0.0011464668
984	4.92	0.0040353727
985	4.925	0.0063228918
986	4.93	0.0067348017
987	4.935	0.0056626287
988	4.94	0.0044278169
989	4.945	0.0036179464
990	4.95	0.0030484348
991	4.955	0.002832589
992	4.96	0.003156786
993	4.965	0.0033269807
994	4.97	0.0025068217
995	4.975	0.0012876007
996	4.98	0.0010604568
997	4.985	0.0018338942
998	4.99	0.002076578
999	4.995	0.00086157337
1000	5	-0.0010539717
1001	5.005	-0.0023928928
1002	5.01	-0.0025940247
1003	5.015	-0.0019123381
1004	5.02	-0.0011967472
1005	5.025	-0.0013882431
1006	5.03	-0.0023985724
1007	5.035	-0.0028282757
1008	5.04	-0.0017019578
1009	5.045	-2.9691445e-005
1010	5.05	0.00040450189
1011	5.055	-0.00057246763
1012	5.06	-0.001518395
1013	5.065	-0.0015497808

1014	5.07	-0.0013087183
1015	5.075	-0.0016324666
1016	5.08	-0.0023166718
1017	5.085	-0.0026173448
1018	5.09	-0.0023037728
1019	5.095	-0.0017553584
1020	5.1	-0.0013810543
1021	5.105	-0.0012929132
1022	5.11	-0.0013784032
1023	5.115	-0.0014576629
1024	5.12	-0.0015240339
1025	5.125	-0.0015391353

Vertical Earthquake Records

Description: Giles County_
Use Baseline Correction: No
Modified Peak Acc.: 0.48380254
Modified Duration: 1

Records

	Time (sec)	Acc (ft/sec²)
1	0.005	-0.0016033751
2	0.01	-0.00094558377
3	0.015	-0.00057697767
4	0.02	-0.0005099847
5	0.025	-0.00058870195
6	0.03	-0.00064258387
7	0.035	-0.00068153972
8	0.04	-0.00074123687
9	0.045	-0.00077343428
10	0.05	-0.00075803406
11	0.055	-0.00075484246
12	0.06	-0.00078559702
13	0.065	-0.00080241052
14	0.07	-0.00080017844
15	0.075	-0.00082386663
16	0.08	-0.00086219537

17	0.085	-0.00087266646
18	0.09	-0.00088534924
19	0.095	-0.00094309065
20	0.1	-0.00099650964
21	0.105	-0.00099179872
22	0.11	-0.00097262568
23	0.115	-0.00097294891
24	0.12	-0.00094472418
25	0.125	-0.00091186805
26	0.13	-0.0010167401
27	0.135	-0.0012892628
28	0.14	-0.001534404
29	0.145	-0.0014658509
30	0.15	-0.00073137555
31	0.155	0.0010761905
32	0.16	0.0040854798
33	0.165	0.0079283573
34	0.17	0.012009993
35	0.175	0.015509942
36	0.18	0.017012134
37	0.185	0.015390435
38	0.19	0.011848883
39	0.195	0.0095911594
40	0.2	0.009911502
41	0.205	0.0096348119
42	0.21	0.0040700112
43	0.215	-0.0079938717
44	0.22	-0.02289069
45	0.225	-0.034116753
46	0.23	-0.03504405
47	0.235	-0.022606709
48	0.24	-0.0012386765
49	0.245	0.018138676
50	0.25	0.025651983
51	0.255	0.019098195
52	0.26	0.0031792801

53	0.265	-0.015185072
54	0.27	-0.029393392
55	0.275	-0.033932803
56	0.28	-0.026257367
57	0.285	-0.0090495666
58	0.29	0.0094864383
59	0.295	0.01886479
60	0.3	0.013322831
61	0.305	-0.0024649332
62	0.31	-0.017394208
63	0.315	-0.025357908
64	0.32	-0.028583563
65	0.325	-0.02764301
66	0.33	-0.015775059
67	0.335	0.0097410625
68	0.34	0.036440502
69	0.345	0.047232181
70	0.35	0.040744264
71	0.355	0.032330988
72	0.36	0.034823493
73	0.365	0.046126746
74	0.37	0.056239931
75	0.375	0.057852044
76	0.38	0.04718446
77	0.385	0.022846232
78	0.39	-0.0092357908
79	0.395	-0.033972978
80	0.4	-0.037635974
81	0.405	-0.020527072
82	0.41	0.0043897114
83	0.415	0.024501988
84	0.42	0.035435505
85	0.425	0.037192108
86	0.43	0.028338024
87	0.435	0.0076283369
88	0.44	-0.019429693

89	0.445	-0.038311104
90	0.45	-0.033968186
91	0.455	-0.0059167533
92	0.46	0.02662282
93	0.465	0.041501682
94	0.47	0.036870399
95	0.475	0.030441623
96	0.48	0.033579892
97	0.485	0.036176914
98	0.49	0.023642704
99	0.495	-0.00065627205
100	0.5	-0.020411951
101	0.505	-0.027904252
102	0.51	-0.029142143
103	0.515	-0.02993576
104	0.52	-0.027517895
105	0.525	-0.017072601
106	0.53	0.0007787407
107	0.535	0.020747221
108	0.54	0.036762415
109	0.545	0.044643826
110	0.55	0.0445026
111	0.555	0.040939941
112	0.56	0.038335985
113	0.565	0.035442439
114	0.57	0.026091975
115	0.575	0.0060133884
116	0.58	-0.020947283
117	0.585	-0.043869583
118	0.59	-0.053570001
119	0.595	-0.050525849
120	0.6	-0.041874885
121	0.605	-0.031546854
122	0.61	-0.019087489
123	0.615	-0.0088298154
124	0.62	-0.010580912

125	0.625	-0.024691547
126	0.63	-0.034799837
127	0.635	-0.026373305
128	0.64	-0.0084183338
129	0.645	-0.0051833996
130	0.65	-0.026905884
131	0.655	-0.058871826
132	0.66	-0.079787193
133	0.665	-0.081402672
134	0.67	-0.069168247
135	0.675	-0.053645151
136	0.68	-0.044174467
137	0.685	-0.042841644
138	0.69	-0.042320893
139	0.695	-0.036404813
140	0.7	-0.031453554
141	0.705	-0.037030284
142	0.71	-0.046283063
143	0.715	-0.040134598
144	0.72	-0.014186092
145	0.725	0.012607219
146	0.73	0.02173213
147	0.735	0.014830733
148	0.74	0.003160467
149	0.745	-0.0097679719
150	0.75	-0.02538238
151	0.755	-0.039475171
152	0.76	-0.044851433
153	0.765	-0.039654532
154	0.77	-0.027052004
155	0.775	-0.012405119
156	0.78	-0.0044773121
157	0.785	-0.0101233
158	0.79	-0.021133068
159	0.795	-0.015756398
160	0.8	0.016299174

161	0.805	0.056035995
162	0.81	0.073099011
163	0.815	0.059012746
164	0.82	0.032808606
165	0.825	0.015242888
166	0.83	0.0090177118
167	0.835	0.0070583767
168	0.84	0.0086094116
169	0.845	0.017749261
170	0.85	0.031221678
171	0.855	0.038082492
172	0.86	0.03222953
173	0.865	0.018635057
174	0.87	0.0055299888
175	0.875	-0.004042745
176	0.88	-0.010402875
177	0.885	-0.012434486
178	0.89	-0.00941917
179	0.895	-0.0042236362
180	0.9	0.00069856225
181	0.905	0.0080708576
182	0.91	0.02031192
183	0.915	0.030772917
184	0.92	0.028601611
185	0.925	0.013923014
186	0.93	0.00020212909
187	0.935	-0.0024862751
188	0.94	0.00063029061
189	0.945	-0.00016843377
190	0.95	-0.0024592434
191	0.955	0.0052257571
192	0.96	0.025442133
193	0.965	0.045188029
194	0.97	0.049073213
195	0.975	0.034887121
196	0.98	0.015031406

197	0.985	0.005287152
198	0.99	0.012210156
199	0.995	0.028841134
200	1	0.042242582
201	1.005	0.046113286
202	1.01	0.044549505
203	1.015	0.042716631
204	1.02	0.038641277
205	1.025	0.029234526
206	1.03	0.020477108
207	1.035	0.022315285
208	1.04	0.032345162
209	1.045	0.034057612
210	1.05	0.017293464
211	1.055	-0.0060261038
212	1.06	-0.014634751
213	1.065	-0.0029027123
214	1.07	0.01503681
215	1.075	0.023569797
216	1.08	0.018567554
217	1.085	0.0036093709
218	1.09	-0.014718976
219	1.095	-0.025634547
220	1.1	-0.020345671
221	1.105	-0.0046617314
222	1.11	0.0045439788
223	1.115	0.00034749465
224	1.12	-0.007320985
225	1.125	-0.011103701
226	1.13	-0.019967778
227	1.135	-0.044371163
228	1.14	-0.078274906
229	1.145	-0.10660243
230	1.15	-0.12211176
231	1.155	-0.12401754
232	1.16	-0.10765983

233	1.165	-0.068927705
234	1.17	-0.016751504
235	1.175	0.02855491
236	1.18	0.049627715
237	1.185	0.041893953
238	1.19	0.014947283
239	1.195	-0.010951055
240	1.2	-0.016813093
241	1.205	-0.0016153462
242	1.21	0.015569287
243	1.215	0.014948404
244	1.22	-0.0052328235
245	1.225	-0.031210666
246	1.23	-0.048551035
247	1.235	-0.050167126
248	1.24	-0.036004283
249	1.245	-0.011976751
250	1.25	0.01322902
251	1.255	0.035601815
252	1.26	0.058616804
253	1.265	0.084895687
254	1.27	0.10720302
255	1.275	0.1125339
256	1.28	0.095021515
257	1.285	0.061278271
258	1.29	0.023291221
259	1.295	-0.0094083614
260	1.3	-0.02954196
261	1.305	-0.03061915
262	1.31	-0.012377485
263	1.315	0.014084328
264	1.32	0.03307046
265	1.325	0.037052615
266	1.33	0.028963801
267	1.335	0.013815846
268	1.34	-0.0048384011

269	1.345	-0.02054298
270	1.35	-0.025416029
271	1.355	-0.019861629
272	1.36	-0.014277761
273	1.365	-0.017210564
274	1.37	-0.027097889
275	1.375	-0.0385855
276	1.38	-0.050215866
277	1.385	-0.060616906
278	1.39	-0.062732946
279	1.395	-0.049628531
280	1.4	-0.024999694
281	1.405	-0.0021220251
282	1.41	0.0087952279
283	1.415	0.0090209034
284	1.42	0.0061647191
285	1.425	0.0037753849
286	1.43	-0.00063200979
287	1.435	-0.0076984705
288	1.44	-0.010834302
289	1.445	-0.0024959723
290	1.45	0.015557153
291	1.455	0.032422963
292	1.46	0.03863781
293	1.465	0.032935454
294	1.47	0.018590089
295	1.475	-0.0012063526
296	1.48	-0.021507597
297	1.485	-0.034509126
298	1.49	-0.036209646
299	1.495	-0.032353421
300	1.5	-0.032285204
301	1.505	-0.036793515
302	1.51	-0.036557051
303	1.515	-0.024028551
304	1.52	-0.0038070562

305	1.525	0.010542674
306	1.53	0.0086631998
307	1.535	-0.0078270215
308	1.54	-0.026467217
309	1.545	-0.033009279
310	1.55	-0.021927195
311	1.555	-0.00061657184
312	1.56	0.017134292
313	1.565	0.023418681
314	1.57	0.021861018
315	1.575	0.02034302
316	1.58	0.02012746
317	1.585	0.015622107
318	1.59	0.0042112165
319	1.595	-0.0089275925
320	1.6	-0.017801672
321	1.605	-0.022362088
322	1.61	-0.024475885
323	1.615	-0.021668298
324	1.62	-0.010307026
325	1.625	0.0079795248
326	1.63	0.028087794
327	1.635	0.046251453
328	1.64	0.057923728
329	1.645	0.05593056
330	1.65	0.038921689
331	1.655	0.018154074
332	1.66	0.0066382176
333	1.665	0.0035030896
334	1.67	-0.0019317426
335	1.675	-0.01271449
336	1.68	-0.021251045
337	1.685	-0.022756602
338	1.69	-0.02015387
339	1.695	-0.013891506
340	1.7	0.001794769

341	1.705	0.027417151
342	1.71	0.051130621
343	1.715	0.059162741
344	1.72	0.049493627
345	1.725	0.031918018
346	1.73	0.018203732
347	1.735	0.014626797
348	1.74	0.020176711
349	1.745	0.027891506
350	1.75	0.028893647
351	1.755	0.018508718
352	1.76	0.00051698685
353	1.765	-0.014614153
354	1.77	-0.017588559
355	1.775	-0.0083891404
356	1.78	0.0036919445
357	1.785	0.0091381768
358	1.79	0.0062728153
359	1.795	-0.00036818497
360	1.8	-0.0065100133
361	1.805	-0.010223922
362	1.81	-0.010397777
363	1.815	-0.0068900683
364	1.82	-0.00077220149
365	1.825	0.0074865504
366	1.83	0.016999286
367	1.835	0.022282349
368	1.84	0.016016417
369	1.845	-0.00042199449
370	1.85	-0.015281534
371	1.855	-0.019748751
372	1.86	-0.016718874
373	1.865	-0.012269603
374	1.87	-0.0072082186
375	1.875	-0.0034499643
376	1.88	-0.0085441215

377	1.885	-0.023303559
378	1.89	-0.0329482
379	1.895	-0.023041297
380	1.9	0.00041172428
381	1.905	0.018019068
382	1.91	0.02045335
383	1.915	0.014326094
384	1.92	0.0079338534
385	1.925	0.0022514327
386	1.93	-0.004320985
387	1.935	-0.010985215
388	1.94	-0.015438462
389	1.945	-0.015363108
390	1.95	-0.01031712
391	1.955	-0.0050115632
392	1.96	-0.006783471
393	1.965	-0.015830835
394	1.97	-0.022033955
395	1.975	-0.016118487
396	1.98	-0.0012062812
397	1.985	0.010174324
398	1.99	0.0082496992
399	1.995	-0.006399898
400	2	-0.023684409
401	2.005	-0.030552463
402	2.01	-0.02037667
403	2.015	0.0014400428
404	2.02	0.022077088
405	2.025	0.031250739
406	2.03	0.02587203
407	2.035	0.0087702865
408	2.04	-0.012266748
409	2.045	-0.026257775
410	2.05	-0.025855002
411	2.055	-0.013570613
412	2.06	0.0010933109

413	2.065	0.010013674
414	2.07	0.010830223
415	2.075	0.0063311614
416	2.08	0.002387254
417	2.085	0.0037912613
418	2.09	0.0095510758
419	2.095	0.014668706
420	2.1	0.017321607
421	2.105	0.019600082
422	2.11	0.020119914
423	2.115	0.013019374
424	2.12	-0.0019608239
425	2.125	-0.015181095
426	2.13	-0.018428877
427	2.135	-0.015253492
428	2.14	-0.014184766
429	2.145	-0.016240644
430	2.15	-0.015602529
431	2.155	-0.0094669114
432	2.16	-0.00097193127
433	2.165	0.0057571836
434	2.17	0.0084442235
435	2.175	0.0064114204
436	2.18	0.0018389824
437	2.185	-0.00070314673
438	2.19	0.00028855103
439	2.195	0.00079023962
440	2.2	-0.0022292036
441	2.205	-0.0052388294
442	2.21	-0.003355287
443	2.215	0.0024467931
444	2.22	0.0084127256
445	2.225	0.015060875
446	2.23	0.025207097
447	2.235	0.036886
448	2.24	0.044027022

449	2.245	0.043392679
450	2.25	0.036260936
451	2.255	0.024442439
452	2.26	0.0095081778
453	2.265	-0.0045641073
454	2.27	-0.01264821
455	2.275	-0.013183033
456	2.28	-0.0091950036
457	2.285	-0.0049141022
458	2.29	-0.0030678597
459	2.295	-0.0040066891
460	2.3	-0.0054053431
461	2.305	-0.0044108494
462	2.31	-0.0018430611
463	2.315	-0.0022130723
464	2.32	-0.0079100235
465	2.325	-0.015735291
466	2.33	-0.020657897
467	2.335	-0.020158866
468	2.34	-0.013549098
469	2.345	-0.00091620373
470	2.35	0.014492811
471	2.355	0.025823289
472	2.36	0.02758652
473	2.365	0.019842052
474	2.37	0.0066874273
475	2.375	-0.006664821
476	2.38	-0.014583053
477	2.385	-0.012980014
478	2.39	-0.0036724992
479	2.395	0.0051536352
480	2.4	0.0054494035
481	2.405	-0.0037914857
482	2.41	-0.016319874
483	2.415	-0.024349546
484	2.42	-0.024747221

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486	2.43	-0.018411033
487	2.435	-0.018776588
488	2.44	-0.018224024
489	2.445	-0.013509024
490	2.45	-0.0063387988
491	2.455	-0.00071131131
492	2.46	0.0017775874
493	2.465	0.0020507903
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495	2.475	-0.00039051902
496	2.48	-0.0015896502
497	2.485	-0.002604609
498	2.49	-0.0046466911
499	2.495	-0.0075974202
500	2.5	-0.009134353
501	2.505	-0.0080555929
502	2.51	-0.0067297033
503	2.515	-0.007857255
504	2.52	-0.0098698481
505	2.525	-0.0081721322
506	2.53	-0.0010205873
507	2.535	0.0077999388
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510	2.55	0.0079988987
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515	2.575	-0.013679821
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517	2.585	0.015366575
518	2.59	0.028400734
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524	2.62	0.0035905986
525	2.625	0.0002497308
526	2.63	-0.0025496176
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528	2.64	-0.006716631
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531	2.655	0.019609463
532	2.66	0.02136372
533	2.665	0.016977465
534	2.67	0.010662384
535	2.675	0.0051034057
536	2.68	2.9539411e-005
537	2.685	-0.0054824819
538	2.69	-0.010278067
539	2.695	-0.011501682
540	2.7	-0.0080971755
541	2.705	-0.0031013256
542	2.71	-0.0011373101
543	2.715	-0.0036413582
544	2.72	-0.0074021515
545	2.725	-0.0076278271
546	2.73	-0.0019442847
547	2.735	0.007602437
548	2.74	0.015272255
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550	2.75	0.0075887937
551	2.755	-0.0025335475
552	2.76	-0.008521811
553	2.765	-0.009419741
554	2.77	-0.0092045478
555	2.775	-0.011024166
556	2.78	-0.013928011

557	2.785	-0.014865198
558	2.79	-0.011738962
559	2.795	-0.0044022739
560	2.8	0.005104354
561	2.805	0.012348629
562	2.81	0.012324666
563	2.815	0.0034531355
564	2.82	-0.010075334
565	2.825	-0.020791577
566	2.83	-0.023368002
567	2.835	-0.017931478
568	2.84	-0.0085712042
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571	2.855	0.010533191
572	2.86	0.0077655552
573	2.865	-0.00062746915
574	2.87	-0.0097844091
575	2.875	-0.012620985
576	2.88	-0.0065383706
577	2.885	0.0032178546
578	2.89	0.0082479657
579	2.895	0.0050875089
580	2.9	-0.0019557867
581	2.905	-0.0057739166
582	2.91	-0.0032859284
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585	2.925	0.010690221
586	2.93	0.0083468441
587	2.935	0.0011419292
588	2.94	-0.0091016213
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590	2.95	-0.018229428
591	2.955	-0.010599266
592	2.96	0.0016556133

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594	2.97	0.01794147
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596	2.98	0.007926634
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598	2.99	-0.0015749771
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603	3.015	-0.010389518
604	3.02	-0.014625268
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606	3.03	-0.0097
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608	3.04	0.0022122464
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611	3.055	0.0002532538
612	3.06	0.0012460385
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614	3.07	0.009391241
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616	3.08	0.0051487611
617	3.085	0.0016878964
618	3.09	0.0019655246
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624	3.12	-0.0088146936
625	3.125	-0.007809432
626	3.13	-0.005173886
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630	3.15	0.0041855715
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632	3.16	-0.0016722851
633	3.165	-0.0024417559
634	3.17	-0.0034141939
635	3.175	-0.0043039462
636	3.18	-0.0028799633
637	3.185	0.00097214235
638	3.19	0.0048462119
639	3.195	0.0075047007
640	3.2	0.0097338024
641	3.205	0.011387376
642	3.21	0.010850515
643	3.215	0.0082072193
644	3.22	0.0063517182
645	3.225	0.007896166
646	3.23	0.01238289
647	3.235	0.016754563
648	3.24	0.017389416
649	3.245	0.012230448
650	3.25	0.0026781483
651	3.255	-0.0067384827
652	3.26	-0.011875905
653	3.265	-0.011952687
654	3.27	-0.0084620271
655	3.275	-0.002586683
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657	3.285	0.011020903
658	3.29	0.013539105
659	3.295	0.011157948
660	3.3	0.0051842765
661	3.305	-0.0019846742
662	3.31	-0.0078828898
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667	3.335	-0.0038723361
668	3.34	-0.0037548996
669	3.345	-0.0050464464
670	3.35	-0.0070686143
671	3.355	-0.007373315
672	3.36	-0.0035511165
673	3.365	0.0037260732
674	3.37	0.010335373
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676	3.38	0.0077211889
677	3.385	0.00073050678
678	3.39	-0.004662486
679	3.395	-0.0061991537
680	3.4	-0.0048226165
681	3.405	-0.0031034975
682	3.41	-0.0028719792
683	3.415	-0.0040945957
684	3.42	-0.0054507903
685	3.425	-0.0056893341
686	3.43	-0.004542643
687	3.435	-0.0024557459
688	3.44	0.00032469257
689	3.445	0.0037633119
690	3.45	0.0068513919
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693	3.465	-0.001942694
694	3.47	-0.0063838381
695	3.475	-0.0075939431
696	3.48	-0.0067899562
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702	3.51	0.003633007
703	3.515	0.0023376058
704	3.52	0.0023214031
705	3.525	0.0033083614
706	3.53	0.0037244417
707	3.535	0.0028804629
708	3.54	0.0012989395
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716	3.58	0.0028563883
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728	3.64	-0.0045328643
729	3.645	-0.0050314265
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734	3.67	0.0013853472
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738	3.69	0.00063927807
739	3.695	-0.00018777506
740	3.7	-0.00071035791
741	3.705	-0.0012316407
742	3.71	-0.002022382
743	3.715	-0.0029876415
744	3.72	-0.0037805955
745	3.725	-0.003886061
746	3.73	-0.0026852962
747	3.735	0.00011716529
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749	3.745	0.0070077904
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756	3.78	-0.0031296625
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760	3.8	0.0039734169
761	3.805	0.0047515346
762	3.81	0.0062541348
763	3.815	0.0060571938
764	3.82	0.0026209646
765	3.825	-0.002304303
766	3.83	-0.0055510044
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768	3.84	-0.0053501377
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770	3.85	-0.0033136637
771	3.855	-0.00031816967
772	3.86	0.0031068319

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774	3.87	0.0028865912
775	3.875	0.00047163455
776	3.88	-0.00071745386
777	3.885	-0.00071426838
778	3.89	-0.00060792495
779	3.895	-0.00044288162
780	3.9	0.0004564301
781	3.905	0.0018211278
782	3.91	0.0026275721
783	3.915	0.0026920363
784	3.92	0.0026935862
785	3.925	0.002619792
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787	3.935	-0.0010447028
788	3.94	-0.0038509126
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791	3.955	-0.0045337106
792	3.96	-0.0032619761
793	3.965	-0.0020351382
794	3.97	-0.0012359131
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796	3.98	-0.0017096666
797	3.985	-0.001734975
798	3.99	-0.00071328235
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804	4.02	-0.0052894667
805	4.025	-0.0019337004
806	4.03	0.0020829204
807	4.035	0.0054640359
808	4.04	0.0069779545

809	4.045	0.0060873356
810	4.05	0.003403783
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813	4.065	-0.006174559
814	4.07	-0.0078681656
815	4.075	-0.0076786581
816	4.08	-0.0057416233
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819	4.095	-0.00019166004
820	4.1	-0.00052335781
821	4.105	-0.0011344244
822	4.11	-0.0010877944
823	4.115	-0.00044539003
824	4.12	-0.00028135312
825	4.125	-0.0012489344
826	4.13	-0.0025721016
827	4.135	-0.0030088304
828	4.14	-0.0024298868
829	4.145	-0.001701968
830	4.15	-0.0012757622
831	4.155	-0.00078257265
832	4.16	-8.2774855e-005
833	4.165	0.00020772917
834	4.17	-0.00032969716
835	4.175	-0.0010126624
836	4.18	-0.00070876925
837	4.185	0.00078114
838	4.19	0.0023736923
839	4.195	0.0027072805
840	4.2	0.0012714999
841	4.205	-0.0013042317
842	4.21	-0.0037178954
843	4.215	-0.0047145406
844	4.22	-0.0037946569

845	4.225	-0.0016028551
846	4.23	0.00044211584
847	4.235	0.0012244621
848	4.24	0.00075893953
849	4.245	-7.1053635e-005
850	4.25	-0.00044719078
851	4.255	-9.0755787e-005
852	4.26	0.00092969104
853	4.265	0.0023023045
854	4.27	0.0032927195
855	4.275	0.003034353
856	4.28	0.001423626
857	4.285	-0.00049225961
858	4.29	-0.0013416539
859	4.295	-0.0005689069
860	4.3	0.0012926277
861	4.305	0.0031444886
862	4.31	0.0039511675
863	4.315	0.0032594983
864	4.32	0.0015146834
865	4.325	-0.00025497808
866	4.33	-0.0012871928
867	4.335	-0.0015695626
868	4.34	-0.0015264097
869	4.345	-0.0015578056
870	4.35	-0.0018727338
871	4.355	-0.0023269501
872	4.36	-0.0023564189
873	4.365	-0.0015954012
874	4.37	-0.00061912206
875	4.375	-0.00043438156
876	4.38	-0.0010564189
877	4.385	-0.0013220455
878	4.39	-0.00041055369
879	4.395	0.0011376568
880	4.4	0.002298858

881	4.405	0.0027339553
882	4.41	0.0025797899
883	4.415	0.0017256246
884	4.42	3.7380545e-005
885	4.425	-0.0020226063
886	4.43	-0.0035977159
887	4.435	-0.0041688692
888	4.44	-0.0037620985
889	4.445	-0.0026519221
890	4.45	-0.0011557153
891	4.455	0.0004214041
892	4.46	0.0018211787
893	4.465	0.0026446926
894	4.47	0.0022193127
895	4.475	0.00021834914
896	4.48	-0.0023942592
897	4.485	-0.0037212807
898	4.49	-0.0027773835
899	4.495	-0.00057448557
900	4.5	0.001160365
901	4.505	0.0019351178
902	4.51	0.0025114
903	4.515	0.0033498929
904	4.52	0.0039759356
905	4.525	0.0038907005
906	4.53	0.0032356684
907	4.535	0.0023164882
908	4.54	0.0012106251
909	4.545	0.00022263587
910	4.55	0.00010145661
911	4.555	0.0012660345
912	4.56	0.0031365861
913	4.565	0.0046761599
914	4.57	0.0053881819
915	4.575	0.0054679617
916	4.58	0.0051997247

917	4.585	0.0046189762
918	4.59	0.003710156
919	4.595	0.0026102886
920	4.6	0.0015034057
921	4.605	0.00045623024
922	4.61	-0.00053635566
923	4.615	-0.0013193535
924	4.62	-0.001488651
925	4.625	-0.00073496482
926	4.63	0.0005725961
927	4.635	0.0013370858
928	4.64	0.0006219221
929	4.645	-0.0012913429
930	4.65	-0.0029899562
931	4.655	-0.0032753645
932	4.66	-0.0023017233
933	4.665	-0.0011637198
934	4.67	-0.00053975528
935	4.675	-0.00015277251
936	4.68	0.00042557153
937	4.685	0.0010322729
938	4.69	0.001321709
939	4.695	0.0014535434
940	4.7	0.0017373815
941	4.705	0.0017926175
942	4.71	0.00078699908
943	4.715	-0.0013221067
944	4.72	-0.0033468135
945	4.725	-0.003984195
946	4.73	-0.0030823595
947	4.735	-0.0015759967
948	4.74	-0.00045016417
949	4.745	5.1359641e-006
950	4.75	0.0001632589
951	4.755	0.00057358214
952	4.76	0.0013701642

953	4.765	0.0019957581
954	4.77	0.0017047313
955	4.775	0.00050323952
956	4.78	-0.00068832773
957	4.785	-0.0010638727
958	4.79	-0.00084087183
959	4.795	-0.00082283369
960	4.8	-0.0013430917
961	4.805	-0.0020668808
962	4.81	-0.0025811257
963	4.815	-0.0026462017
964	4.82	-0.0020145304
965	4.825	-0.00061988682
966	4.83	0.0010150219
967	4.835	0.0020750178
968	4.84	0.0022967676
969	4.845	0.0021562149
970	4.85	0.0021514632
971	4.855	0.0022329051
972	4.86	0.0020284797
973	4.865	0.0013171714
974	4.87	0.00017034159
975	4.875	-0.0011309269
976	4.88	-0.0021510146
977	4.885	-0.0024249822
978	4.89	-0.0017194759
979	4.895	-0.00024031814
980	4.9	0.0014453248
981	4.905	0.0027430203
982	4.91	0.0033497706
983	4.915	0.0032677577
984	4.92	0.0026100133
985	4.925	0.0015481391
986	4.93	0.00041791577
987	4.935	-0.000414663
988	4.94	-0.00090271133

989	4.945	-0.0013281126
990	4.95	-0.0018677067
991	4.955	-0.0023791883
992	4.96	-0.00266943
993	4.965	-0.0026885184
994	4.97	-0.0023832467
995	4.975	-0.0017288773
996	4.98	-0.0010505353
997	4.985	-0.00093848578
998	4.99	-0.0015901601
999	4.995	-0.0025056592
1000	5	-0.0030290099
1001	5.005	-0.0029339146
1002	5.01	-0.0023091261
1003	5.015	-0.0011969206
1004	5.02	0.00035436831
1005	5.025	0.0020520547
1006	5.03	0.0034436321
1007	5.035	0.0041964719
1008	5.04	0.0041985419
1009	5.045	0.0035143673
1010	5.05	0.0023853064
1011	5.055	0.0011922708
1012	5.06	0.0002644509
1013	5.065	-0.00031285612
1014	5.07	-0.00066928622
1015	5.075	-0.00091704701
1016	5.08	-0.00097053737
1017	5.085	-0.00065557561
1018	5.09	-3.3627511e-005
1019	5.095	0.00046641481
1020	5.1	0.00036907005
1021	5.105	-0.00038066075
1022	5.11	-0.0013290711
1023	5.115	-0.0018691343
1024	5.12	-0.0022463241

1025	5.125	-0.002336372

Cyclic Number Functions

Cyclic Triaxial Results for Fly Ash

Model: Spline Data Point Function
Function: Cyclic Number vs. Shear Stress Ratio
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Y-Intercept: 500
Data Points: Shear Stress Ratio, Cyclic Number
Data Point: (0.16, 500)
Data Point: (0.17, 200)
Data Point: (0.185, 100)
Data Point: (0.225, 40)
Data Point: (0.265, 20)
Data Point: (0.315, 10)
Data Point: (0.37, 5)
Data Point: (0.425, 3)
Estimation Properties
Sample Material: Loose Sand

Pore Pressure Functions

New Function

Model: Spline Data Point Function
Function: PWP Ratio vs. Cyclic Number Ratio N/NL
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Y-Intercept: 0
Data Points: Cyclic Number Ratio N/NL, PWP Ratio
Data Point: (0, 0)
Data Point: (0.05, 0.075089716)
Data Point: (0.1, 0.12368875)
Data Point: (0.15, 0.16607762)
Data Point: (0.2, 0.20519259)
Data Point: (0.25, 0.24231186)
Data Point: (0.3, 0.2781656)
Data Point: (0.35, 0.31324362)
Data Point: (0.4, 0.3479165)
Data Point: (0.45, 0.38249492)
Data Point: (0.5, 0.41726502)
Data Point: (0.55, 0.45251442)
Data Point: (0.6, 0.48855688)

Data Point: (0.65, 0.52576183)
Data Point: (0.7, 0.56459752)
Data Point: (0.75, 0.60570358)
Data Point: (0.8, 0.65003056)
Data Point: (0.85, 0.69915001)
Data Point: (0.9, 0.75610124)
Data Point: (0.95, 0.82872015)
Data Point: (1, 1)

Estimation Properties

N-Exponent: 0.7

Regions

	Material	Points	Area (ft²)
Region 1	Sandy Silty Clay (1)	106,1,2,107	171.12382
Region 2	Sandy Silty Clay (1)	1,108,3,4,5,6,7,8,9,10,11,12,2	962.07207
Region 3	Gravelly Silty Sand (2)	5,13,14,15,6	31.119887
Region 4	Gravelly Silty Sand (2)	7,8,15,6	819.48221
Region 5	Bottom Ash (3)	9,16,17,18,19,20,21,22,23,24,25,26,10	423.64067
Region	Bottom Ash	18,27,28,29,30,31,19	32.648671

6	(3)		
Region 7	Sandy Silt (5)	24,32,33,34,35,21,22,23	282.19505
Region 8	Silty Sand and Gravel (4)	21,20,19,31,36,37,38,39,40,41,42,43,44,45,35	1565.2892
Region 9	Sandy Silt (5)	34,35,45,46	531.21818
Region 10	Silty Clay (6)	34,46,47,48,49,50,51,52,53,33	989.52619
Region 11	Fly Ash (7)	54,55,56,57,58,59,60,53,33,32,24,25,26,12,2,107	6796.582
Region 12	Brown Clay (8)	54,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,109,91,92,93,94,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,60,59,58,57,56,55	6482.6655
Region 13	Silty Clay (9)	89,95,96,97,98,99,100,101,102,103,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88	22802.05
Region 14	Sandstone (10)	103,104,105,96,97,98,99,100,101,102	31286.194
Region 15	Bottom Ash 2	10,26,12,11	324.85555

	(11)		

Lines

	Start Point	End Point	Stress/Strain Boundary
Line 1	1	2	
Line 2	3	4	
Line 3	4	5	
Line 4	5	6	
Line 5	6	7	
Line 6	7	8	
Line 7	8	9	
Line 8	9	10	
Line 9	10	11	
Line 10	11	12	
Line 11	12	2	
Line 12	5	13	
Line 13	13	14	
Line 14	14	15	
Line 15	15	6	
Line 16	8	15	
Line 17	9	16	
Line 18	16	17	
Line 19	17	18	
Line 20	18	19	
Line 21	19	20	
Line 22	20	21	
Line 23	21	22	
Line 24	22	23	
Line 25	23	24	
Line 26	24	25	
Line 27	25	26	
Line 28	26	12	
Line 29	18	27	
Line 30	27	28	
Line 31	28	29	

Line 32	29	30	
Line 33	30	31	
Line 34	31	19	
Line 35	24	32	
Line 36	32	33	
Line 37	33	34	
Line 38	34	35	
Line 39	35	21	
Line 40	31	36	
Line 41	36	37	
Line 42	37	38	
Line 43	38	39	
Line 44	39	40	
Line 45	40	41	
Line 46	41	42	
Line 47	42	43	
Line 48	43	44	
Line 49	44	45	
Line 50	45	35	
Line 51	45	46	
Line 52	46	34	
Line 53	46	47	
Line 54	47	48	
Line 55	48	49	
Line 56	49	50	
Line 57	50	51	
Line 58	51	52	
Line 59	52	53	
Line 60	53	33	
Line 61	54	55	
Line 62	55	56	
Line 63	56	57	
Line 64	57	58	
Line 65	58	59	
Line 66	59	60	
Line 67	60	53	

Line 68	54	61	Fixed Y
Line 69	61	62	
Line 70	62	63	
Line 71	63	64	
Line 72	64	65	
Line 73	65	66	
Line 74	66	67	
Line 75	67	68	
Line 76	68	69	
Line 77	69	70	
Line 78	70	71	
Line 79	71	72	
Line 80	72	73	
Line 81	73	74	
Line 82	74	75	
Line 83	75	76	
Line 84	76	77	
Line 85	77	78	
Line 86	78	79	
Line 87	79	80	
Line 88	80	81	
Line 89	81	82	
Line 90	82	83	
Line 91	83	84	
Line 92	84	85	
Line 93	85	86	
Line 94	86	87	
Line 95	87	88	
Line 96	88	89	
Line 97	89	90	
Line 98	91	92	
Line 99	92	93	
Line 100	93	94	
Line 101	94	37	
Line 102	89	95	
Line 103	95	96	Fixed Y

Line 104	96	97	
Line 105	97	98	
Line 106	98	99	
Line 107	99	100	
Line 108	100	101	
Line 109	101	102	
Line 110	102	103	
Line 111	103	61	Fixed Y
Line 112	103	104	Fixed Y
Line 113	104	105	Fixed X/Y
Line 114	105	96	Fixed Y
Line 115	106	1	
Line 116	2	107	
Line 117	107	106	Fixed Y
Line 118	1	108	
Line 119	108	3	
Line 120	90	109	
Line 121	109	91	
Line 122	26	10	
Line 123	54	107	Fixed Y

Points

	X (ft)	Y (ft)
Point 1	35.36015	595.10746
Point 2	35.37077	593.10938
Point 3	60.72629	605.9827
Point 4	74.8905	612.04606
Point 5	89.08286	617.98267
Point 6	93.72016	617.98376
Point 7	69.42633	602.00461
Point 8	151.61692	602.00605
Point 9	158.87128	599.99208
Point 10	171.82425	595.91741
Point 11	60.47732	595.91216
Point 12	56.0411	593.12487

Point 13	95.74708	619.48275
Point 14	106.57718	619.95406
Point 15	114.07579	617.99114
Point 16	166.70528	600.0213
Point 17	169.58045	600.43082
Point 18	200.94364	600.90024
Point 19	217.30273	592.80917
Point 20	213.38189	590.83858
Point 21	200.88583	589.29528
Point 22	195.25394	588.59744
Point 23	189.42126	588.62008
Point 24	184.5	590.20374
Point 25	181.51772	591.16693
Point 26	177.65846	593.12697
Point 27	204.98541	600.97594
Point 28	206.35442	602.21331
Point 29	206.71422	599.99306
Point 30	214.00828	595.98847
Point 31	222.27612	592.82454
Point 32	168.66722	580.09858
Point 33	175.21974	580.09858
Point 34	184.51087	580.09817
Point 35	213.24737	580.09272
Point 36	255.42934	580.07172
Point 37	317.48058	559.92079
Point 38	315.59736	559.88781
Point 39	309.9739	558.80103
Point 40	307.4465	558.76312
Point 41	287.58173	560.34006
Point 42	273.69358	560.81173
Point 43	259.80542	560.94275
Point 44	255.45555	560.94275
Point 45	239.61428	560.44981
Point 46	215.41971	560.03735
Point 47	206.90911	559.67804
Point 48	185.33019	558.38907

Point 49	177.08328	558.01754
Point 50	173.62075	558.106
Point 51	169.80438	558.01754
Point 52	164.66112	558.14391
Point 53	135.13429	560.09691
Point 54	-50	561.74545
Point 55	20.16974	561.49271
Point 56	28.34588	561.72018
Point 57	50.65765	561.88173
Point 58	61.94724	561.81622
Point 59	89.85457	561.6852
Point 60	105.36228	561.59785
Point 61	-50	552.17166
Point 62	19.23461	550.94335
Point 63	32.24565	551.32246
Point 64	41.85988	551.67124
Point 65	47.10676	551.74706
Point 66	56.64516	551.4741
Point 67	78.08761	551.61058
Point 68	95.40534	551.48927
Point 69	105.51999	551.66113
Point 70	114.75208	551.07983
Point 71	124.43302	550.29735
Point 72	142.61209	549.56582
Point 73	165.69351	548.62684
Point 74	187.96697	548.08092
Point 75	205.85125	547.44765
Point 76	216.92246	547.535
Point 77	233.69307	548.10276
Point 78	236.99041	548.14643
Point 79	242.18755	547.92806
Point 80	246.77327	547.31663
Point 81	252.65171	546.21606
Point 82	273.24811	541.09055
Point 83	281.07788	538.66929
Point 84	297.9009	534.10978

Point 85	305.69923	532.66332
Point 86	316.39049	531.68853
Point 87	338.77924	530.77663
Point 88	389.87718	528.88993
Point 89	422.60496	527.57608
Point 90	411.3282	538.58079
Point 91	401.8504	540.81657
Point 92	388.80805	543.92059
Point 93	352.80366	551.31013
Point 94	329.44346	556.01129
Point 95	550	524.91002
Point 96	550	499.15439
Point 97	396.01919	499.3174
Point 98	313.20998	500.09985
Point 99	256.3846	503.93603
Point 100	240.95296	504.37072
Point 101	191.37067	504.40695
Point 102	86.37793	504.45549
Point 103	-50	504
Point 104	-50	450
Point 105	550	450.03403
Point 106	-49.99913	595.11744
Point 107	-49.99813	593.10625
Point 108	58.47531	605
Point 109	405.33383	539.99484

APPENDIX V

SLOPE STABILITY ANALYSES

SLOPE STABILITY ANALYSIS SUMMARY
EASTERN DIKE LIQUEFACTION ASSESSMENT
FLY ASH DISPOSAL FACILITY
PHILIP SPORN PLANT
NEW HAVEN, MASON COUNTY, WEST VIRGINIA
GA FILE NO. 09-387

GENERAL

Geo/Environmental Associates, Inc. (GA) has prepared slope stability analyses for the Eastern Dike of the Fly Ash Disposal Facility at the Philip Sporn Plant. Specifically, GA has evaluated Section K-K, Section L-L, and Section M-M of the Fly Ash Disposal Facility – Eastern Dike. The slope stability analyses were conducted using the computer program *SLOPE/W*. *SLOPE/W* is developed by GEO-SLOPE International, Ltd. of Calgary, Alberta, Canada.

The slope stability analyses provided herein are based on the Newmark-type method provided in the *SLOPE/W* program. Specifically, the *SLOPE/W* Newmark-type stability analysis is based on results from the *QUAKE/W* finite element analysis discussed in Appendix IV. *SLOPE/W* uses the initial stress conditions provided by the *QUAKE/W* analysis to perform an initial static analysis for each slice. Next, *SLOPE/W* steps through the seismic event to calculate the mobilized shear stress along each slip surface. The result is a dynamic analysis for the specified seismic event. Slope stability analyses were performed in both the upstream and downstream directions for Section K-K, Section L-L, and Section M-M.

MATERIAL PARAMETERS

Material parameters for the various embankment and foundation materials used in the slope stability analyses for critical Sections K-K, L-L, and M-M are provided in Tables V-1.1, V-1.2, V-2, and V-3 respectively. In general, parameters were based on site specific data and from accepted reference materials in relation to the site specific soils/conditions. Unit weight and material strength parameters were determined from in situ and laboratory testing performed by AEP and GA.

TABLE IV.1.1. *SLOPE/W* MATERIAL PARAMETERS FOR SECTION K-K SLOPE STABILITY ANALYSIS

	Silty Clay (1)	Gravelly Silty Sand (2)	Sand and Gravel (3)	Bottom Ash (4)	Gravelly Silty Sand (5)	Silty Clay (6)	Bottom Ash 65 (7)	Fly Ash (8)	Sandy Silt (9)	Clay Foundation (10)	Clay Foundation (11)	Silty Clay Foundation (12)
Unit Weight γ (pcf)	125	108	114	100	110	128	90	98	100	125	130	125
Source	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)
Phi Angle φ	34	33	36	31	35	34	29	27	31	33	39	37
Source	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)	AEP(1,2)

Notes:

(1) AEP Philip Sporn Electric Generating Plant Bottom Ash Facility - Engineering Report, 1996

(2) AEP Philip Sporn Power Plant Bottom Ash Disposal Facility - Stability Analysis, 2009

TABLE IV.1.2. *SLOPE/W* MATERIAL PARAMETERS FOR SECTION K-K SLOPE STABILITY ANALYSIS

	Original Dike (13)	Foundation Soil (14)
Unit Weight γ (pcf)	130	130
Source	AEP(1,2)	AEP(1,2)
Phi Angle φ	33	32
Source	AEP(1,2)	AEP(1,2)

Notes:

(1) AEP Philip Sporn Electric Generating Plant Bottom Ash Facility - Engineering Report, 1996

(2) AEP Philip Sporn Power Plant Bottom Ash Disposal Facility - Stability Analysis, 2009

TABLE V.2. *SLOPE/W* MATERIAL PARAMETERS FOR SECTION L-L SLOPE STABILITY ANALYSIS

	Sandy Silty Clay (1)	**Road Fill (2)**	**Gravelly Silty Sand (3)**	**Gravelly Silty Sand (4)**	**Bottom Ash (5)**	**Silty Sand and Gravel (6)**	**Silty Sandy Clay (7)**	**Silty Clay (8)**	**Fly Ash (9)**	**Clay Foundation (10)**	**Clay Foundation (11)**	**Silty Clay Foundation (12)**
Unit Weight γ (pcf)	130	110	110	100	65	115	130	130	110	125	125	130
Source	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]
Phi Angle φ	34	35	34	32	35	32	34	33	27	39	37	32
Source	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]

Notes:

(1) AEP Philip Sporn Electric Generating Plant Fly Ash Facility - Engineering Report, 1998

(2) AEP Philip Sporn Power Plant Fly Ash Disposal Facility - Stability Analysis, 2009

TABLE V.3. *SLOPE/W* MATERIAL PARAMETERS FOR SECTION M-M SLOPE STABILITY ANALYSIS

	Sandy Silty Clay (1)	**Gravelly Silty Sand (2)**	**Bottom Ash (3)**	**Silty Sand and Gravel (4)**	**Sandy Silt (5)**	**Silty Clay (6)**	**Fly Ash (7)**	**Brown Clay (8)**	**Silty Clay (9)**	**Sandstone (10)**	**Bottom Ash 2 (11)**
Unit Weight γ (pcf)	125	125	65	115	115	130	110	125	126	140	90
Source	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	-	AEP[1,2]
Phi Angle φ	34	35	36	32	34	33	27	39	31.2	Impenetrable	32
Source	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	AEP[1,2]	-	AEP[1,2]

Notes:

(1) AEP Philip Sporn Electric Generating Plant Fly Ash Facility - Engineering Report, 1998

(2) AEP Philip Sporn Power Plant Fly Ash Disposal Facility - Stability Analysis, 2009

SLOPE STABILITY ANALYSIS RESULTS

GA used *SLOPE/W* (i.e., in conjunction with *SEEP/W* and *QUAKE/W*) to perform slope stability analyses for Sections K-K, L-L, and M-M of the Fly Ash Disposal Facility – Eastern Dike. Specifically, the Newmark-type method was used in *SLOPE/W* to analyze the slope stability of the eastern dike critical sections at specified time steps during the design earthquake event. Graphical output from the *SLOPE/W* slope stability analyses are provided in this appendix. As shown on the graphical output, the critical slip surface and corresponding stability factor is provided for each of the modeled conditions. A summary of the slope stability analysis results is provided in Table V-4.

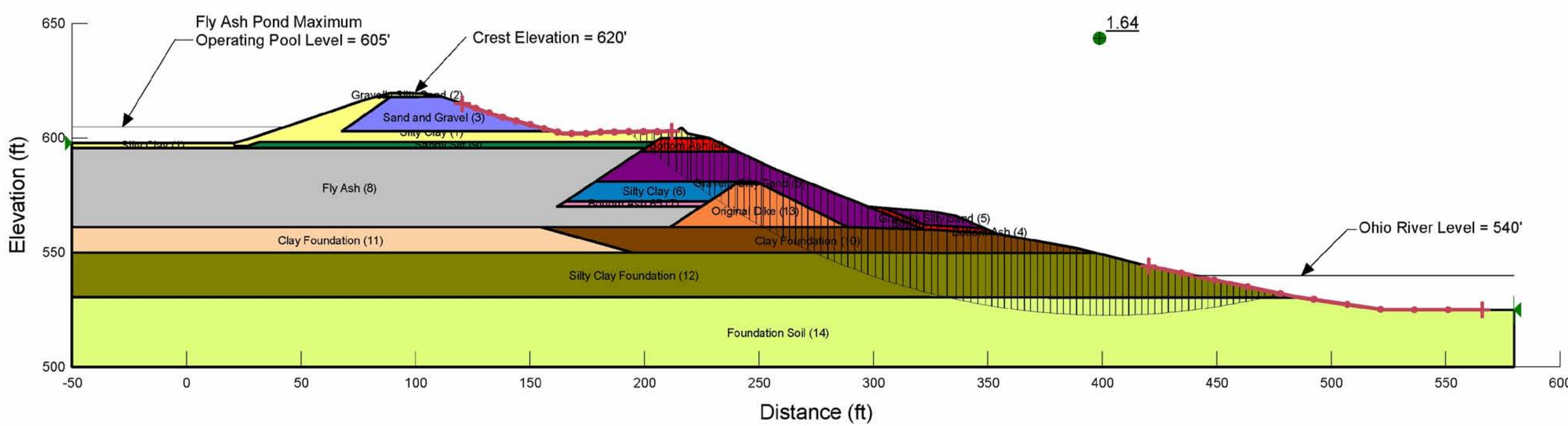
TABLE V-4
SUMMARY OF *SLOPE/W* STABILITY ANALYSES

Critical Section	Condition	Stability Factor
Fly Ash Disposal Facility Section K-K	Downstream	1.64
	Upstream	2.17
Fly Ash Disposal Facility Section L-L	Downstream	2.35
	Upstream	2.32
Fly Ash Disposal Facility Section M-M	Downstream	1.75
	Upstream	1.93

As shown in Table V-4, the slope stability factors exceed 1.5 for the critical sections of the Fly Ash Disposal Facility – Eastern Dike. Based on the results obtained through our stability analyses, it is our opinion that the Fly Ash Disposal Facility – Eastern Dike will exhibit adequate slope stability during the design earthquake event, as modeled herein.

SECTION K-K

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section K-K Downstream Slope Stability Analysis
File Name: FAP_K-K_SLOPE_DS.gsz
Date: 7/23/2010



AEPSPP004525

Newmark Deformation

File Information

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section K-K Downstream Slope Stability Analysis
Revision Number: 134
Last Edited By: Seth Frank
Date: 7/23/2010
Time: 2:17:00 PM
File Name: FAP_K-K_SLOPE_DS.gsz
Directory: P:\Frank\Philip Sporn\SEISMIC REPORT\Updated Analysis Files\Stability\
Last Solved Date: 7/23/2010
Last Solved Time: 3:03:53 PM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Newmark Deformation

Kind: SLOPE/W
Parent: Dynamic QUAKE/W
Method: QUAKE/W Newmark Deformation
Settings
- Initial Stress: Parent Analysis
- PWP Conditions Source: Parent Analysis

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack
  - Tension Crack Option: (none)

FOS Distribution

FOS Calculation Option: Constant

Time

Starting Time: 0 sec

Duration: 5.125 sec

# of Steps: 1025

Advanced

Number of Slices: 100

Optimization Tolerance: 0.01

Minimum Slip Surface Depth: 10 ft

Optimization Maximum Iterations: 2000

Optimization Convergence Tolerance: 1e-007

Starting Optimization Points: 8

Ending Optimization Points: 16

Complete Passes per Insertion: 1

Driving Side Maximum Convex Angle: 5 °

Resisting Side Maximum Convex Angle: 1 °

Materials

Silty Clay (1)

Model: Mohr-Coulomb

Unit Weight: 130 pcf

Unit Wt. Above Water Table: 125 pcf

Cohesion: 0 psf

Phi: 34 °

Phi-B: 0 °

Gravelly Silty Sand (2)

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Unit Wt. Above Water Table: 108 pcf

Cohesion: 0 psf

Phi: 33 °

Phi-B: 0 °

Sand and Gravel (3)

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Unit Wt. Above Water Table: 114 pcf

Cohesion: 0 psf

Phi: 36 °

Phi-B: 0 °

Bottom Ash (4)

Model: Mohr-Coulomb

Unit Weight: 105 pcf

Unit Wt. Above Water Table: 100 pcf
Cohesion: 0 psf
Phi: 31 °
Phi-B: 0 °

Gravelly Silty Sand (5)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Unit Wt. Above Water Table: 110 pcf
Cohesion: 0 psf
Phi: 35 °
Phi-B: 0 °

Silty Clay (6)

Model: Mohr-Coulomb
Unit Weight: 128 pcf
Unit Wt. Above Water Table: 120 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Bottom Ash 65 (7)

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Unit Wt. Above Water Table: 65 pcf
Cohesion: 0 psf
Phi: 29 °
Phi-B: 0 °

Fly Ash (8)

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Unit Wt. Above Water Table: 80 pcf
Cohesion: 0 psf
Phi: 27 °
Phi-B: 0 °

Sandy Silt (9)

Model: Mohr-Coulomb
Unit Weight: 105 pcf
Unit Wt. Above Water Table: 100 pcf
Cohesion: 0 psf
Phi: 31 °
Phi-B: 0 °

Clay Foundation (10)

Model: Mohr-Coulomb
Unit Weight: 125 pcf

Unit Wt. Above Water Table: 120 pcf
Cohesion: 0 psf
Phi: 33 °
Phi-B: 0 °

Clay Foundation (11)

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Unit Wt. Above Water Table: 125 pcf
Cohesion: 0 psf
Phi: 39 °
Phi-B: 0 °

Silty Clay Foundation (12)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Unit Wt. Above Water Table: 120 pcf
Cohesion: 0 psf
Phi: 37 °
Phi-B: 0 °

Original Dike (13)

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Unit Wt. Above Water Table: 125 pcf
Cohesion: 0 psf
Phi: 33 °
Phi-B: 0 °

Foundation Soil (14)

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Unit Wt. Above Water Table: 125 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (120.41704, 615) ft
Left-Zone Right Coordinate: (212, 602.93855) ft
Left-Zone Increment: 15
Right Projection: Range
Right-Zone Left Coordinate: (420.19438, 544) ft
Right-Zone Right Coordinate: (566, 525) ft
Right-Zone Increment: 10

Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-50.00109, 597.74003) ft
Right Coordinate: (580, 525) ft

Regions

	Material	Points	Area (ft²)
Region 1	Silty Clay (1)	63,2,24,3,1	143.25612
Region 2	Silty Clay (1)	2,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24	1176.8788
Region 3	Gravelly Silty Sand (2)	9,25,26,27,10	33.408658
Region 4	Sand and Gravel (3)	10,11,12,28,29,27	841.1626
Region 5	Sandy Silt (9)	3,30,21,22,23,24	425.72956
Region 6	Bottom Ash (4)	30,21,20,19,31,32,33	190.90717
Region 7	Silty Clay (6)	34,36,37,38,39,35	554.67017
Region 8	Bottom Ash 65 (7)	36,40,41,37	147.83552
Region 9	Original Dike (13)	41,37,38,39,42,43	841.25177
Region 10	Fly Ash (8)	44,61,43,41,40,36,34,33,30,3,1	8369.164
Region 11	Gravelly Silty Sand (5)	32,31,45,46,64,42,39,35,34,33	1406.9906
Region 12	Silty Clay Foundation (12)	51,54,55,56,57,52,62	9525.1236
Region 13	Foundation Soil (14)	55,58,69,70,59,60,54	18789.697

Region 14	Clay Foundation (11)	44,61,62,51	2466.2444
Region 15	Clay Foundation (10)	61,43,42,64,50,68,49,53,52,62	2091.4421
Region 16	Bottom Ash (4)	46,65,66,67,68,50,64	102.11485
Region 17	Gravelly Silty Sand (5)	65,47,48,67,66	161.58666
Region 18	Bottom Ash (4)	67,68,49	5.722693

Points

	X (ft)	Y (ft)
Point 1	-50.00109	595.71827
Point 2	20.87006	597.74003
Point 3	20.88514	595.7195
Point 4	28.29932	599.9386
Point 5	43.4	605
Point 6	66.4449	612.83618
Point 7	71.00682	614.37347
Point 8	75.83799	615.92596
Point 9	83.12625	618.01207
Point 10	89.16676	618.0063
Point 11	67.99514	603.00606
Point 12	160.50996	603.01085
Point 13	164.36012	602.00265
Point 14	175.56909	602.00354
Point 15	179.88561	602.4977
Point 16	214.07092	602.96698
Point 17	216.26115	604.4504
Point 18	218.92113	601.99621
Point 19	228.49429	599.98195
Point 20	207.18559	599.99735

Point 21	204.40592	598.13958
Point 22	32.02668	598.14303
Point 23	26.54626	596.50886
Point 24	20.87931	596.50076
Point 25	89.27093	619.72571
Point 26	103.77188	619.42032
Point 27	111.47933	618.0121
Point 28	135.19671	609.9055
Point 29	123.47463	613.96956
Point 30	200.77083	595.72596
Point 31	240.76421	594.01059
Point 32	222.79049	594.01222
Point 33	198.17913	594.01083
Point 34	178.5748	580.99902
Point 35	248.77756	581.00098
Point 36	165.52362	572.33858
Point 37	228.39764	572.33563
Point 38	239.8063	579.91496
Point 39	250.94764	579.91496
Point 40	161.97373	569.98666
Point 41	224.86913	569.98596
Point 42	288.91143	560.96382
Point 43	211.29094	560.95827
Point 44	-50	560.99795
Point 45	257.89685	585.94071
Point 46	297.73567	569.9851
Point 47	325.50196	568.0018
Point 48	336.18826	565.99579
Point 49	354.42618	558.00394
Point 50	328.18785	559.80842
Point 51	-50	550.07288
Point 52	397.53591	549.83795
Point 53	388.85171	551.97178
Point 54	-50	530.60542
Point 55	486.17654	530.37993
Point 56	440.71606	539.69843

Point 57	420.04463	544.03139
Point 58	523	525
Point 59	523	500.03246
Point 60	-50	499.97967
Point 61	154.97895	560.96884
Point 62	194.99536	549.95765
Point 63	-50.00109	597.74003
Point 64	321.98827	559.99079
Point 65	304.18497	569.49578
Point 66	322.21879	562.20928
Point 67	349.0118	560.43036
Point 68	348.85409	558.38715
Point 69	580	525
Point 70	580	500

Critical Slip Surfaces

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	1500	1.64	(401.771, 833.9)	311.325	(193.298, 602.682)	(478.008, 532.054)

Slices of Slip Surface: 1500

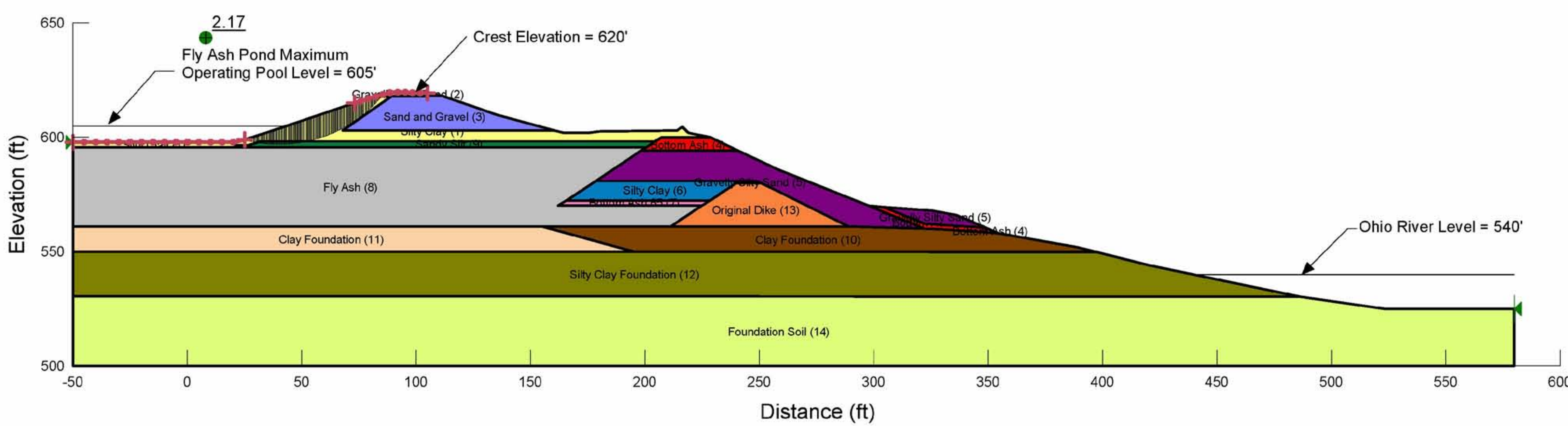
	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1500	194.5855	601.53365	0	210.72251	142.13413	0
2	1500	197.1609	599.2626	0	328.23481	221.39717	0
3	1500	199.7525	597.02765	0	510.61478	306.80831	0
4	1500	202.1965	594.96335	0	674.11729	405.05053	0
5	1500	203.87125	593.5708	0	741.59203	519.26833	0
6	1500	205.79575	592.00455	0	850.97355	595.85809	0
7	1500	208.90695	589.5201	0	1041.6759	729.38934	0
8	1500	212.3496	586.84185	0	1262.8614	884.26506	0
9	1500	215.166	584.70205	0	1415.9947	991.49018	0
10	1500	217.5911	582.90605	0	1560.2391	1092.4912	0
11	1500	219.5653	581.46515	0	1666.4128	1166.8348	0

12	1500	221.5	580.08365	0	1774.5653	1196.9594	0
13	1500	224.21645	578.177	0	1926.9121	1299.7186	0
14	1500	227.06835	576.22015	0	2051.3629	1383.6617	0
15	1500	229.56845	574.5402	0	2113.1518	1425.3389	0
16	1500	232.16985	572.8348	0	2199.4605	1428.3464	0
17	1500	235.2244	570.87555	0	2335.3708	1516.6075	0
18	1500	238.279	568.966	0	2410.9151	1565.6666	0
19	1500	240.28525	567.7329	0	2455.0505	1594.3285	0
20	1500	242.09975	566.6444	0	2501.9219	1624.7671	0
21	1500	244.77085	565.0665	0	2567.9339	1667.6358	0
22	1500	247.442	563.5242	0	2619.4385	1701.0832	0
23	1500	249.8626	562.15535	0	2671.096	1734.63	0
24	1500	251.4806	561.255	0	2710.1903	1760.0182	0
25	1500	253.4844	560.16445	0	2737.1432	1777.5215	0
26	1500	256.426	558.5912	0	2766.2522	1796.4252	0
27	1500	259.25585	557.11495	0	2795.4692	1815.3989	0
28	1500	261.97395	555.7322	0	2829.6844	1837.6185	0
29	1500	264.692	554.3827	0	2868.4504	1862.7935	0
30	1500	267.41005	553.066	0	2920.2611	1896.4397	0
31	1500	270.1281	551.78165	0	2979.3919	1934.8397	0
32	1500	272.84615	550.52915	0	3048.8787	1979.965	0
33	1500	275.6758	549.25935	0	3134.6608	2362.1363	0
34	1500	278.61705	547.97445	0	3229.9978	2433.9779	0
35	1500	281.5583	546.7254	0	3311.5356	2495.421	0
36	1500	284.49955	545.5118	0	3382.2205	2548.686	0
37	1500	287.4408	544.33315	0	3427.9834	2583.1708	0
38	1500	290.3821	543.18895	0	3467.6862	2613.089	0
39	1500	293.32355	542.07885	0	3506.1029	2642.038	0
40	1500	296.265	541.00255	0	3548.1409	2673.716	0
41	1500	299.348	539.91105	0	3592.3619	2707.0389	0
42	1500	302.57265	538.8073	0	3643.18	2745.333	0
43	1500	305.6686	537.78385	0	3690.8921	2781.2867	0
44	1500	308.6358	536.83725	0	3737.4221	2816.3496	0
45	1500	311.603	535.92315	0	3786.3405	2853.2122	0
46	1500	314.5702	535.0413	0	3834.4273	2889.4482	0
47	1500	317.53745	534.19145	0	3870.9615	2916.9787	0

48	1500	320.5047	533.3733	0	3901.0485	2939.6509	0
49	1500	322.10355	532.9416	0	3914.4527	2949.7517	0
50	1500	323.8604	532.48675	0	3926.48	2958.8149	0
51	1500	326.84495	531.7294	0	3945.4646	2973.1208	0
52	1500	330.2025	530.92055	0	3959.0745	2983.3766	0
53	1500	334.2027	530.0032	0	3973.0492	2482.6367	0
54	1500	337.7715	529.22915	0	3985.3936	2490.3503	0
55	1500	340.93795	528.58115	0	3993.8712	2495.6477	0
56	1500	344.1044	527.96725	0	3998.7971	2498.7258	0
57	1500	347.3497	527.3737	0	4000.7085	2499.9201	0
58	1500	350.3654	526.852	0	3999.0994	2498.9147	0
59	1500	353.0726	526.411	0	3996.8171	2497.4885	0
60	1500	355.8606	525.98275	0	3991.7159	2494.3009	0
61	1500	358.7294	525.56865	0	3983.6209	2489.2426	0
62	1500	361.5982	525.18175	0	3971.6818	2481.7822	0
63	1500	364.467	524.822	0	3956.9299	2472.5642	0
64	1500	367.3358	524.48925	0	3944.9078	2465.052	0
65	1500	370.20455	524.1834	0	3931.8143	2456.8703	0
66	1500	373.0733	523.9044	0	3908.6295	2442.3828	0
67	1500	375.9421	523.6522	0	3879.5033	2424.1827	0
68	1500	378.8109	523.4267	0	3841.6507	2400.5298	0
69	1500	381.6797	523.22785	0	3804.1079	2377.0705	0
70	1500	384.5485	523.05565	0	3770.0204	2355.7702	0
71	1500	387.4173	522.91	0	3727.9132	2329.4587	0
72	1500	390.29905	522.7904	0	3678.3223	2298.4709	0
73	1500	393.1938	522.6971	0	3628.317	2267.2241	0
74	1500	396.08855	522.6308	0	3573.8266	2233.1747	0
75	1500	398.9427	522.5916	0	3512.8759	2195.0885	0
76	1500	401.7563	522.57875	0	3448.9744	2155.1584	0
77	1500	404.5699	522.59135	0	3383.938	2114.5192	0
78	1500	407.3835	522.62935	0	3315.1188	2071.5161	0
79	1500	410.1971	522.6928	0	3242.568	2026.1814	0
80	1500	413.01065	522.7817	0	3165.8808	1978.2619	0
81	1500	415.8242	522.8961	0	3084.8288	1927.615	0
82	1500	418.6378	523.036	0	2999.8637	1874.5229	0
83	1500	421.52115	523.20615	0	2907.7851	1816.9858	0

84	1500	424.47425	523.408	0	2807.9549	1754.605	0
85	1500	427.4273	523.6381	0	2702.1326	1688.4799	0
86	1500	430.38035	523.89645	0	2589.7539	1618.2578	0
87	1500	433.3334	524.18315	0	2472.884	1545.2294	0
88	1500	436.28645	524.49835	0	2351.0969	1469.1284	0
89	1500	439.23955	524.8421	0	2227.7324	1392.0417	0
90	1500	442.0958	525.2013	0	2105.0426	1315.3766	0
91	1500	444.85525	525.5743	0	1987.1469	1241.7072	0
92	1500	447.6147	525.9725	0	1867.8363	1167.1537	0
93	1500	450.3741	526.396	0	1746.8584	1091.5583	0
94	1500	453.13355	526.8449	0	1627.6447	1017.0653	0
95	1500	455.893	527.31925	0	1509.753	943.39837	0
96	1500	458.65245	527.8192	0	1401.508	875.75942	0
97	1500	461.4119	528.3449	0	1296.8074	810.33521	0
98	1500	464.17135	528.8965	0	1199.0681	749.26091	0
99	1500	466.9308	529.4741	0	1103.0324	689.25112	0
100	1500	469.69025	530.07785	0	1008.6449	630.2713	0
101	1500	472.8045	530.7928	0	913.2875	688.2115	0
102	1500	476.27355	531.6268	0	786.36578	592.56912	0

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section K-K Upstream Slope Stability Analysis
File Name: FAP_K-K_SLOPE_US.gsz
Date: 7/23/2010



Newmark Deformation

File Information

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section K-K Upstream Slope Stability Analysis
Revision Number: 135
Last Edited By: Seth Frank
Date: 7/23/2010
Time: 2:55:44 PM
File Name: FAP_K-K_SLOPE_US.gsz
Directory: P:\Frank\Philip Sporn\SEISMIC REPORT\Updated Analysis Files\Stability\
Last Solved Date: 7/23/2010
Last Solved Time: 3:28:21 PM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Newmark Deformation

Kind: SLOPE/W
Parent: Dynamic QUAKE/W
Method: QUAKE/W Newmark Deformation
Settings
- Initial Stress: Parent Analysis
- PWP Conditions Source: Parent Analysis

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack
  - Tension Crack Option: (none)

FOS Distribution

FOS Calculation Option: Constant

Time

Starting Time: 0 sec

Duration: 5.125 sec

# of Steps: 1025

Advanced

Number of Slices: 100

Optimization Tolerance: 0.01

Minimum Slip Surface Depth: 10 ft

Optimization Maximum Iterations: 2000

Optimization Convergence Tolerance: 1e-007

Starting Optimization Points: 8

Ending Optimization Points: 16

Complete Passes per Insertion: 1

Driving Side Maximum Convex Angle: 5 °

Resisting Side Maximum Convex Angle: 1 °

Materials

Silty Clay (1)

Model: Mohr-Coulomb

Unit Weight: 130 pcf

Unit Wt. Above Water Table: 125 pcf

Cohesion: 0 psf

Phi: 34 °

Phi-B: 0 °

Gravelly Silty Sand (2)

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Unit Wt. Above Water Table: 108 pcf

Cohesion: 0 psf

Phi: 33 °

Phi-B: 0 °

Sand and Gravel (3)

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Unit Wt. Above Water Table: 114 pcf

Cohesion: 0 psf

Phi: 36 °

Phi-B: 0 °

Bottom Ash (4)

Model: Mohr-Coulomb

Unit Weight: 105 pcf

Unit Wt. Above Water Table: 100 pcf
Cohesion: 0 psf
Phi: 31 °
Phi-B: 0 °

Gravelly Silty Sand (5)

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Unit Wt. Above Water Table: 110 pcf
Cohesion: 0 psf
Phi: 35 °
Phi-B: 0 °

Silty Clay (6)

Model: Mohr-Coulomb
Unit Weight: 128 pcf
Unit Wt. Above Water Table: 120 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Bottom Ash 65 (7)

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Unit Wt. Above Water Table: 65 pcf
Cohesion: 0 psf
Phi: 29 °
Phi-B: 0 °

Fly Ash (8)

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Unit Wt. Above Water Table: 80 pcf
Cohesion: 0 psf
Phi: 27 °
Phi-B: 0 °

Sandy Silt (9)

Model: Mohr-Coulomb
Unit Weight: 105 pcf
Unit Wt. Above Water Table: 100 pcf
Cohesion: 0 psf
Phi: 31 °
Phi-B: 0 °

Clay Foundation (10)

Model: Mohr-Coulomb
Unit Weight: 125 pcf

Unit Wt. Above Water Table: 120 pcf
Cohesion: 0 psf
Phi: 33 °
Phi-B: 0 °

Clay Foundation (11)

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Unit Wt. Above Water Table: 125 pcf
Cohesion: 0 psf
Phi: 39 °
Phi-B: 0 °

Silty Clay Foundation (12)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Unit Wt. Above Water Table: 120 pcf
Cohesion: 0 psf
Phi: 37 °
Phi-B: 0 °

Original Dike (13)

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Unit Wt. Above Water Table: 125 pcf
Cohesion: 0 psf
Phi: 33 °
Phi-B: 0 °

Foundation Soil (14)

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Unit Wt. Above Water Table: 125 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-50.00109, 597.74003) ft
Left-Zone Right Coordinate: (25, 598.96222) ft
Left-Zone Increment: 15
Right Projection: Range
Right-Zone Left Coordinate: (72.95651, 615) ft
Right-Zone Right Coordinate: (105, 619.19593) ft
Right-Zone Increment: 10

Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-50.00109, 597.74003) ft
Right Coordinate: (580, 525) ft

Regions

	Material	Points	Area (ft²)
Region 1	Silty Clay (1)	63,2,24,3,1	143.25612
Region 2	Silty Clay (1)	2,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24	1176.8788
Region 3	Gravelly Silty Sand (2)	9,25,26,27,10	33.408658
Region 4	Sand and Gravel (3)	10,11,12,28,29,27	841.1626
Region 5	Sandy Silt (9)	3,30,21,22,23,24	425.72956
Region 6	Bottom Ash (4)	30,21,20,19,31,32,33	190.90717
Region 7	Silty Clay (6)	34,36,37,38,39,35	554.67017
Region 8	Bottom Ash 65 (7)	36,40,41,37	147.83552
Region 9	Original Dike (13)	41,37,38,39,42,43	841.25177
Region 10	Fly Ash (8)	44,61,43,41,40,36,34,33,30,3,1	8369.164
Region 11	Gravelly Silty Sand (5)	32,31,45,46,64,42,39,35,34,33	1406.9906
Region 12	Silty Clay Foundation (12)	51,54,55,56,57,52,62	9525.1236
Region 13	Foundation Soil (14)	55,58,69,70,59,60,54	18789.697

Region 14	Clay Foundation (11)	44,61,62,51	2466.2444
Region 15	Clay Foundation (10)	61,43,42,64,50,68,49,53,52,62	2091.4421
Region 16	Bottom Ash (4)	46,65,66,67,68,50,64	102.11485
Region 17	Gravelly Silty Sand (5)	65,47,48,67,66	161.58666
Region 18	Bottom Ash (4)	67,68,49	5.722693

Points

	X (ft)	Y (ft)
Point 1	-50.00109	595.71827
Point 2	20.87006	597.74003
Point 3	20.88514	595.7195
Point 4	28.29932	599.9386
Point 5	43.4	605
Point 6	66.4449	612.83618
Point 7	71.00682	614.37347
Point 8	75.83799	615.92596
Point 9	83.12625	618.01207
Point 10	89.16676	618.0063
Point 11	67.99514	603.00606
Point 12	160.50996	603.01085
Point 13	164.36012	602.00265
Point 14	175.56909	602.00354
Point 15	179.88561	602.4977
Point 16	214.07092	602.96698
Point 17	216.26115	604.4504
Point 18	218.92113	601.99621
Point 19	228.49429	599.98195
Point 20	207.18559	599.99735

Point 21	204.40592	598.13958
Point 22	32.02668	598.14303
Point 23	26.54626	596.50886
Point 24	20.87931	596.50076
Point 25	89.27093	619.72571
Point 26	103.77188	619.42032
Point 27	111.47933	618.0121
Point 28	135.19671	609.9055
Point 29	123.47463	613.96956
Point 30	200.77083	595.72596
Point 31	240.76421	594.01059
Point 32	222.79049	594.01222
Point 33	198.17913	594.01083
Point 34	178.5748	580.99902
Point 35	248.77756	581.00098
Point 36	165.52362	572.33858
Point 37	228.39764	572.33563
Point 38	239.8063	579.91496
Point 39	250.94764	579.91496
Point 40	161.97373	569.98666
Point 41	224.86913	569.98596
Point 42	288.91143	560.96382
Point 43	211.29094	560.95827
Point 44	-50	560.99795
Point 45	257.89685	585.94071
Point 46	297.73567	569.9851
Point 47	325.50196	568.0018
Point 48	336.18826	565.99579
Point 49	354.42618	558.00394
Point 50	328.18785	559.80842
Point 51	-50	550.07288
Point 52	397.53591	549.83795
Point 53	388.85171	551.97178
Point 54	-50	530.60542
Point 55	486.17654	530.37993
Point 56	440.71606	539.69843

Point 57	420.04463	544.03139
Point 58	523	525
Point 59	523	500.03246
Point 60	-50	499.97967
Point 61	154.97895	560.96884
Point 62	194.99536	549.95765
Point 63	-50.00109	597.74003
Point 64	321.98827	559.99079
Point 65	304.18497	569.49578
Point 66	322.21879	562.20928
Point 67	349.0118	560.43036
Point 68	348.85409	558.38715
Point 69	580	525
Point 70	580	500

Critical Slip Surfaces

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	1864	2.17	(40.166, 655.155)	58.203	(85.523, 618.681)	(25, 598.962)

Slices of Slip Surface: 1864

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1864	25.32993	598.87525	0	534.71007	360.66649	0
2	1864	25.989795	598.70545	0	518.97967	350.05621	0
3	1864	26.64966	598.5438	0	503.45528	339.58487	0
4	1864	27.309525	598.39025	0	488.16299	329.2701	0
5	1864	27.96939	598.2448	0	465.91212	314.26169	0
6	1864	28.593755	598.1144	0	446.28822	301.02521	0
7	1864	29.182625	597.9981	0	431.48899	291.043	0
8	1864	29.771495	597.88805	0	419.97185	283.27459	0
9	1864	30.360365	597.7843	0	411.40925	277.49904	0
10	1864	30.99777	597.67925	0	435.76852	261.83614	0
11	1864	31.68371	597.574	0	484.50802	291.12179	0

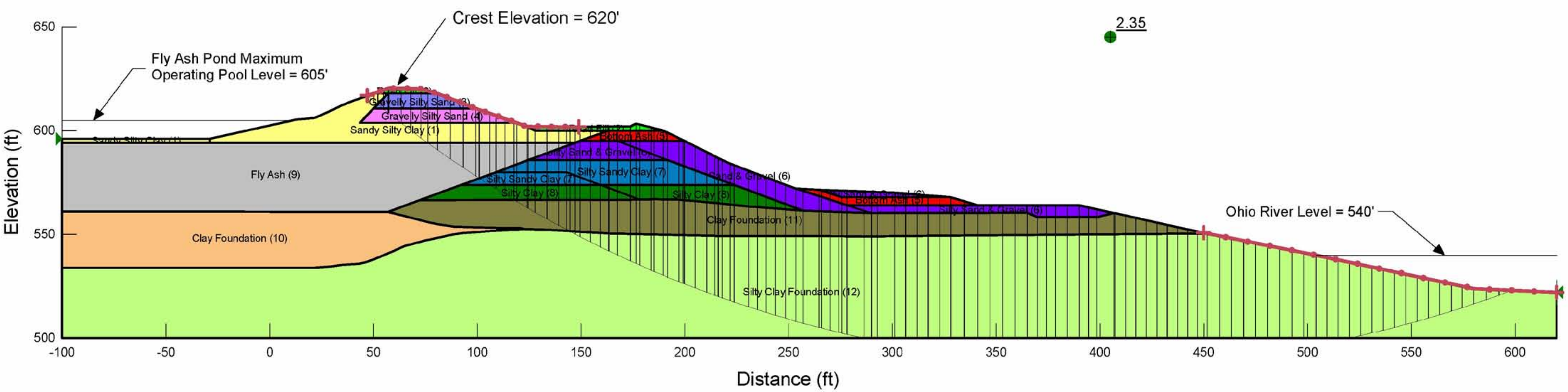
12	1864	32.32598	597.4828	0	514.3835	309.07279	0
13	1864	32.924575	597.4046	0	540.6081	324.83012	0
14	1864	33.52317	597.3327	0	566.42513	340.34255	0
15	1864	34.121765	597.26705	0	591.72541	355.5445	0
16	1864	34.72036	597.20765	0	616.39955	370.37022	0
17	1864	35.318955	597.1545	0	640.33818	384.75399	0
18	1864	35.91755	597.1076	0	663.43217	398.63027	0
19	1864	36.51615	597.0669	0	685.53881	411.91327	0
20	1864	37.114745	597.03235	0	717.09295	430.87291	0
21	1864	37.71334	597.004	0	747.8868	449.37573	0
22	1864	38.311935	596.98185	0	777.19178	466.98393	0
23	1864	38.91053	596.96585	0	804.93026	483.65089	0
24	1864	39.50913	596.956	0	831.09226	499.37061	0
25	1864	40.107725	596.9523	0	855.61867	514.10756	0
26	1864	40.70632	596.9548	0	878.45143	527.82687	0
27	1864	41.304915	596.96345	0	899.5835	540.5243	0
28	1864	41.90351	596.97825	0	920.91241	553.34	0
29	1864	42.502105	596.9992	0	941.92998	565.96863	0
30	1864	43.1007	597.0263	0	961.41188	577.67454	0
31	1864	43.702885	597.05985	0	979.4985	588.54208	0
32	1864	44.308655	597.0999	0	996.19486	598.57426	0
33	1864	44.914425	597.1463	0	1011.4073	607.7148	0
34	1864	45.520195	597.1991	0	1025.1827	615.99191	0
35	1864	46.125965	597.2583	0	1037.5523	623.42433	0
36	1864	46.731735	597.32385	0	1048.5316	630.02137	0
37	1864	47.337505	597.3958	0	1056.0399	634.5328	0
38	1864	47.94328	597.47425	0	1062.0657	638.15346	0
39	1864	48.549055	597.5592	0	1066.7751	640.98314	0
40	1864	49.154825	597.65065	0	1070.2193	643.0526	0
41	1864	49.760595	597.7486	0	1072.4177	644.37357	0
42	1864	50.366365	597.8531	0	1073.3904	644.95799	0
43	1864	50.972135	597.96425	0	1073.1737	644.82782	0
44	1864	51.577905	598.08205	0	1071.7728	643.98609	0
45	1864	52.18421	598.20665	0	1075.05	725.13039	0
46	1864	52.79105	598.3381	0	1081.2553	729.31588	0
47	1864	53.397885	598.47635	0	1085.974	732.49869	0

48	1864	54.00472	598.6215	0	1089.7082	735.01747	0
49	1864	54.61156	598.7735	0	1092.4453	736.86364	0
50	1864	55.2184	598.93245	0	1094.1882	738.03929	0
51	1864	55.82524	599.09845	0	1094.9256	738.53665	0
52	1864	56.432075	599.2715	0	1094.6621	738.35893	0
53	1864	57.03891	599.45175	0	1093.403	737.50964	0
54	1864	57.64575	599.6392	0	1091.1384	735.98215	0
55	1864	58.25259	599.8339	0	1088.1726	733.9817	0
56	1864	58.859425	600.036	0	1084.6031	731.57403	0
57	1864	59.46626	600.24555	0	1080.4797	728.79278	0
58	1864	60.0731	600.46265	0	1075.8519	725.67128	0
59	1864	60.67994	600.6874	0	1070.7532	722.23213	0
60	1864	61.28678	600.91985	0	1065.2626	718.52869	0
61	1864	61.893615	601.1601	0	1059.4431	714.60337	0
62	1864	62.50045	601.40825	0	1053.4019	710.52855	0
63	1864	63.10729	601.66445	0	1044.0793	704.24035	0
64	1864	63.71413	601.92885	0	1029.0935	694.13233	0
65	1864	64.32097	602.2015	0	1012.9377	683.23508	0
66	1864	64.927805	602.48255	0	995.61628	671.55166	0
67	1864	65.53464	602.77215	0	977.10618	659.06644	0
68	1864	66.14148	603.0704	0	953.16829	642.92013	0
69	1864	66.73002	603.36795	0	927.78202	625.79687	0
70	1864	67.30026	603.66445	0	902.89132	609.00789	0
71	1864	67.8705	603.969	0	878.62753	592.64175	0
72	1864	68.44074	604.2818	0	858.95736	579.37405	0
73	1864	69.01098	604.603	0	838.25801	565.41217	0
74	1864	69.58122	604.93265	0	816.55456	550.77301	0
75	1864	70.15146	605.271	0	793.88877	535.48474	0
76	1864	70.7217	605.6183	0	770.2728	519.55556	0
77	1864	71.30877	605.98545	0	745.02351	502.5247	0
78	1864	71.912665	606.3732	0	718.12194	484.37937	0
79	1864	72.51656	606.77155	0	689.68175	465.19622	0
80	1864	73.120455	607.18085	0	660.5212	445.52718	0
81	1864	73.72435	607.60135	0	631.13646	425.70692	0
82	1864	74.32825	608.03335	0	601.52618	405.73453	0
83	1864	74.932145	608.47715	0	571.75732	385.65518	0

84	1864	75.53604	608.9331	0	541.84394	365.47835	0
85	1864	76.14167	609.40295	0	520.68874	351.20899	0
86	1864	76.749025	609.88715	0	497.14782	335.33044	0
87	1864	77.35638	610.38485	0	467.74537	315.49823	0
88	1864	77.963735	610.89645	0	439.12515	296.19365	0
89	1864	78.571085	611.4225	0	411.46424	277.53613	0
90	1864	79.17844	611.96345	0	384.98001	259.6723	0
91	1864	79.7858	612.5199	0	359.90213	242.75705	0
92	1864	80.393155	613.09255	0	336.55358	227.00826	0
93	1864	81.00051	613.682	0	319.83539	215.73169	0
94	1864	81.607865	614.28895	0	303.44386	204.67547	0
95	1864	82.21522	614.91425	0	286.90509	193.51993	0
96	1864	82.822575	615.55875	0	269.96641	182.09464	0
97	1864	83.43451	616.22855	0	252.08329	170.03233	0
98	1864	84.051025	616.92505	0	233.22178	157.31007	0
99	1864	84.66754	617.6446	0	216.02648	145.7117	0
100	1864	85.24939	618.3454	0	191.3133	124.24031	0

SECTION L-L

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section L-L Downstream Slope Stability Analysis
File Name: FAP_L-L_Slope_DS.gsz
Date: 7/23/2010



Newmark Deformation

File Information

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section L-L Downstream Slope Stability Analysis
Revision Number: 75
Last Edited By: Seth Frank
Date: 7/23/2010
Time: 8:11:51 AM
File Name: FAP_L-L_Slope_DS.gsz
Directory: P:\Frank\Philip Sporn\SEISMIC REPORT\Updated Analysis Files\Stability\
Last Solved Date: 7/23/2010
Last Solved Time: 10:11:14 AM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Newmark Deformation

- Kind: SLOPE/W
- Parent: Dynamic QUAKE/W
- Method: QUAKE/W Newmark Deformation
- Settings
  - Initial Stress: Parent Analysis
  - PWP Conditions Source: Parent Analysis
- Slip Surface
  - Direction of movement: Left to Right
  - Use Passive Mode: No
  - Slip Surface Option: Entry and Exit
  - Critical slip surfaces saved: 1
  - Optimize Critical Slip Surface Location: No
  - Tension Crack
    - Tension Crack Option: (none)
- FOS Distribution

FOS Calculation Option: Constant

Time

Starting Time: 0 sec

Duration: 5.125 sec

# of Steps: 1025

Advanced

Number of Slices: 100

Optimization Tolerance: 0.01

Minimum Slip Surface Depth: 5 ft

Optimization Maximum Iterations: 2000

Optimization Convergence Tolerance: 1e-007

Starting Optimization Points: 8

Ending Optimization Points: 16

Complete Passes per Insertion: 1

Driving Side Maximum Convex Angle: 5 °

Resisting Side Maximum Convex Angle: 1 °

Materials

Sandy Silty Clay (1)

Model: Mohr-Coulomb

Unit Weight: 130 pcf

Unit Wt. Above Water Table: 125 pcf

Cohesion: 0 psf

Phi: 34 °

Phi-B: 0 °

Road Fill (2)

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Unit Wt. Above Water Table: 110 pcf

Cohesion: 0 psf

Phi: 35 °

Phi-B: 0 °

Gravelly Silty Sand (3)

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Unit Wt. Above Water Table: 110 pcf

Cohesion: 0 psf

Phi: 34 °

Phi-B: 0 °

Gravelly Silty Sand (4)

Model: Mohr-Coulomb

Unit Weight: 105 pcf

Unit Wt. Above Water Table: 100 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °

Bottom Ash (5)

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Unit Wt. Above Water Table: 65 pcf
Cohesion: 0 psf
Phi: 35 °
Phi-B: 0 °

Silty Sand & Gravel (6)

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Unit Wt. Above Water Table: 115 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °

Silty Sandy Clay (7)

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Unit Wt. Above Water Table: 125 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Silty Clay (8)

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Unit Wt. Above Water Table: 125 pcf
Cohesion: 0 psf
Phi: 33 °
Phi-B: 0 °

Fly Ash (9)

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Unit Wt. Above Water Table: 102 pcf
Cohesion: 0 psf
Phi: 27 °
Phi-B: 0 °

Clay Foundation (10)

Model: Mohr-Coulomb
Unit Weight: 125 pcf

Unit Wt. Above Water Table: 120 pcf
Cohesion: 0 psf
Phi: 39 °
Phi-B: 0 °

Clay Foundation (11)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Unit Wt. Above Water Table: 120 pcf
Cohesion: 0 psf
Phi: 37 °
Phi-B: 0 °

Silty Clay Foundation (12)

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Unit Wt. Above Water Table: 125 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (47, 616.85551) ft
Left-Zone Right Coordinate: (149, 601.77043) ft
Left-Zone Increment: 16
Right Projection: Range
Right-Zone Left Coordinate: (450, 550.79041) ft
Right-Zone Right Coordinate: (620, 522) ft
Right-Zone Increment: 16
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100.04534, 596.07808) ft
Right Coordinate: (620, 522) ft

Regions

	Material	Points	Area (ft^2)
Region 1	Sandy Silty Clay (1)	103,1,2,104	141.20465

Region 2	Sandy Silty Clay (1)	1,3,4,5,6,7,8,9,10,97,11,12,13,14,15,16,17,2	1797.2287
Region 3	Road Fill (2)	9,18,19,20,10	50.839704
Region 4	Road Fill (2)	13,22,23,24,25,15,14	116.203
Region 5	Bottom Ash (5)	15,25,26,27,16	191.73337
Region 6	Silty Sand & Gravel (6)	17,16,27,28,29	391.82116
Region 7	Silty Sand & Gravel (6)	27,26,30,31,32,33,34,100,99,35,36,98,28	923.61928
Region 8	Silty Sandy Clay (7)	37,47,39,38	312.45828
Region 9	Silty Clay (8)	47,48,40,39	623.99905
Region 10	Fly Ash (9)	48,49,50,104,2,17,29,37,47	6698.0183
Region 11	Clay Foundation (10)	50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,49	4580.0299
Region 12	Clay Foundation (11)	49,48,40,41,42,43,44,45,46,36,35,74,75,76,77,78,79,80,81,82,83,84,85,86,87,67,68,69,70,71,72,73	4582.5269
Region 13	Silty Sand & Gravel (6)	101,88,89,90,102	107.81573
Region	Silty Clay	51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,87,86,85,84,83,82,81,93,94,105,106,95,96	30694.491

14	Foundation (12)		
Region 15	Gravelly Silty Sand (3)	10,20,21,97	270.1759
Region 16	Gravelly Silty Sand (4)	21,12,11,97	428.27559
Region 17	Silty Clay (8)	98,36,46,45,44,43,42,41,40,39	583.66388
Region 18	Silty Sandy Clay (7)	98,39,38,37,29,28	875.82886
Region 19	Bottom Ash (5)	101,102,90,91,99,100,34	285.90427
Region 20	Silty Sand & Gravel (6)	99,91,92,77,76,75,74,35	493.02893

Points

	X (ft)	Y (ft)
Point 1	-28.73928	596.09012
Point 2	-28.7343	594.10387
Point 3	10.87106	605.00492
Point 4	12.47008	605.36299
Point 5	21.58957	606.0128
Point 6	27.88941	608.93894
Point 7	34.84064	612.1236
Point 8	39.1222	614.02931
Point 9	50.19567	618.00197
Point 10	57.04232	618.00197

Point 11	43.46173	603.74724
Point 12	118.92142	603.75291
Point 13	123.93504	601.99213
Point 14	127.87795	600.00591
Point 15	163.14756	600.01118
Point 16	149.56535	595.01063
Point 17	147.06988	594.09744
Point 18	57.38569	620.4397
Point 19	72.81546	619.98477
Point 20	80.84007	617.99987
Point 21	99.3055	610.6283
Point 22	139.17652	601.67587
Point 23	173.72543	602.00845
Point 24	176.45339	603.29228
Point 25	189.71063	600.00886
Point 26	199.68996	595.00886
Point 27	167.47087	595.01
Point 28	191.72441	585.79626
Point 29	124.59213	585.79827
Point 30	210.5102	589.59755
Point 31	218.12189	585.75717
Point 32	221.75303	584.00508
Point 33	243.39222	575.85019
Point 34	253.50591	571.98819
Point 35	289.84961	560.28268
Point 36	256.97717	561.34945
Point 37	108.92713	580.01604
Point 38	142.96147	580.0084
Point 39	159.35433	573.84449
Point 40	178.27362	566.74311
Point 41	185.14195	566.8803
Point 42	197.25818	566.77308
Point 43	199.06388	566.49447
Point 44	214.43065	565.09473
Point 45	230.53524	563.39632
Point 46	234.91774	563.19918

Point 47	92.17246	573.83178
Point 48	72.44646	566.50502
Point 49	57.05752	560.85717
Point 50	-100	561.11382
Point 51	-100	533.82575
Point 52	21.33315	533.86583
Point 53	28.78186	534.53132
Point 54	34.71071	535.25795
Point 55	39.46011	535.53175
Point 56	42.85104	535.87926
Point 57	45.71543	536.46899
Point 58	49.77857	537.76077
Point 59	59.1159	541.81514
Point 60	64.62858	544.24532
Point 61	75.01429	546.95559
Point 62	83.26625	548.88905
Point 63	88.53588	549.98847
Point 64	93.23684	550.64559
Point 65	106.0002	551.53018
Point 66	116.47627	552.07357
Point 67	122.52939	552.65487
Point 68	120.68438	552.98343
Point 69	113.2235	552.91166
Point 70	98.93865	553.2756
Point 71	88.31144	553.78513
Point 72	81.74223	554.71319
Point 73	77.73883	555.51387
Point 74	364.93178	560.3689
Point 75	369.84787	558.28744
Point 76	398.62803	558.25568
Point 77	406.56907	560.14614
Point 78	407.16945	560.17165
Point 79	432.46006	554.51883
Point 80	442.14574	552.40143
Point 81	451.7179	550.43805
Point 82	378.61552	549.7332

Point 83	292.87496	549.02254
Point 84	215.96602	549.23217
Point 85	183.76122	549.91347
Point 86	163.4328	550.32461
Point 87	134.5598	552.09884
Point 88	274.22203	571.1344
Point 89	301.03752	569.99889
Point 90	328.15873	568.01175
Point 91	341.0609	563.99026
Point 92	390.16826	564.00289
Point 93	504	540
Point 94	580	523.86886
Point 95	580	500.03246
Point 96	-100	499.99472
Point 97	49.98781	610.59727
Point 98	223.72901	573.80581
Point 99	278.12773	564.05804
Point 100	265.81244	568.02452
Point 101	264.70006	571.52684
Point 102	275.69963	568.00897
Point 103	-100.04534	596.07808
Point 104	-100.00866	594.10293
Point 105	620	522
Point 106	620	500

Critical Slip Surfaces

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	158	2.35	(403.224, 1043)	555.426	(47, 616.856)	(598.423, 523.008)

Slices of Slip Surface: 158

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	158	48.597835	615.52995	0	448.68051	302.63883	0

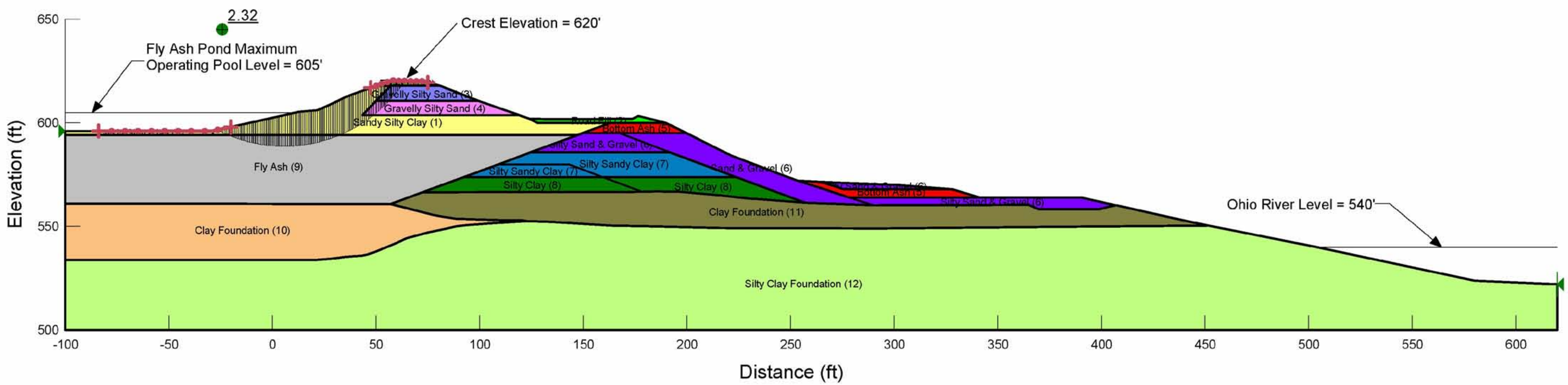
2	158	51.102105	613.46135	0	526.03334	354.81397	0
3	158	53.314075	611.65925	0	609.90554	411.38648	0
4	158	55.830965	609.62915	0	738.80528	461.65678	0
5	158	57.214005	608.5214	0	807.76596	504.74819	0
6	158	60.33948	606.0667	0	968.35579	605.09585	0
7	158	65.673815	601.9269	0	1316.1924	887.783	0
8	158	70.43491	598.32355	0	1672.3776	1128.033	0
9	158	74.47819	595.321	0	1948.6782	1314.4	0
10	158	78.490495	592.40675	0	2202.9246	1122.4461	0
11	158	83.91764	588.55115	0	2506.9913	1277.3759	0
12	158	90.072785	584.2878	0	2811.4824	1432.5218	0
13	158	96.22793	580.1456	0	2994.601	1525.8254	0
14	158	100.109	577.5811	0	3020.0747	1538.8049	0
15	158	103.42605	575.4461	0	3165.3847	2135.0789	0
16	158	107.43335	572.8945	0	3308.216	2148.3806	0
17	158	111.11165	570.6038	0	3581.3658	2325.7662	0
18	158	115.4807	567.9299	0	3866.7138	2511.0733	0
19	158	118.2933	566.2314	0	4033.7261	3039.6306	0
20	158	121.4282	564.3801	0	4240.7672	3195.6473	0
21	158	124.26355	562.71335	0	4434.3628	3341.532	0
22	158	126.23505	561.57725	0	4575.7451	3448.0713	0
23	158	130.7026	559.04145	0	4901.7718	3693.75	0
24	158	136.35185	555.90335	0	5272.4454	3973.0726	0
25	158	141.069	553.3426	0	5564.5322	4193.1757	0
26	158	143.76125	551.90685	0	5723.907	4313.2733	0
27	158	145.81545	550.8282	0	5834.8497	3646.0188	0
28	158	148.31765	549.5276	0	5963.8905	3726.6524	0
29	158	152.0126	547.64205	0	6124.9327	3827.2828	0
30	158	156.90705	545.1901	0	6315.1144	3946.1215	0
31	158	161.25095	543.0612	0	6458.9216	4035.9821	0
32	158	163.2902	542.0749	0	6520.339	4074.36	0
33	158	165.45185	541.0502	0	6572.8855	4107.1947	0
34	158	170.59815	538.6514	0	6688.3465	4179.3428	0
35	158	175.0894	536.5945	0	6779.7551	4236.4611	0
36	158	177.3635	535.5749	0	6817.4027	4259.986	0
37	158	181.0174	533.97205	0	6867.6175	4291.3637	0

38	158	184.4516	532.4785	0	6909.3654	4317.4507	0
39	158	187.4263	531.21945	0	6948.8661	4342.1335	0
40	158	190.7175	529.83925	0	6992.0445	4369.1143	0
41	158	194.4913	528.30025	0	7049.9792	4405.3159	0
42	158	198.16105	526.8195	0	7113.8478	4445.2255	0
43	158	199.37695	526.3373	0	7128.6202	4454.4563	0
44	158	202.39505	525.1647	0	7151.8049	4468.9437	0
45	158	207.80515	523.09885	0	7237.7785	4522.6659	0
46	158	212.47045	521.3653	0	7338.3775	4585.5272	0
47	158	215.19835	520.3723	0	7396.5304	4621.8652	0
48	158	217.04395	519.7126	0	7441.9153	4650.2248	0
49	158	219.93745	518.6944	0	7512.8353	4694.5405	0
50	158	222.741	517.72025	0	7582.208	4737.8894	0
51	158	227.1321	516.24315	0	7692.089	4806.5507	0
52	158	232.72645	514.3987	0	7834.1739	4895.3352	0
53	158	237.03635	513.02755	0	7938.8742	4960.7592	0
54	158	241.2736	511.7174	0	8039.3162	5023.5223	0
55	158	245.92065	510.32495	0	8145.1165	5089.6337	0
56	158	250.9775	508.85765	0	8257.3162	5159.7438	0
57	158	255.24155	507.6572	0	8347.4967	5216.0948	0
58	158	260.83865	506.15325	0	8458.3004	5285.3327	0
59	158	265.25625	504.9865	0	8538.3408	5335.3475	0
60	158	267.9148	504.3158	0	8537.1336	5334.5931	0
61	158	272.1196	503.277	0	8531.179	5330.8723	0
62	158	274.9608	502.59095	0	8524.0293	5326.4046	0
63	158	276.91365	502.1321	0	8516.3742	5321.6212	0
64	158	282.2325	500.9324	0	8491.7126	5306.2109	0
65	158	288.09345	500.0163	0	8968.5333	5604.1616	0
66	158	291.3623	500.01645	0	8868.0649	5541.3819	0
67	158	296.95625	500.01675	0	8705.7247	5439.9405	0
68	158	303.74965	500.01715	0	8531.5146	5331.082	0
69	158	309.1739	500.01745	0	8414.8163	5258.1608	0
70	158	314.5981	500.01775	0	8319.1347	5198.3723	0
71	158	320.02235	500.01805	0	8245.3917	5152.2926	0
72	158	325.4466	500.01835	0	8192.2967	5119.1151	0
73	158	331.38425	500.01865	0	8151.497	5093.6206	0

74	158	337.83535	500.019	0	8120.3394	5074.1512	0
75	158	344.04475	500.01935	0	8094.3811	5057.9307	0
76	158	350.01245	500.0197	0	8064.2188	5039.0832	0
77	158	355.9802	500.02005	0	8021.6565	5012.4873	0
78	158	361.94795	500.02035	0	7966.5266	4978.0383	0
79	158	367.38985	500.02065	0	7905.4696	4939.8857	0
80	158	372.0398	500.0209	0	7845.4318	4902.3699	0
81	158	376.4236	500.02115	0	7782.7012	4863.1714	0
82	158	381.5037	500.02145	0	7701.8958	4812.6787	0
83	158	387.2801	500.02175	0	7600.6212	4749.3952	0
84	158	392.2832	500.02205	0	7506.3506	4690.4885	0
85	158	396.51305	500.0223	0	7423.3697	4638.6362	0
86	158	402.59855	500.0226	0	7301.3107	4562.3653	0
87	158	406.86925	500.02285	0	7215.2637	4508.5971	0
88	158	409.6985	500.023	0	7158.388	4473.0573	0
89	158	414.75665	500.02325	0	7056.3739	4409.3118	0
90	158	419.81475	500.02355	0	6954.3597	4345.5663	0
91	158	424.87285	500.02385	0	6851.3571	4281.2031	0
92	158	429.931	500.02415	0	6749.1452	4217.334	0
93	158	434.8815	500.0244	0	6656.8377	4159.6539	0
94	158	439.7243	500.02465	0	6571.7637	4106.4937	0
95	158	444.53875	500.02495	0	6487.355	4053.7493	0
96	158	449.32485	500.0252	0	6401.481	4000.0893	0
97	158	454.62245	500.0255	0	6300.9522	3937.2719	0
98	158	460.43155	500.02585	0	6183.7228	3864.0188	0
99	158	466.2407	500.02615	0	6057.8862	3785.3874	0
100	158	472.04985	500.02645	0	5926.3689	3703.2063	0
101	158	477.85895	500.0268	0	5801.7373	3625.3278	0
102	158	483.66805	500.02715	0	5684.3358	3551.9672	0
103	158	489.4772	500.02745	0	5562.2863	3475.7023	0
104	158	495.28635	500.02775	0	5431.9741	3394.2741	0
105	158	501.09545	500.02805	0	5301.6618	3312.846	0
106	158	506.6952	500.02835	0	5177.1313	3235.0307	0
107	158	512.08565	500.02865	0	5057.6604	3160.377	0
108	158	517.4761	500.02895	0	4935.5924	3084.1004	0
109	158	522.8908	500.62915	0	4982.6008	3113.4745	0

110	158	528.3298	501.8579	0	4766.7422	2978.5911	0
111	158	533.76875	503.1442	0	4556.6888	2847.3352	0
112	158	539.2077	504.4885	0	4343.9059	2714.3736	0
113	158	544.6467	505.89125	0	4090.9631	2556.3174	0
114	158	550.08565	507.3529	0	3787.2615	2366.5437	0
115	158	555.5246	508.87395	0	3491.4879	2181.7238	0
116	158	560.9636	510.4549	0	3188.1633	1992.1856	0
117	158	566.4026	512.09625	0	2882.56	1801.2234	0
118	158	571.84155	513.7986	0	2587.7722	1617.0195	0
119	158	577.2805	515.56255	0	2269.7611	1418.3042	0
120	158	583.0705	517.51085	0	1933.3834	1208.112	0
121	158	589.2115	519.6529	0	1645.0167	1027.9205	0
122	158	595.3525	521.8761	0	1475.4635	921.97191	0

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section L-L Upstream Slope Stability Analysis
File Name: FAP_L-L_Slope_US.gsz
Date: 7/23/2010



Newmark Deformation

File Information

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section L-L Upstream Slope Stability Analysis
Revision Number: 74
Last Edited By: Seth Frank
Date: 7/23/2010
Time: 12:44:15 PM
File Name: FAP_L-L_Slope_US.gsz
Directory: P:\Frank\Philip Sporn\SEISMIC REPORT\Updated Analysis Files\Stability\
Last Solved Date: 7/23/2010
Last Solved Time: 1:03:30 PM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Newmark Deformation

Kind: SLOPE/W
Parent: Dynamic QUAKE/W
Method: QUAKE/W Newmark Deformation
Settings
- Initial Stress: Parent Analysis
- PWP Conditions Source: Parent Analysis

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack
  - Tension Crack Option: (none)

FOS Distribution

FOS Calculation Option: Constant

Time

Starting Time: 0 sec

Duration: 5.125 sec

# of Steps: 1025

Advanced

Number of Slices: 100

Optimization Tolerance: 0.01

Minimum Slip Surface Depth: 10 ft

Optimization Maximum Iterations: 2000

Optimization Convergence Tolerance: 1e-007

Starting Optimization Points: 8

Ending Optimization Points: 16

Complete Passes per Insertion: 1

Driving Side Maximum Convex Angle: 5 °

Resisting Side Maximum Convex Angle: 1 °

Materials

Sandy Silty Clay (1)

Model: Mohr-Coulomb

Unit Weight: 130 pcf

Unit Wt. Above Water Table: 125 pcf

Cohesion: 0 psf

Phi: 34 °

Phi-B: 0 °

Road Fill (2)

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Unit Wt. Above Water Table: 110 pcf

Cohesion: 0 psf

Phi: 35 °

Phi-B: 0 °

Gravelly Silty Sand (3)

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Unit Wt. Above Water Table: 110 pcf

Cohesion: 0 psf

Phi: 34 °

Phi-B: 0 °

Gravelly Silty Sand (4)

Model: Mohr-Coulomb

Unit Weight: 105 pcf

Unit Wt. Above Water Table: 100 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °

Bottom Ash (5)

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Unit Wt. Above Water Table: 65 pcf
Cohesion: 0 psf
Phi: 35 °
Phi-B: 0 °

Silty Sand & Gravel (6)

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Unit Wt. Above Water Table: 115 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °

Silty Sandy Clay (7)

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Unit Wt. Above Water Table: 125 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Silty Clay (8)

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Unit Wt. Above Water Table: 125 pcf
Cohesion: 0 psf
Phi: 33 °
Phi-B: 0 °

Fly Ash (9)

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Unit Wt. Above Water Table: 102 pcf
Cohesion: 0 psf
Phi: 27 °
Phi-B: 0 °

Clay Foundation (10)

Model: Mohr-Coulomb
Unit Weight: 125 pcf

Unit Wt. Above Water Table: 120 pcf
Cohesion: 0 psf
Phi: 39 °
Phi-B: 0 °

Clay Foundation (11)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Unit Wt. Above Water Table: 120 pcf
Cohesion: 0 psf
Phi: 37 °
Phi-B: 0 °

Silty Clay Foundation (12)

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Unit Wt. Above Water Table: 125 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-84, 596.08079) ft
Left-Zone Right Coordinate: (-20.25328, 598) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (47.40276, 617) ft
Right-Zone Right Coordinate: (75, 619.44442) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-100.04534, 596.07808) ft
Right Coordinate: (620, 522) ft

Regions

	Material	Points	Area (ft^2)
Region 1	Sandy Silty Clay (1)	103,1,2,104	141.20465

Region 2	Sandy Silty Clay (1)	1,3,4,5,6,7,8,9,10,97,11,12,13,14,15,16,17,2	1797.2287
Region 3	Road Fill (2)	9,18,19,20,10	50.839704
Region 4	Road Fill (2)	13,22,23,24,25,15,14	116.203
Region 5	Bottom Ash (5)	15,25,26,27,16	191.73337
Region 6	Silty Sand & Gravel (6)	17,16,27,28,29	391.82116
Region 7	Silty Sand & Gravel (6)	27,26,30,31,32,33,34,100,99,35,36,98,28	923.61928
Region 8	Silty Sandy Clay (7)	37,47,39,38	312.45828
Region 9	Silty Clay (8)	47,48,40,39	623.99905
Region 10	Fly Ash (9)	48,49,50,104,2,17,29,37,47	6698.0183
Region 11	Clay Foundation (10)	50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,49	4580.0299
Region 12	Clay Foundation (11)	49,48,40,41,42,43,44,45,46,36,35,74,75,76,77,78,79,80,81,82,83,84,85,86,87,67,68,69,70,71,72,73	4582.5269
Region 13	Silty Sand & Gravel (6)	101,88,89,90,102	107.81573
Region	Silty Clay	51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,87,86,85,84,83,82,81,93,94,105,106,95,96	30694.491

14	Foundation (12)		
Region 15	Gravelly Silty Sand (3)	10,20,21,97	270.1759
Region 16	Gravelly Silty Sand (4)	21,12,11,97	428.27559
Region 17	Silty Clay (8)	98,36,46,45,44,43,42,41,40,39	583.66388
Region 18	Silty Sandy Clay (7)	98,39,38,37,29,28	875.82886
Region 19	Bottom Ash (5)	101,102,90,91,99,100,34	285.90427
Region 20	Silty Sand & Gravel (6)	99,91,92,77,76,75,74,35	493.02893

Points

	X (ft)	Y (ft)
Point 1	-28.73928	596.09012
Point 2	-28.7343	594.10387
Point 3	10.87106	605.00492
Point 4	12.47008	605.36299
Point 5	21.58957	606.0128
Point 6	27.88941	608.93894
Point 7	34.84064	612.1236
Point 8	39.1222	614.02931
Point 9	50.19567	618.00197
Point 10	57.04232	618.00197

Point 11	43.46173	603.74724
Point 12	118.92142	603.75291
Point 13	123.93504	601.99213
Point 14	127.87795	600.00591
Point 15	163.14756	600.01118
Point 16	149.56535	595.01063
Point 17	147.06988	594.09744
Point 18	57.38569	620.4397
Point 19	72.81546	619.98477
Point 20	80.84007	617.99987
Point 21	99.3055	610.6283
Point 22	139.17652	601.67587
Point 23	173.72543	602.00845
Point 24	176.45339	603.29228
Point 25	189.71063	600.00886
Point 26	199.68996	595.00886
Point 27	167.47087	595.01
Point 28	191.72441	585.79626
Point 29	124.59213	585.79827
Point 30	210.5102	589.59755
Point 31	218.12189	585.75717
Point 32	221.75303	584.00508
Point 33	243.39222	575.85019
Point 34	253.50591	571.98819
Point 35	289.84961	560.28268
Point 36	256.97717	561.34945
Point 37	108.92713	580.01604
Point 38	142.96147	580.0084
Point 39	159.35433	573.84449
Point 40	178.27362	566.74311
Point 41	185.14195	566.8803
Point 42	197.25818	566.77308
Point 43	199.06388	566.49447
Point 44	214.43065	565.09473
Point 45	230.53524	563.39632
Point 46	234.91774	563.19918

Point 47	92.17246	573.83178
Point 48	72.44646	566.50502
Point 49	57.05752	560.85717
Point 50	-100	561.11382
Point 51	-100	533.82575
Point 52	21.33315	533.86583
Point 53	28.78186	534.53132
Point 54	34.71071	535.25795
Point 55	39.46011	535.53175
Point 56	42.85104	535.87926
Point 57	45.71543	536.46899
Point 58	49.77857	537.76077
Point 59	59.1159	541.81514
Point 60	64.62858	544.24532
Point 61	75.01429	546.95559
Point 62	83.26625	548.88905
Point 63	88.53588	549.98847
Point 64	93.23684	550.64559
Point 65	106.0002	551.53018
Point 66	116.47627	552.07357
Point 67	122.52939	552.65487
Point 68	120.68438	552.98343
Point 69	113.2235	552.91166
Point 70	98.93865	553.2756
Point 71	88.31144	553.78513
Point 72	81.74223	554.71319
Point 73	77.73883	555.51387
Point 74	364.93178	560.3689
Point 75	369.84787	558.28744
Point 76	398.62803	558.25568
Point 77	406.56907	560.14614
Point 78	407.16945	560.17165
Point 79	432.46006	554.51883
Point 80	442.14574	552.40143
Point 81	451.7179	550.43805
Point 82	378.61552	549.7332

Point 83	292.87496	549.02254
Point 84	215.96602	549.23217
Point 85	183.76122	549.91347
Point 86	163.4328	550.32461
Point 87	134.5598	552.09884
Point 88	274.22203	571.1344
Point 89	301.03752	569.99889
Point 90	328.15873	568.01175
Point 91	341.0609	563.99026
Point 92	390.16826	564.00289
Point 93	504	540
Point 94	580	523.86886
Point 95	580	500.03246
Point 96	-100	499.99472
Point 97	49.98781	610.59727
Point 98	223.72901	573.80581
Point 99	278.12773	564.05804
Point 100	265.81244	568.02452
Point 101	264.70006	571.52684
Point 102	275.69963	568.00897
Point 103	-100.04534	596.07808
Point 104	-100.00866	594.10293
Point 105	620	522
Point 106	620	500

Critical Slip Surfaces

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	1161	2.32	(5.594, 658.201)	69.46	(63.7713, 620.251)	(-26.4931, 596.596)

Slices of Slip Surface: 1161

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)

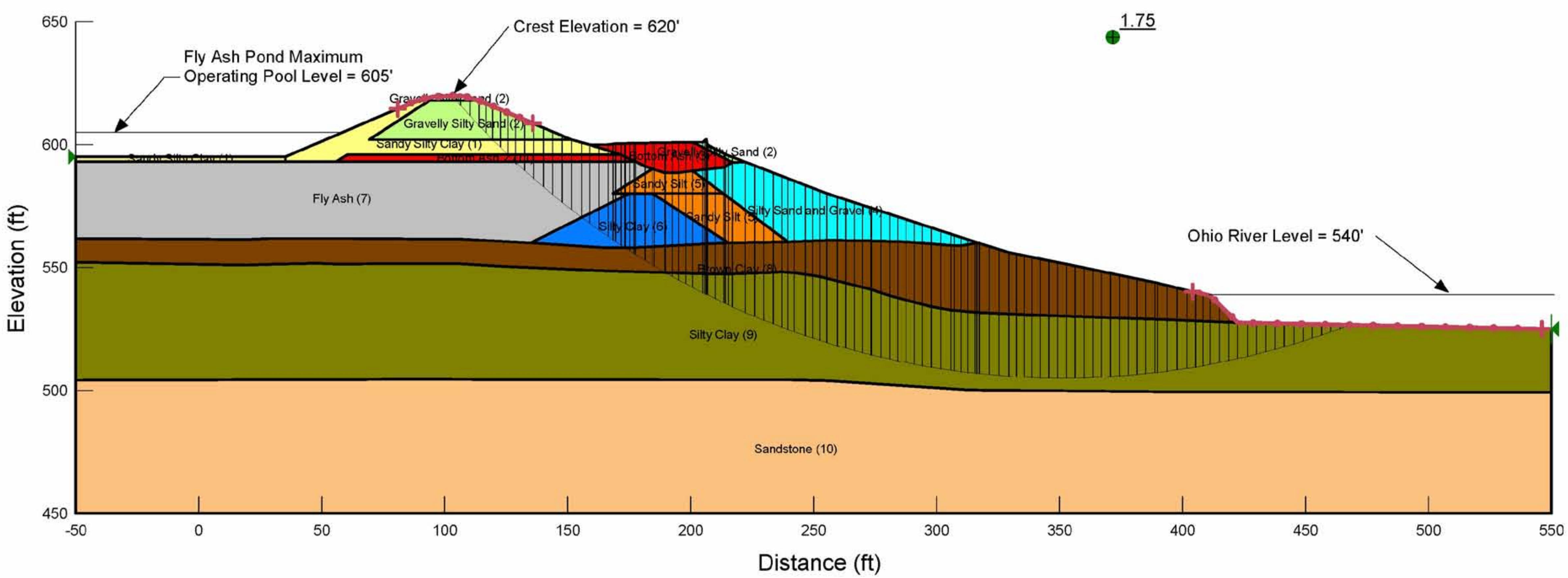
1	1161	-26.049525	596.36865	0	759.16507	512.06331	0
2	1161	-25.16238	595.92255	0	808.69712	545.47309	0
3	1161	-24.27524	595.49225	0	851.77572	574.52998	0
4	1161	-23.388095	595.0773	0	889.51623	599.98627	0
5	1161	-22.50095	594.67745	0	923.42765	622.85981	0
6	1161	-21.613805	594.29245	0	954.4654	643.79504	0
7	1161	-20.7125	593.9163	0	992.64805	505.77944	0
8	1161	-19.797035	593.5492	0	1040.1244	529.96985	0
9	1161	-18.88157	593.19705	0	1087.6001	554.15994	0
10	1161	-17.966105	592.85965	0	1134.7592	578.18869	0
11	1161	-17.05064	592.53675	0	1180.6403	601.5663	0
12	1161	-16.135175	592.22815	0	1225.0957	624.21742	0
13	1161	-15.219705	591.93365	0	1268.2904	646.22625	0
14	1161	-14.30424	591.65305	0	1309.9768	667.46652	0
15	1161	-13.388775	591.38615	0	1350.7462	688.23955	0
16	1161	-12.47331	591.13275	0	1390.8853	708.69145	0
17	1161	-11.557845	590.8928	0	1429.7335	728.48562	0
18	1161	-10.64238	590.66615	0	1467.1544	747.55253	0
19	1161	-9.726916	590.45255	0	1503.224	765.93086	0
20	1161	-8.811449	590.252	0	1537.9149	783.60679	0
21	1161	-7.8959835	590.06435	0	1576.2373	803.13303	0
22	1161	-6.980518	589.88945	0	1614.5526	822.65564	0
23	1161	-6.065052	589.72725	0	1651.5527	841.50811	0
24	1161	-5.1495865	589.57765	0	1687.3208	859.73291	0
25	1161	-4.234121	589.44055	0	1721.7261	877.26329	0
26	1161	-3.3186555	589.3159	0	1753.5549	893.48083	0
27	1161	-2.40319	589.20365	0	1781.3697	907.65321	0
28	1161	-1.4877245	589.1037	0	1805.9007	920.15237	0
29	1161	-0.57225915	589.016	0	1828.6481	931.74272	0
30	1161	0.34320645	588.9405	0	1850.0315	942.63811	0
31	1161	1.2586721	588.87715	0	1870.2564	952.94325	0
32	1161	2.1741375	588.82595	0	1892.3667	964.209	0
33	1161	3.089603	588.7869	0	1913.737	975.09769	0
34	1161	4.0050685	588.7599	0	1933.9196	985.38123	0
35	1161	4.920534	588.74495	0	1952.5759	994.8871	0
36	1161	5.8359995	588.7421	0	1970.024	1003.7773	0

37	1161	6.751465	588.75135	0	1988.1111	1012.9932	0
38	1161	7.6669305	588.77265	0	2008.356	1023.3085	0
39	1161	8.582396	588.80605	0	2027.0344	1032.8256	0
40	1161	9.4978615	588.85155	0	2044.1374	1041.54	0
41	1161	10.413327	588.90915	0	2059.5477	1049.392	0
42	1161	11.270815	588.97375	0	2072.5668	1056.0255	0
43	1161	12.070325	589.04395	0	2087.899	1063.8377	0
44	1161	12.926055	589.1298	0	2104.195	1072.1409	0
45	1161	13.838005	589.2327	0	2119.0254	1079.6974	0
46	1161	14.749955	589.34785	0	2131.684	1086.1472	0
47	1161	15.661905	589.4753	0	2142.2774	1091.5448	0
48	1161	16.57385	589.6151	0	2151.0213	1096.0001	0
49	1161	17.485795	589.7673	0	2159.6436	1100.3934	0
50	1161	18.397745	589.93205	0	2165.761	1103.5103	0
51	1161	19.309695	590.10945	0	2169.2715	1105.2991	0
52	1161	20.221645	590.2995	0	2170.0768	1105.7094	0
53	1161	21.133595	590.5024	0	2167.9747	1104.6383	0
54	1161	22.03956	590.71675	0	2160.7104	1100.937	0
55	1161	22.939535	590.94245	0	2149.2877	1095.1168	0
56	1161	23.83951	591.181	0	2135.2322	1087.9551	0
57	1161	24.73949	591.43255	0	2118.4601	1079.4093	0
58	1161	25.63947	591.6972	0	2098.9987	1069.4933	0
59	1161	26.539445	591.97515	0	2076.7716	1058.168	0
60	1161	27.43942	592.2666	0	2056.4532	1047.8152	0
61	1161	28.33581	592.57035	0	2034.333	1036.5445	0
62	1161	29.22861	592.88655	0	2010.3131	1024.3057	0
63	1161	30.12141	593.2166	0	1984.437	1011.1212	0
64	1161	31.014205	593.56065	0	1956.5239	996.89872	0
65	1161	31.907	593.9189	0	1928.7836	982.76431	0
66	1161	32.76794	594.27785	0	1905.2406	1285.101	0
67	1161	33.59702	594.6367	0	1881.9622	1269.3995	0
68	1161	34.4261	595.00845	0	1856.3611	1252.1314	0
69	1161	35.268795	595.3999	0	1827.5834	1232.7205	0
70	1161	36.125105	595.81175	0	1795.4593	1211.0526	0
71	1161	36.98142	596.2382	0	1760.7904	1187.6681	0
72	1161	37.837735	596.6795	0	1725.8057	1164.0707	0

73	1161	38.694045	597.13595	0	1688.5662	1138.9523	0
74	1161	39.556155	597.61125	0	1648.6206	1112.0086	0
75	1161	40.42406	598.106	0	1605.8512	1083.1603	0
76	1161	41.291965	598.6175	0	1560.4568	1052.5414	0
77	1161	42.15987	599.1462	0	1512.5199	1020.2076	0
78	1161	43.027775	599.69255	0	1459.6096	984.51911	0
79	1161	43.89969	600.25975	0	1398.3264	943.18303	0
80	1161	44.775615	600.8485	0	1336.5145	901.49043	0
81	1161	45.65154	601.4569	0	1274.3053	859.52981	0
82	1161	46.52746	602.08555	0	1211.5812	817.22186	0
83	1161	47.403385	602.73515	0	1148.2359	774.49492	0
84	1161	48.27931	603.40645	0	1084.1744	731.28485	0
85	1161	49.35254	604.263	0	980.02662	612.3886	0
86	1161	50.09174	604.8651	0	913.5151	570.82759	0
87	1161	50.623185	605.3158	0	868.30693	542.57839	0
88	1161	51.47822	606.056	0	800.03161	499.91523	0
89	1161	52.333255	606.8211	0	742.79624	464.1506	0
90	1161	53.18829	607.61225	0	701.15438	438.12988	0
91	1161	54.043325	608.43065	0	657.83321	411.05981	0
92	1161	54.89836	609.27765	0	610.52422	381.49787	0
93	1161	55.753395	610.15485	0	556.2077	347.55715	0
94	1161	56.611615	611.0674	0	496.71224	335.03664	0
95	1161	57.214005	611.72425	0	453.27732	305.73941	0
96	1161	57.871125	612.46985	0	405.04607	273.20702	0
97	1161	58.841995	613.6044	0	336.54259	227.00085	0
98	1161	59.81287	614.7903	0	298.68944	201.46857	0
99	1161	60.783745	616.03195	0	266.29054	179.61524	0
100	1161	61.754615	617.3344	0	238.44356	160.83221	0
101	1161	62.62287	618.55215	0	213.72313	149.65055	0
102	1161	63.38851	619.6771	0	190.73739	133.55576	0

SECTION M-M

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section M-M Downstream Slope Stability Analysis
File Name: FAP_M-M_Slope_DS.gsz
Date: 7/23/2010



Newmark Deformation

File Information

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section M-M Downstream Slope Stability Analysis
Revision Number: 97
Last Edited By: Seth Frank
Date: 7/23/2010
Time: 11:26:50 AM
File Name: FAP_M-M_Slope_DS.gsz
Directory: P:\Frank\Philip Sporn\SEISMIC REPORT\Updated Analysis Files\Stability\
Last Solved Date: 7/23/2010
Last Solved Time: 12:36:35 PM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Newmark Deformation

Kind: SLOPE/W
Parent: Dynamic QUAKE/W
Method: QUAKE/W Newmark Deformation
Settings
- Initial Stress: Parent Analysis
- PWP Conditions Source: Parent Analysis

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack
  - Tension Crack Option: (none)

FOS Distribution

FOS Calculation Option: Constant

Time

Starting Time: 0 sec

Duration: 5.125 sec

# of Steps: 1025

Advanced

Number of Slices: 100

Optimization Tolerance: 0.01

Minimum Slip Surface Depth: 10 ft

Optimization Maximum Iterations: 2000

Optimization Convergence Tolerance: 1e-007

Starting Optimization Points: 8

Ending Optimization Points: 16

Complete Passes per Insertion: 1

Driving Side Maximum Convex Angle: 5 °

Resisting Side Maximum Convex Angle: 1 °

Materials

Sandy Silty Clay (1)

Model: Mohr-Coulomb

Unit Weight: 130 pcf

Unit Wt. Above Water Table: 125 pcf

Cohesion: 0 psf

Phi: 34 °

Phi-B: 0 °

Gravelly Silty Sand (2)

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Unit Wt. Above Water Table: 125 pcf

Cohesion: 0 psf

Phi: 35 °

Phi-B: 0 °

Bottom Ash (3)

Model: Mohr-Coulomb

Unit Weight: 90 pcf

Unit Wt. Above Water Table: 65 pcf

Cohesion: 0 psf

Phi: 36 °

Phi-B: 0 °

Silty Sand and Gravel (4)

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Unit Wt. Above Water Table: 115 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °

Sandy Silt (5)

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Unit Wt. Above Water Table: 125 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Silty Clay (6)

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Unit Wt. Above Water Table: 125 pcf
Cohesion: 0 psf
Phi: 33 °
Phi-B: 0 °

Fly Ash (7)

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Unit Wt. Above Water Table: 110 pcf
Cohesion: 0 psf
Phi: 27 °
Phi-B: 0 °

Brown Clay (8)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Unit Wt. Above Water Table: 120 pcf
Cohesion: 0 psf
Phi: 37 °
Phi-B: 0 °

Silty Clay (9)

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Unit Wt. Above Water Table: 122 pcf
Cohesion: 170 psf
Phi: 31.2 °
Phi-B: 0 °

Sandstone (10)

Model: Bedrock (Impenetrable)

Bottom Ash 2 (11)

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Unit Wt. Above Water Table: 65 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (81, 614.60164) ft
Left-Zone Right Coordinate: (136, 608.65577) ft
Left-Zone Increment: 10
Right Projection: Range
Right-Zone Left Coordinate: (404.24331, 540.25209) ft
Right-Zone Right Coordinate: (546.10179, 524.9916) ft
Right-Zone Increment: 15
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-49.97613, 595.11744) ft
Right Coordinate: (550, 524.91002) ft

Regions

	Material	Points	Area (ft²)
Region 1	Sandy Silty Clay (1)	106,1,2,107	171.07169
Region 2	Sandy Silty Clay (1)	1,108,3,4,5,6,7,8,9,10,11,12,2	962.07207
Region 3	Gravelly Silty San	5,13,14,15,6	31.119887

	d (2)		
Region 4	Gravelly Silty Sand (2)	7,8,15,6	819.48221
Region 5	Bottom Ash (3)	9,16,17,18,19,20,21,22,23,24,25,26,10	423.64067
Region 6	Gravelly Silty Sand (2)	18,27,28,29,30,31,19	32.648671
Region 7	Sandy Silt (5)	24,32,33,34,35,21,22,23	282.19505
Region 8	Silty Sand and Gravel (4)	21,20,19,31,36,37,38,39,40,41,42,43,44,45,35	1565.2892
Region 9	Sandy Silt (5)	34,35,45,46	531.21818
Region 10	Silty Clay (6)	34,46,47,48,49,50,51,52,53,33	989.52619
Region 11	Fly Ash (7)	54,55,56,57,58,59,60,53,33,32,24,25,26,12,2,107	6796.1273
Regio	Brown	54,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,109,91,92,93,94,37,38,39,40,41,42,43,44,45,46,47,48,49,5	6482.6655

n 12	Clay (8)	0,51,52,53,60,59,58,57,56,55	
Region 13	Silty Clay (9)	89,95,96,97,98,99,100,101,102,103,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88	22793.126
Region 14	Sandstone (10)	103,104,105,96,97,98,99,100,101,102	31301.229
Region 15	Bottom Ash 2 (11)	10,26,12,11	324.85555

Points

	X (ft)	Y (ft)
Point 1	35.36015	595.10746
Point 2	35.37077	593.10938
Point 3	60.72629	605.9827
Point 4	74.8905	612.04606
Point 5	89.08286	617.98267
Point 6	93.72016	617.98376
Point 7	69.42633	602.00461
Point 8	151.61692	602.00605
Point 9	158.87128	599.99208
Point 10	171.82425	595.91741
Point 11	60.47732	595.91216
Point 12	56.0411	593.12487
Point 13	95.74708	619.48275
Point 14	106.57718	619.95406
Point 15	114.07579	617.99114
Point 16	166.70528	600.0213
Point 17	169.58045	600.43082
Point 18	200.94364	600.90024

Point 19	217.30273	592.80917
Point 20	213.38189	590.83858
Point 21	200.88583	589.29528
Point 22	195.25394	588.59744
Point 23	189.42126	588.62008
Point 24	184.5	590.20374
Point 25	181.51772	591.16693
Point 26	177.65846	593.12697
Point 27	204.98541	600.97594
Point 28	206.35442	602.21331
Point 29	206.71422	599.99306
Point 30	214.00828	595.98847
Point 31	222.27612	592.82454
Point 32	168.66722	580.09858
Point 33	175.21974	580.09858
Point 34	184.51087	580.09817
Point 35	213.24737	580.09272
Point 36	255.42934	580.07172
Point 37	317.48058	559.92079
Point 38	315.59736	559.88781
Point 39	309.9739	558.80103
Point 40	307.4465	558.76312
Point 41	287.58173	560.34006
Point 42	273.69358	560.81173
Point 43	259.80542	560.94275
Point 44	255.45555	560.94275
Point 45	239.61428	560.44981
Point 46	215.41971	560.03735
Point 47	206.90911	559.67804
Point 48	185.33019	558.38907
Point 49	177.08328	558.01754
Point 50	173.62075	558.106
Point 51	169.80438	558.01754
Point 52	164.66112	558.14391
Point 53	135.13429	560.09691
Point 54	-50	561.74545

Point 55	20.16974	561.49271
Point 56	28.34588	561.72018
Point 57	50.65765	561.88173
Point 58	61.94724	561.81622
Point 59	89.85457	561.6852
Point 60	105.36228	561.59785
Point 61	-50	552.17166
Point 62	19.23461	550.94335
Point 63	32.24565	551.32246
Point 64	41.85988	551.67124
Point 65	47.10676	551.74706
Point 66	56.64516	551.4741
Point 67	78.08761	551.61058
Point 68	95.40534	551.48927
Point 69	105.51999	551.66113
Point 70	114.75208	551.07983
Point 71	124.43302	550.29735
Point 72	142.61209	549.56582
Point 73	165.69351	548.62684
Point 74	187.96697	548.08092
Point 75	205.85125	547.44765
Point 76	216.92246	547.535
Point 77	233.69307	548.10276
Point 78	236.99041	548.14643
Point 79	242.18755	547.92806
Point 80	246.77327	547.31663
Point 81	252.65171	546.21606
Point 82	273.24811	541.09055
Point 83	281.07788	538.66929
Point 84	297.9009	534.10978
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Point 86	316.39049	531.68853
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Point 89	422.60496	527.57608
Point 90	411.3282	538.58079

Point 91	401.8504	540.81657
Point 92	388.80805	543.92059
Point 93	352.80366	551.31013
Point 94	329.44346	556.01129
Point 95	550	524.91002
Point 96	550	499.15439
Point 97	396.01919	499.3174
Point 98	313.20998	500.09985
Point 99	256.3846	503.93603
Point 100	240.95296	504.37072
Point 101	191.37067	504.40695
Point 102	86.37793	504.45549
Point 103	-50	504.13087
Point 104	-50	449.97963
Point 105	550	450.03403
Point 106	-49.97613	595.11744
Point 107	-49.96913	593.10625
Point 108	58.47531	605
Point 109	405.33383	539.99484

Critical Slip Surfaces

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	786	1.75	(351.406, 830.484)	325.442	(103.353, 619.814)	(467.954, 526.627)

Slices of Slip Surface: 786

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	786	104.1338	618.90075	0	322.3099	225.68382	0
2	786	105.7461	617.03135	0	341.85923	239.37241	0
3	786	108.45185	613.9713	0	404.00029	282.88405	0
4	786	112.20115	609.8354	0	507.92357	355.65191	0
5	786	115.4698	606.33575	0	625.98401	438.31872	0
6	786	118.2578	603.43695	0	826.73788	578.8881	0

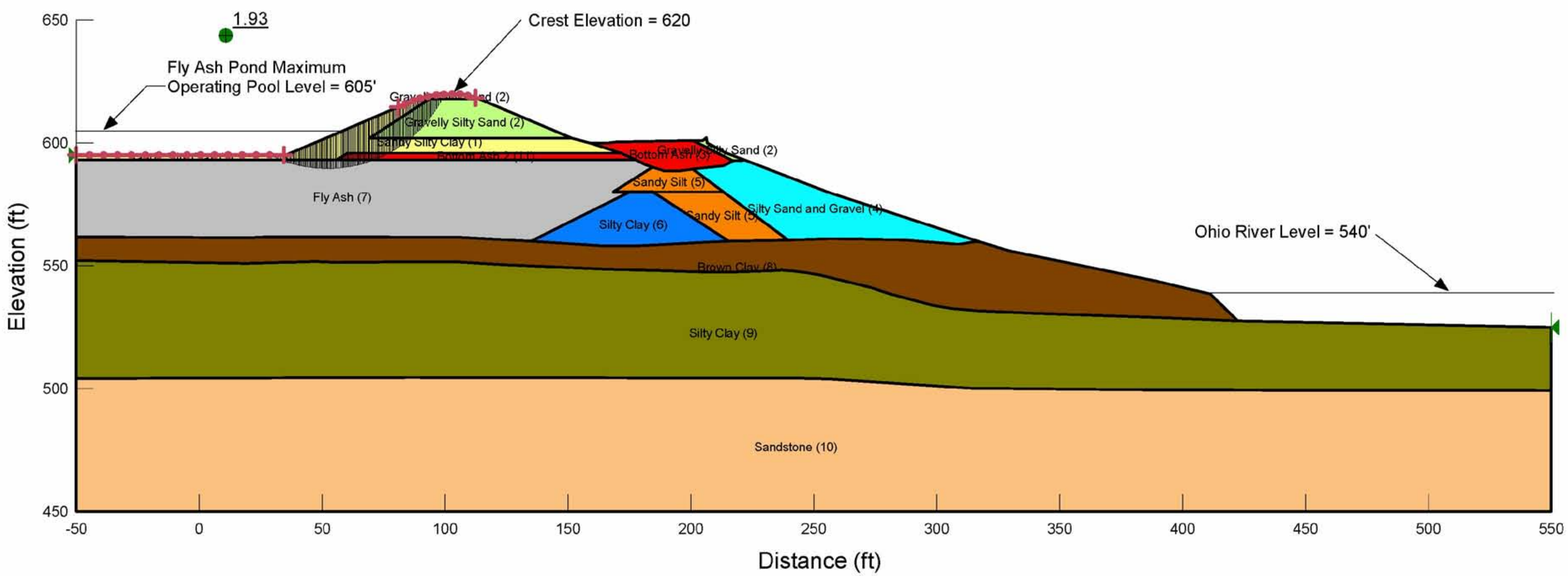
7	786	121.1934	600.46265	0	995.73727	671.63327	0
8	786	124.27655	597.4175	0	1134.0753	764.94347	0
9	786	127.28635	594.52065	0	1323.1456	826.79314	0
10	786	130.6598	591.3673	0	1537.5727	783.43243	0
11	786	134.4702	587.9047	0	1721.384	877.08896	0
12	786	138.2806	584.54985	0	2002.5422	1020.3462	0
13	786	142.09095	581.29845	0	2339.4868	1192.0281	0
14	786	145.9013	578.1465	0	2467.9751	1257.4961	0
15	786	149.7117	575.0903	0	2696.6147	1373.9938	0
16	786	153.69965	571.99275	0	2879.4022	1467.1287	0
17	786	157.32685	569.25235	0	3040.4647	1974.5009	0
18	786	160.8298	566.69	0	3209.474	2084.2568	0
19	786	164.7468	563.90375	0	3549.1168	2304.8234	0
20	786	167.68625	561.8615	0	3757.3073	2440.0239	0
21	786	169.12385	560.8819	0	3851.8653	2501.4306	0
22	786	170.7024	559.82415	0	3955.2634	2568.5781	0
23	786	172.56645	558.58695	0	4084.6249	2652.5864	0
24	786	173.46465	557.99685	0	4149.8829	3127.1611	0
25	786	174.4202	557.3768	0	4197.1963	3162.8142	0
26	786	176.1515	556.2632	0	4276.5167	3222.5865	0
27	786	177.3709	555.4857	0	4335.3323	3266.9072	0
28	786	179.5881	554.1041	0	4450.9191	3354.0081	0
29	786	183.00885	552.00285	0	4621.3418	3482.4308	0
30	786	184.9151	550.85405	0	4709.3823	3548.7741	0
31	786	187.37575	549.41315	0	4817.6228	3630.3392	0
32	786	189.5979	548.11815	0	4906.1071	3697.0169	0
33	786	191.14435	547.24185	0	4962.1186	3005.1658	170
34	786	193.88405	545.70905	0	5058.919	3063.7903	170
35	786	196.6619	544.1903	0	5153.1399	3120.8525	170
36	786	199.50675	542.67095	0	5248.6144	3178.6739	170
37	786	202.9645	540.87675	0	5354.9643	3243.0816	170
38	786	205.4183	539.62365	0	5431.461	3289.4097	170
39	786	206.1028	539.28085	0	5452.4865	3302.1432	170
40	786	206.5343	539.06585	0	5465.3064	3309.9072	170
41	786	206.81165	538.9281	0	5473.4535	3314.8413	170
42	786	208.49365	538.10525	0	5522.1162	3344.3125	170

43	786	211.73005	536.5458	0	5622.1599	3404.9011	170
44	786	213.6951	535.6146	0	5701.727	3453.0886	170
45	786	214.714	535.1417	0	5742.347	3477.689	170
46	786	216.1711	534.4718	0	5800.3278	3512.8034	170
47	786	217.1126	534.0424	0	5839.2108	3536.3518	170
48	786	219.7894	532.8566	0	5953.3114	3605.4535	170
49	786	224.17895	530.9487	0	6148.6734	3723.769	170
50	786	227.9846	529.3606	0	6306.0005	3819.0497	170
51	786	231.79025	527.82865	0	6446.0948	3903.8938	170
52	786	235.34175	526.44725	0	6576.416	3982.8191	170
53	786	238.30235	525.3316	0	6651.8863	4028.5255	170
54	786	240.9009	524.38085	0	6709.5131	4063.4256	170
55	786	244.4804	523.11875	0	6818.1486	4129.2176	170
56	786	248.2429	521.8299	0	6922.4462	4192.3824	170
57	786	251.1821	520.863	0	6964.5222	4217.8646	170
58	786	254.0405	519.95185	0	7016.2324	4249.1814	170
59	786	257.61735	518.85785	0	7081.8737	4288.9352	170
60	786	261.48575	517.71625	0	7115.9264	4309.5582	170
61	786	264.84645	516.76955	0	7147.7908	4328.856	170
62	786	268.2071	515.86155	0	7171.0674	4342.9528	170
63	786	271.56775	514.99195	0	7143.0014	4325.9554	170
64	786	273.47085	514.5118	0	7131.1112	4318.7544	170
65	786	275.53965	514.01435	0	7121.335	4312.8338	170
66	786	279.2318	513.1519	0	7094.7871	4296.7558	170
67	786	282.70385	512.38085	0	7055.5087	4272.9679	170
68	786	285.95575	511.69585	0	7035.1577	4260.643	170
69	786	289.3016	511.02765	0	6996.0484	4236.9575	170
70	786	292.74135	510.3781	0	6929.3462	4196.5612	170
71	786	296.18105	509.76675	0	6871.8135	4161.7182	170
72	786	299.8505	509.1578	0	6820.6554	4130.7357	170
73	786	303.74965	508.5564	0	6775.0695	4103.1279	170
74	786	306.57285	508.1463	0	6754.7574	4090.8265	170
75	786	308.7102	507.85755	0	6734.8229	4078.7537	170
76	786	311.37975	507.5161	0	6693.0416	4053.4501	170
77	786	314.1915	507.18005	0	6646.3013	4025.1431	170
78	786	315.99395	506.9748	0	6617.5148	4007.7094	170

79	786	316.93555	506.87335	0	6601.6454	3998.0986	170
80	786	319.4744	506.6187	0	6561.5796	3973.8338	170
81	786	323.462	506.25025	0	6504.0829	3939.0126	170
82	786	327.44965	505.93125	0	6449.2088	3905.7797	170
83	786	330.99945	505.68635	0	6396.2787	3873.7241	170
84	786	334.11135	505.5058	0	6348.1724	3844.5898	170
85	786	337.22325	505.3551	0	6300.0701	3815.458	170
86	786	340.53225	505.2286	0	6248.4607	3784.2023	170
87	786	344.0384	505.1303	0	6191.0394	3749.4267	170
88	786	347.54455	505.0698	0	6130.5881	3712.8162	170
89	786	351.05065	505.0471	0	6071.121	3676.8016	170
90	786	354.6039	505.0629	0	6010.6432	3640.1749	170
91	786	358.2043	505.1182	0	5946.0323	3601.0451	170
92	786	361.80475	505.21335	0	5874.3384	3557.6258	170
93	786	365.4052	505.3484	0	5793.9244	3508.9254	170
94	786	369.00565	505.5234	0	5701.5028	3452.9529	170
95	786	372.6061	505.73845	0	5598.2326	3390.4102	170
96	786	376.2065	505.99355	0	5494.9696	3327.8719	170
97	786	379.80695	506.2888	0	5385.9358	3261.8387	170
98	786	383.4074	506.6244	0	5266.4849	3189.4966	170
99	786	387.0078	507.00045	0	5136.411	3110.7211	170
100	786	389.3426	507.26135	0	5048.3572	3057.3938	170
101	786	391.87275	507.57415	0	4946.4348	2995.6674	170
102	786	395.8638	508.0994	0	4775.8116	2892.3343	170
103	786	399.85485	508.675	0	4608.2184	2790.8363	170
104	786	403.5921	509.2584	0	4432.2915	2684.2912	170
105	786	406.8324	509.8004	0	4277.3217	2590.4381	170
106	786	409.8296	510.33285	0	4135.9748	2504.8354	170
107	786	413.20765	510.96985	0	3968.824	2403.6053	170
108	786	416.96655	511.71995	0	3769.0233	2282.6016	170
109	786	420.7255	512.51625	0	3551.1458	2150.6503	170
110	786	424.4945	513.36145	0	3318.6097	2009.8215	170
111	786	428.27355	514.2562	0	3072.9451	1861.0417	170
112	786	432.0526	515.19885	0	2783.0688	1685.4864	170
113	786	435.83165	516.18975	0	2538.4434	1537.336	170
114	786	439.61075	517.22935	0	2315.7075	1402.4423	170

115	786	443.3898	518.31815	0	2111.8829	1279.0018	170
116	786	447.16885	519.4567	0	1920.0946	1162.8507	170
117	786	450.9479	520.64555	0	1740.9623	1054.3643	170
118	786	454.72695	521.8852	0	1613.5779	977.21751	170
119	786	458.50605	523.17635	0	1531.1394	927.29099	170
120	786	462.2851	524.51965	0	1443.3684	874.13496	170
121	786	466.06415	525.9157	0	1348.5208	816.69322	170

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section M-M Upstream Slope Stability Analysis
File Name: FAP_M-M_Slope_US.gsz
Date: 7/23/2010



Newmark Deformation

File Information

Title: Philip Sporn Fly Ash Disposal Facility
Comments: Section M-M Upstream Slope Stability Analysis
Revision Number: 94
Last Edited By: Seth Frank
Date: 7/23/2010
Time: 11:14:44 AM
File Name: FAP_M-M_Slope_US.gsz
Directory: P:\Frank\Philip Sporn\SEISMIC REPORT\Updated Analysis Files\Stability\
Last Solved Date: 7/23/2010
Last Solved Time: 12:22:13 PM

Project Settings

Length(L) Units: feet
Time(t) Units: Seconds
Force(F) Units: lbf
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D

Analysis Settings

Newmark Deformation

Kind: SLOPE/W
Parent: Dynamic QUAKE/W
Method: QUAKE/W Newmark Deformation
Settings
- Initial Stress: Parent Analysis
- PWP Conditions Source: Parent Analysis

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack
  - Tension Crack Option: (none)

FOS Distribution

FOS Calculation Option: Constant

Time

Starting Time: 0 sec

Duration: 5.125 sec

# of Steps: 1025

Advanced

Number of Slices: 100

Optimization Tolerance: 0.01

Minimum Slip Surface Depth: 10 ft

Optimization Maximum Iterations: 2000

Optimization Convergence Tolerance: 1e-007

Starting Optimization Points: 8

Ending Optimization Points: 16

Complete Passes per Insertion: 1

Driving Side Maximum Convex Angle: 5 °

Resisting Side Maximum Convex Angle: 1 °

Materials

Sandy Silty Clay (1)

Model: Mohr-Coulomb

Unit Weight: 130 pcf

Unit Wt. Above Water Table: 125 pcf

Cohesion: 0 psf

Phi: 34 °

Phi-B: 0 °

Gravelly Silty Sand (2)

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Unit Wt. Above Water Table: 125 pcf

Cohesion: 0 psf

Phi: 35 °

Phi-B: 0 °

Bottom Ash (3)

Model: Mohr-Coulomb

Unit Weight: 90 pcf

Unit Wt. Above Water Table: 65 pcf

Cohesion: 0 psf

Phi: 36 °

Phi-B: 0 °

Silty Sand and Gravel (4)

Model: Mohr-Coulomb

Unit Weight: 120 pcf

Unit Wt. Above Water Table: 115 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °

Sandy Silt (5)

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Unit Wt. Above Water Table: 125 pcf
Cohesion: 0 psf
Phi: 34 °
Phi-B: 0 °

Silty Clay (6)

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Unit Wt. Above Water Table: 125 pcf
Cohesion: 0 psf
Phi: 33 °
Phi-B: 0 °

Fly Ash (7)

Model: Mohr-Coulomb
Unit Weight: 110 pcf
Unit Wt. Above Water Table: 110 pcf
Cohesion: 0 psf
Phi: 27 °
Phi-B: 0 °

Brown Clay (8)

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Unit Wt. Above Water Table: 120 pcf
Cohesion: 0 psf
Phi: 37 °
Phi-B: 0 °

Silty Clay (9)

Model: Mohr-Coulomb
Unit Weight: 126 pcf
Unit Wt. Above Water Table: 122 pcf
Cohesion: 170 psf
Phi: 31.2 °
Phi-B: 0 °

Sandstone (10)

Model: Bedrock (Impenetrable)

Bottom Ash 2 (11)

Model: Mohr-Coulomb
Unit Weight: 90 pcf
Unit Wt. Above Water Table: 65 pcf
Cohesion: 0 psf
Phi: 32 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-49.97913, 595.11744) ft
Left-Zone Right Coordinate: (34.47473, 595.10756) ft
Left-Zone Increment: 15
Right Projection: Range
Right-Zone Left Coordinate: (80.99733, 614.60052) ft
Right-Zone Right Coordinate: (112.54302, 618.39237) ft
Right-Zone Increment: 10
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-49.97913, 595.11744) ft
Right Coordinate: (550, 524.91002) ft

Regions

	Material	Points	Area (ft^2)
Region 1	Sandy Silty Clay (1)	106,1,2,107	171.07469
Region 2	Sandy Silty Clay (1)	1,108,3,4,5,6,7,8,9,10,11,12,2	962.07207
Region 3	Gravelly Silty San	5,13,14,15,6	31.119887

	d (2)		
Region 4	Gravelly Silty Sand (2)	7,8,15,6	819.48221
Region 5	Bottom Ash (3)	9,16,17,18,19,20,21,22,23,24,25,26,10	423.64067
Region 6	Gravelly Silty Sand (2)	18,27,28,29,30,31,19	32.648671
Region 7	Sandy Silt (5)	24,32,33,34,35,21,22,23	282.19505
Region 8	Silty Sand and Gravel (4)	21,20,19,31,36,37,38,39,40,41,42,43,44,45,35	1565.2892
Region 9	Sandy Silt (5)	34,35,45,46	531.21818
Region 10	Silty Clay (6)	34,46,47,48,49,50,51,52,53,33	989.52619
Region 11	Fly Ash (7)	54,55,56,57,58,59,60,53,33,32,24,25,26,12,2,107	6796.1273
Regio	Brown	54,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,109,91,92,93,94,37,38,39,40,41,42,43,44,45,46,47,48,49,5	6482.6655

n 12	Clay (8)	0,51,52,53,60,59,58,57,56,55	
Region 13	Silty Clay (9)	89,95,96,97,98,99,100,101,102,103,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88	22793.126
Region 14	Sandstone (10)	103,104,105,96,97,98,99,100,101,102	31301.229
Region 15	Bottom Ash 2 (11)	10,26,12,11	324.85555

Points

	X (ft)	Y (ft)
Point 1	35.36015	595.10746
Point 2	35.37077	593.10938
Point 3	60.72629	605.9827
Point 4	74.8905	612.04606
Point 5	89.08286	617.98267
Point 6	93.72016	617.98376
Point 7	69.42633	602.00461
Point 8	151.61692	602.00605
Point 9	158.87128	599.99208
Point 10	171.82425	595.91741
Point 11	60.47732	595.91216
Point 12	56.0411	593.12487
Point 13	95.74708	619.48275
Point 14	106.57718	619.95406
Point 15	114.07579	617.99114
Point 16	166.70528	600.0213
Point 17	169.58045	600.43082
Point 18	200.94364	600.90024

Point 19	217.30273	592.80917
Point 20	213.38189	590.83858
Point 21	200.88583	589.29528
Point 22	195.25394	588.59744
Point 23	189.42126	588.62008
Point 24	184.5	590.20374
Point 25	181.51772	591.16693
Point 26	177.65846	593.12697
Point 27	204.98541	600.97594
Point 28	206.35442	602.21331
Point 29	206.71422	599.99306
Point 30	214.00828	595.98847
Point 31	222.27612	592.82454
Point 32	168.66722	580.09858
Point 33	175.21974	580.09858
Point 34	184.51087	580.09817
Point 35	213.24737	580.09272
Point 36	255.42934	580.07172
Point 37	317.48058	559.92079
Point 38	315.59736	559.88781
Point 39	309.9739	558.80103
Point 40	307.4465	558.76312
Point 41	287.58173	560.34006
Point 42	273.69358	560.81173
Point 43	259.80542	560.94275
Point 44	255.45555	560.94275
Point 45	239.61428	560.44981
Point 46	215.41971	560.03735
Point 47	206.90911	559.67804
Point 48	185.33019	558.38907
Point 49	177.08328	558.01754
Point 50	173.62075	558.106
Point 51	169.80438	558.01754
Point 52	164.66112	558.14391
Point 53	135.13429	560.09691
Point 54	-50	561.74545

Point 55	20.16974	561.49271
Point 56	28.34588	561.72018
Point 57	50.65765	561.88173
Point 58	61.94724	561.81622
Point 59	89.85457	561.6852
Point 60	105.36228	561.59785
Point 61	-50	552.17166
Point 62	19.23461	550.94335
Point 63	32.24565	551.32246
Point 64	41.85988	551.67124
Point 65	47.10676	551.74706
Point 66	56.64516	551.4741
Point 67	78.08761	551.61058
Point 68	95.40534	551.48927
Point 69	105.51999	551.66113
Point 70	114.75208	551.07983
Point 71	124.43302	550.29735
Point 72	142.61209	549.56582
Point 73	165.69351	548.62684
Point 74	187.96697	548.08092
Point 75	205.85125	547.44765
Point 76	216.92246	547.535
Point 77	233.69307	548.10276
Point 78	236.99041	548.14643
Point 79	242.18755	547.92806
Point 80	246.77327	547.31663
Point 81	252.65171	546.21606
Point 82	273.24811	541.09055
Point 83	281.07788	538.66929
Point 84	297.9009	534.10978
Point 85	305.69923	532.66332
Point 86	316.39049	531.68853
Point 87	338.77924	530.77663
Point 88	389.87718	528.88993
Point 89	422.60496	527.57608
Point 90	411.3282	538.58079

Point 91	401.8504	540.81657
Point 92	388.80805	543.92059
Point 93	352.80366	551.31013
Point 94	329.44346	556.01129
Point 95	550	524.91002
Point 96	550	499.15439
Point 97	396.01919	499.3174
Point 98	313.20998	500.09985
Point 99	256.3846	503.93603
Point 100	240.95296	504.37072
Point 101	191.37067	504.40695
Point 102	86.37793	504.45549
Point 103	-50	504.13087
Point 104	-50	449.97963
Point 105	550	450.03403
Point 106	-49.97913	595.11744
Point 107	-49.96913	593.10625
Point 108	58.47531	605
Point 109	405.33383	539.99484

Critical Slip Surfaces

	Slip Surface	FOS	Center (ft)	Radius (ft)	Entry (ft)	Exit (ft)
1	1767	1.93	(52.244, 642.12)	52.513	(99.7095, 619.655)	(28.8445, 595.108)

Slices of Slip Surface: 1767

	Slip Surface	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
1	1767	29.222985	594.9236	0	761.49572	513.63535	0
2	1767	29.98002	594.5618	0	814.36155	549.2938	0
3	1767	30.737055	594.21465	0	868.67703	585.93005	0
4	1767	31.494085	593.88185	0	923.98857	623.23816	0
5	1767	32.251115	593.56315	0	978.01031	659.67628	0
6	1767	33.00815	593.2583	0	1030.7221	695.2308	0

7	1767	33.71558	592.98525	0	1075.8324	548.164	0
8	1767	34.373405	592.7422	0	1113.1877	567.19748	0
9	1767	35.031235	592.50905	0	1149.2066	585.54999	0
10	1767	35.721845	592.275	0	1185.822	604.20651	0
11	1767	36.439925	592.04265	0	1222.8267	623.06131	0
12	1767	37.152695	591.82325	0	1258.2447	641.10767	0
13	1767	37.865465	591.61485	0	1292.3744	658.49764	0
14	1767	38.578235	591.41735	0	1325.1849	675.21545	0
15	1767	39.291005	591.2306	0	1356.6877	691.26691	0
16	1767	40.003775	591.05445	0	1386.8416	706.63111	0
17	1767	40.716545	590.8888	0	1417.0719	722.03421	0
18	1767	41.429315	590.7336	0	1449.0971	738.35184	0
19	1767	42.142085	590.58875	0	1479.6162	753.90212	0
20	1767	42.854855	590.45415	0	1509.0185	768.88333	0
21	1767	43.567625	590.32965	0	1537.1453	783.21466	0
22	1767	44.280395	590.21525	0	1563.8376	796.81504	0
23	1767	44.993165	590.1109	0	1589.2143	809.74513	0
24	1767	45.705935	590.0165	0	1613.2584	821.99622	0
25	1767	46.418705	589.932	0	1641.3907	836.33034	0
26	1767	47.131475	589.85735	0	1668.0341	849.90584	0
27	1767	47.844245	589.79255	0	1693.3106	862.78484	0
28	1767	48.557015	589.7375	0	1717.2043	874.95929	0
29	1767	49.269785	589.69215	0	1739.7002	886.42154	0
30	1767	49.982555	589.65655	0	1760.7847	897.16463	0
31	1767	50.695325	589.6307	0	1780.5851	907.25344	0
32	1767	51.408095	589.6145	0	1799.2305	916.75373	0
33	1767	52.120865	589.608	0	1816.71	925.65996	0
34	1767	52.833635	589.6112	0	1833.0144	933.9675	0
35	1767	53.546405	589.62405	0	1847.9941	941.60001	0
36	1767	54.259175	589.64655	0	1861.5009	948.48206	0
37	1767	54.971945	589.67875	0	1873.5279	954.61015	0
38	1767	55.684715	589.7207	0	1884.2094	960.05264	0
39	1767	56.4468	589.7767	0	1898.2461	967.20467	0
40	1767	57.258205	589.8482	0	1920.9255	978.76045	0
41	1767	58.06961	589.9324	0	1942.2054	989.60308	0
42	1767	58.80898	590.0197	0	1960.561	998.95573	0

43	1767	59.476315	590.1081	0	1976.2309	1006.9399	0
44	1767	60.14365	590.2053	0	1991.3534	1014.6452	0
45	1767	60.601805	590.27615	0	2001.4711	1019.8005	0
46	1767	61.08879	590.35815	0	2011.6613	1024.9926	0
47	1767	61.813795	590.4873	0	2022.5106	1030.5206	0
48	1767	62.5388	590.62695	0	2031.242	1034.9695	0
49	1767	63.2638	590.7772	0	2038.5303	1038.6831	0
50	1767	63.988805	590.9382	0	2044.3723	1041.6597	0
51	1767	64.71381	591.11	0	2048.8992	1043.9663	0
52	1767	65.43881	591.29275	0	2051.84	1045.4647	0
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54	1767	66.88882	591.69145	0	2050.5812	1044.8233	0
55	1767	67.61382	591.90765	0	2045.7458	1042.3595	0
56	1767	68.338825	592.13535	0	2038.9643	1038.9042	0
57	1767	69.06383	592.37465	0	2030.2489	1034.4635	0
58	1767	69.85539	592.64995	0	2018.28	1028.365	0
59	1767	70.71351	592.9639	0	2002.6358	1020.3939	0
60	1767	71.51736	593.273	0	1970.4013	1231.2434	0
61	1767	72.266945	593.5755	0	1921.2023	1200.5005	0
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63	1767	73.76612	594.2213	0	1819.3456	1136.8533	0
64	1767	74.515705	594.56525	0	1766.8974	1104.08	0
65	1767	75.27461	594.92825	0	1713.2186	1070.5378	0
66	1767	76.042835	595.311	0	1658.3642	1036.261	0
67	1767	76.81106	595.7096	0	1603.056	1001.7006	0
68	1767	77.53891	596.10185	0	1562.6514	1054.0217	0
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70	1767	78.91388	596.88495	0	1504.4867	1014.7891	0
71	1767	79.601365	597.2974	0	1470.7794	992.05323	0
72	1767	80.288855	597.72435	0	1433.8972	967.17584	0
73	1767	80.97634	598.1662	0	1401.3642	945.23211	0
74	1767	81.663825	598.6234	0	1370.2817	924.26671	0
75	1767	82.35131	599.09645	0	1339.5298	903.52427	0
76	1767	83.038795	599.58585	0	1309.0939	882.99499	0
77	1767	83.726285	600.0922	0	1278.8416	862.58955	0
78	1767	84.41377	600.61615	0	1248.6444	842.22129	0

79	1767	85.101255	601.15835	0	1216.3358	820.42882	0
80	1767	85.78874	601.7195	0	1171.1368	789.94177	0
81	1767	86.50128	602.32235	0	1114.7502	780.55651	0
82	1767	87.238875	602.96945	0	1049.7243	735.02486	0
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85	1767	89.414095	605.02805	0	862.14866	603.68299	0
86	1767	90.076565	605.7041	0	797.89481	558.69196	0
87	1767	90.739035	606.40525	0	731.13862	511.94877	0
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89	1767	92.063985	607.88905	0	609.7933	426.98186	0
90	1767	92.726455	608.6753	0	570.28174	399.31557	0
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96	1767	96.922965	614.536	0	396.21808	277.43489	0
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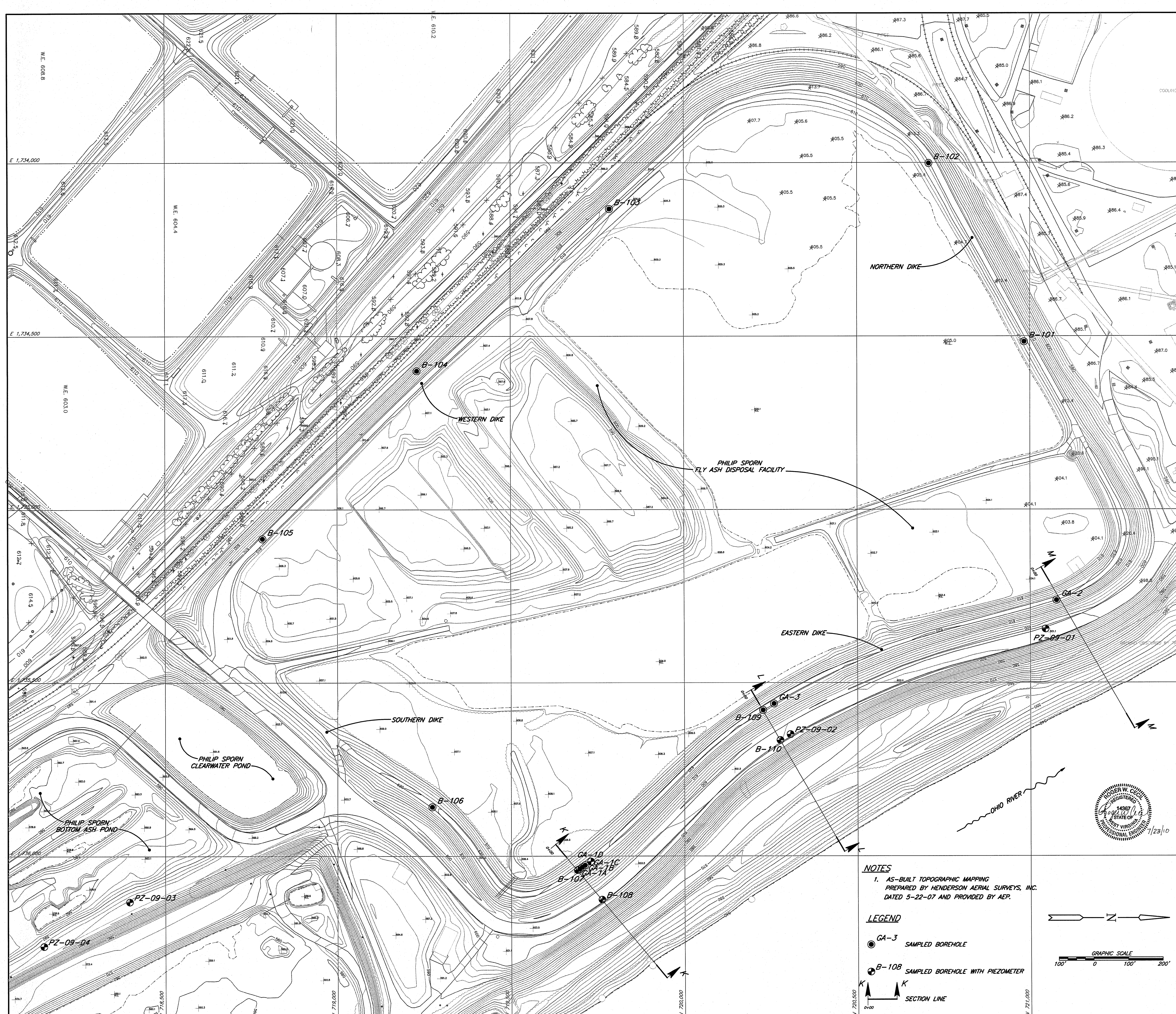
APPENDIX VI

DRAWINGS



NOTES

1. AS-BUILT TOPOGRAPHIC MAPPING PREPARED BY HENDERSON AERIAL SURVEYS, INC. DATED 5-22-07 AND PROVIDED BY AEP.

LEGEND

GA-3 SAMPLED BOREHOLE

B-108 SAMPLED BOREHOLE WITH PIEZOMETER

K K 0+00 SECTION LINE

N

GRAPHIC SCALE
100' 0 100' 200'

THESE DRAWINGS ARE PART OF A SET OF DESIGN DOCUMENTS WHICH ALSO CONTAINS A WRITTEN TEXT. THAT TEXT EXPLAINS SOME OF THE DETAILS SHOWN HEREIN AND THEREFORE THESE DRAWINGS SHOULD ONLY BE USED IN CONJUNCTION WITH THE TEXT.

DATE	REVISIONS	BY

SITE MAP

FLY ASH DISPOSAL FACILITY
PHILIP SPORN PLANT

NEW HAVEN, WEST VIRGINIA

SCALE: AS SHOWN | DR RWC | CHK RWC | REV SWF

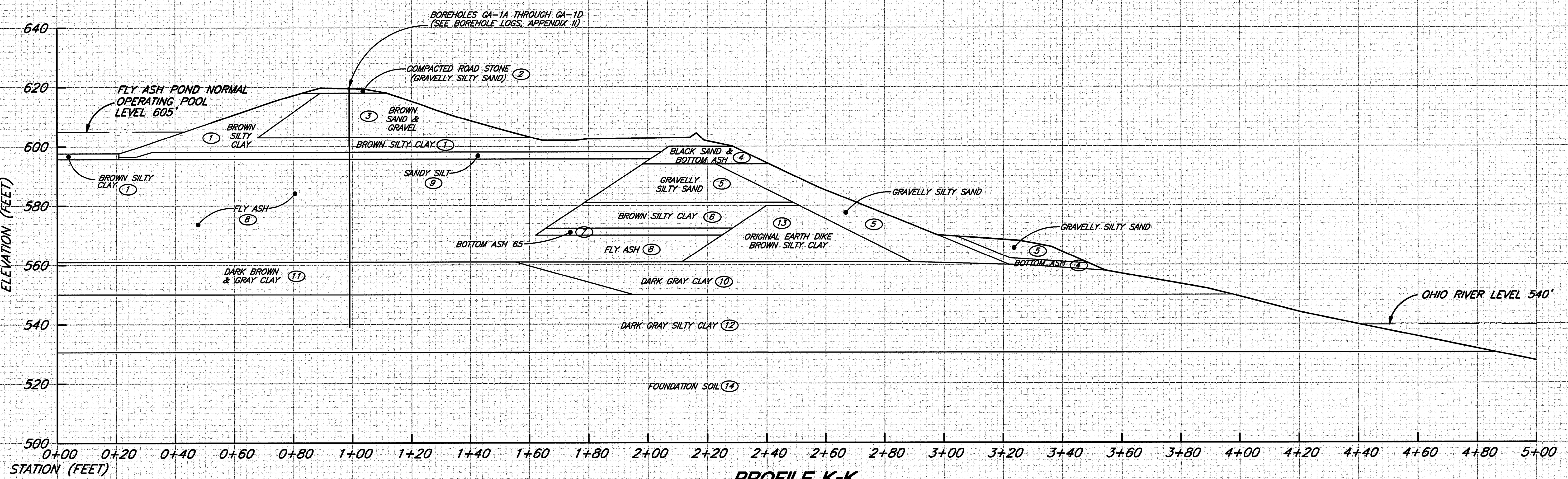
PREPARED FOR:

AMERICAN ELECTRIC POWER

PREPARED BY:

GA Geo/Environmental Associates, Inc.
3502 OVERLOOK CIRCLE • KNOXVILLE, TENNESSEE 37909 • (865) 584-0344

PROJ: 09-387 | DATE: 7-23-10 | SHEET 1 OF 2



PROFILE K-K

NOTES

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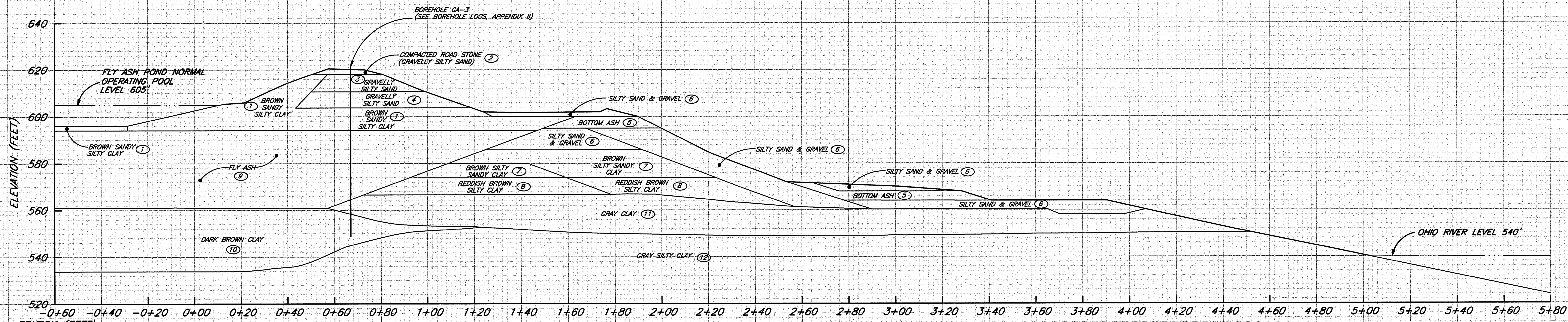
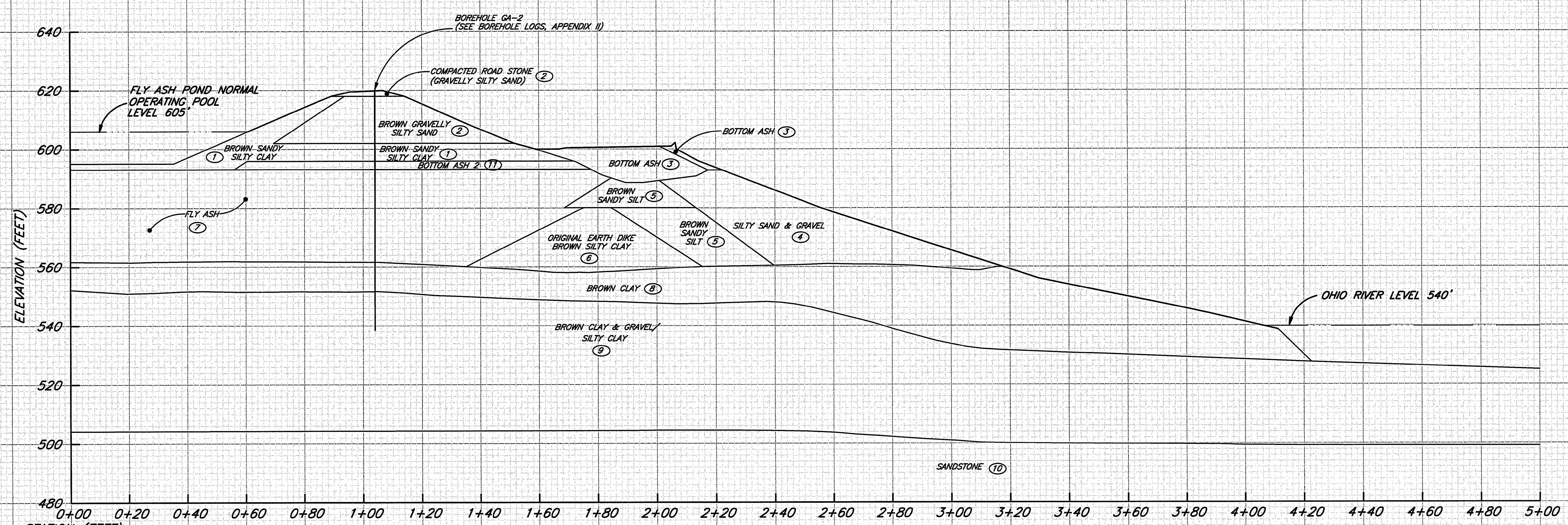


PROFILE L-L



PROFILE M-M

7/23/10

THESE DRAWINGS ARE PART OF A SET OF DESIGN DOCUMENTS WHICH ALSO CONTAINS A WRITTEN TEXT. THAT TEXT EXPLAINS SOME OF THE DETAILS SHOWN HEREIN AND THEREFORE THESE DRAWINGS SHOULD ONLY BE USED IN CONJUNCTION WITH THE TEXT.

DATE	REVISIONS	BY

EASTERN DIKE SECTIONS

FLY ASH DISPOSAL FACILITY
PHILIP SPORN PLANT
NEW HAVEN, WEST VIRGINIA

SCALE: AS SHOWN | DR RWC | CHK RWC | REV SWF

PREPARED FOR:

AMERICAN ELECTRIC POWER

PREPARED BY:

GA Geo/Environmental Associates, Inc.
3502 OVERLOOK CIRCLE • KNOXVILLE, TENNESSEE 37909 • (865) 584-0344

PROJ: 09-367 | DATE: 7-23-10 | SHEET 2 OF 2

AEPSPP004607

APPENDIX VII

REFERENCES

Procedures and Methods for a Liquefaction Assessment using GeoStudio 2007

SWF [Sporn Liquefaction Assessment_Response 1a-1r_7-23-10]

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ASTM D 2573 "Standard Test Method for Field Vane Shear Test in Cohesive Soil."

ASTM D 4318 "Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils."

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Procedures and Methods for a Liquefaction Assessment using GeoStudio 2007

1 Introduction

The purpose of this document is to highlight the key issues in a liquefaction assessment, and to outline the procedures and methods that can be used in GeoStudio 2007 to perform such an assessment.

2 Behavior of loose sands

The first and foremost requirement for doing a liquefaction assessment is to have a clear understanding of the collapsible nature of fine loose sand soils.

Research has conclusively demonstrated that loose sands can shear and fail at strengths significantly below the strength associated with conventional peak effective strength parameters c' and ϕ'. The reasons for this phenomenon are discussed below.

2.1 Stress space definitions

Most of the more recent laboratory test results on sand reported in the literature are presented in a *q-p′* stress space as illustrated in Figure 1.

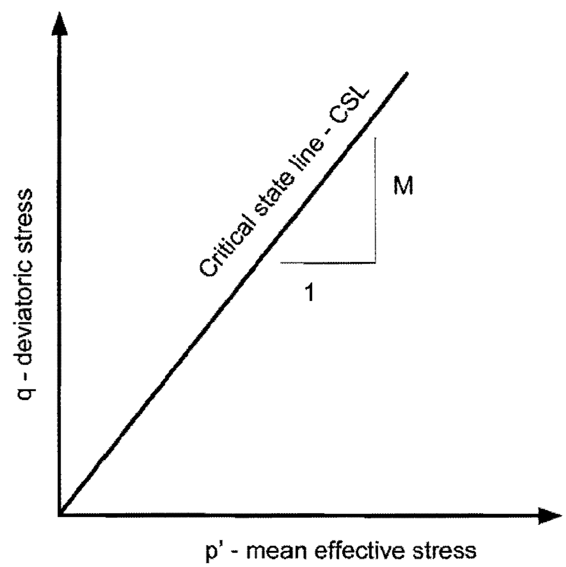

Figure 1 Stress space variables

The deviator stress q represents the shear in the soil sample. In a triaxial test setup, q is equal to $(\sigma_1 - \sigma_3)$ where σ_1 is the major principal stress and σ_3 is the minor principal stress.

The parameter p' is the mean effective stress, which is defined in terms of effective principal stress as follows:

$$p' = \frac{(\sigma_1' + \sigma_2' + \sigma_3')}{3}$$

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In a triaxial test, σ_2 is equal to σ_3 and the mean effective stress then becomes,

$$p' = \frac{(\sigma_1' + 2\sigma_3')}{3}$$

The critical state line (CSL) represents the strength developed at large strains when the shear resistance and volume remain constant with continued ongoing strain. The critical state strength is sometimes also referred to as the steady-state strength. Fundamentally, the critical-state and steady-state definitions are slightly different but for practical purposes here the two can be considered to be analogous and will consequently be used interchangeably in this discussion.

The slope of the CSL in a q-p' stress space is usually defined by the capital Greek letter M (mu). The slope M is related to the effective friction angle ϕ' by:

$$\mathrm{M} = \frac{6\sin\phi'}{3-\sin\phi'}$$

2.2 Sand grain-structure collapse

Consider an undrained triaxial test on a loose sand sample consolidated to the isotropic stress state represented by Point A in Figure 2. Upon loading the effective stress path follows a curved path with rising deviator stress until the maximum deviator stress – referred to as the collapse point – is encountered. At that point there is a sudden tendency for volumetric compression, that is, collapse, which is offset by a rapid and large increase in the pore water pressures. The rapid rise in pore pressures leads to a decrease in mean effective stress and deviator stress. The rapid decrease in the deviator stress, which can be viewed as a loss of strength, is termed liquefaction. The strength path eventually intersects the CSL, at which point the mean effective stress, deviator stress, and void ratio remain constant with further shearing.

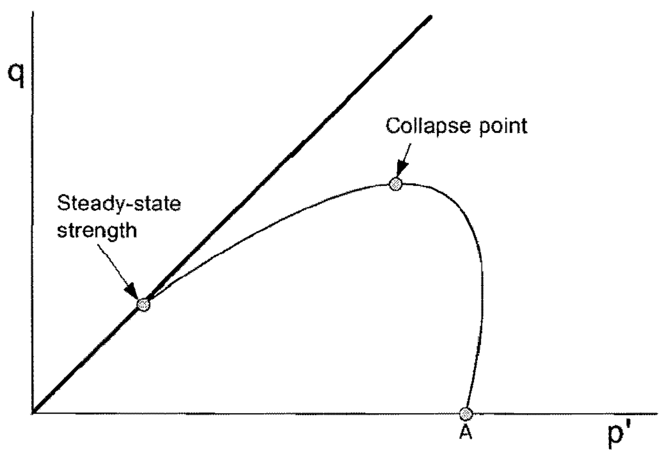

Figure 2 Effective stress path for loose sand in an undrained triaxial test

If a series of undrained triaxial tests are completed on a series of samples at the same initial void ratio the stress paths will appear as illustrated in Figure 3. A straight line can be drawn from the steady-state strength through the peaks or collapse points. Sladen, D'Hollander and Krahn (1985a) called this line a Collapse Surface.

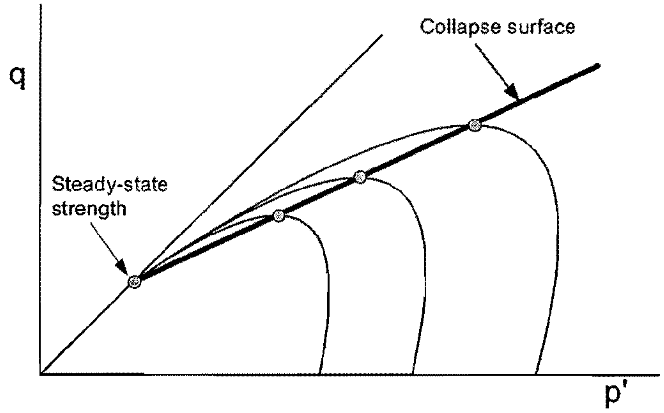

Figure 3 Collapse surface illustration

Some researchers have proposed that the collapse surface line should pass through the origin of the plot (e.g., Vaid and Chern (1983). Since flow liquefaction cannot occur below the steady-state point, the authors crop the lower end of the collapse line as illustrated in Figure 4.

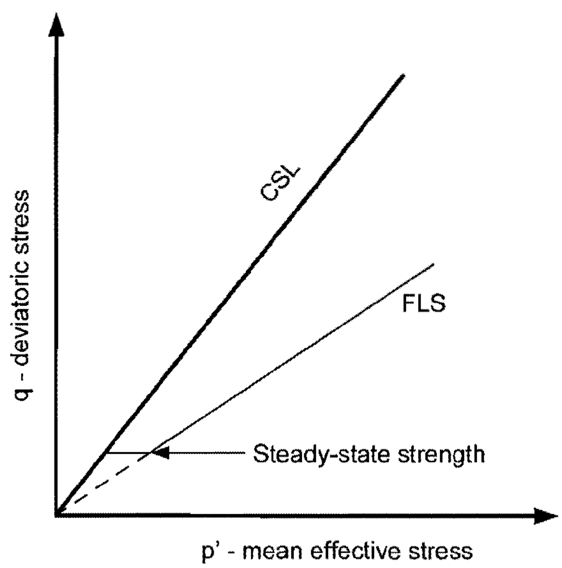

Figure 4 Definition of Flow Liquefaction Surface (FLS)

As noted, a soil can liquefy when the stress path reaches the collapse surface during undrained loading; consequently, Kramer (1996, p. 363) named the collapse surface a *flow liquefaction surface* (FSL). As discussed subsequently, other research has demonstrated that loose sands can also collapse under drained loading; however, once collapse is initiated the soil can either: a) liquefy and follow a similar stress path as shown in Figure 2 *if drainage is impeded*; or b) undergo volumetric compression if *drainage is permitted*, allowing the stress path to proceed more steadily towards the CSL. Research has shown that collapse can be initiated during drained loading for both dry and saturated soils. The FSL designation is consequently too narrow because a soil can collapse without 'flowing' (that is, liquefying). The collapse surface designation is more general.

The undrained steady-state strength of loose sand tends to be a relatively small value. Consequently, the difference between whether the collapse surface is projected through the origin or through the steady-state point on the CSL is relatively small. For practical purposes and the interpretation of field behavior the two approaches are in essence the same.

Chu et al. (2003) called the collapse line an *Instability Line* (IL). The reasons for this choice of nomenclature is rather perplexing considering that the collapse phenomenon had been adequately described by previous researches. Nonetheless, the instability line is essentially equivalent to the FLS and the collapse line.

The more general collapse surface designation and a line that passes through the steady-state point on the CSL are used here and in GeoStudio.

Drained conditions

Sasitharan et al. (1993) at the University of Alberta were able to clearly demonstrate that the sand grain-structure can collapse during fully drained loading as well as during undrained loading. Collapse can occur at a mobilized friction angle ϕ_m that is well below the conventional effective friction angle ϕ'.

The fact that collapse of a loose sand grain-structure can be initiated during fully drained loading is critical to understanding the stability of the sand slopes. The initiation of collapse during drained loading can result in: a) an undrained liquefaction type response resulting in rapid loss of strength (described previously); or b) a drained response that is characterized by a decrease in the void ratio (that is, collapse). It is tempting to conclude that scenario (b) would improve the stability of a slope because the decrease in void ratio leads to a more stable grain-structure. This, however, is not necessarily the case because collapse in one region of a slope would cause the redistribution of stresses to other regions of the slope. This would in turn promote a slope failure.

Dry sand

Skopek et al. (1994) at the University of Alberta demonstrated that collapse of a loose sand grain-structure can even occur in dry sand (Figure 5 and Figure 6). The soil specimens were loaded by decreasing the mean effective stress at a constant deviator stress.

Of great significance is the associated change in volume or void ratio. Initially, the void ratio remained relatively constant while the mean effective stress diminished (Figure 6), but then the void ratio suddenly decreased dramatically, particularly for the very loose sample. The sudden decrease in void ratio reflects the collapse in the grain-structure. After the collapse, the void ratio continues to decrease with a further reduction in the mean effective stress. This continues until the stress state reaches the CSL.

The tendency for volume change would have resulted in a dramatic and sudden increase in the pore pressures had the specimen been initially saturated and the drainage valve closed at the point of collapse. Such a condition would have triggered liquefaction.

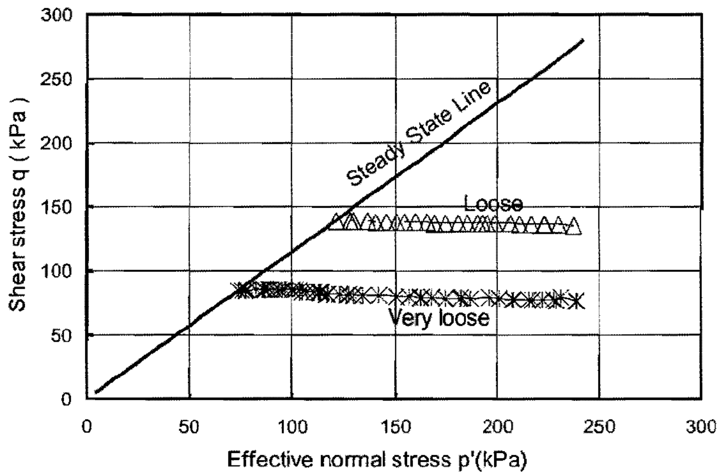

Figure 5 Tests on dry sand (after Gu and Krahn, 2002)

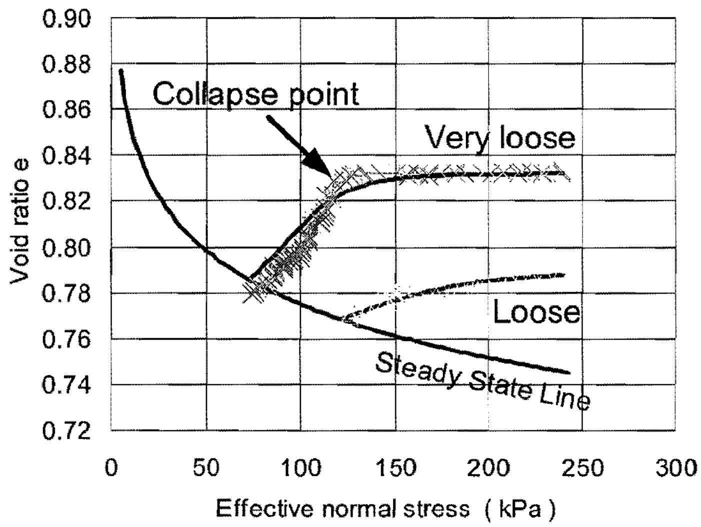

Figure 6 Tests on dry sand (after Gu and Krahn, 2002)

Cyclic or dynamic loading

The above discussion on collapse behavior has considered only monotonic (static) loading. Cyclic loading can also lead to liquefaction, as is illustrated in Figure 7. Consider a soil at Point B subject to a cyclic load. The cyclic loading causes a continuous increase in the pore pressures (and therefore decrease in mean effective stress) until the cyclic stress path intersects the collapse surface. Under saturated undrained conditions the sand can then liquefy and the strength will suddenly fall along the collapse surface to the steady-state point.

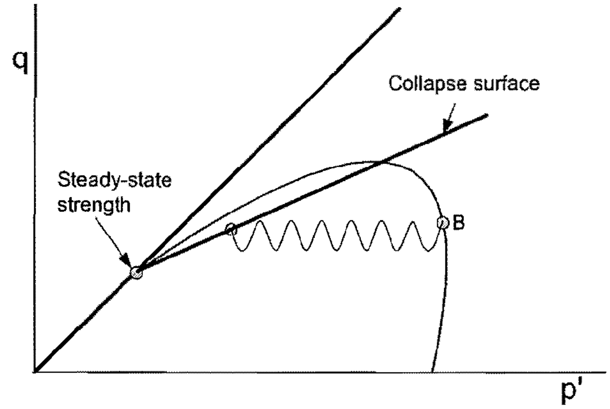

Figure 7 Cyclic stress path from B to the collapse surface

State boundary surface

Incidentally, the straight-line collapse surface defined by Sladen et al. (1985) is actually a simplification of the actual shape. Sasitharan et al. (1993) demonstrate that the collapse surface is actually curved to form a true state boundary surface. For practical purposes, however, the straight line approximation is more than adequate, particularly given the uncertainty associated with measuring or estimating the collapse surface parameters.

2.3 Required stress path

Sasitharan et al. (1993) have argued that a stress path must attempt to cross the collapse surface for the sand-grain structure to collapse (Figure 8). The stress state must therefore be on or below the collapse surface at the initiation of loading. The shortest stress path shown in Figure 8 that intersects the collapse surface is generated by decreasing the mean effective stress while maintaining constant deviator stress. Such a stress path is very similar to the path followed when an unsaturated slope becomes partially submerged. The rising water levels and associated loss of soil suction can therefore be trigger mechanism for slope instability.

In the strictest sense, a stress state cannot exist above the current collapse surface. As explained in the next section, the collapse surface can be 'dragged open' (that is, the collapse line is 'dragged' to a higher position or steeper inclination) under certain loading conditions. Such loading conditions are associated with a decrease in void ratio or with densification.

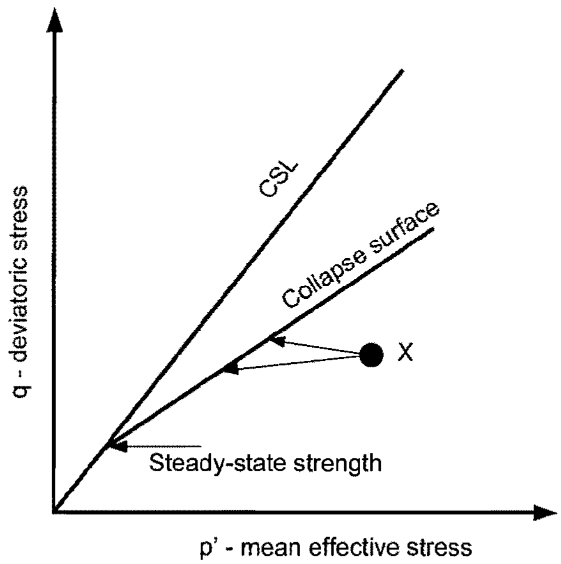

Figure 8 Illustrative stress paths from X to collapse surface for grain-structure collapse

2.4 Collapse surface parameters

The two parameters required to define the collapse surface in *q-p'* stress space are the angle of inclination of the collapse surface M_L and its intersection q_{ss} with the critical state line (the subscript *L* stands for 'liquefy'). The parameter q_{ss} represents the steady-state strength and is approximately equal to 2 x C_{ss}, where C_{ss} is the intersection of the collapse line with the Mohr-Coulomb failure line in $\tau : \sigma$ stress space. (Note: this is only strictly valid for triaxial loading conditions; however, the approximation is reasonable for the purpose of field analyses). The slope M_L is related to the friction angle ϕ_L by the relationship:

$$M_L = \frac{6 \sin \phi'_L}{3 - \sin \phi'_L}$$

Collapse surface angles

The collapse surface inclination generally increases as the initial density increases. The lowest ϕ_L values correspond with very loose sand. As the density increases the inclination increases and may approach the critical state line when the sand reaches a medium density. Chu et al. (2003) show collapse line slopes greater than the CSL for dense sands but this issue will not be addressed in this report.

Figure 9 is a graph published by Chu et al. (2003). The inclinations ϕ_L vary between 18.3 and 34.5 degrees (M_L is between 0. 7 and 1.4). The corresponding void ratios vary between 0.972 and 0.864.

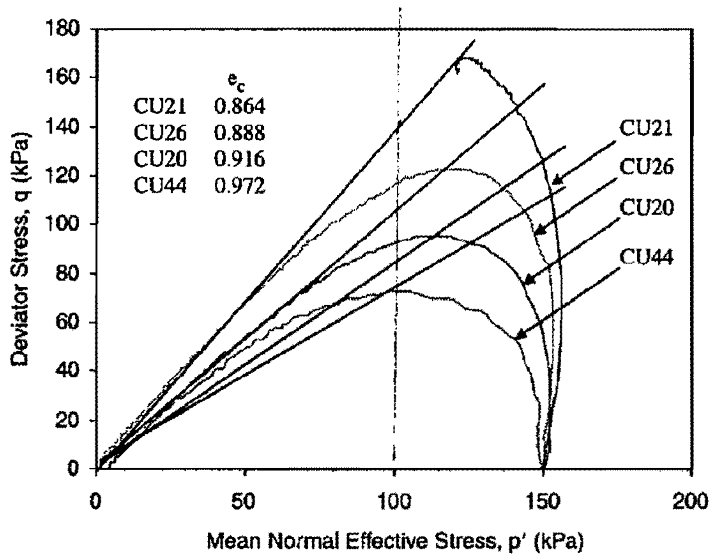

Figure 9 Collapse line inclination as a function of density (after Chu, et al. 2003)

Sladen et al. (1985a) presented the data for three different isotropically consolidated sands as shown in Table 1. The lowest ϕ_L is 14.3 degrees and the highest is 18.5 degrees.

Table 1 Table of data showing measured collapse line inclinations (after Sladen et al. 1985b)

Sand	Source	Property					
		C_{ss}	e_1	M	ϕ'_{ss} (deg.)	M_L	ϕ_L (deg.)
Nerlerk 0%	Present study	—	—	1.19	30	0.62	16.3
Nerlerk 2%	Present study	0.04	0.88	1.20	30	0.60	15.8
Nerlerk 12%	Present study	0.07	0.80	1.24	31	0.59	15.6
Leighton Buzzard	Present study	0.08	1.00	1.19	30	0.54	14.3
Leighton Buzzard	Stroud (1971)	0.06*	0.93*	1.13*	35*	—	—
Banding No. 1	Castro *et al.* (1982)	0.02	0.85	1.29	32	0.67	17.5
Banding No. 5	Castro *et al.* (1982)	0.045	0.92	1.19	30	0.71	18.5
Banding No. 6	Castro *et al.* (1982)	0.04	0.85	1.14	29	0.66	17.2
Banding No. 9	Castro *et al.* (1982)	0.03	0.85	1.06	27	—	—

*Critical state conditions measured in the simple shear apparatus.

Lade (1993) presented a summary of ϕ_L values as shown in Figure 10. Despite the scatter, there is clear evidence for the trend of increasing ϕ_L with increasing density. For relative densities less than 50 percent the range is about 15 to 25 degrees.

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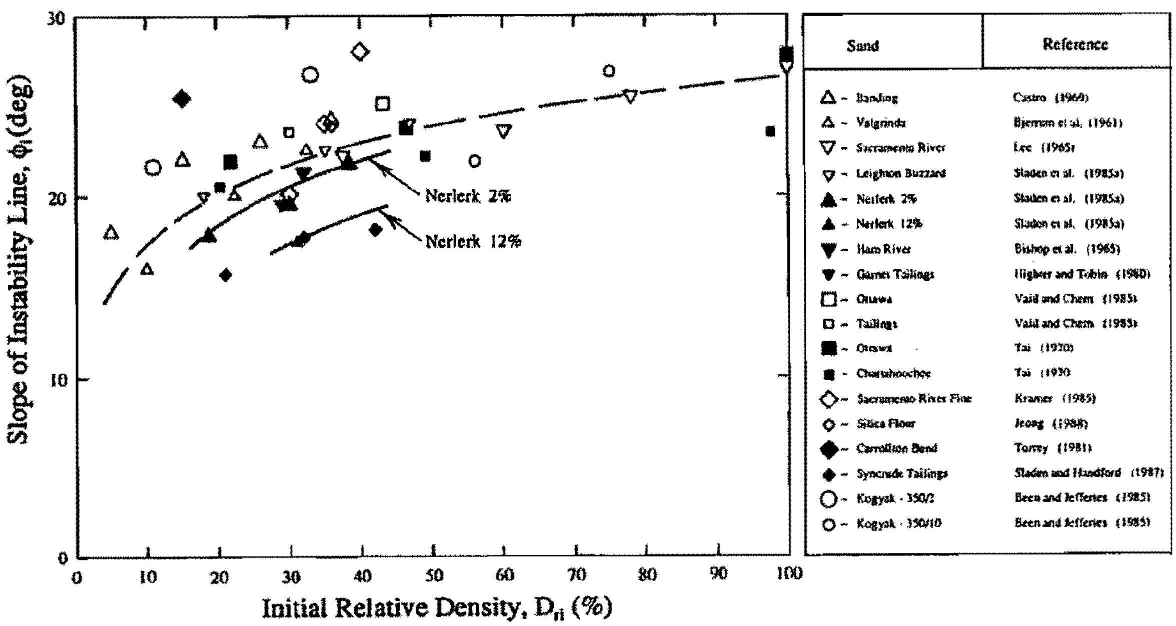


Figure 10 Range of ϕ_L for variation of initial relative density (Lade, 1993).

Kramer (1996, p. 364) makes this statement in his text book: *for 'isotropic initial conditions, the slope of the FLS (ϕ_L) is often about two-thirds the slope of the drained failure envelope for clean sand.'* These data can be used as a guide for selecting ϕ_L values.

Steady-state strengths

The steady-state strengths of loose sand tend to be relatively small. Sladen et al. (1985b) were of the view that the undrained steady-state strengths at the Nerlerk Berm failures in the Beaufort Sea were less than about 2 kPa. This was based on back analyses of the failures and the eventual very flat slopes of the sliding mass.

The data presented in Figure 9, also suggests that the steady-state strength for loose clean sands is very low as the curves tend to converge near the origin of the graph.

Castro el al. (1992), as part of a re-evaluation of the liquefaction failure that occurred at the Lower San Fernando Dam in 1971, concluded that the undrained steady-state strength for the hydraulic fill in the dam was likely in the range of 20 to 30 kPa. This relatively high value is likely reflective of the significant fines content in the hydraulic fill.

The published information on the steady-state strength is rather meager and not sufficient to select a value for stability analyses with any confidence. Fortunately, stability analyses are not all that sensitive to the steady-state strength parameter. The analyses are much more sensitive to the inclination of the collapse surface, which can be estimated more accurately.

Effect of fines content

The amount of fines (silt and clay) in the sand can have a significant effect on the potential liquefaction of the sand. Sladen et al. (1985b) concluded: *"the potential for liquefaction is much lower for clean sand* *than for dirty sand, all else being equal"*. They go on to state: "*a high fines content will also reduce permeability and increase compressibility making an undrained response to any given loading condition more likely*".

More recently, Seid-Karbasi and Byrne (2007) have investigated the effect of silty-clayey layers on the liquefaction behavior of sands. They have shown that these types of layers can act as barrier to the dissipation of excess pore-pressure associated with the collapse of the sand grain structure and thereby contribute to the potential instability. The inference is that in the absence of such impeding layers the excess pore pressure could likely dissipate faster and the sand would fail more in a drained manner than in an undrained manner. The outwash sand can be stratified with layers of varying fines content. This stratification can played an important role in the behavior of the sand and the resulting stability of earth structures.

2.5 Case histories

The concept of a collapsible sand grain-structure has provided the basis for a rational explanation for the failure of various earth structures. The following sections briefly highlight the key aspects of three case histories.

Nerlerk Berm

In the early 1980's artificial sand islands were constructed in the Beaufort Sea to facilitate hydrocarbon exploration. Construction of the Nerlerk berm started in 1982 at a location where the sea depth was about 45 m. The berm was initially constructed by dumping sand from barges. More sand was later added on the berm via hydraulic methods. The sand was dredged from the seabed and pumped through a floating pipeline.

The sand placement caused at least five side-slope failures as illustrated in Figure 11. Subsequent studies by Sladen et al. (1985a, 1985b) provided the collapse surface rational for the slope failures. Ultimately, it was concluded that the failures were the result of liquefaction in the sand due to the static loading resulting from the hydraulically placed sand.

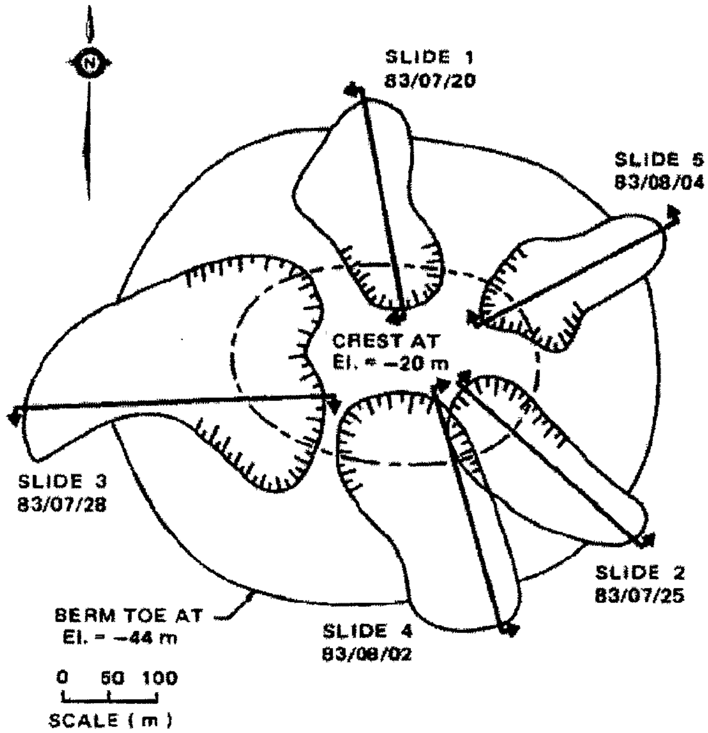


Figure 11 Beaufort Sea Nerlerk Berm liquefaction slope failures (after Sladen et al. 1985b)

Hill-side mine waste dumps

There have been numerous hill-side waste dump slope failures at open-pit coal mining operations in the Canadian Rocky Mountains, some with very large run-out distances (Dawson et al. 1998). The following two figures (Figure 12 and Figure 13) illustrate the Cougar 7 dump failure at the Greenhills Mine located near Elkford, British Columbia. Of significance is the very long run-out distance relative to the dump size.

Dawson et al (1998) did an extensive study of these dump failures and came to the conclusion that the dumping process created layers of fine sediments at the base of the dump and/or within the dump. These fine layers became saturated due to hill-side seepage or infiltration. The subsequent dumping caused further static loading of these fine-sediment layers, which in turn caused the grain-structure to collapse. Furthermore, the authors demonstrate that the strength mobilized in the fine-grained layers at the point of collapse was significantly less than the peak c' and ϕ' strength parameters. The large run-out distances are attributed to the excess pore-pressures that developed subsequent to the grain-structure collapse.

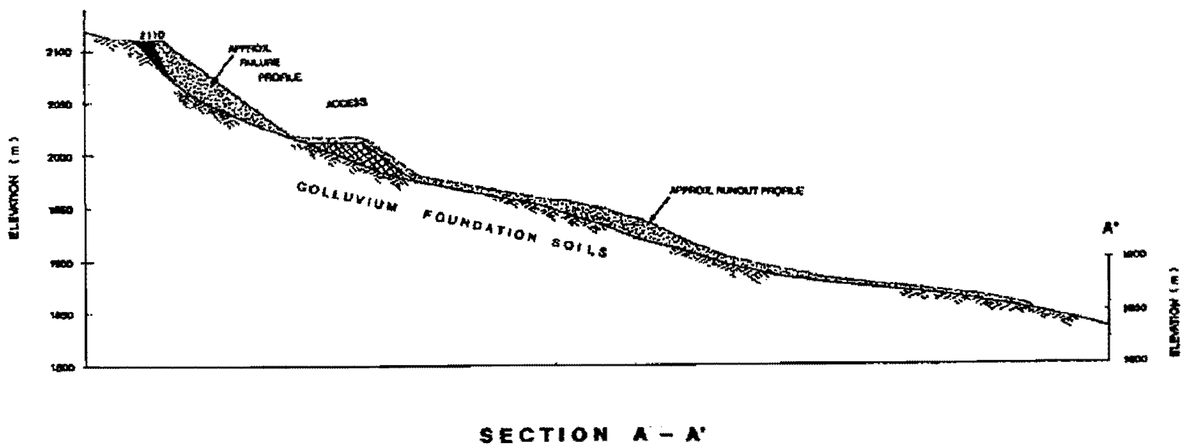


Figure 12 Profile of the Cougar 7 dump failure at the Greenhills Mine (after Dawson et al, 1998)

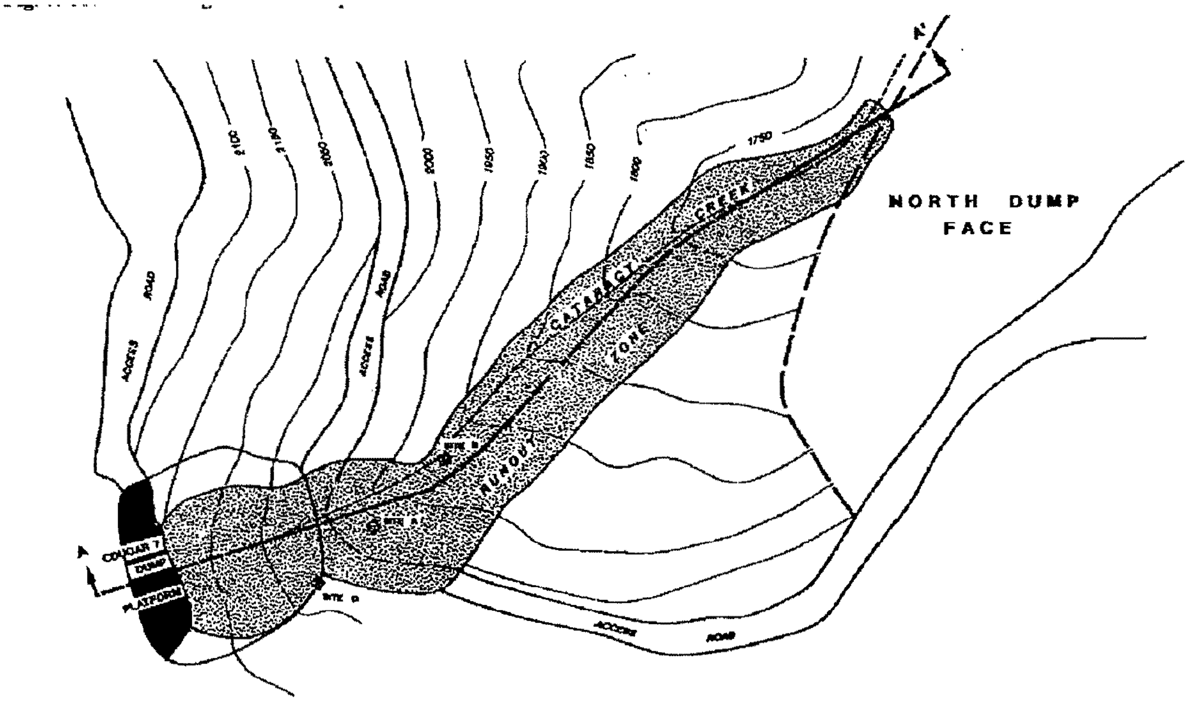


Figure 13 Plan view of run-out at the Cougar 7 dump failure at the Greenhills Mine (after Dawson et al 1998)

Coal stockpiles

Dramatic flow-like slope failures have occurred in stockpiles of coking coal at a north Australian coal export terminal. Some of the slips have flowed up to 60 m beyond the original stockpile toe when the dumps where 10 to 14 m high (Eckersley, 1990). The failures occurred after the coal became saturated (or nearly saturated) due to heavy rainfall. Eckersley (1990) also concluded that the failures were initiated under essentially static drained conditions at a mobilized strength much less than what would be represented by conventional peak effective stress strength parameters c' and ϕ'. The resulting initial movements lead to the rapid generation of excess pore-pressures and the accompanying strength loss that caused the sudden acceleration of the sliding mass. Eckersley's explanation of why the failures occurred is entirely consistent with the concepts associated with a sand grain-structure collapse.

2.6 Commentary and summary

The fact that loose sands can have a collapsible grain-structure has now been well established. It is not only a laboratory observed phenomena but supported by observed field behavior.

When the grain-structure collapses, the mobilized shear strength can be well below the conventional peak effective strength parameters c' and ϕ'.

Under undrained conditions, the pore-pressures can rise sharply at the point of collapse and the strength fall down suddenly to low undrained steady state strength. This sudden rise in pore-pressure and associated strength loss can manifest itself in liquefaction.

The concept of a collapse surface is a highly useful tool for assessing the liquefaction potential of earth structures.

3 Stress state regions

When interrupting the results of a GeoStudio analysis it can be useful to think of the q-p′ space in terms of regions. It helps to understand why certain elements are marked as liquefiable and others are not.

3.1 Liquefiable region

The shaded region in Figure 14 is the region where the sand grain structure can collapse and under undrained condition the strength can suddenly fall down to the steady-state strength.

Any stress state with a q-p′ ratio in this region could potential move onto collapse surface and potentially liquefy. Any increase in pore-pressure, from earthquake shaking for example, would cause p′ to diminish and the stress state point could move to the left unto the collapse surface. Additional external static loading could also cause the shear stress (q) to increase and thereby move onto the collapse surface.

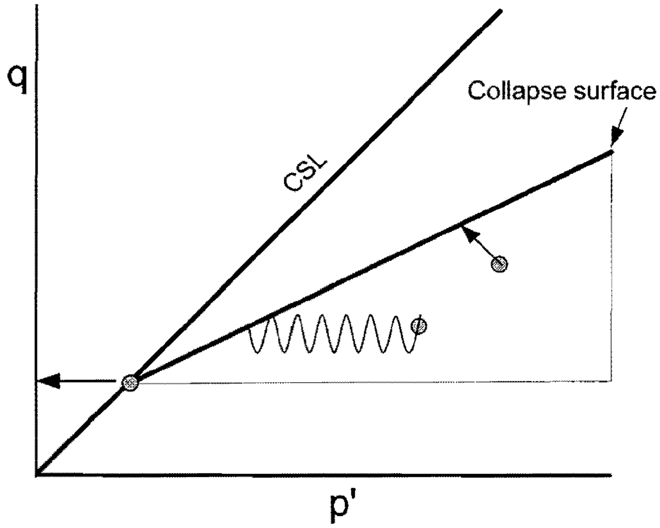


Figure 14 Potentially liquefiable region

Any stress state points in GeoStudio based on static stress that fall in this region are not marked as liquefied prior to an earthquake analysis but may be marked as liquefied during the earthquake shaking as the pore-pressures increase.

Any stress state points that fall into this region are of the greatest interest as far as assessing the potential for liquefaction.

3.2 Low shear stress region

Stress state points where the deviatoric stress is less than q_{ss} can develop excess pore-pressures due to cyclic loading causing p' to move to the right as illustrated in Figure 15. The increase in pore-pressures can be sufficient for the stress state to reach the CSL but the sand grain-structure will not collapse and suddenly loose strength. In fact as the stress state approaches the critical state line, the sand begins to dilate and the ultimate steady state strength lands up at q_{ss}. There is more to the details of the sand behavior when this happens but the details are beyond what is required for the discussion here. Currently, GeoStudio does not attempt to account for this possibility of dilation and the effect this has on the resulting excess pore-pressure

Suffice it to say here, that stress state points below the CSL line but with q is less than q_{ss}, can develop excess pore-pressures during cyclic loading but the strength will not be less than what is described by conventional peak strength parameters c' and ϕ'.

State points that fall in this region are **not** marked as liquefied or liquefiable in GeoStudio.

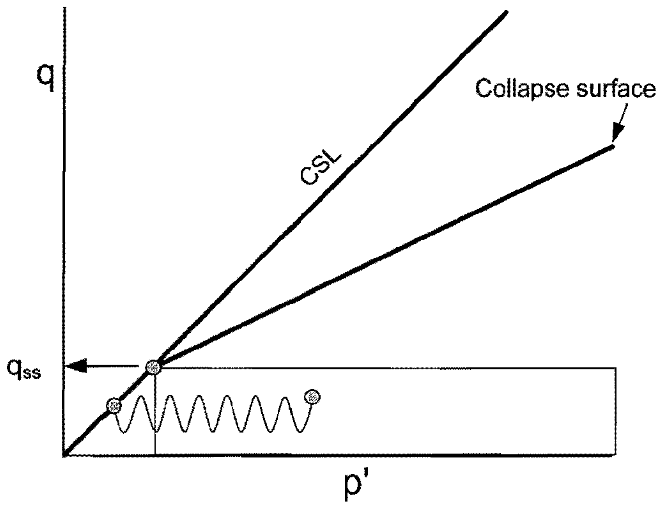


Figure 15 Stress states where q is less than q_{ss}

3.3 Region between CSL and collapse surface

Conceptually, stress state points cannot exist in the region between the collapse surface and the steady-state line. Or stated another way, stress state points cannot exist above the collapse surface. If there was a tendency for a stress path to cause the stress state point to move above to the collapse surface, the sand-grain structure would either collapse or possibly the sand would densify and the collapse surface would shift upwards with the stress state point as already discussed in Section 2.3 above.

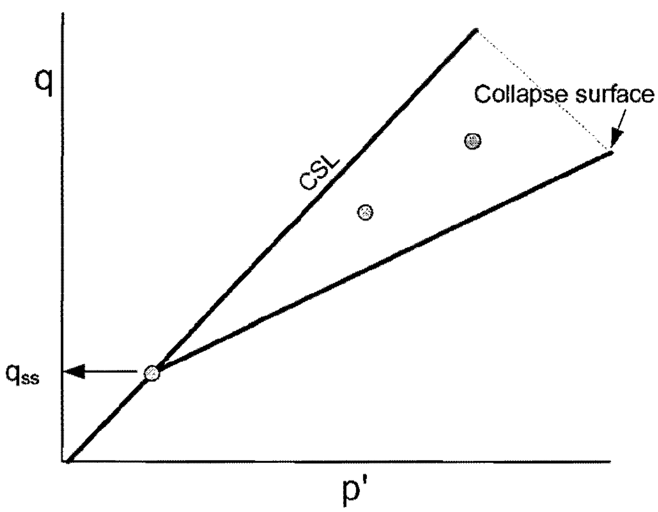


Figure 16 Region where elements are marked as liquefied

Numerically, in a GeoStudio analysis a stress state point can exist above the collapse surface. This is results from an inaccurate description of the stress - distribution or collapse surface definition. Practically what it means is that the soil is in a very precarious unstable state and that any amount of static or dynamic disturbance could cause the sand grain-structure to collapse.

In GeoStudio any computed stress state points that fall into this zone are marked as liquefied and no excess pore-pressures are allowed to develop.

3.4 Stress state points above the CSL

Of course in reality no stress state points can exist above the CSL – the shear stress cannot be greater than the shear strength. Again, numerical in a GeoStudio analysis it is possible to compute stresses that fall above the CSL line. What this means is that the computed stress distribution is not perfect.

Elements with a stress state that fall above the CSL are not marked as liquefied or liquefiable. Practically, the field shears stress is at the peak shear strength and for analysis purposes the soil is assign the conventional peak strength parameters c' and ϕ'. Also no excess pore-pressure is allowed to develop.

4 Effect of initial static shear and confining stress

The confining stress and shear stress that exist in the ground prior have a major influence on the liquefaction potential.

Consider Points A and B in Figure 17. Let's assume the shear stress is the same at both points. Point A being at a lower confining stress (low p′) is very close to the collapse surface and any amount of strong motion shaking could cause the stress state to move onto the collapse surface and suddenly fall down to the steady-state strength. Point B on the other hand is at a much higher confining stress (higher p′) and therefore a very significant amount of excess pore-pressure would need to develop during the shaking for the stress state to reach the collapse surface.

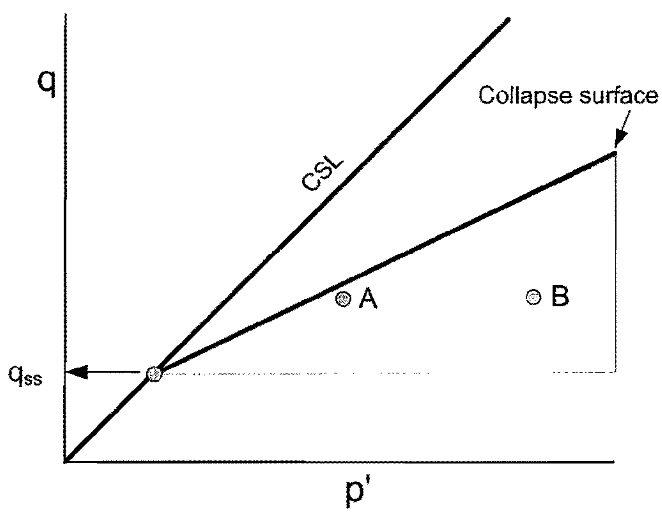


Figure 17 Effect of confining stress on the liquefaction potential

Now consider Points A and B at different initial shear stresses but at the same confining stress as illustrated in Figure 18. Point A is again very close to the collapse surface and any amount of shaking disturbance could cause liquefaction. Whereas Point B is a long way away from the collapse surface and high excess pore-pressures would need to develop during earthquake shaking for liquefaction to occur.

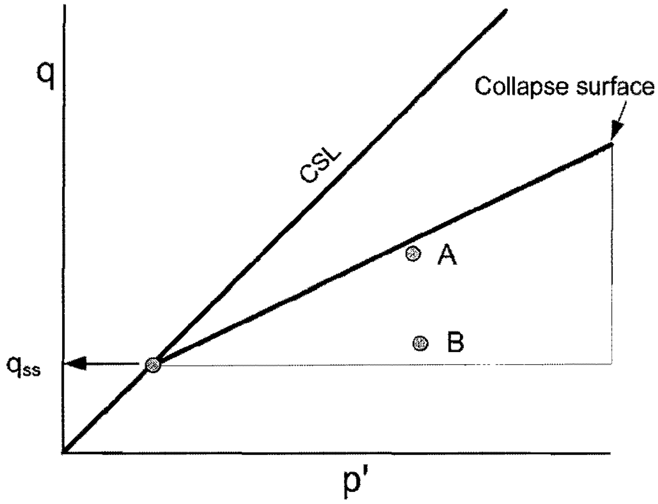


Figure 18 Effect of initial static shear stress on the liquefaction potential

This illustrates why the initial static stress conditions are so critical to assessing the liquefaction potential.

Researchers that have used a cyclic stress approach to assessing the potential for liquefaction early on recognized the strong influence of the initial static confining stress and initial static shear stress. From this evolved what are known as Confining Stress (K_s) and Shear Stress (K_a) correction factors. Such correction factors are not required in the context of a collapse surface.

More details on these correction factors are given in the QUAKE/W Engineering Book on pages 99 to 104.

The beauty about the collapse surface concept is that it inherently accounts for the initial shear and confining stresses as illustrated above. No correction factors are required as in the cyclic stress approach.

5 Initial insitu stress conditions

Now let's look at the influence of the initial insitu static stress condition and how to use GeoStudio to examine this. We will start with a simple 1D column illustrated in Figure 19, which is adequate for representing horizontal ground surface conditions.

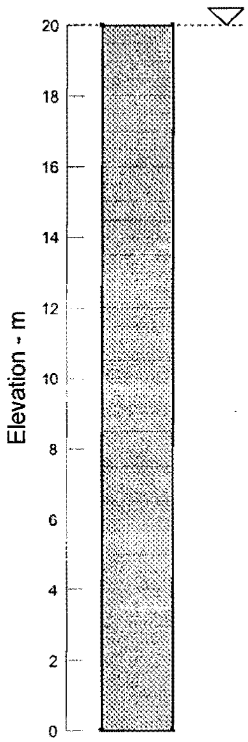


Figure 19 One dimensional column representing horizontal ground

The water table is at the ground surface. The total unit weight of the soil is 20 kN/m^3 and the unit weight of the water is taken to be 10 kN/m^3 for convenient discussion purposes.

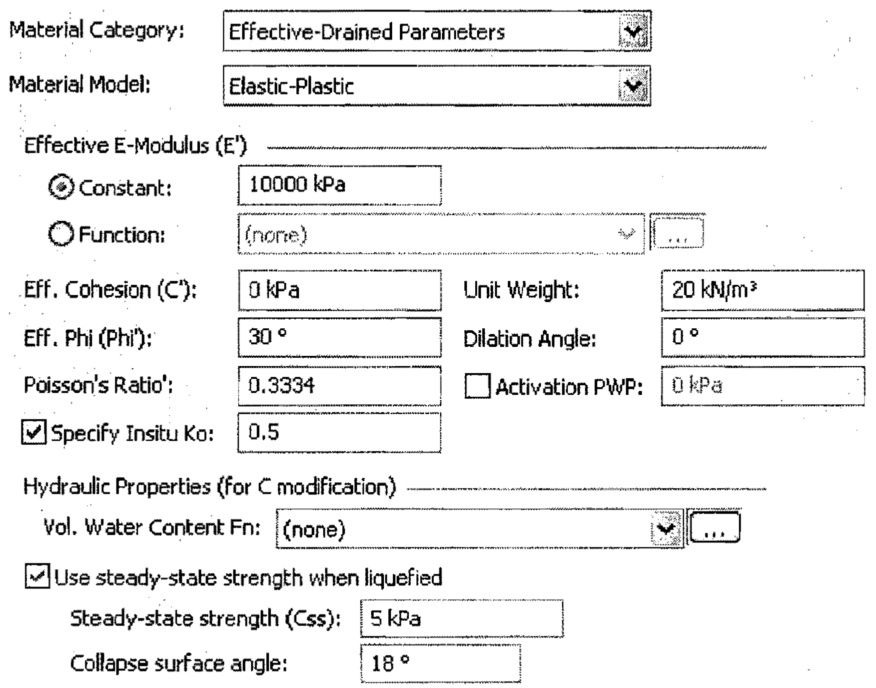
The convention effective strength parameters c′ and φ′ are zero and 30 degrees.

To begin with we'll set K_o to 0.5.

The steady-state shear strength is set to 5 kPa; this makes q_{ss} = to 10 kPa.

Also, to start with we'll make the collapse surface inclination 18 degrees.

Now we can do an Insitu type of analysis in SIGMA/W. It is necessary to select the Elastic-Plastic Material Model for this analysis. The specified material properties are shown in the following screen capture.



The SIGMA/W Insitu results indicate that the lower 14 m of the soil column is liquefied or in a liquefiable state as shown in Figure 20.

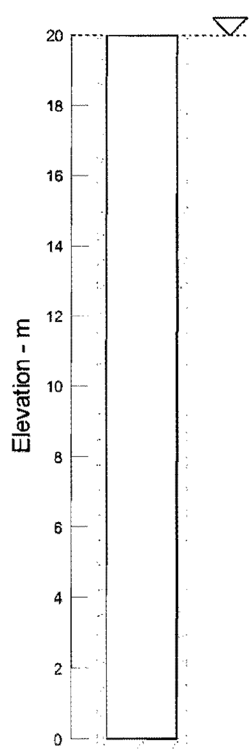


Figure 20 Liquefaction zone with K_o equal to 0.5

The reason for this is that the q/p′ ratio is above or very close to the specified collapse surface. This can be vividly illustrated by taking the q and p′ stress profiles into EXCEL and plot these values relative to the CSL and the position of the collapse surface. The end result is shown in Figure 21. At low stress levels the field q/p′ ratio is just below the collapse surface and at higher stress levels the q/p′ ratio is just above collapse surface and consequently the liquefaction shading in Figure 20.

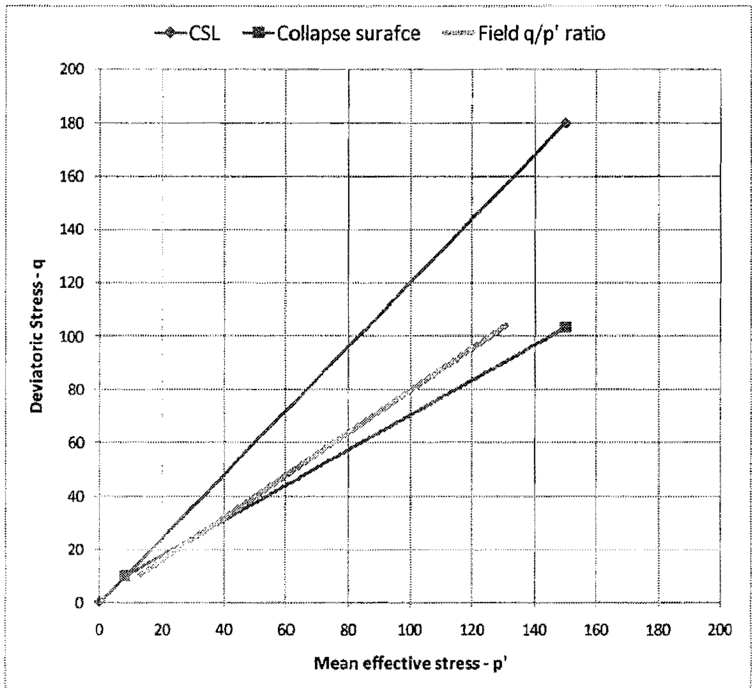


Figure 21 Field q/p′ ratios relative to the collapse surface with K_o equal to 0.5

If this was indeed representative of the actual field conditions, there would be little or no value doing a QUAKE/W dynamic earthquake analysis. The simply SIGMA/W Insitu analysis implies that any amount of strong motion shaking could in all likelyhood cause the soil to liquefy.

The situations for K_o equal to 0.6, 0.8 and 0.95 are shown in the following graphs.

When K_o is 0.6, some strong ground motion may result in sufficient generation of excess pore-pressure for a significant portion of the column to liquefy. If K_o is 0.8 the field q/p′ is fairly far away from the collapse surface and it would mean that large excess pore-pressures would need to develop for liquefaction to occur. If K_o were to be 0.95, large excess pore-pressures might develop but liquefaction would be highly unlikely.

The SIGMA/W Insitu analyses indicate no liquefaction shading when K_o is greater than 0.6. This is because the field q/p′ ratios are not on or above the collapse surface.

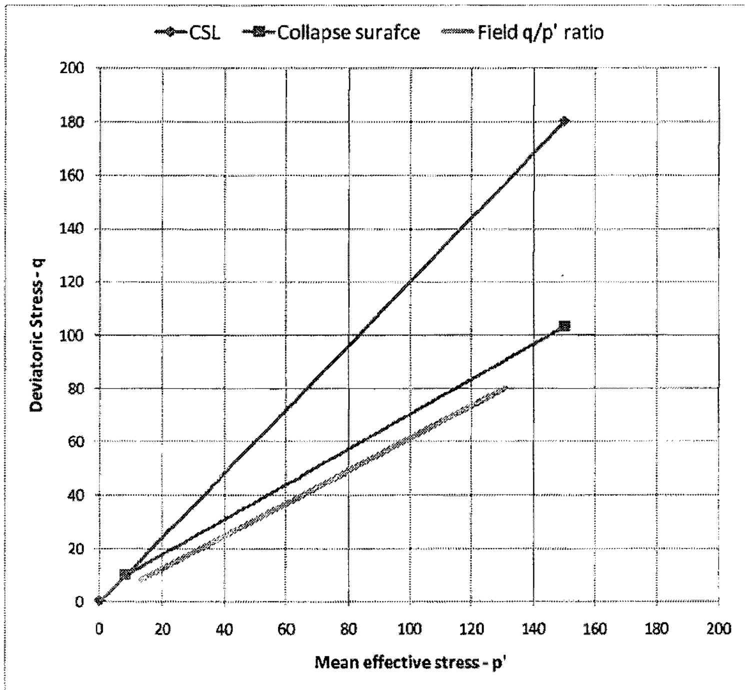


Figure 22 Field q/p′ ratios relative to the collapse surface with K_o equal to 0.6

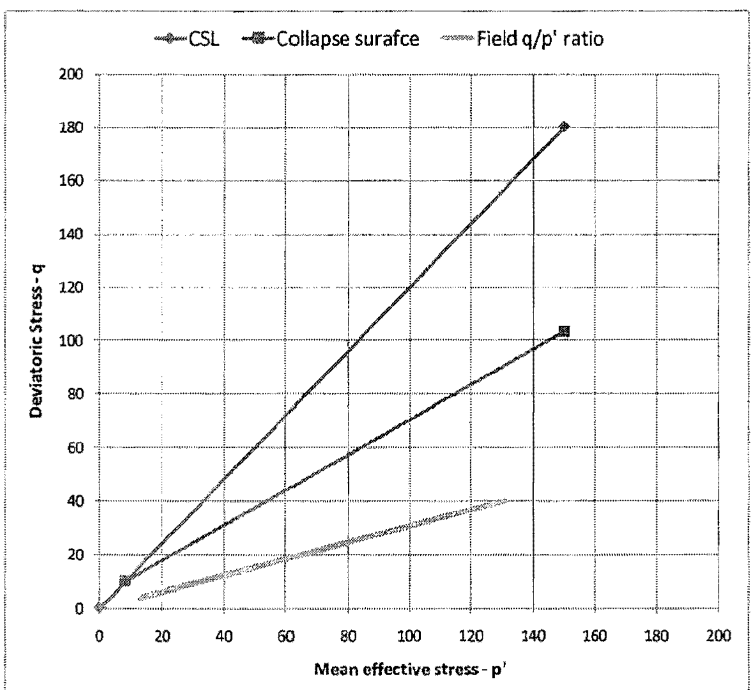


Figure 23 Field q/p′ ratios relative to the collapse surface with K_o equal to 0.8

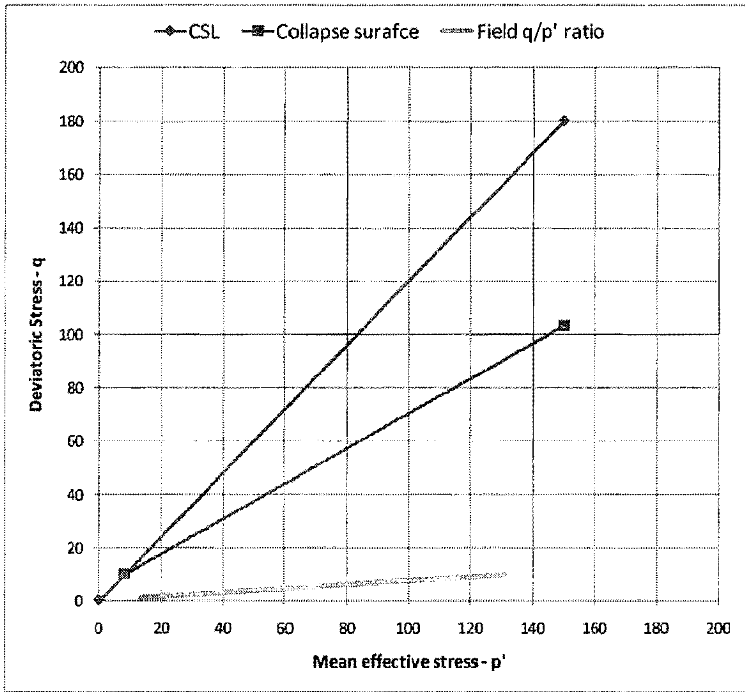


Figure 24 Field q/p′ ratios relative to the collapse surface with K_o equal to 0.95

From these simply SIGMA Insitu analyses we can readily see how strongly the potential for liquefaction is influenced by the initial static insitu stress state conditions.

From these analyses we can see that potential for liquefaction is heavily influenced by the shear stresses that exist in the ground prior to any earthquake shaking.

A simple preliminary SIGMA/W analysis can also help with understanding the generation of liquefaction zones in a later QAUKE/W analysis. If the field q/p′ ratios are close to the collapse surface then liquefactions zones will develop very quickly in a QUAKE/W analysis where as if the static field q/p′ ratios are far removed from the collapse surface the QUAKE/W analysis may not show any liquefaction zones at the end of the earthquake shaking. This is discussed further below.

6 Two-dimensional situation

Now let's look at the following simple 2D case. It is assumed that the foundation material is loose and potentially liquefiable. The dam embankment material is assigned the same material properties as the foundation except that it is not deemed to be liquefiable; that is, no collapse properties are assigned to the dam.

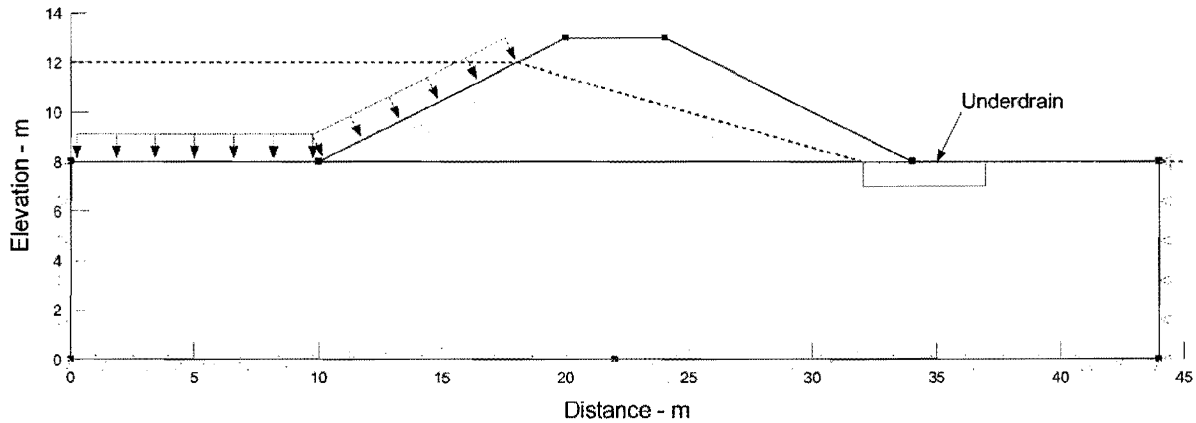


Figure 25 Illustrative 2D case

Both materials are assigned an effective friction angle φ′ equal to 30 degrees with c′ equal to zero. This makes the slope of the CSL equal to 1.2.

For illustrative purposes, the foundation is assigned collapse surface properties. The inclination is 18 degrees. The steady-state strength is set to zero. This is an unrealistic field value but it is useful for illustration purposes. By making C_{ss} zero, the q/p′ ratio is a constant making it easier to compare the liquefiable shaded areas with q/p′ contours. For 18 degrees the slope of the collapse surface in q - p′ space is 0.69.

The following figure shows the CSL and collapse surface with these parameters. Any q/p′ ratios that fall between the two lines will be marked as liquefiable.

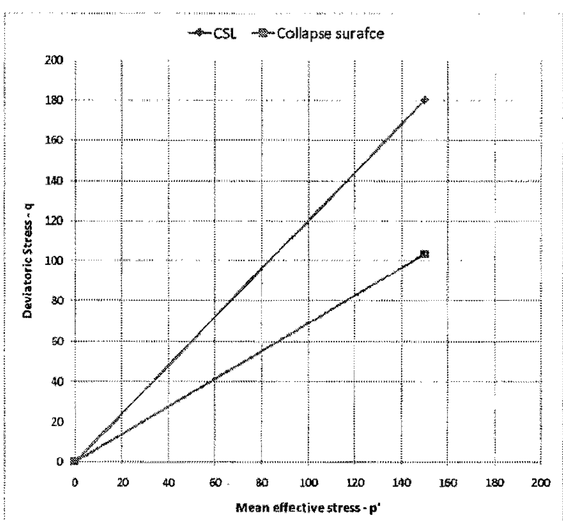


Figure 26 Position of CSL and collapse surface

We can do a SIGMA/W Insitu type of analysis to look at the situation under static insitu loading conditions. The pore-pressure conditions will come from the Water Table definition. To obtain the information of interest, it is necessary to use Effective-Drained Parameters with an Elastic-Plastic constitutive model.

6.1 K_o equal to 0.5

The following Figure 27 shows the results when Poisson's ratio is 0.3334 which represents a K_o of 0.5. The shaded area is where the q/p′ ratio is between the CSL and the collapse surface. Shown as well are q/p′ contours. Recall that the slopes of the two lines are 1.2 and 0.69, consequently the shaded area falls between the 1.2-contour and the 0.7-contour.

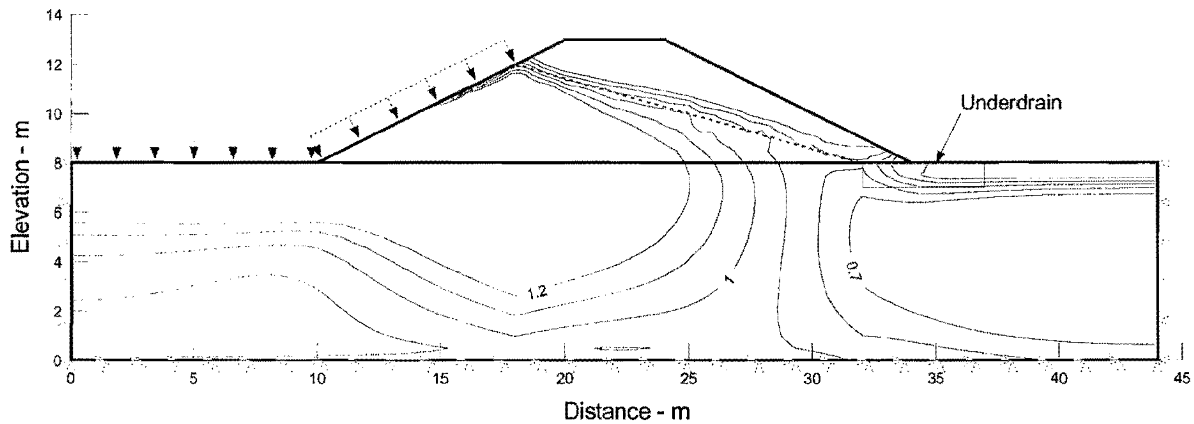


Figure 27 Liquefiable zone and q/p' contours with K_o equal to 0.5

6.2 K_o equal to 0.667

Now if we set K_o to 0.667 (Poisson's ratio = 0.4) the situation is as follows. The potentially liquefiable zone has now shifted and shrunk because of a different insitu static stress distribution.

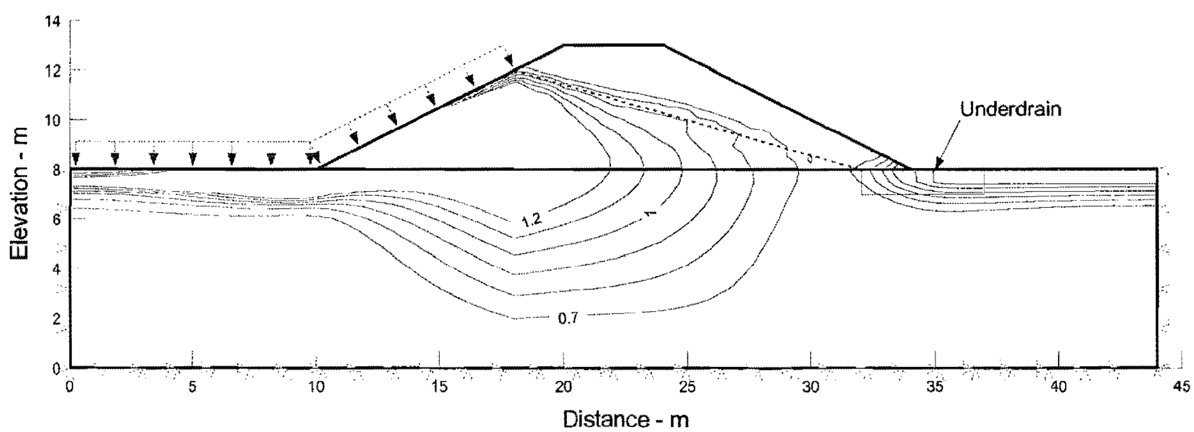


Figure 28 Liquefiable zone and q/p' contours with K_o equal to 0.667

6.3 K_o equal to 0.818

Setting Poisson's ratio to 0.45 and making K_o 0.818 results in the following situation. Again the potentially liquefiable area has shifted and become smaller.

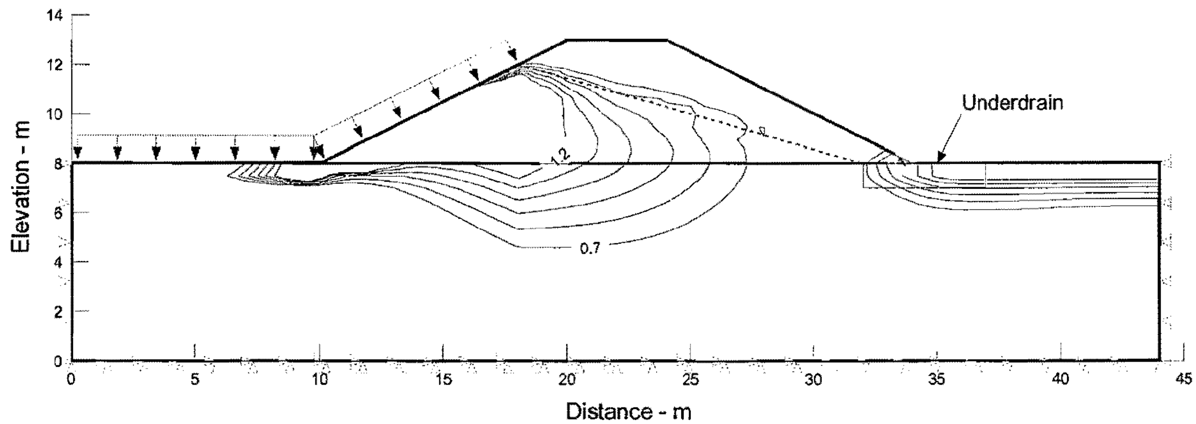


Figure 29 Liquefiable zone and q/p' contours with K_o equal to 0.818

6.4 Effect of insitu static stresses

Again as was demonstrated earlier for the 1D analysis, the above figures demonstrate the strong influence that the static insitu stresses have on the potential for liquefaction.

6.5 Stability based on static stresses

At this stage it is possible to do a stability analysis with SLOPE/W to look at the situation if indeed the strength in the liquefiable zone should fall to the specified steady state strength.

The following diagram shows a potentially liquefiable zone when C_{ss} is 5 kPa and K_o is 0.667.

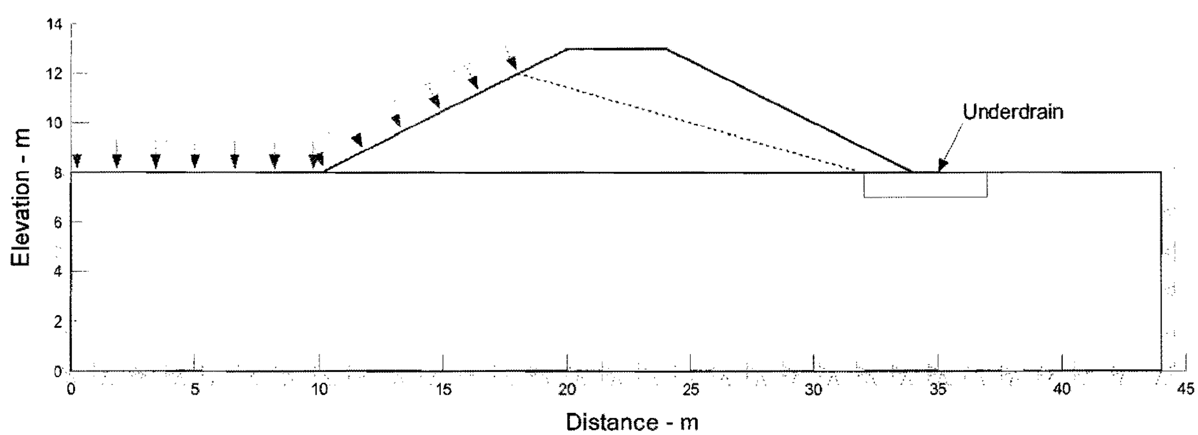


Figure 30 Liquefiable zone with K_o equal to 0.5 and C_{ss} equal to 5 kPa

Let us now make the assumption that the strength in the shaded area has fallen down to the undrained steady-state strength for some undefined reason. We need to define a new material for the stability analysis. The new foundation material will have all the properties as before except the collapse surface angle will be set to zero. This means that when the slip surface is in the shaded area the strength will be 5 kPa.

Consider the slip surface in the following figure. The cohesive and frictional strength along the slip surface are shown in figure. Notice how in the middle portion of the slip surface the frictional strength is zero and the cohesive strength is 5 kPa which represents the C_{ss} strength.

(Unfortunately, currently it is not possible to show the shaded liquefiable zone in SLOPE/W – watch for this in a future version).

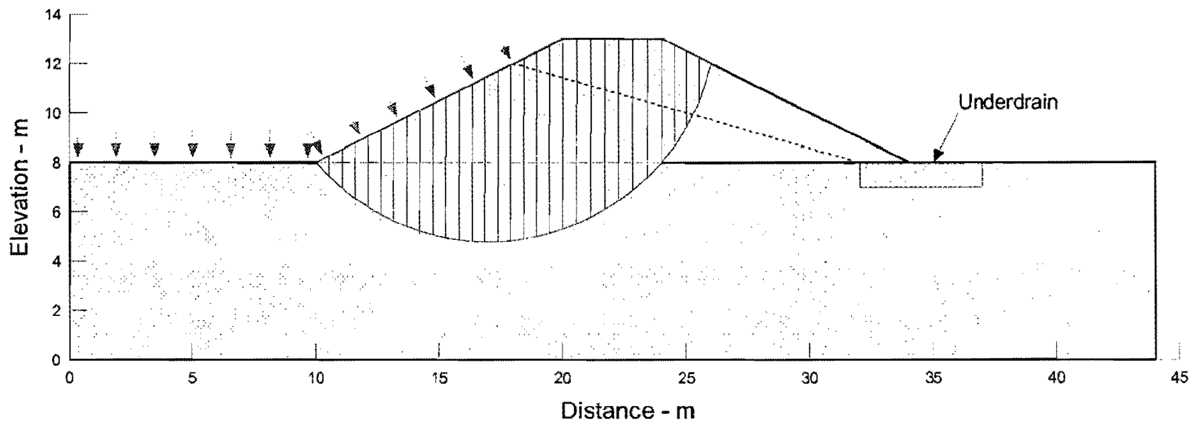


Figure 31 Stability with reduced strength in the liquefiable area

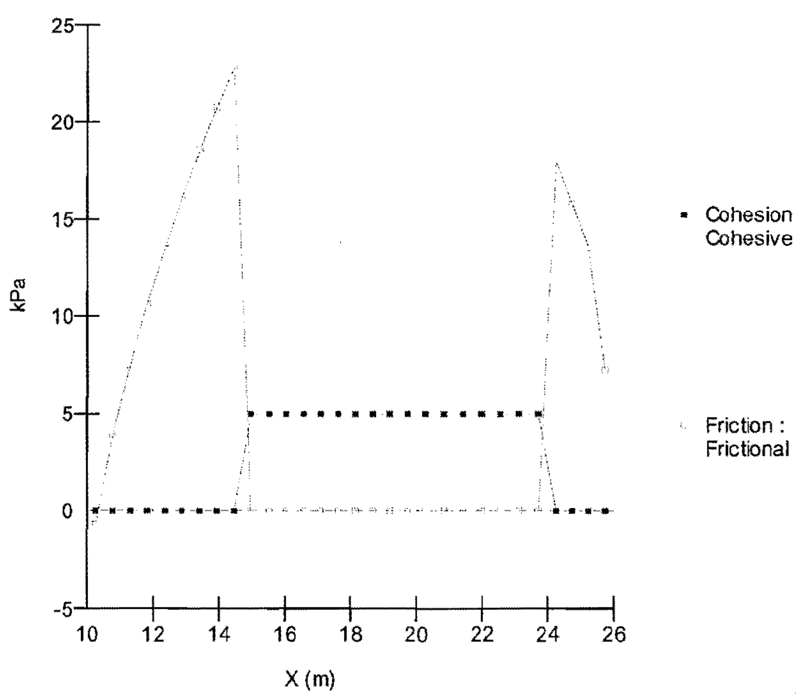


Figure 32 Cohesive and frictional strength along the slip surface

Often it is necessary to create a new material for the stability analysis if the objective is to look at the C_{ss} strength alone; that is, use the C_{ss} strength but make the collapse surface inclination zero.

It is important to note at this stage that much can be done in the liquefaction evaluation process without using QUAKE/W. Adding a QUAKE/W analysis is necessary only in the later stages of the evaluation process, if at all. Sometimes, a definitive conclusion can be reached before even proceeding onto a dynamic shaking analysis with QUAKE/W. If, for example, the margin of safety is already less than 1.0 under static conditions, then there is likely no value in doing a QUAKE/W analysis.

7 Case history

Now let's look at the above discussion in the context of a case history. We can do this by abstracting information from the QUAKE/W Detailed Example called the Upper San Fernando Dam.

7.1 Development of liquefiable zone during the earthquake shaking

Figure 33 shows the zone where q/p′ ratio falls between the collapse surface and the CSL under the initial static conditions. In this case the initial condition was established with QUAKE/W but could have been just as easily been done with SIGMA/W. The figure below represents the QUAKE/W analysis at time zero; that is, just before the shaking starts (generally it is easier to do this with SIGMA/W than making it part of the QUAKE/W analysis).

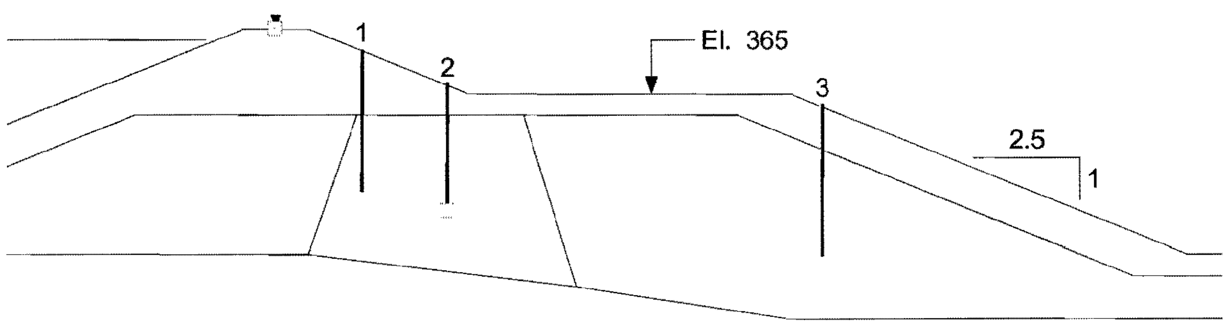


Figure 33 Liquefiable zone in the Upper san Fernando Dam prior to the earthquake

What the initial conditions suggest is that there are potentially zones where the q/p′ ratio is very close to the collapse surface and that any generation of excess pore-pressures may cause the stress state to move onto the collapse surface. This is indeed what happens in this case as shown in Figure 34. The zones of potential liquefaction have grown and developed.

In this case the QUAKE/W analysis is an essential part of the evaluation.

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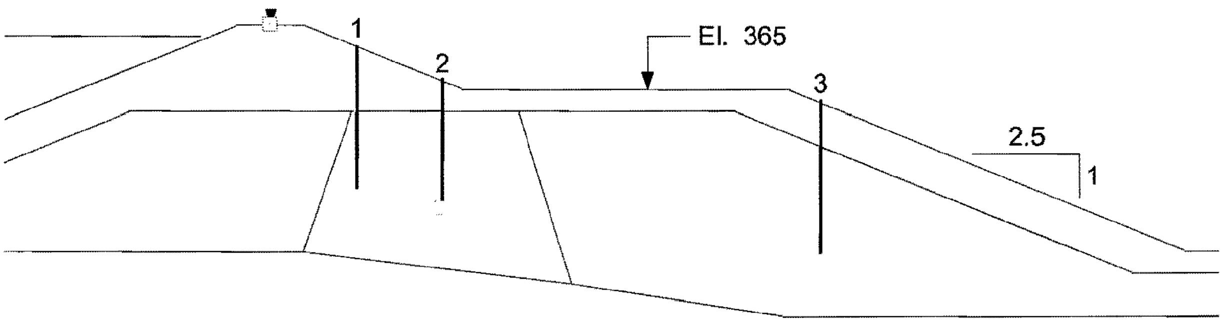


Figure 34 Liquefiable zones in the Upper San Fernando Dam after the earthquake

You will notice in this Detailed Example, that special materials have been created for the post-earthquake analyses so that the liquefied zones have just the steady-state strength C_{ss}.

7.2 Post-earthquake permanent deformation

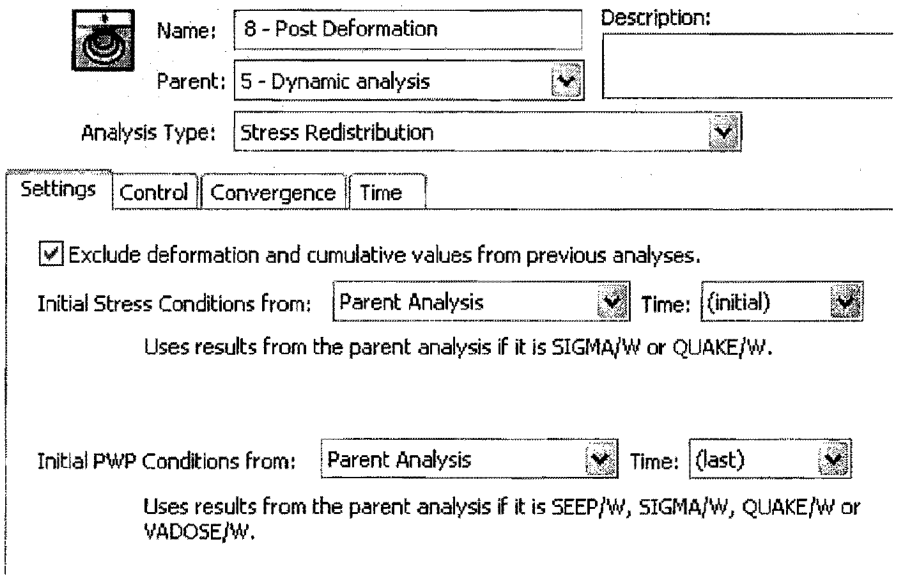
As presented in the Detailed Example documentation, it is possible to evaluate the post-earthquake deformation using a SIGMA/W Stress Redistribution type of analysis. This can be done based on static stresses or by including the dynamic inertial forces.

Using static stresses

There is field evidence indicating that sometimes the most significant deformations occur after the shaking has stop. At the Lower San Fernando Dam, for example, it is believed that the upstream failure occurred immediately after the earthquake strong motion had stop. The thinking is that the dynamic inertial stress had disappeared by the time the failure or large deformations occur due to the associate strength loss.

The same logic is used in the post-earthquake analysis of the Upper San Fernando Dam.

When this is the objective it is important to indentify the initial **static** stresses in the Stress Redistribution analysis. Using the stresses at the end of the shaking may numerically still include some residual dynamic stresses which is not desirable. This can be avoided by selecting the initial static stress as highlighted in the following dialog box in SIGMA/W. Note the selection of Time:(initial) for the stresses conditions and Time:(last) for the PWP conditions. We want to use the pore-pressure conditions at the end of the shaking but use the initial static stress conditions.



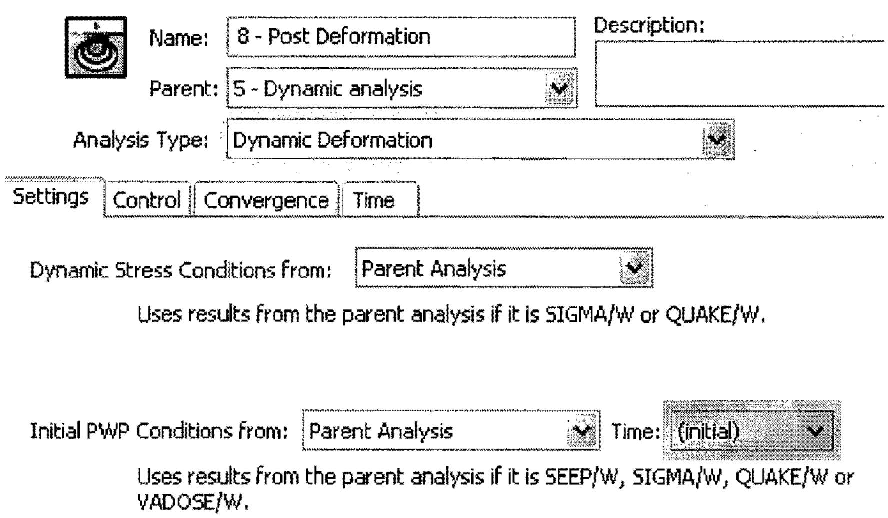
Including the dynamic inertial forces

It is also possible to include the earthquake induced inertial forces in the permanent deformation analysis. This is done with a SIGMA/W Dynamic Deformation type of analysis. With this type of analysis SIGMA automatically does a stress redistribution analysis at each saved time step. If QUAKE/W, for example saved the results for 100 times steps, SIGMA/W would do 100 stress redistribution analyses.

The selections in the KeyIn Analysis dialog box in this case would be as shown below. There is no option as to which stress condition is used. The static plus dynamic stresses are automatically used at each time step.

The starting pore-pressures come from the initial conditions. The increasing pore-pressures are used at each time step as they develop.

The reduced strengths for the liquefiable zones are also used as they develop during the shaking.



8 QUAKE/W analysis

It is very important to use only the strong motion portion of an earthquake time history record in the QUAKE/W analysis step in a liquefaction evaluation. Including the early small trembling motion at the start and the end of record makes the QUAKE/W analysis unnecessarily difficult (and even frustrating sometimes). The computing time takes too long and it creates too much data making the viewing of results too slow.

Remember, it is only the large dynamic shear stresses that cause the generation of excess pore-pressures and this happens only during the most intense motion.

This is discussed on Pages 155 and 156 in the QUAKE/W Engineering Book.

The record shown in Figure 35 has a duration of almost 50 sec and includes over 12,000 data points. This record could be easily reduced to the one in Figure 36 for a QUAKE/W liquefaction-assessment studying. The modified record is only about 18 sec with about 5000 data points. The record could be further modified by deleting every other data point without having a noticeable effect on the QUAKE/W results.

Modifying the earthquake record is often the most conveniently done in a spreadsheet (EXCEL). Once the data has been imported into QUAKE/W, all the data can be selected and copied into EXCEL for modification (right mouse click in the list box of the data). Once the record has been modified, you can paste the data back into QUAKE/W through the clipboard.

The modification can also be done directly in QUAKE/W by group selection of certain portions of the data points and clicking on delete.

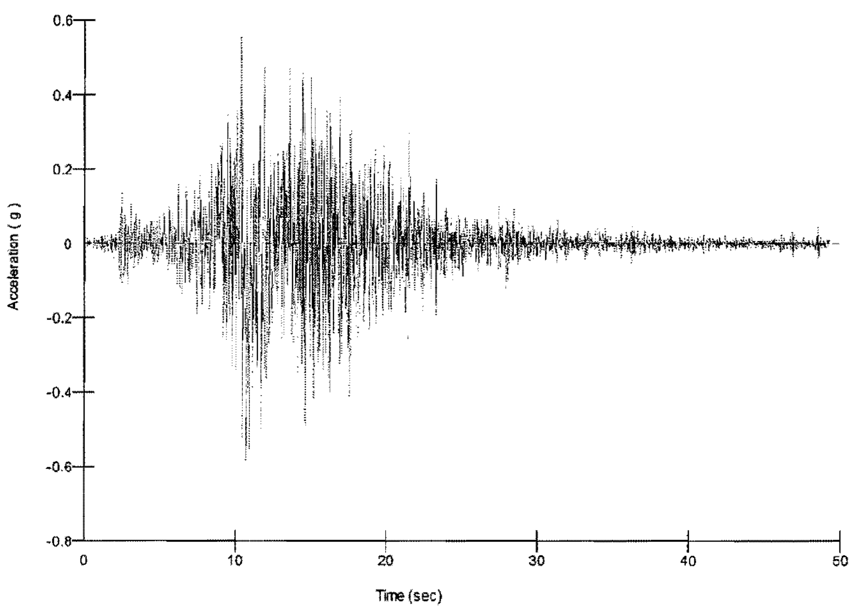


Figure 35 Raw time history record

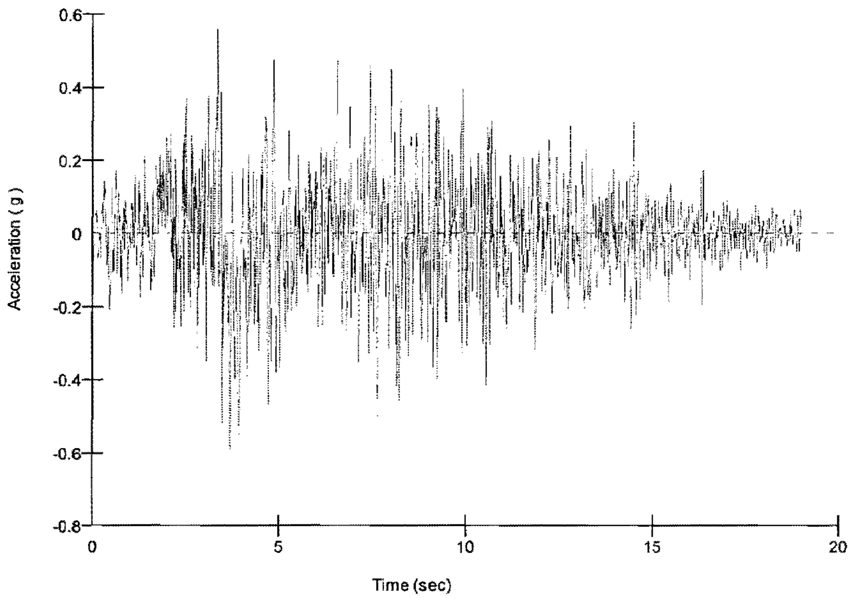


Figure 36 Modifies time history record

The first step is to remove the low trembling noise at the ends of the record and then consider removing every other data point, for example, if the data was recorded at a very small time interval.

Remember, when in doubt you should do most of your preliminary work with a simplified analysis and then near the end of the modeling try some more complicated analyses to determine if it makes a significant difference to your conclusions.

9 Field K_o conditions

Earlier it was been demonstrated that the potential for liquefaction is highly dependent on the static insitu stress state. This then begs the question, what is an appropriate K_o.

Generally, liquefaction is associated with loose fine sands. For a sand to be in a loose state in the field it likely was deposited in a calm fluvial or sedimentation environment and has not been subject to past loading and unloading. In a sense, it is like the material is normally consolidated.

For normally, consolidated soils K_o can be estimated from the relationship:

$$K_o = 1 - \sin\phi'$$

Looking at it another way, it is unlikely that loose liquefiable sands have a high K_o. If the sand has a high K_o it is likely no longer in a loose state because the past loading and unloading that caused K_o to be high also densified the soil.

These are general comments intended to start the GeoStudio user's thought process on this issue. Clearly, this is an important issue and needs to be assessed carefully in the context of project specific conditions.

10 Commentary and recommendations

The purpose here has been to provide GeoStudio Users with a guideline for doing a liquefaction assessment. In summary, to use GeoStudio effectively for a liquefaction assessment the following is essential.

- First and foremost, it is essential to have a clear understanding of the collapsible grain-structure of loose fine sands. That the grain-structure can collapse and that the strength can suddenly fall down to the undrained steady-state strength has been conclusively demonstrated by laboratory tests and field observation.
- The user must have an understanding of how GeoStudio flags elements as potentially liquefiable in the context of regions in q-p′ stress space.
- Recognize that the definition of a collapse surface automatically accounts (corrects) for the shear and confining stress in the ground. No other correction factors are required like those used in the cyclic stress approach.
- Accept that fact that the liquefaction potential is tightly tied to the insitu static stress state.
- Use SIGMA/W, and maybe SLOPE/W, to assess the situation before moving unto a QUAKE/W analysis. A QUAKE/W analysis should only be undertaken after an initial assessment based on static stresses. Starting with a complicated QUAKE/W analysis should be avoided.
- When a QUAKE/W analysis is undertaken, only the strong motion portion of a time history record should be used.
- To be clear that QUAKE/W **alone** cannot provide any information about permanent deformations. QUAKE/W can only provide information about the dynamic inertial forces and the resulting associated generation of excess pore-pressures.
- Understand that permanent deformations can only be estimated by doing a SIGMA/W Stress Redistribution type of analysis or a SIGMA/W Dynamic Deformation type of analysis.
- Before doing a permanent deformation analysis, it is important to first check the stability using the post-earthquake pore-pressures and reduced strengths resulting from collapse of the sand-grain structure. If the stability analysis shows the structure to be unstable at this stage (factor of safety close to or less than 1.0) then there is little value in a permanent deformation analysis – the structure has already failed and collapsed. If such an analysis is done it may provide a picture of the post-failure displacement field, as in the Lower San Fernando Dam case history, but the magnitudes of the computed displacements will be meaningless. In short, GeoStudio cannot be used for a post-failure deformation analysis.

Prepared by:

Dr. John Krahn

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