FINAL REPORT
ROUND 10 DAM ASSESSMENT
AMERICAN ELECTRIC POWER
PICWAY GENERATING STATION
ASH POND

August 17, 2012

PREPARED FOR:

U.S. Environmental Protection Agency
Office of Resource Conservation and Recovery (5304P) USEPA
2733 Crystal Drive, 5th Floor
Arlington, VA 22202

PREPARED BY:

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GZA File No. 01.0170142.30

GZA
GeoEnvironmental, Inc.

Engineers and Scientists

August 17, 2012
File No. 01.0170142.30

Mr. Stephen Hoffman
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Re: Round 10 Dam Assessment - Final Report
EPA Contract No. EP10W001313
American Electric Power – Picway Generating Station
Ash Pond
Lockbourne, Ohio

Dear Mr. Hoffman:

In accordance with our proposal 01.P000177.11, dated March 28, 2011, and U.S. Environmental Protection Agency (EPA) Contract No. EP10W001313, Order No. EP-B11S-00049, GZA GeoEnvironmental, Inc. (GZA) has completed our inspection of the American Electric Power (AEP) Picway Generating Station (PGS, Site) Ash Pond located in Lockbourne, Ohio. The Site visit was conducted on June 9, 2011. The purpose of our efforts was to provide the EPA with a Site-specific evaluation of the impoundments to assist EPA in visually assessing the structural stability of the impoundments under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act Section 104(e). We are submitting one hard copy and one CD-ROM copy of this Final Report directly to the EPA.

Based on our visual inspection, and in accordance with the EPA's criteria, the Ash Pond is currently in **SATISFACTORY** condition, in our opinion. Further discussion of our evaluation and recommended actions are presented in the Round 10 Dam Assessment Report. The report includes: (a) completed Field Assessment Checklists; (b) figures of the impoundments; and (c) selected photographs with captions. Our services and report are subject to the Limitations found in **Appendix A** and the Terms and Conditions of our contract agreement.

We are happy to have been able to assist you with this inspection and appreciate the opportunity to continue to provide you with dam engineering consulting services. Please contact the undersigned if you have any questions or comments regarding the content of this Round 10 Dam Assessment Report.

Sincerely,

GZA GEOENVIRONMENTAL, INC.

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EXECUTIVE SUMMARY

This Inspection Report presents the results of a visual inspection of the American Electric Power (AEP, Owner) Picway Generating Station (PGS, Site) Ash Pond located in Lockbourne, Ohio. The visual inspection was performed on June 9, 2011 by representatives of GZA GeoEnvironmental, Inc (GZA), accompanied by representatives of AEP and the Ohio Department of Natural Resources (ODNR).

Based on the maximum height of 24 feet and a storage volume of approximately 275 acre-feet (at the maximum elevation of approximately 573 feet NGVD 29), the Ash Pond is classified as a **Small** sized structure. Size classifications are based on U.S. Army Corps of Engineers (COE) guidelines. The ODNR has assigned an overall classification of "Class II" based on height ("Class IV", less than 25 feet), storage capacity ("Class III", greater than 50 acre-feet but less than 500 acre-feet) and hazard classification of "Class II".

Under the EPA classification system, as presented on page 2 of the EPA checklist (**Appendix C**) and Definitions section (**Appendix B**), it is GZA's opinion that the Ash Pond would be considered as having a **Significant** hazard potential. The hazard potential rating was assigned based on the available information that indicated that the failure or misoperation of the dam would result in no probable loss of life but could cause economic loss, environmental damage, damage of lifeline facilities (plant) or could impact other concerns. Losses would be primarily limited to the Owner's property, but the Scioto River is located in close proximity to the west embankment of the south pond and could receive ash-related material in the event of a failure or misoperation of the Ash Pond. The ODNR has assigned a hazard classification of "Class II" based on the potential for loss of public water supply, loss of a wastewater treatment facility or release of health hazardous waste, but has assigned an overall (combined size, storage and hazard) "Class II" designation to the Ash Pond.

Based on the results of the visual inspection, discussions with AEP personnel, and a review of available design documentation, the Ash Pond was found to have the following deficiencies:

1. Portions of the outer embankment slopes had not been mowed recently;
2. Presence of minor rodent burrows in the exterior slopes of the embankments;
3. Presence of a bare area on the western exterior embankment of the south pond;
4. No instrumentation (i.e., staff gauge) to observe the elevation of the water within the pond/impoundment;
5. No instrumentation (i.e., survey/settlement monuments) to monitor crest elevations and/or embankment movement;
6. Bare areas, areas of limited vegetative growth or areas of gravel cover present on crest;
7. Presence of vegetation on the interior slopes of the embankment;
8. AEP personnel were unsure if the discharge pipe from the concrete discharge structure has been inspected internally since it was installed;
9. Visible variations in crest elevations, particularly along the west embankment of the south pond;
10. Minor ruts on crest from vehicle traffic;
11. Minor surficial pitting or flaking/cracking on the concrete discharge structure;

12. Reported crest and maximum pool elevations indicate potential for non-compliance with state freeboard requirement of five feet for Class II dams per OAC Rule 1501:21-13-07; and,
13. Presence of standing water at or near the toe of the exterior embankment slopes of the south pond, particularly near the southwest corner.

GZA recommends that the Owner arrange for the following to be performed:

Studies and Analyses:

1. Survey of the crest of both ponds by a licensed Professional Surveyor to evaluate the current elevation profile of the crest and confirm that survey monuments are not moving horizontally;
2. Evaluate freeboard conditions based on maximum pool elevation and more recent topographical data; and,
3. Camera survey of the CMP outfall should be performed.

Operation & Maintenance Activities:

1. Frequent monitoring of steep slopes for evidence of sloughing or erosion that could lead to instability, movement or failure of the embankments;
2. Review emergency action plan annually per OAC Rule 1501:21-21-04 and update as applicable;
3. Clear vegetation from the interior embankment slopes;
4. Remove trees and resulting stumps on or near the exterior slopes of the embankment, particularly near the west embankment of the south pond, Outfall 601 and the northern end of the clearwater pond;
5. Continue to monitor and control rodent activities and repair burrows as they are discovered. Keeping the embankments mowed can help to reduce populations of certain species;
6. Maintain interior slopes of at least 2H:1V during ash excavation as recommended by BBC&M;
7. Install a staff gauge on or near the outlet structure in Cell S3 and on or near the concrete discharge structure in the clearwater pond in order to take periodic measurements of the Ash Pond water surface elevation;
8. Inspect each of the monitoring wells installed in 2009 and ensure each well has a cap, lockable protective cover/casing and is visible during mowing operations;
9. Perform periodic water level measurements in the monitoring wells to evaluate water levels below the crest and at the toe of the embankments; and,
10. If AEP has the opportunity to stop discharging from the clearwater pond for a limited time period, inspect the discharge pipe from the concrete discharge structure to the duck-bill flap gate to verify that the pipe is operating correctly and is in good condition. This may be performed by video photography.

Repair Recommendations:

1. Minor concrete repair work on the concrete discharge structure in the clearwater pond;
2. Re-seed and/or over seed bare areas of the embankments and crest to establish healthy grass cover;
3. Clear the area of established vegetation near the lower portion and toe of the outer embankment slopes near the outfall structure; and,
4. Regrade areas near the toe of exterior slopes to facilitate proper drainage away from the embankments.

PREFACE

The assessment of the general condition of the embankments at the American Electric Power (AEP) Picway Generating Station is based upon available data and visual inspections. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of this report.

In reviewing this report, it should be realized that the reported condition of the embankments is based on observations of field conditions at the time of inspection, along with data available to the inspection team. In cases where an impoundment is lowered or drained prior to inspection, such action, while improving the stability and safety of the embankment, removes the normal load on the structure and may obscure certain conditions, which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is critical to note that the condition of the embankments depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the embankment will continue to represent the condition of the embankment at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Prepared by:

GZA GeoEnvironmental, Inc.

STATE OF OHIO
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ASH POND
AMERICAN ELECTRIC POWER
PICWAY GENERATING STATION
LOCKBOURNE, OHIO

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

1.0 DESCRIPTION OF PROJECT

1.1 General

1.1.1 Authority

The United States Environmental Protection Agency (EPA) has retained GZA GeoEnvironmental, Inc. (GZA) to perform a visual inspection and develop a report of conditions for American Electric Power (AEP, Owner) Picway Generating Station (PGS, Site) Ash Pond in Lockbourne, Ohio. This assessment was authorized by the EPA under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 104(e). This assessment and final report were performed in accordance with Round 10 of the Assessment of Dam Safety of Coal Combustion Surface Impoundments, RFQ-DC-16, dated March 16, 2011, and EPA Contract No. EP10W001313, Order No. EP-B11S-00049. The assessment generally conformed to the requirements of the Federal Guidelines for Dam Safety[1]. This report is subject to the limitations contained in **Appendix A** and the Terms and Conditions of our Contract Agreement.

1.1.2 Purpose of Work

The purpose of this assessment was to visually assess and evaluate the present condition of the Impoundment(s) and appurtenant structures to attempt to identify observable conditions that may adversely affect their structural stability and functionality, to note the extent of any deterioration that may be observed, review the status of maintenance and needed repairs, and to evaluate the conformity with current design and construction standards of care.

The assessment was divided into five parts: 1) obtain and review available reports, investigations, and data from the Owner pertaining to the impoundments and appurtenant structures; 2) perform an on-Site review with the Owner of available design, inspection, and maintenance data and procedures for the Impoundments; 3) perform a visual assessment of the Site; 4) prepare and submit a field assessment checklist; and, 5) prepare and submit a draft and a final report presenting the evaluation of the Impoundments, including recommendations and proposed remedial actions.

1.1.3 Definitions

To provide the reader with a better understanding of the report, definitions of commonly used terms associated with dams are provided in **Appendix B**. Many of these terms may be included within this report. The terms are presented under common categories associated with dams which include: 1) orientation; 2) dam components; 3) size classification; 4) hazard classification; 5) general; and, 6) condition rating.

[1] FEMA/ICODS, April 2004: http://www.ferc.gov/industries/hydropower/safety/guidelines/fema-93.pdf

1.2 Description of Project

1.2.1 Location

The Picway Generating Station (PGS) is located approximately 2 miles southwest of the city of Lockbourne, Ohio, along the shore of the Scioto River, at the address 9301 South U.S. Route 23, Lockbourne, Ohio 43137. The Picway Ash Pond is located approximately 350 feet east of the PGS at latitude 39˚ 47' 21" North and longitude 83˚ 0' 34" West. A Site locus of the Ash Pond and surrounding area is shown on **Figure 1**. An aerial photograph of the Ash Pond and surrounding area is provided as **Figure 2**.

1.2.2 Owner/Caretaker

The PGS is owned and operated by Columbus Southern Power Company, a subsidiary of AEP of Columbus, Ohio.

	Dam Owner/Caretaker
Name	Columbus Southern Power Company, a subsidiary of American Electric Power, Picway Generating Station
Mailing Address	9301 U.S. Route 23
City, State, Zip	Lockbourne, Ohio 43137
Contact	Gary Zych, PE
Title	Manager – Geotechnical Services
E-Mail	gfzych@aep.com
Phone Number	614-716-2917

1.2.3 Purpose of the Pond

The PGS is a one unit (formerly 5 units) coal-fired power plant with a maximum generating capacity of approximately 106 megawatts. Commercial operation of the PGS facility began in 1955. The Ash Pond was constructed in conjunction with the PGS facility for the purpose of storing and disposing coal combustion byproducts and was commissioned in 1954. Wastewater discharged from the Ash Pond is regulated under a National Pollution Discharge Elimination System (NPDES) permit[2] issued by the Ohio Environmental Protection Agency (OEPA).

The Ash Pond was constructed for the purpose of storing and disposing plant wastewater, bottom ash and fly ash from the PGS facility. In addition to direct precipitation, the Ash Pond also receives inputs from the floor, lab and roof drain sump, the sump discharge collection pit runoff and water from the plant drains. The estimated combined average rate of all identified Ash Pond inputs is 644,710 gallons per day[3], assuming Unit 5 of the PGS is operating at average load during the summer. The combined maximum rate of all identified Ash

[2] National Pollutant Discharge Elimination System (NPDES) Permit No. 4IB00000*GD, Picway Generating Station, Ohio Environmental Protection Agency, March 30, 2007.

[3] Based on estimated flows from a Water Balance Diagram provided by Mr. Gary Zych of AEP on June 16, 2011.

Pond inputs is 1,584,710 gallons per day, assuming a 10-year, 24-hour storm event[4]. Wastewater from the Ash Pond is discharged via Outfall 601 to a discharge canal at an estimated average rate of 100,000 gallons per day and an estimated maximum rate of 628,000 gallons per day[5]. The discharge canal ultimately discharges to the Scioto River at Outfall 001. The overall Fly Ash Pond plan is shown on **Figure 3**.

1.2.4 Description of the Ash Pond and Appurtenances

The following description of the Ash Pond is based on the Owner interview, design reports provided by the Owner, as-built drawings, and field observations by GZA.

The Ash Pond dam consists of approximately 4,900 feet of earthfill embankment and approximately 1,000 feet of natural embankment. The maximum crest height (from the lowest toe elevation to the top of embankment) is approximately 24 feet. An access road along the top of the crest has a width of approximately 10 to 15 feet and a design elevation of approximately 693 feet, National Geodetic Vertical Datum of 1929 (NGVD 29). Actual crest elevations are reportedly as low as 690 feet[6]. Portions of the Ash Pond base were reportedly keyed into the existing natural grade, and the design elevation of the base of the Ash Pond is 673 feet[7]. The inner slope of the embankment has a slope of approximately 1.5 horizontal to 1 vertical (1.5H:1V) and the outer slopes of the embankment have a slope of approximately 2H:1V. The Ash Pond has not been expanded or raised since its original construction.

The Ash Pond has one discharge point. The discharge (decant) structure is located in the southwestern portion of the clearwater pond and consists of a concrete tower with 36-inch stop-logs. The tower is equipped with a skimmer to prevent debris from clogging the screen affixed to the tower. Once water enters the discharge structure, it is conveyed through a 36-inch diameter corrugated metal pipe (CMP), through a duck-bill flap gate, and then into a canal that joins the Scioto River. The duck-bill flap gate at the end of the 36-inch CMP is identified as "Outfall 601" in the 2007 NDPES permit (refer to **Figure 3** for location).

No information was provided regarding invert elevations of the 36-inch CMP. However, based on a review of AEP Drawing 15-30011-0 provided by the Owner, the ground elevation in the immediate vicinity of the discharge point of the 36-inch CMP is approximately 668 feet, based on the 2006 contours shown. No information was provided regarding the presence of seepage collars along the 36-inch CMP as it penetrates the embankment.

The Ash Pond facility does not have any instrumentation or seepage collection systems. No survey monuments were observed along the top of the embankment during our site visit. Five monitoring wells (MW-0901S, MW-0901D, MW-0902S, MW-0902D and MW-0903S) were installed around the Ash Pond in 2009 as part of an evaluation of the embankments. At the time of the site visit, AEP personnel stated that no samples from the monitoring wells have been collected to date, and no water level measurement data was available. Additional information on the construction and performance history of the Ash Pond is provided in Sections 1.3.5 and

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4 Based on estimated flows from a Water Balance Diagram provided by Mr. Gary Zych of AEP on June 16, 2011.

5 Based on estimated flows from a Water Balance Diagram provided by Mr. Gary Zych of AEP on June 16, 2011.

6 Based on Plate 3, Section E of Appendix A, of the report entitled AEP Picway Plant Ash Pond Investigation prepared by BBC&M Engineering, Inc. and dated April 2010.

7 Based on review of Drawing No. 18-530.00 provided by AEP, originally dated June 26, 1953.

1.3.6 of this report. Additional information on the construction and performance history of the Fly Ash Pond is provided in Section 1.3.7 of this report.

1.2.5 Operations and Maintenance of the Ash Pond

The Ash Pond operates under the regulations of the Ohio Department of Natural Resources (ODNR), including their dam safety regulations. According to the most recent ODNR dam safety report (February 9, 2009 inspection date), there is no permit number for the Ash Pond (permit no. listed as "N/A"), but the ODNR lists the Ash Pond as File No. 9630-001. In accordance with Ohio Revised Code Section 1521.062, owners of dams must monitor, maintain and operate their dams safely.

Operation and maintenance of the Ash Pond is regulated by the EPA, ODNR and the OEPA (NPDES Permit). Monitoring requirements under the NPDES permit are discussed below.

The Ash Pond and the surrounding area are operated and maintained by AEP personnel. A summary of the maintenance and inspection items listed in AEP's February 2010 Operation, Maintenance and Inspection manual (OMI) (as provided to GZA) is provided below.

- Mow grassed slopes of embankments (external and internal) 4 times per year;
- Special maintenance items including seepage control, sloughing or slides of the embankments, and rehabilitation of rock berms are to be performed based on the recommendations in engineering inspection reports or as identified during quarterly plant inspections and discussions;
- Repair erosion gullies with compacted fill and stabilize with seed and mulch as appropriate as needed;
- Re-grade and compact ruts along the crest of the embankments as needed;
- Repair rodent damage by backfilling with mud packs as needed. If animals are persistent, trapping and/ or fumigants may be necessary;
- Remove debris around skimmer and discharge structure as needed;
- Repair discharge structure and skimmer as needed;
- Inspection within 24 to 48 hours after placing 3 or more stop logs in any discharge tower;
- Inspection within 3 days of switching between active cells in the south pond;
- Inspection within 24 hours of each rainfall event which results in 3 or more inches of rain over a 24-hour period;
- Inspection by a qualified individual experienced in dam engineering and under the supervision of a registered professional engineer at least once every 2 years;

- Monitoring of the items associated with the NPDES Permit in accordance with the permitted frequencies, which range from daily to monthly; and,

- Periodic (every 5 years) safety inspection performed by ODNR.

Inspection reports produced by ODNR are provided to AEP. If necessary, these reports may include required remedial measures or other discussion items that require action and/or response by AEP. The most recent ODNR report is dated May 4, 2009 and describes conditions and observations noted on February 9, 2009. According to this report, AEP is required to address any deficiencies noted in the inspection within 5 years, provide the ODNR with any plans, specifications, investigative reports or other supporting documentation for review and approval prior to construction and provide a record of all repairs in the OMI.

Based on GZA's discussions with AEP personnel and a review of the May 4, 2009 ONDR inspection report (refer to Section 1.3.7), it appears that progress toward completing the required remedial measures listed in the May 4, 2009 ODNR report is being made.

According to the NPDES permit, AEP is required to submit a monthly report to the OEPA that includes NPDES monitoring data. Specifically, at Outfall 601, AEP is required to record the flow rate daily, collect grab samples for pH twice each week, collect grab samples for total suspended solids on a weekly basis and collect grab samples for oil and grease and hexane on a monthly basis.

1.2.6 Size Classification

For the purposes of this EPA-mandated inspection, the size classifications will be based on United States Army Corps of Engineers (COE) criteria. According to guidelines established by the COE, dams with a storage volume between 50 to 1,000 acre-feet and/or a height between 25 and 40 feet are classified as Small sized structures. Based on the maximum height of 24 feet and a storage volume of approximately 275 acre-feet, the Ash Pond is classified as a **Small** sized structure.

The ODNR has assigned an overall classification of "Class II" based on height ("Class IV", less than 25 feet), storage capacity ("Class III", greater than 50 acre-feet but less than 500 acre-feet) and hazard classification of "Class II", discussed in Section 1.2.7 below.

1.2.7 Hazard Potential Classification

Under the EPA classification system, as presented on page 2 of the EPA checklist (**Appendix C**) and Definitions section (**Appendix B**), it is GZA's opinion that the Ash Pond would be considered as having a **Significant** hazard potential. The hazard potential rating was assigned based on the available information, which indicated that the failure or misoperation of the dam would result in no probable loss of life, but could cause economic loss, environmental damage, damage of lifeline facilities (plant) or could impact other concerns. Losses would be primarily limited to the Owner's property, but the Scioto River is located in close proximity to the west embankment of the south pond and could receive ash-related material in the event of a failure or misoperation of the Ash Pond. The overall site plan is shown on **Figure 3**.

The ODNR has assigned a hazard classification of "Class II" based on the potential for loss of public water supply, loss of a wastewater treatment facility or release of health hazardous waste, but has assigned an overall (combined size, storage and hazard) "Class II" designation to the Ash Pond. ODNR assigns a "Class I" hazard rating to those dams with the highest hazard potential and a "Class IV" hazard rating to those dams with the lowest hazard potential.

1.3 Pertinent Engineering Data

1.3.1 Drainage Area

The Ash Pond is an enclosed embankment built up from the natural ground surface. As such, the contributory drainage area is the surface area of the impoundment, approximately 27 acres. The Ash Pond also receives stormwater runoff from the roof drain of the power plant/generation building. The roof drain stormwater collection area was not visited by GZA during the Ash Pond inspection, and the associated drainage area acreage of this area was not provided but is presumed to be equal to the footprint of the building, or approximately 51,400 square feet based on measurements made from aerial photographs.

1.3.2 Ash Pond

The Ash Pond is located approximately 425 feet east of the Scioto River and is bordered by farmland to the north, east and south and by the PGS and the Scioto River to the west.

The Ash Pond consists of approximately 4,900 feet of earthfill embankment and approximately 1,000 feet of natural embankment. The maximum crest height (from the lowest toe elevation to the top of embankment) is approximately 24 feet. An access road along the top of the crest has a width of approximately 10 to 15 feet and a design elevation of approximately 693 feet, National Geodetic Vertical Datum of 1929 (NGVD 29). Actual crest elevations are reportedly as low as 690 feet[8]. Portions of the Ash Pond base were reportedly keyed into the existing natural grade and the design elevation of the base of the Ash Pond is 673 feet[9]. The inner slope of the embankment has a slope of approximately 1.5 horizontal to 1 vertical (1.5H:1V) and the outer slopes of the embankment have a slope of approximately 2H:1V. The Ash Pond has not been expanded or raised since its original construction.

At the crest elevation of 693 feet, the Ash Pond is estimated to have a surface area of approximately 27 acres and a storage volume of approximately 275 acre-feet.

1.3.3 Discharges at the Site

Discharges at the Site are regulated under the previously noted NPDES Permit. Under normal operating conditions, wastewater outflows from the Ash Pond to Outfall 601 and thence to a canal leading to the Scioto River where it is ultimately discharged at an estimated average rate of 100,000 gallons per day (assuming Unit 5 of the PGS is operating at average load during summer) and an estimated maximum rate of 628,000 gallons per day (assuming a 10-year, 24-

[8] Based on Plate 3, Section E of Appendix A, of the report entitled AEP Picway Plant Ash Pond Investigation prepared by BBC&M Engineering, Inc. and dated April 2010.
[9] Based on review of Drawing No. 18-530.00 provided by AEP, originally dated June 26, 1953.

hour storm event). Values were based on data provided on AEP's water balance diagram (undated).

1.3.4 General Elevations

Ash Pond elevations presented in this report, where available, are taken from design drawings, reports and other data provided by AEP. Elevations are based upon the NGVD 29 vertical datum. Actual elevations may be lower than design elevations.

A. Top of Embankment	± 693.0 feet
B. Maximum Operating Pool	± 688.0 feet
C. Normal Operating Pool	Variable, based on operations
D. Outlet Structure Inlet (Cell S3)	± 682.0 feet (681.0 feet plus estimated height of stop-logs present during site visit)
E. Discharge Structure Inlet	Not Available, estimated at ± 674.8 feet based on 2006 topographic contours
F. Invert of Outfall 601	Not Available, estimated at ± 668.0 feet based on 2006 topographic contours

1.3.5 Design and Construction Records and History of the Ash Pond

According to the information provided by AEP, the Ash Pond was designed by Columbus & Southern Ohio Electric Company of Columbus, Ohio. Construction of the Ash Pond was completed in 1955. The embankment was constructed to its full height prior to filling it with coal ash wastewater. The origin of the materials comprising the embankments and base of the pond was not specified, although it is possible that some portion of the fill material used in construction of the embankments was taken from the native soils. Select record drawings were provided to GZA for review including Drawing Nos. 18-530.00, Sheet 8 dated June 26, 1953, 18-530.00, Sheet 1 dated January 6, 1970 and 15-30011-0 dated September 22, 2006. These drawings are provided for reference in **Appendix E.**

1.3.6 Operating Records

Based on our interviews with AEP personnel and our review of Drawing No. 15-30011-0 dated September 22, 2006, the interior of the south pond was modified in 2007 by adding interior dikes to create three cells labeled Cells S1, S2 and S3. The three cells are reportedly used to facilitate operations and typically involves filling of only one cell at a time beginning with Cell S1 followed by Cell S2 and then by Cell S3.

The availability of operating records was limited to select inspection reports performed by AEP or an outside engineering firm. Findings from the reports provided to GZA are summarized in Section 1.3.7 below. No other operating records were provided by AEP.

1.3.7 Previous Inspection Reports

Various types of visual inspections of the Ash Pond are conducted by AEP on a monthly, quarterly or bi-annual basis. Informal inspections by the Owner are performed as needed during and after heavy rainfall events, defined by AEP as three inches or more in a 24-

hour period. Records of these inspections are maintained internally. In addition, AEP contracts with a Registered Professional Engineer to perform an inspection every two years.

The ODNR Division of Water performs an inspection every five years and prepares a report including remedial measures that is provided to AEP. A representative from ODNR was on-site during the assessment. The most recent ODNR inspection was performed on February 9, 2009. Key findings or recommendations from this inspection include, but were not limited to, the following:

1. Trees and brush are not permitted on embankment surfaces. Remove the trees and brush from all embankment surfaces.
2. The embankment crest must have a uniform elevation
3. Rodent burrows weaken dam embankments and must be repaired. Rodent activity must be controlled.
4. The embankment and spillways must be protected from erosion. A healthy grass cover should be present on embankment and spillways as needed. Establish a healthy grass cover on the embankment crest.
5. The owner must provide a device or plan to permit draining of the reservoir within a reasonable period of time in accordance with OAC Rule 1501:21-13-06.
6. The reservoir/lagoon must be maintained at or below its maximum operating level to ensure sufficient freeboard. Modify the operation of the reservoir to maintain sufficient freeboard. A written request for variance from this rule may be made to the chief if adequate justification is provided.
7. This dam must have an operation, maintenance and inspection manual (OMI). Prepare and OMI.
8. Monitor the steepest portions of the exterior slope for any signs of instabilities.

A separate Ash Pond Inspection was performed by BBC&M Engineering, Inc. (BBC&M) on March 16, 2009. Based on the findings of this inspection, BBC&M concluded that the north pond portion of the Ash Pond was in good condition and the south pond was in fair condition. Refer to Figure 3 for location of interior cells and ponds. Key findings or recommendations from this inspection include, but are not limited to, the following:

1. Due to the excessive number of rodent burrows and recurrence, fumigation and/or trapping should be considered.
2. Repair concrete riser in the south pond. The excessive honeycombing of the concrete will reduce its service life since the aggregate is not well proteted.
3. Remove trees on the outboard slope of the western embankment of the south pond near the outlet structure.
4. Regrade any areas along the toe of the embankment where surface water is not draining away from the toe.
5. Repair bare areas on the slope by overseeding the embankment.
6. Continue to monitor the embankments. There are several areas that appear to have been eroded (over-steepened slopes) and/or had failures in the past.

Based on the findings of BBC&M's March 16, 2009 inspection, an investigation of the Ash Pond was performed by BBC&M in August and November of 2009 to develop subsurface data at five cross-sections through the Ash Pond embankments. Seepage and slope stability analyses to provide an indication as to the level of safety provided by the embankments were performed at two cross-sections. The investigation consisted of the installation of eleven soil borings, including five borings (B-0903, B-0904, B-0906, B-0907 and B-0909) completed through the crest of the embankments, and four borings (B-0905, B-0908, B-0910 and B-0911) at the toe of the embankments.

According to BBC&M's report, static and seismic analyses were performed for two cross-sections (Sections C and D) in the south pond since this area of the Ash Pond is periodically filled and excavated. The purpose of the cross-sections was to determine the factor of safety against rotational failure for the interior and exterior slopes using drained soil strength parameters. Rapid drawdown was also investigated for the interior slopes. A table summarizing the results of BBC&M's stability analysis is provided below:

Analysis Case	**Computed Factor of Safety**			
	Interior Slopes		**Exterior Slopes**	
	Section C	**Section D**	**Section C**	**Section D**
Static (Steady-State Seepage)	2.51	4.15	1.53	1.54
Pseudo-Static	2.16	2.96	1.54	1.48
Rapid Drawdown	1.13 [1]	1.24	Not Applicable	Not Applicable

Notes:
1. Assumes interior slope will be maintained at a 2H:1V or flatter when ash excavation occurs.

Based on the results of their analyses, BBC&M concluded that at the two cross-sections evaluated, the embankments exhibit an adequate factor of safety relative to those recommended by the United States Army Corps of Engineers for existing facilities and assuming interior slopes of 2H:1V during ash excavation.

2.0 INSPECTION

2.1 Visual Inspection

The PGS Bottom Ash Pond and Fly Ash Pond were inspected on June 9, 2011 by Frank Vetere, P.E., and Matthew Vander Eide, P.G., of GZA. The weather conditions during the inspection were sunny with temperatures above 90 degrees Fahrenheit. The weather during the weeks leading up to GZA's site visit was wet with higher than normal rainfall. Photographs to document the current conditions of the embankments were taken during the inspection and are included in **Appendix D**. Underwater areas were not inspected, as this level of investigation was beyond GZA's scope of services. A copy of the EPA Checklist for both ponds is included in **Appendix C**.

With respect to our visual inspection, there was no evidence of prior releases, failures, or patchwork observed by GZA.

2.1.1 General Findings

In general, the PGS Ash Pond was found to be in **SATISFACTORY** condition and the Specific concerns are identified in more detail in the sections below.

2.1.2 Ash Pond

An overall Ash Pond site plan showing the pertinent features, including the location and orientation of photographs provided in **Appendix D**, is detailed on **Figure 3**.

2.1.2.1 Outer Embankment Slope (Photos 7, 10, 15, 17-19, 20, 24-26, 29, 30)

The outer embankment slope generally appeared to be steep, but in good condition. Most portions of the slopes had been mowed recently. Mowing in those areas not completed before GZA's site visit (south and east embankment of north pond) was reportedly scheduled to be completed in the near future. Similar to previous inspections by others, rodent burrows were observed in multiple locations, but did not appear to be excessive in size. One area on the western exterior embankment of the south pond was observed to be bare of vegetation (Photo 17). Evidence of standing water at the toe of the embankments was observed, particularly in the southwest corner of the south pond where an area of standing water measuring approximately 30 feet long by 5 feet wide was present (Photo 18). According to AEP personnel, recent rainfall had been excessive and the Scioto River had risen and flooded the portions of the area surrounding the south pond embankments. Rip rap has been used to address areas of erosion on the slope, such as the area shown in Photo 24. No unusual movement or sloughing was observed in the slope.

2.1.2.2 Crest (Photos 2, 5, 7, 9, 10, 15, 17, 21, 25, 27-30)

The crest of the Ash Pond serves as an access road around the perimeter of the pond and was generally grass covered, but had areas that were bare or covered with gravel. Minor ruts from vehicle traffic were observed on the crest between Cell S2 and the clearwater pond (Photo 7). The alignment of the top of the embankment appeared to vary, with visible elevation changes along the western embankment of the south pond in the vicinity of the clearwater pond and BBC&M boring B-0903 (Photo 15). Evidence of elevations less than the design elevation (693 feet) is noted in the topographic contours shown on Drawing No. 15-30011-0, dated September 22, 2006. According to AEP personnel, efforts to address the crest elevation have been ongoing. An elevation survey along the crest by a Professional Surveyor would be required to further evaluate the actual alignment of the top of the embankment and to determine current conditions.

2.1.2.3 Interior of Embankment (Photos 1, 2, 3, 5- 9, 21, 22, 23, 27)

The interior embankment slope generally appeared to be in good condition. As a result of the ash filling operations in the south pond, the volume of fly ash and water is variable and is not continuous during the year. As such, some vegetation has grown within the cells of the south pond (Photos 5-8, 21-23). Ash is periodically excavated from the south pond and relocated to the north pond, which is partially capped with cohesive materials, topsoil and grass. It is GZA's understanding, through interviews with AEP personnel, that operations at the PGS may be limited further than current levels or possibly ceased within 5 years.

Freeboard was not observed to be a concern during GZA's site visit based on the current operations. However, based on the information provided to GZA, freeboard could potentially be a concern in certain areas considering a maximum operating pool elevation of 688 feet and multiple areas of the crest shown with a 2006 elevation less than 693 feet (i.e., certain areas have less than 3 feet of freeboard at the maximum operating pool and less than the ODNR requirement of 5 feet). More recent topographical information was not available at the time of GZA's site visit.

According to AEP, the volume of material stored in the Ash Pond is variable, as ash is occasionally removed for beneficial reuse.

2.1.2.4 Appurtenant Structures (Photos 1, 2, 4, 5, 9-14, 16, 21-23)

There is one discharge structure associated with the Ash Pond. The concrete discharge structure is located in the clearwater pond located near the southwest portion of the pond (Photos 7, 9-14). Additionally, an outlet structure is located in Cell S3 of the south pond (Photos 2, 4, 23) and conveys water to the clearwater pond. Both of these structures were observed to be in good condition and clear of debris. The concrete visible above the water surface in the discharge structure appeared intact with minor surficial pitting or flaking/cracking. The interior of the concrete discharge structure could not be observed below the water level to evaluate sluice gates, piping or other features. The CMP discharge pipe associated with the concrete discharge structure is sub-grade and could not be visually inspected during the assessment. However, AEP reportedly has never had an issue with the discharge pipe since the Ash Pond was originally constructed. The terminus of the CMP was visible and was fitted with a duck-bill flap gate that appeared to be in good condition (Photo 16).

2.2 Caretaker Interview

Maintenance of the Ash Pond is the responsibility of AEP personnel. As detailed in previous sections, GZA met with AEP personnel and discussed the current operations and maintenance procedures, regulatory requirements, and the history of the Ash Pond since it was constructed.

2.3 Operation and Maintenance Procedures

As discussed in Section 1.2.5, AEP personnel are responsible for the regular operation and maintenance of the Ash Pond. AEP has developed internal inspection forms that are to be completed upon completion of the various inspections that are scheduled to be performed on a monthly, quarterly or bi-annual basis.

Routine maintenance procedures also include monitoring and sampling of the outfall from the clearwater pond in accordance with the existing NPDES permit (Outfall 601).

2.4 Emergency Action Plan

In accordance with Rules 1501:21-21-04 and 1501:21-15-07 of the Ohio Administrative Code (OAC), owners of Class I, Class II and Class III dams must prepare and maintain an emergency action plan (EAP). Further, Rule 1501:21-21-04 states the following: "The emergency action plan shall be updated on at least an annual basis including updating all emergency contact information. The owner or the owner's representative shall meet with the local county emergency management director annually to review and update the plan. The owner shall annually submit to the division updated pages of the emergency action plan including a signature page from the county director indicating that the annual update meeting occurred and that the county director received a copy of the updated pages of the plan".

Review of AEP's EAP indicates that emergency detection, evaluation, classification, notification, contact information and procedures are addressed and provided in the plan.

2.5 Hydrologic/Hydraulic Data

GZA did not perform an independent assessment of the hydraulics and hydrology for the embankments, as this was beyond the scope of services. However, we did review available design documentation for the Ash Pond.

According to design drawings provided by AEP, the design crest elevation of the Ash Pond is 693 feet. The normal pool elevation varies, but the maximum operating pool elevation is documented as 688 feet. Subtracting the maximum pool elevation from the design crest elevation results in a theoretical freeboard of 5 feet. Actual crest elevations appear to vary however, and are as low as 690 feet (based on the available 2006 topographic data), which results in certain areas having freeboard less than the ODNR requirement of 5 feet. OAC Rule 1501:21-13-07 states that "For class I and class II dams that are upground reservoirs, the minimum elevation of the top of the dam shall be at least five feet higher than the elevation of the designed maximum operating pool level unless otherwise approved by the chief". According ONDR representatives, AEP may request a variance to this rule that would decrease the minimum freeboard at this dam from 5 feet to 3 feet. More recent topographical information was not available at the time of GZA's site visit.

Additionally, GZA reviewed a Hydrology/Hydraulic report prepared by AEP and dated June 13, 2011[10]. The objective of this report was to "evaluate the hydraulic capacity of the diking system by analyzing the change in water surface elevation within [the] south ash pond during an extreme weather event". The design flood used in AEP's analysis was for a Class II structure, and was a 6-hour, 0.5 Probable Maximum Flood (PMF), which was generated from the 50 percent Probable Maximum Precipitation (PMP). According to AEP's evaluation, the maximum water surface elevation reached during the 50% PMF is 688.71 feet, when assuming a pool maximum operating pool elevation of 688 feet. This results in a potential pool elevation that is less than the documented crest elevations (approximately 690 to 693 feet) but also less than the ODNR requirement for freeboard (5 feet).

Based on the findings of their evaluation, AEP concluded that "the ash pond complex analysis has demonstrated that it is of adequate hydraulic capacity and storage. The ash pond complex can safely contain the design flood (50% PMF) without overtopping of the dike". A copy of this report is provided in Appendix E.

[10] Hydrology/Hydraulic Report, Ash Pond Complex – File #9630-001, Picway Power Plant, prepared by AEP Civil Engineering Department, Geotechnical Engineering Section, June 13, 2011.

2.6 Structural and Seepage Stability

The original structural and seepage stability analyses, if any exist, were not available to GZA at the time of inspection. Slope stability analyses and seepage analyses have been performed recently in 2009 and are discussed above in Section 1.3.7. Foundation liquefaction analyses and settlement analyses reports were not available. The hydraulic conductivity of the earthfill materials was not available.

3.0 ASSESSMENTS AND RECOMMENDATIONS

3.1 Assessments

In general, based upon the information provided and our observations, the overall condition of PGS Ash Pond is judged to be **SATISFACTORY.**

The Ash Pond was found to have the following deficiencies:

1. Portions of the outer embankment slopes had not been mowed recently;
2. Presence of minor rodent burrows in the exterior slopes of the embankments;
3. Presence of a bare area on the western exterior embankment of the south pond;
4. No instrumentation (i.e., staff gauge) to observe the elevation of the water within the pond/impoundment;
5. No instrumentation (i.e., survey/settlement monuments) to monitor crest elevations and/or embankment movement;
6. Bare areas, areas of limited vegetative growth or areas of gravel cover present on crest;
7. Presence of vegetation on the interior slopes of the embankment;
8. AEP personnel were unsure if the discharge pipe from the concrete discharge structure has been inspected internally since it was installed;
9. Visible variations in crest elevations, particularly along the west embankment of the south pond;
10. Minor ruts on crest from vehicle traffic;
11. Minor surficial pitting or flaking/cracking on the concrete discharge structure;
12. Reported crest and maximum pool elevations indicate potential for non-compliance with state freeboard requirement of five feet for Class II dams per OAC Rule 1501:21-13-07; and,
13. Presence of standing water at or near the toe of the exterior embankment slopes of the south pond, particularly near the southwest corner.

3.2 Studies and Analyses

The following recommendations and remedial measures generally describe the recommended approach to address current deficiencies. Prior to undertaking recommended maintenance, repairs, or remedial measures, the applicability of environmental permits needs to be determined for activities that may occur within resource areas under the jurisdiction of the appropriate regulatory agencies.

GZA recommends the following studies and analyses:

1. Survey of the crest of both ponds by a licensed Professional Surveyor to evaluate the current elevation profile of the crest and confirm that survey monuments are not moving horizontally;
2. Evaluate freeboard conditions based on maximum pool elevation and more recent topographical data; and,
3. Camera survey of the CMP outfall should be performed.

3.3 Recurrent Operation & Maintenance Recommendations

GZA recommends the following operation and maintenance level activities:

1. Frequent monitoring of steep slopes for evidence of sloughing or erosion that could lead to instability, movement or failure of the embankments;
2. Review emergency action plan annually per OAC Rule 1501:21-21-04 and update as applicable;
3. Clear vegetation from the interior embankment slopes;
4. Remove trees and resulting stumps on or near the exterior slopes of the embankment, particularly near the west embankment of the south pond, Outfall 601 and the northern end of the clearwater pond;
5. Continue to monitor and control rodent activities and repair burrows as they are discovered. Keeping the embankments mowed can help to reduce populations of certain species;
6. Maintain interior slopes of at least 2H:1V during ash excavation as recommended by BBC&M;
7. Install a staff gauge on or near the outlet structure in Cell S3 and on or near the concrete discharge structure in the clearwater pond in order to take periodic measurements of the Ash Pond water surface elevation;
8. Inspect each of the monitoring wells installed in 2009 and ensure each well has a cap, lockable protective cover/casing and is visible during mowing operations;
9. Perform periodic water level measurements in the monitoring wells to evaluate water levels below the crest and at the toe of the embankments; and,
10. If AEP has the opportunity to stop discharging from the clearwater pond for a limited time period, inspect the discharge pipe from the concrete discharge structure to the duck-bill flap gate to verify that the pipe is operating correctly and is in good condition. This may be performed by video photography.

3.4 Repair Recommendations

GZA recommends the following repairs which may improve the overall condition of the Ash Pond, but do not alter the current design of the embankment. The recommendations may require design by a licensed Professional Engineer and construction contractor experienced in embankment construction.

1. Minor concrete repair work on the concrete discharge structure in the clearwater pond;
2. Re-seed and/or over seed bare areas of the embankments and crest to establish healthy grass cover;

3. Clear the area of established vegetation near the lower portion and toe of the outer embankment slopes near the outfall structure; and,
4. Regrade areas near the toe of exterior slopes to facilitate proper drainage away from the embankments.

3.5 Alternatives

There are no practical alternatives to the repairs itemized above.

4.0 ENGINEER'S CERTIFICATION

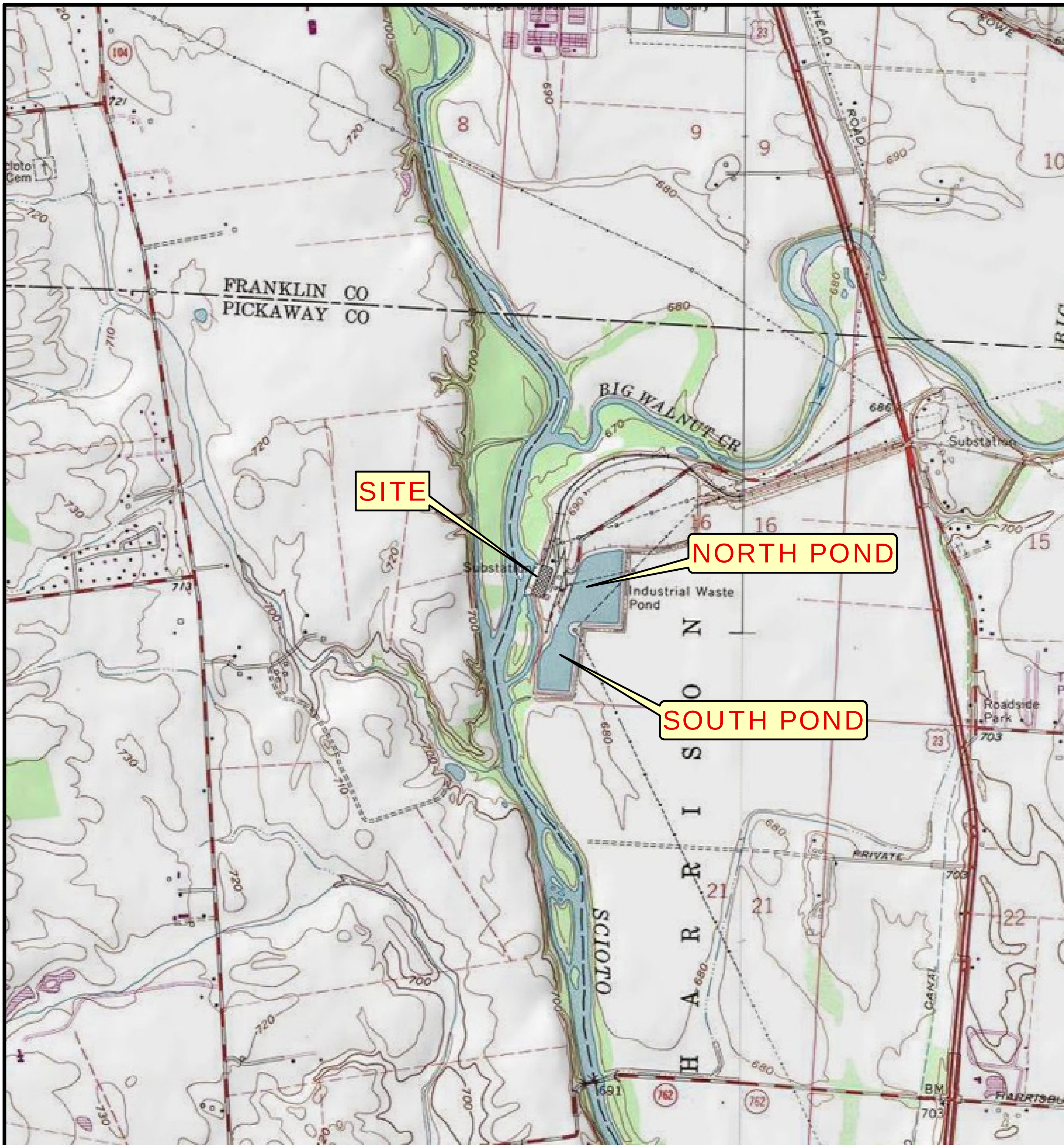
I acknowledge that the management units referenced herein, the Picway Generating Station Ash Pond, has been assessed to be in **SATISFACTORY** condition on June 9, 2011.

Frank Vetere, P.E.
Senior Project Manager

STATE OF OHIO
FRANK S. VETERE
E-62568
REGISTERED
PROFESSIONAL ENGINEER

X:\01.xx Norwood\01.0170142.30 CCW Dams Round 10\AEP_Southern Picway\Report\AEP Southern Picway - Report_FINAL.docx

Figures



SOURCE : This map contains the ESRI ArcGIS Online World Topographic Map service, published February 2011 by ESRI ARCIMS Services. The service was compiled to uniform cartography using a variety of best available sources from several data providers.

Data Supplied by : esri

0 1,000 2,000 4,000 6,000

SCALE IN FEET

N W E S

PROJ. MGR.: MAV
DESIGNED BY: MAV
REVIEWED BY: PHB
OPERATOR: EMD

DATE: 11-14-2011

LOCUS PLAN
(USGS TOPOGRAPHIC QUAD)

PICWAY GENERATING STATION
AMERICAN ELECTRIC POWER

JOB NO.
01.0170142.30

FIGURE NO.
1

SOURCE : This map contains the ESRI ArcGIS Online World Imagery Map service, published February 2011 by ESRI ARCIMS Services. The service was compiled to uniform cartography using a variety of best available sources from several data providers.

Data Supplied by : esri

0 1,000 2,000 4,000 6,000

SCALE IN FEET

N S E W

PROJ. MGR.: MAV
DESIGNED BY: MAV
REVIEWED BY: PHB
OPERATOR: JRC

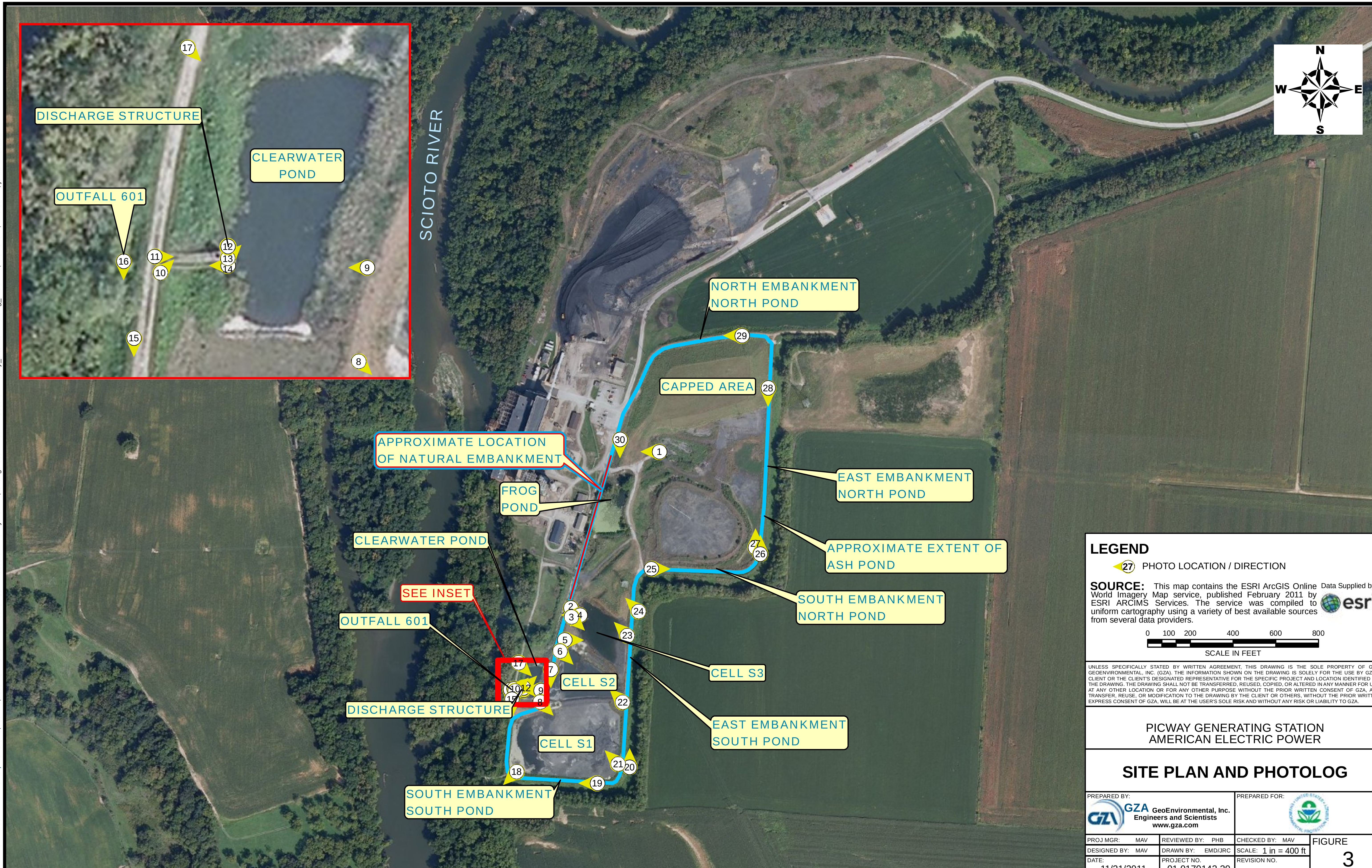
DATE: 11-14-2011

LOCUS PLAN
(DIGITAL ORTHOPHOTO/AERIAL IMAGERY)

PICWAY GENERATING STATION
AMERICAN ELECTRIC POWER

JOB NO.
01.0170142.30

FIGURE NO.
2



LEGEND

27 PHOTO LOCATION / DIRECTION

SOURCE: This map contains the ESRI ArcGIS Online World Imagery Map service, published February 2011 by ESRI ARCIMS Services. The service was compiled to uniform cartography using a variety of best available sources from several data providers.

Data Supplied by : esri

0 100 200 400 600 800

SCALE IN FEET

PICWAY GENERATING STATION
AMERICAN ELECTRIC POWER

SITE PLAN AND PHOTOLOG

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:

PROJ MGR: MAV	REVIEWED BY: PHB	CHECKED BY: MAV	FIGURE 3
DESIGNED BY: MAV	DRAWN BY: EMD/JRC	SCALE: 1 in = 400 ft	
DATE: 11/21/2011	PROJECT NO. 01.0170142.30	REVISION NO.	

Appendix A

Limitations

DAM ENGINEERING & VISUAL INSPECTION LIMITATIONS

1. The observations described in this report were made under the conditions stated herein. The conclusions presented in the report were based solely on the services described therein, and not on scientific tasks or procedures beyond the scope of described services or the time and budgetary constraints imposed by the United States Environmental Protection Agency (EPA).

2. In preparing this report, GZA GeoEnvironmental, Inc. (GZA) has relied on certain information provided by American Electric Power (AEP) (and their affiliates) as well as Federal, state, and local officials and other parties referenced therein. GZA has also relied on certain information contained on the State of Ohio's website as well as Federal, state, and local officials and other parties which were available to GZA at the time of the inspection. Although there may have been some degree of overlap in the information provided by these various sources, GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this work.

3. In reviewing this Report, it should be noted that the reported condition of the Ash Ponds is based on observations of field conditions during the course of this study along with data made available to GZA. The observations of conditions at the Ash Ponds reflect only the situation present at the specific moment in time the observations were made, under the specific conditions present. It may be necessary to reevaluate the recommendations of this report when subsequent phases of evaluation or repair and improvement provide more data.

4. It is important to note that the condition of a dam or embankment depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam or embankment will continue to represent the condition of the dam or embankment at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions may be detected.

5. Water level readings have been reviewed and interpretations have been made in the text of this report. Fluctuations in the level of the groundwater and surface water may occur due to variations in rainfall, temperature, and other factors different than at the time measurements were made.

6. GZA's comments on the history, hydrology, hydraulics, and embankment stability for the Ash Ponds are based on a limited review of available design documentation for the Picway Generating Station. Calculations and computer modeling used in these analyses were not available and were not independently reviewed by GZA.

7. This report has been prepared for the exclusive use of EPA for specific application to the existing dam facilities, in accordance with generally accepted dam engineering practices. No other warranty, express or implied, is made.

8. This dam inspection verification report has been prepared for this project by GZA. This report is for broad evaluation and management purposes only and is not sufficient, in and of itself, to prepare construction documents or an accurate bid.

9. The Phase I investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

Appendix B

Definitions

COMMON DAM SAFETY DEFINITIONS

For a comprehensive list of dam engineering terminology and definitions refer to references published by the U.S. Army Corps of Engineers, the Federal Energy Regulatory Commission, the Department of the Interior Bureau of Reclamation, or the Federal Emergency Management Agency.

Orientation

Upstream – Shall mean the side of the dam that borders the impoundment.

Downstream – Shall mean the high side of the dam, the side opposite the upstream side.

Right – Shall mean the area to the right when looking in the downstream direction.

Left – Shall mean the area to the left when looking in the downstream direction.

Dam Components

Dam – Shall mean any artificial barrier, including appurtenant works, which impounds or diverts water.

Embankment – Shall mean the fill material, usually earth or rock, placed with sloping sides, such that it forms a permanent barrier that impounds water.

Crest – Shall mean the top of the dam, usually provides a road or path across the dam.

Abutment – Shall mean that part of a valley side against which a dam is constructed. An artificial abutment is sometimes constructed as a concrete gravity section, to take the thrust of an arch dam where there is no suitable natural abutment.

Appurtenant Works – Shall mean structures, either in dams or separate there from, including but not be limited to, spillways; reservoirs and their rims; low level outlet works; and water conduits including tunnels, pipelines, or penstocks, either through the dams or their abutments.

Spillway – Shall mean a structure over or through which water flows are discharged. If the flow is controlled by gates or boards, it is a controlled spillway; if the fixed elevation of the spillway crest controls the level of the impoundment, it is an uncontrolled spillway.

General

EAP – Emergency Action Plan - Shall mean a predetermined plan of action to be taken to reduce the potential for property damage and/or loss of life in an area affected by an impending dam break.

O&M Manual – Operations and Maintenance Manual; Document identifying routine maintenance and operational procedures under normal and storm conditions.

Normal Pool – Shall mean the elevation of the impoundment during normal operating conditions.

Acre-foot – Shall mean a unit of volumetric measure that would cover one acre to a depth of one foot. It is equal to 43,560 cubic feet. One million U.S. gallons = 3.068 acre feet.

Height of Dam – Shall mean the vertical distance from the lowest portion of the natural ground, including any stream channel, along the downstream toe of the dam to the crest of the dam.

Spillway Design Flood (SDF) – Shall mean the flood used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works, and for determining maximum temporary storage and height of dam requirements.

Condition Rating

SATISFACTORY - No existing or potential management unit safety deficiencies are recognized. Acceptable performance is expected under all applicable loading conditions (static, hydrologic, seismic) in accordance with the applicable criteria. Minor maintenance items may be required.

FAIR - Acceptable performance is expected under all required loading conditions (static, hydrologic, seismic) in accordance with the applicable safety regulatory criteria. Minor deficiencies may exist that require remedial action and/or secondary studies or investigations.

POOR - A management unit safety deficiency is recognized for any required loading condition (static, hydrologic, seismic) in accordance with the applicable dam safety regulatory criteria. Remedial action is necessary. POOR also applies when further critical studies or investigations are needed to identify any potential dam safety deficiencies.

UNSATISFACTORY - Considered unsafe. A dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution. Reservoir restrictions may be necessary.

Hazard Potential

(In the event the impoundment should fail, the following would occur):

LESS THAN LOW HAZARD POTENTIAL: Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

LOW HAZARD POTENTIAL: Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

SIGNIFICANT HAZARD POTENTIAL: Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

HIGH HAZARD POTENTIAL: Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

Appendix C

Inspection Checklists

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name:	Picway Generating Station	Date:	June 9, 2011
Unit Name:	Ash Pond	Operator's Name:	AEP Ohio
Unit I.D.:	Ohio 9630-001; National # OH00570	Hazard Potential Classification:	High **Significant** (circled) Low
Inspector's Name:	Frank Vetere, P.E. & Matt Vander Eide, P.G.		

Check the appropriate box below. Provide comments when appropriate. If not applicable or not available, record "N/A". Any unusual conditions or construction practices that should be noted in the comments section. For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

Item	Yes	No	Item	Yes	No
1. Frequency of Company's Dam Inspections?	Quarterly		18. Sloughing or bulging on slopes?		✓
2. Pool elevation (operator records)?	Unavailable		19. Major erosion or slope deterioration?		✓
3. Decant inlet elevation (operator records)?	682 +/- feet		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	N/A		Is water entering inlet, but not exiting outlet?		✓
5. Lowest dam crest elevation (operator records)?	690.0 feet		Is water exiting outlet, but not entering inlet?		✓
6. If instrumentation is present, are readings recorded (operator records)?	N/A		Is water exiting outlet flowing clear?	✓	
7. Is the embankment currently under construction?		✓	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation,stumps, topsoil in area where embankment fill will be placed)?	✓		From underdrain?	N/A	
9. Trees growing on embankment? (If so, indicate largest diameter below)	✓		At isolated points on embankment slopes?		✓
10. Cracks or scarps on crest?		✓	At natural hillside in the embankment area?		✓
11. Is there significant settlement along the crest?		✓	Over widespread areas?		✓
12. Are decant trashracks clear and in place?	✓		From downstream foundation area?		✓
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		✓	"Boils" beneath stream or ponded water?		✓
14. Clogged spillways, groin or diversion ditches?	N/A		Around the outside of the decant pipe?		✓
15. Are spillway or ditch linings deteriorated?	N/A		22. Surface movements in valley bottom or on hillside?	N/A	
16. Are outlets of decant or underdrains blocked?		✓	23. Water against downstream toe?	✓	
17. Cracks or scarps on slopes?		✓	24. Were Photos taken during the dam inspection?	✓	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Inspection Issue #	Comments

The embankment comprised one unit but contained multiple "cells" which were separated by interior dikes. Additional comments corresponding to the checklist above are provided below:

2) The maximum operating elevation, or normal pool, is reportedly 688 feet. However, the plant does not operate continuously and the current pool elevation was not known during visit and varies depending on operations.
3) Decant inlet invert elevation is reported as 681 feet. Two stop logs were present and each appeared to be approximately 6-inches tall. Elevation of the top of the stop logs was estimated to be approximately 682 +/- feet.
5) Crest is reported as 693 feet in some documents including the but a cross section in a 2010 engineering report shows crest as low as 690 feet.
8) According to plant personnel, foundation preparation was performed.
9) Vegetation including small diameter trees (<2-inches) was present on downstream slope near the outlet structure in the "Clear Water Pond". The plant was actively cutting/mowing vegetation during site visit. Mature trees present around portions of the downstream perimeter of the embankment, but these trees were set back from the toe of the embankment.
23) Remnants of standing water observed against the downstream toe (east, south and west), reportedly due to excessive spring precipitation and resulting high Scioto River levels. Local soils are reportedly slow draining.

Based on the information provided, it does not appear that the impoundment was constructed over wet ash or slag.

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # OH0005398 INSPECTOR Frank Vetere, P.E. / Matt Vander Eide, P.G.

Date June 9, 2011

Impoundment Name Picway Generating Station Ash Pond
Impoundment Company AEP Ohio (a.k.a Columbus & Southern Ohio Electric Co.)
EPA Region 5
State Agency (Field Office) Addresss 2045 Morse Road, Bldg. B-2
Columbus, Ohio 43229
Name of Impoundment Picway Generating Station Ash Pond
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New X Update ____

	Yes	No
Is impoundment currently under construction?		X
Is water or ccw currently being pumped into the impoundment?	X	

IMPOUNDMENT FUNCTION: Storage of bottom and fly ash sluice

Nearest Downstream Town : Name Circleville, OH
Distance from the impoundment 13.25 miles
Impoundment
Location: Longitude 83 Degrees 0 Minutes 34 Seconds
Latitude 39 Degrees 47 Minutes 21 Seconds
State OH County Pickaway

Does a state agency regulate this impoundment? YES X NO ____

If So Which State Agency? Ohio DNR Division of Water I.D. 9630-001

<u>HAZARD POTENTIAL</u> (In the event the impoundment should fail, the following would occur):

______ **LESS THAN LOW HAZARD POTENTIAL:** Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

______ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

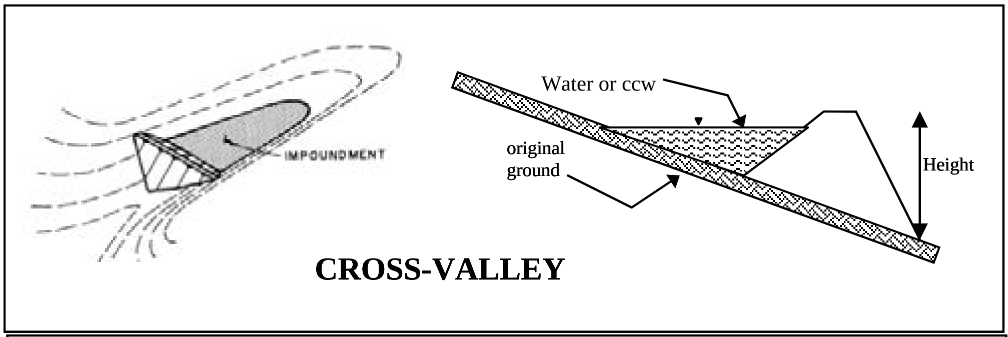
__X__ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

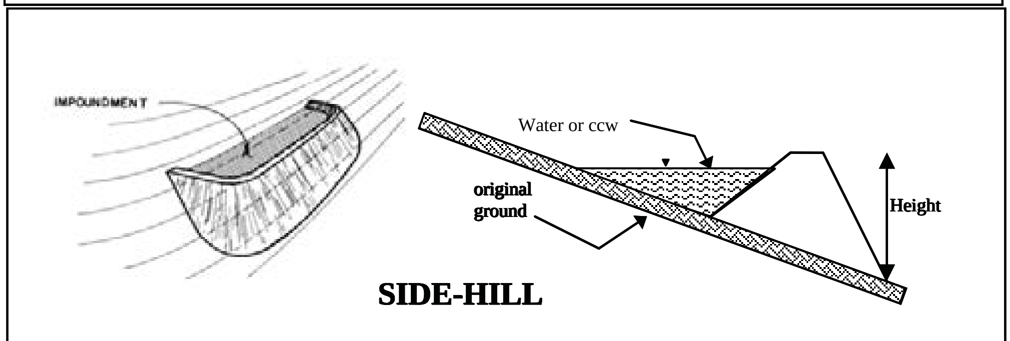
______ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

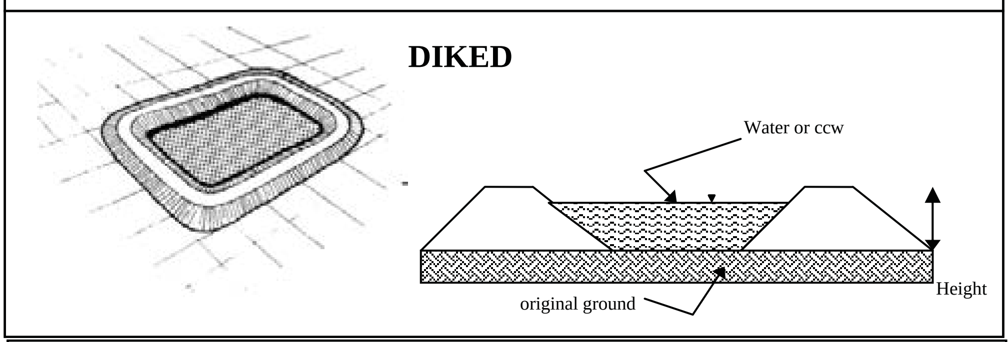
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

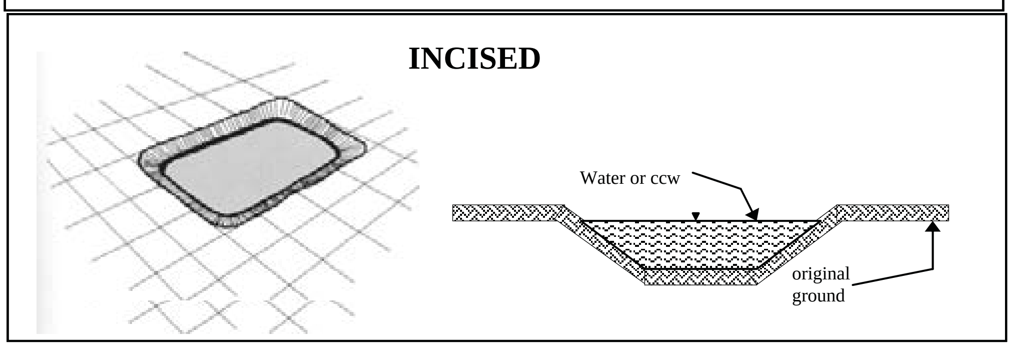
Dam failure or misoperation would result in no probable loss of human life but could cause economic loss, environmental damage, damage of lifeline facilities (plant) or could impact other concerns. The losses would be primarily limited to the owner's property, but the Scioto River is located to the west of the western dike.

CONFIGURATION:









_____ Cross-Valley
_____ Side-Hill
__X__ Diked
_____ Incised (form completion optional)
_____ Combination Incised/Diked

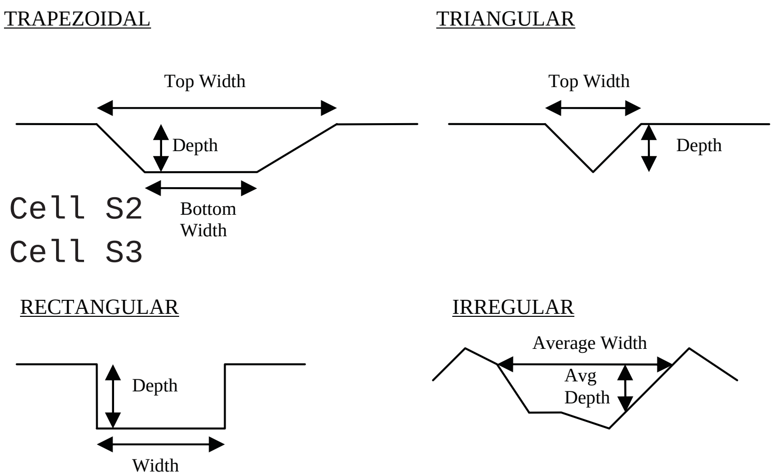
Embankment Height ____24____ feet   Embankment Material Compacted clay
Pool Area ____26____ acres   Liner Compacted clay
Current Freeboard ____>5____ feet   Liner Permeability unknown

TYPE OF OUTLET (Mark all that apply)

__X__ **Open Channel Spillway**
X(2) Trapezoidal
______ Triangular
______ Rectangular
______ Irregular

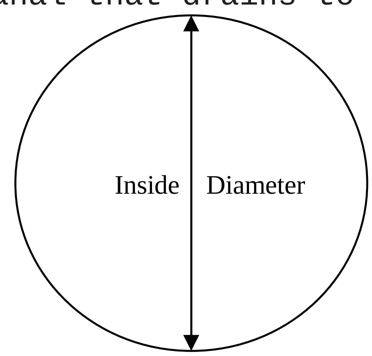
1. Cell S1 to Cell S2
2. Cell S2 to Cell S3

______ depth
______ bottom (or average) width
______ top width



__X__ **Outlet** (from "Clear Water Pond" to canal that drains to Scioto River)

36 in inside diameter



Material
__X__ corrugated metal (with duckbill valve at outlet)
______ welded steel
______ concrete
______ plastic (hdpe, pvc, etc.)
______ other (specify) _______________________

Is water flowing through the outlet? YES __X__ NO _______

______ **No Outlet**

__X__ **Other Type of Outlet** (specify) 30-inch corrugated metal pipe decants from Cell S3 to "Clear Water Pond"

The Impoundment was Designed By Columbus & Southern Ohio Electric Co.

Has there ever been a failure at this site? YES ___________ NO ____X________

If So When? ______________________________

If So Please Describe : ____

Has there ever been significant seepages at this site? YES ________ NO __X____

If So When? ______________________________

IF So Please Describe: ____

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES ________ NO __X__

If so, which method (e.g., piezometers, gw pumping,...)? ____________________

If so Please Describe : No past seepages or breeches.

Appendix D

Photographs

GZA GeoEnvironmental, Inc. — PHOTOGRAPHIC LOG

Client Name: U.S. Environmental Protection Agency	Site Location: American Electric Power (AEP) Picway Generating Station Lockbourne, Ohio	Project No. 01.0170142.30

Photo No. 1 **Date:** 06/09/11

Direction Photo Taken:
West

Description:
Discharge pipe conveying bottom ash into the north pond. Picway Plant is shown in the background.

Photo No. 2 **Date:** 06/09/11

Direction Photo Taken:
South

Description:
Outlet structure located in Cell S3 of south pond.

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. Environmental Protection Agency	Site Location: American Electric Power (AEP) Picway Generating Station Lockbourne, Ohio	Project No. 01.0170142.30

Photo No. 3	Date: 06/09/11
Direction Photo Taken: Southeast	
Description: View of Cell S3 in south pond.	

Photo No. 4	Date: 06/09/11
Direction Photo Taken: West	
Description: View of outlet structure located in Cell S3 of south pond.	

GZA GeoEnvironmental, Inc.		PHOTOGRAPHIC LOG
Client Name: U.S. Environmental Protection Agency	**Site Location: American Electric Power (AEP) Picway Generating Station Lockbourne, Ohio**	**Project No.** 01.0170142.30

Photo No. 5	**Date:** 06/09/11

Direction Photo Taken:
East

Description:
View of rock berm separating Cell S2 (right) from Cell S3 (left).

Photo No. 6	**Date:** 06/09/11

Direction Photo Taken:
Southeast

Description:
View of Cell S2 of south pond.

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. Environmental Protection Agency	Site Location: American Electric Power (AEP) Picway Generating Station Lockbourne, Ohio	Project No. 01.0170142.30

Photo No. 7

Date: 06/09/11

Direction Photo Taken:
South

Description:
View of berm dividing Cell S2 (left) from clearwater pond (right). Note concrete discharge structure in clearwater pond.

Photo No. 8

Date: 06/09/11

Direction Photo Taken:
Southeast

Description:
View of Cell S1 in south pond.

Client Name: U.S. Environmental Protection Agency	Site Location: American Electric Power (AEP) Picway Generating Station Lockbourne, Ohio	Project No. 01.0170142.30

Photo No. 9 **Date:** 06/09/11

Direction Photo Taken: Southwest

Description: View of concrete discharge structure in clearwater pond.

Photo No. 10 **Date:** 06/09/11

Direction Photo Taken: Northeast

Description: View of concrete discharge structure in clearwater pond.

GZA GeoEnvironmental, Inc. — PHOTOGRAPHIC LOG

Client Name: U.S. Environmental Protection Agency	Site Location: American Electric Power (AEP) Picway Generating Station Lockbourne, Ohio	Project No. 01.0170142.30

Photo No. 11 **Date:** 06/09/11

Direction Photo Taken:
East

Description:
View of access ramp to concrete discharge structure in clearwater pond .

Photo No. 12 **Date:** 06/09/11

Direction Photo Taken:
Not Applicable

Description:
View of interior of concrete discharge structure in clearwater pond.

GZA GeoEnvironmental, Inc.		PHOTOGRAPHIC LOG
Client Name: U.S. Environmental Protection Agency	**Site Location: American Electric Power (AEP) Picway Generating Station Lockbourne, Ohio**	**Project No.** 01.0170142.30

Photo No. 13

Date: 06/09/11

Direction Photo Taken:
Northeast

Description:
View of skimmer preceding inlet of concrete discharge structure in clearwater pond.

Photo No. 14

Date: 06/09/11

Direction Photo Taken:
West

Description:
View of screen located on concrete discharge structure in clearwater pond. Screen is positioned after the skimmer shown in photo 13 and precedes the inlet.

Client Name: U.S. Environmental Protection Agency	Site Location: American Electric Power (AEP) Picway Generating Station Lockbourne, Ohio	Project No. 01.0170142.30

Photo No. 15 **Date:** 06/09/11

Direction Photo Taken:
South

Description:
View of west embankment of the south pond in vicinity of concrete discharge structure in clearwater pond and vicinity of boring B-0903 performed by BBC&M in August 2009. Note variable elevation of crest

Photo No. 16 **Date:** 06/09/11

Direction Photo Taken:
South

Description:
View of duck-bill flap gate outfall (Outfall 601 in NPDES permit). Water discharges from clearwater pond to a canal that ultimately discharge into the Scioto River.

GZA GeoEnvironmental, Inc. — PHOTOGRAPHIC LOG

Client Name: U.S. Environmental Protection Agency	Site Location: American Electric Power (AEP) Picway Generating Station Lockbourne, Ohio	Project No. 01.0170142.30

Photo No. 17 | **Date:** 06/09/11

Direction Photo Taken:
Southeast

Description:
Area of outer west embankment observed to be bare of vegetation. Note hand rail of concrete discharge structure in background for reference point (circled).

Photo No. 18 | **Date:** 06/09/11

Direction Photo Taken:
Southwest

Description:
Area of standing water at the toe of the southwest corner of the outer south embankment of the south pond.

GZA GeoEnvironmental, Inc.		PHOTOGRAPHIC LOG
Client Name: U.S. Environmental Protection Agency	**Site Location: American Electric Power (AEP) Picway Generating Station Lockbourne, Ohio**	**Project No.** 01.0170142.30

Photo No. 19

Date: 06/09/11

Direction Photo Taken:
West

Description:
View of outer south embankment of south pond. Photo taken near the southeast corner of the south pond.

Photo No. 20

Date: 06/09/11

Direction Photo Taken:
North

Description:
View of outer east embankment of south pond. Photo taken near the southeast corner of the south pond. Picway Plant stack is shown in background.

Client Name: U.S. Environmental Protection Agency	Site Location: American Electric Power (AEP) Picway Generating Station Lockbourne, Ohio	Project No. 01.0170142.30

Photo No. 21 **Date:** 06/09/11

Direction Photo Taken:
Northwest

Description:
View of Cell S1 of the south pond and fly ash slurry pipeline. Picway Plant is shown in the background.

Photo No. 22 **Date:** 06/09/11

Direction Photo Taken:
Northwest

Description:
View of Cell S2 of the south pond and fly ash slurry pipeline. Picway Plant is shown in the background. Cell S2 was the active cell during the June 9, 2011 site visit.

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. Environmental Protection Agency	Site Location: American Electric Power (AEP) Picway Generating Station Lockbourne, Ohio	Project No. 01.0170142.30

Photo No. 23

Date: 06/09/11

Direction Photo Taken:
Northwest

Description:
View of Cell S3 of the south pond. Picway Plant and outlet structure (circled) are shown in the background.

Photo No. 24

Date: 06/09/11

Direction Photo Taken:
Northwest

Description:
View of rip rap placed on the outer east embankment to address isolated area of erosion.

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. Environmental Protection Agency	Site Location: American Electric Power (AEP) Picway Generating Station Lockbourne, Ohio	Project No. 01.0170142.30

Photo No. 25 **Date:** 06/09/11

Direction Photo Taken:
East-Southeast

Description:
View of crest and outer south embankment of the north pond. Note un-mowed vegetation.

Photo No. 26 **Date:** 06/09/11

Direction Photo Taken:
North

Description:
View of outer east embankment of the north pond. Note un-mowed vegetation.

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. Environmental Protection Agency	Site Location: American Electric Power (AEP) Picway Generating Station Lockbourne, Ohio	Project No. 01.0170142.30

Photo No. 27

Date: 06/09/11

Direction Photo Taken:
North

Description:
View of crest of east embankment of the north pond. Note un-mowed vegetation on outer embankment and capped portion of north pond in left background.

Photo No. 28

Date: 06/09/11

Direction Photo Taken:
South

Description:
View of crest of east embankment of the north pond. Note capped portion of north pond to right.

GZA GeoEnvironmental, Inc. **PHOTOGRAPHIC LOG**

Client Name: U.S. Environmental Protection Agency	**Site Location:** American Electric Power (AEP) Picway Generating Station Lockbourne, Ohio	**Project No.** 01.0170142.30

Photo No. 29 **Date:** 06/09/11

Direction Photo Taken:
West

Description:
View of crest of north embankment of the north pond. Note capped portion of north pond to left and Picway Plant in the background.

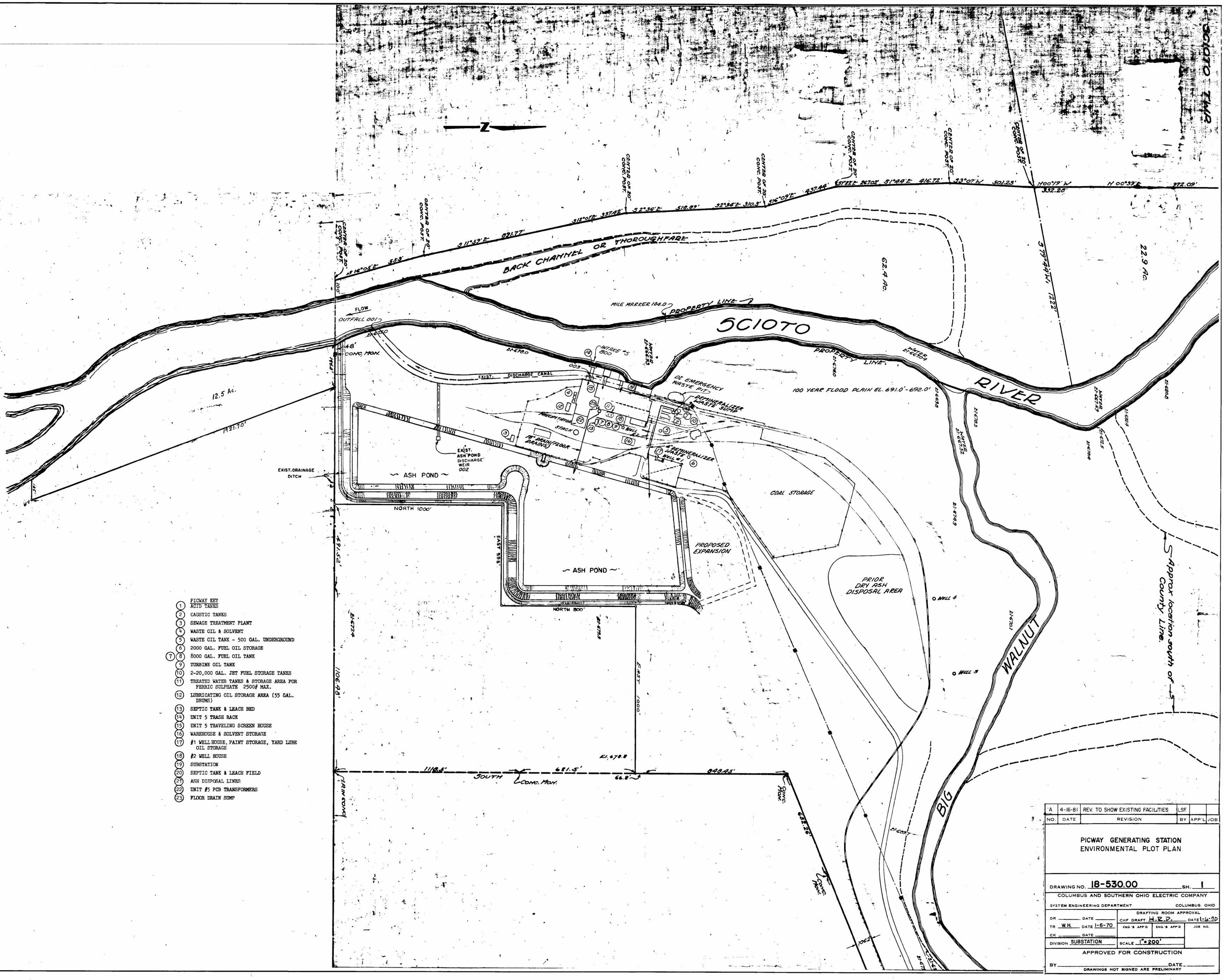
Photo No. 30 **Date:** 06/09/11

Direction Photo Taken:
South

Description:
View of crest of west embankment of the north pond. Note capped portion of north pond to left.

Appendix E

Selected Studies, Analyses, Reports and Engineering Drawings Provided by AEP



PICWAY KEY

1. ACID TANKS
2. CAUSTIC TANKS
3. SEWAGE TREATMENT PLANT
4. WASTE OIL & SOLVENT
5. WASTE OIL TANK - 500 GAL. UNDERGROUND
6. 2000 GAL. FUEL OIL STORAGE
7. 8. 8000 GAL. FUEL OIL TANK
9. TURBINE OIL TANK
10. 2-20,000 GAL. JET FUEL STORAGE TANKS
11. TREATED WATER TANKS & STORAGE AREA FOR FERRIC SULPHATE 2500# MAX.
12. LUBRICATING OIL STORAGE AREA (55 GAL. DRUMS)
13. SEPTIC TANK & LEACH BED
14. UNIT 5 TRASH RACK
15. UNIT 5 TRAVELING SCREEN HOUSE
16. WAREHOUSE & SOLVENT STORAGE
17. #1 WELL HOUSE, PAINT STORAGE, YARD LUBE OIL STORAGE
18. #2 WELL HOUSE
19. SUBSTATION
20. SEPTIC TANK & LEACH FIELD
21. ASH DISPOSAL LINES
22. UNIT #5 PCB TRANSFORMERS
23. FLOOR DRAIN SUMP

NO.	DATE	REVISION	BY	APP'L	JOB
A	4-16-81	REV. TO SHOW EXISTING FACILITIES	LSF		

PICWAY GENERATING STATION
ENVIRONMENTAL PLOT PLAN

DRAWING NO. 18-530.00 SH. 1

COLUMBUS AND SOUTHERN OHIO ELECTRIC COMPANY

SYSTEM ENGINEERING DEPARTMENT COLUMBUS, OHIO

DR ____ DATE ____
TR W.H. DATE 1-6-70
CK ____ DATE ____
DIVISION SUBSTATION

DRAFTING ROOM APPROVAL
CHF DRAFT. H.R.D. DATE 1-6-70
ENG.'S APP'D | ENG.'S APP'D | JOB NO.
SCALE 1" = 200'

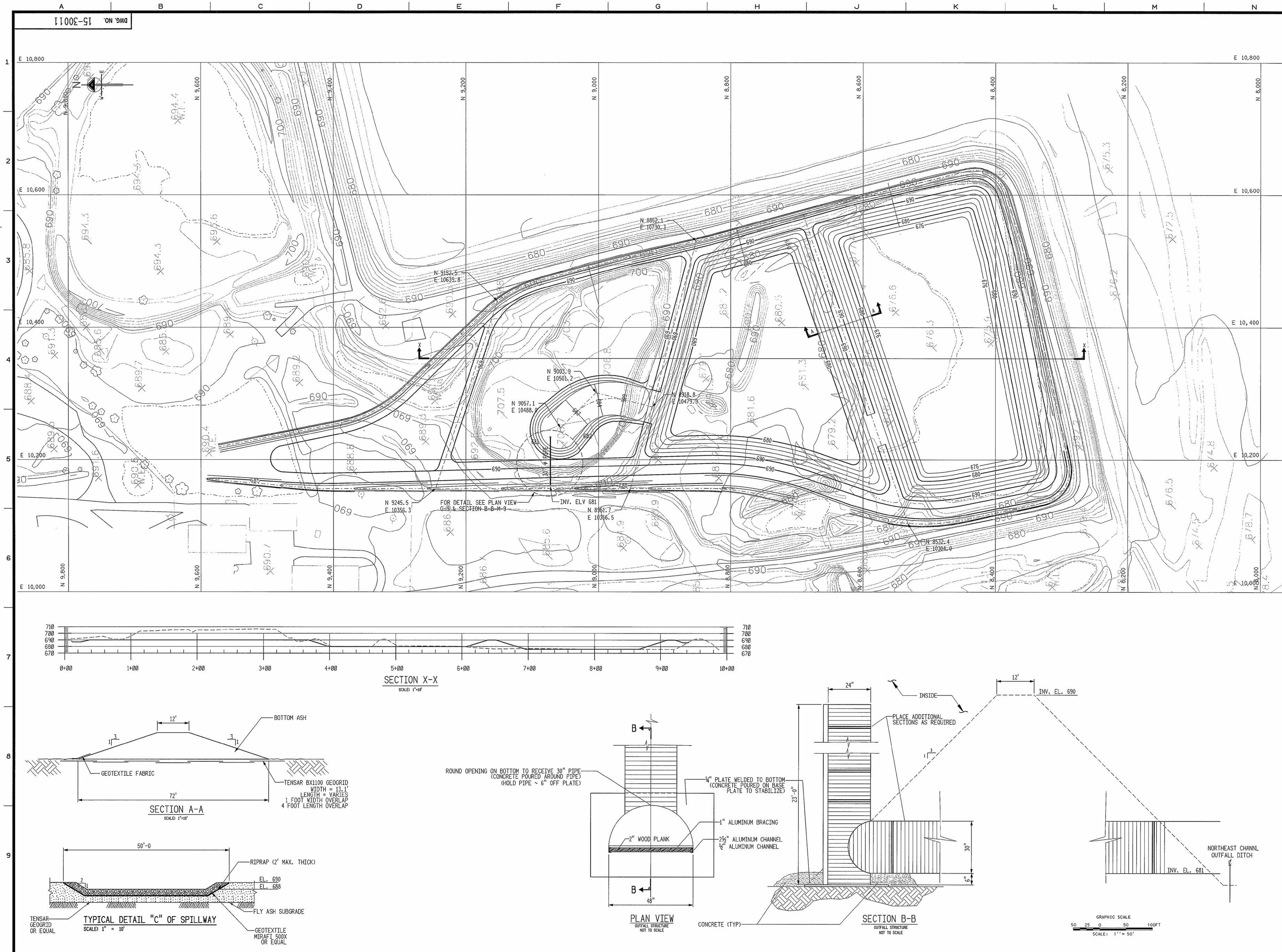
APPROVED FOR CONSTRUCTION

BY ____ DATE ____

DRAWINGS NOT SIGNED ARE PRELIMINARY

AEPPIP000238

SCIOTO RIVER
SCREEN HSE #2
SCREEN HSE #1
40 KV SUBSTATION
TURBINE ROOM
BOILER ROOM
SERVICE BLDG
ASH TUNNEL
CONVEYOR
MACH. SHOP
WAREHSE
PARKING LOT
STORAGE (TEMP. BLDGS.)
CONST. OFFICE (TEMP.)
℄ OUTLET WEIR
EL. 673.0' TOP OF PILING
EL. 682.0' TOP OF PILING
EL. 679.0' TOP OF PILING
EL. 685.0' TOP OF PILING (BOTH SIDES)
BOTTOM OF ALL PILING EL. 665.0'
DETAIL "A"
PILING ARRANGEMENT
SCALE ½" = 1'-0"
1050.0' ① ROW
Ⓐ ROW
290.0'
69 KV TRANS. LINE
120°19'
EL. 669.0'
EL. 691.0'
℄ OUTLET WEIR
BOTTOM OF PILING EL. 666.0'
200.0'
FOR PILING ARRANGEMENT SEE DETAIL "A"
"TEMPORARY ASH PIT"
EL. 673.0'
250.0'
140.0'
40.0'
240.0'
EL. 672.67'
EL. 672.33'
EL. 672.0'
700.0'
EL. 670.0'
OPEN DRAIN DITCH FROM TEMPERORY ASH PIT
EL. 671.0'
EXTENT OF TEMPORARY ASH PIT
498.51' ① ROW
1167.6' N 2° 56' W
588.0'
164.96'
328.7'
℄ PROPOSED LOCATION OF C. & S.O.E. STR. TO BE USED JOINTLY BY O.M.L. & P. COMPANY.
℄ PROPOSED O.M.L. & P. CO. DBL. CKT. 40KV POLE LINE
107°16'
EL. 693.0'
EL. 673.0'
EL. 678.0'
704.3'
1000'
598'
800'
EL. 674.5'
PROPERTY LINE
℄ 138 KV TRANSMISSION LINE
A
10.0' 20.0' 6.0' 46.0' 15.0' 30.0'
PROPERTY LINE
PRESENT GRADE
EL. 693.0'
EL. 673.0'
ELEVATION AS NOTED
SECTION "A-A"
TYPICAL DIKE CROSS SECTION
SCALE 1" = 10.0'
C 10-22-59 GENERAL REVISION LAC
B 4-5-54 ADD. PROP. TOWER LOCATION
A 3-5-54 ADD TURB. & BLR. RM. ADDITION & STACK
NO. DATE REVISION
PICWAY GENERATING PLANT
PLOT PLAN
ASH PIT LAYOUT
DRAWING NO. 18-530.00 8
6-26-53
Harry P Wilson 6-26-53
8
AEPPIP000239



GENERAL NOTES

LEGEND - EXISTING

- SPOT ELEVATION
- INTERMEDIATE CONTOUR
- INDEX CONTOUR
- DEPRESSION CONTOUR
- TREES AND TREELINE
- STRUCTURE AND BUILDING
- FENCE
- POLE
- ROADS
- EDGE OF WATER
- MANHOLES / CATCH BASIN
- POWER POLE
- PIPES
- TOWER

LEGEND - PROPOSED

- INDEX CONTOUR
- INTERMEDIATE CONTOUR

REFERENCE DRAWINGS

15-30003 - FINAL GRADING PLAN
15-30006 - NORTH PROFILES FILL
15-30010 - NORTH AND SOUTH FILL DITCH VERTICAL PROFILES

DATE	NO.	DESCRIPTION	APPD.
9/22/06	0	PRELIMINARY FOR COMMENTS	

REVISIONS

S:/PI/15/GHS/30011.dgn

COLUMBUS SOUTHERN POWER CO.

PICWAY PLANT

LOCKBOURNE OHIO

PHASE II
SOUTH FILL
STAGE 1 CONSTRUCTION

DWG. NO. 15-30011-0

SCALE: 1"=50' CIVIL ENGINEERING

AEP AMERICAN ELECTRIC POWER
AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

SYSTEM DATE-9/22/2006
SYSTEM TIME-1:17:15 PM

IGS0694

AEPPIP000240

AEP Picway Plant
Ash Pond Investigation

Lockbourne, Ohio

Report to

American Electric Power Service Corp.
Columbus, Ohio

Prepared by

BBC&M Engineering, Inc.
Dublin, Ohio

APRIL 2010

GEVR-10-012

April 30, 2010
011-11497-019

Mr. Pedro Amaya, P.E.
American Electric Power
1 Riverside Plaza
Columbus, OH 43215

Re: Subsurface Investigation and Analysis
Ash Pond Dike Evaluation
AEP Picway Plant
Lockbourne, Ohio

Dear Mr. Amaya:

In accordance with our proposal dated June 3, 2009, and our signed contract dated October 7, 2009, BBC&M Engineering, Inc. (BBCM) has completed a g eotechnical assessment of the As h Pond Complex located at the AEP Picway Plant in Lockbourne, Ohio.

BBCM's scope of work, as developed by AEP, consisted of developing subsurface data at five cross-sections through the ash pond complex dam, and performing seepage and slope stability analyses to provide an indication a s to the level of safety pr ovided by the embankments. The following report is a summary of our investigation. It should be noted that during the summer of 2009, BBCM installed 5 wells at the ash ponds, the results of which have been used to supplement this investigation where applicable. A report describing the well installation process which included the well logs was submitted to AEP on September 4, 2009.

We appreciate having been given the opportunity to be of service on this project. If you ha ve any questions, please do not hesitate to contact this office.

Respectfully submitted,

BBC&M ENGINEERING, INC.
Columbus, Ohio

Jason D. Ross, E.I.
Staff Engineer

Michael G. Rowland, P.E.
Senior Engineer

Submitted: 1 bound copy
1 electronic copy on CDROM

TABLE OF CONTENTS

LIST OF APPENDICES

APPENDIX A

APPENDIX B

APPENDIX C

APPENDIX D

APPENDIX E

INTRODUCTION

The Picway Generating Plant is located in Lockbourne, Ohio in Pickaway County, as shown on the Vicinity Map included as Plate 1 of Appendix A. The plant is located on the east bank of the Scioto River, just south of the confluence with Big Walnut Creek. The bottom ash pond complex is located immediately east of the plant and consists of a multi-sided upground earthen embankment structure. The embankment ranges between 15 and 20 feet above the natural grade and has an overall length of approximately 6,000 feet. A drainage swale was routed along the toe of the embankment on the east side during construction of the ash pond. BBCM understands the drainage swale can become inundated by several feet of water during periods of prolonged rainfall events. The drainage swale drains surface water into the Scioto River on the southwest side of the complex. The west embankment sits approximately 100 feet from a diversion channel of the Scioto River. The ponds are completely isolated from exterior surface water inflow. At the time of the investigation, all ponds were dry, as the plant had not been operating for approximately 1 month.

The bottom ash complex is divided into two main ponds, denoted as the north pond and south pond. The north pond contains 2 cells, N1 and N2, and the south pond contains 3 cells, S1, S2 and S3. Cell N1 of the north pond is out of service and has been capped. BBCM understands plans have been developed by AEP to cap the remaining cell in the north pond, and the entire south pond area. The analyses performed for the ash pond embankments considered only the existing conditions and did not evaluate the stability of the embankments under any future loading conditions.

SCOPE OF WORK

As developed by AEP, the scope of work which was performed as part of this geotechnical investigation consisted of 1) a review of original plans; 2) cursory visual observation of the pond embankments at the boring locations; 3) the performance of eight soil borings, four through the crest of the ash pond dikes and four along the toe; 4) laboratory testing on the recovered samples; and 5) engineering analyses of the existing embankments with consideration given to seepage and varying slope stability conditions including steady-state, seismic and rapid drawdown.

REVIEW OF HISTORICAL PLANS AND INFORMATION

Based on discussions with AEP, construction or design records were not available for the ash pond complex. BBCM received a copy of the 'Deep Well Water Supply Study' performed by The Layne Ohio Company, dated November 21, 1945. The report documents the groundwater investigation and findings related to the installation of groundwater wells for the plant. As part of this report, a number of well logs were provided that contain information on the subsurface stratigraphy, including bedrock elevations. Bedrock consisting of shale, limestone, or soapstone was indicated to be at depths ranging from 75 to 116 feet below the ground surface at varying locations around the plant.

BBCM performed a Dam and Dike Condition Survey of Ash Pond Complex on two separate occasions prior to this investigation. The surveys were completed on October 17, 2007 and March 16, 2009 as part of an overall inspection of all of the dams at the facility. Additional information concerning the visual condition of the dam may be found in these reports.

BBCM installed 5 monitoring wells at three separate locations around the ash pond complex in August, 2009. The wells are denoted as MW-0901S and MW-0901D, MW-0902S and 0902D and MW-0903S. Three borings, denoted as B-0901, B-0902, and B-0903, were drilled to determine the well screen intervals, however no laboratory work was performed and all recovered samples were submitted to AEP. B-0901 and B-0902 were drilled at or beyond the toe of the north pond embankment on the east and west side, respectively and B-0903 was drilled from the crest of the west embankment of the south pond. Boring locations are included on the 'Plan of Borings' included as Plate 2 of Appendix A. The boring logs and well logs have been included in Appendix E.

GEOLOGY

The site lies within the Columbus Lowland Till Plains physiographic section of the Central Lowland Province. The natural soils in the area generally consist of a relatively thin layer of alluvium silt and clay over glacial outwash deposits of variable thickness overlying the bedrock surface. The alluvium clays and silts consist of sedimentary matter and are typically no more than 10 feet thick, while the outwash materials typically consist of sand, gravel and silt deposits. Based on available geologic literature, the glacial outwash extends to bedrock, estimated to be roughly 90 feet below the ground surface. The upper most bedrock at the ash pond complex likely consists of Ohio Shale of Devonian Age.

FIELD WORK

Site Reconnaissance

On November 17, 2009, a Staff Engineer from our office visited the site to observe and layout the boring locations as proposed by BBCM and approved by AEP. The boring locations were selected to obtain subsurface cross sectional data from each embankment side and complement the locations of the previous borings. At each of the cross-section locations, the outboard slope was grass covered and no seepage was observed emanating from the embankments themselves. At the toe of the outboard slopes, no evidence of seepage or ponded water was evident. The south embankment of the south pond did appear steeper than a 2H:1V slope. It should be noted that the ponds were inactive at the time these observations were made as the plant had been shut down for an extended period of time prior to the observation. Please note that the site reconnaissance to locate borings should not be considered a formal inspection of the facility.

Soil Borings

During the period of November 19 through November 24, 2009, BBCM was on-site and performed a total of eight (8) soil borings, designated B-0904 through B-0911, that were extended to depths ranging from 20 to 37.5 feet below existing grades. Borings B-0904, B-0906, B-0907 and B-0909 were located at the crest of the ash pond embankments at the designated cross-sections The remaining borings were located at the toe of the embankment slopes. The boring location areas were selected and field located by BBCM, and approved by AEP. The boring locations are shown on the 'Plan of Borings' presented as Plate 2 of Appendix A. All boring elevations were surveyed by AEP personnel after completion of the drilling.

Surface profiles were then created based on the boring elevations and topographic information of the ash pond complex provided by AEP.

All borings were performed with a track-mounted drill rig and were advanced between sampling attempts using 3¼-inch I.D. hollow-stem augers. Disturbed, but representative samples were obtained by lowering a 2-inch O.D. split-barrel sampler to the bottom of the hole and driving it into the soil by blows from a 140-pound automatic hammer freely falling 30 inches (Standard Penetration Test, ASTM D1586). The automatic hammer used to advance the SPT sampler had previously been calibrated for energy transmission using dynamic pile monitoring methods. The energy calibration factor is included on the boring logs. SPT sampling was performed continuously through the embankment fill and at 2½-foot intervals once the native soil was encountered. Split barrel samples were examined immediately after recovery and representative portions of each sample were placed in air tight jars and retained for subsequent laboratory testing.

<u>Undisturbed Soil Sample</u>

In addition to the disturbed samples, thin-walled press tube samples ("Shelby" tubes) were also attempted at various depths to obtain relatively undisturbed soil samples for strength testing. The samples were collected by hydraulically pressing a 3-inch diameter thin-walled steel (Shelby) tube at the end of the drill rod stem into the soil at a uniform rate. The samples were preserved inside the Shelby tube sampler and sealed with wax. The sample collection was completed in accordance with ASTM D 1587 Method for Thin-Walled Tube Geotechnical Sampling of Soils.

<u>Borehole Backfilling and Extended Groundwater Measurements</u>

During and at the completion of drilling, groundwater measurements were measured and recorded in all borings. In Borings B-0909 and B-0911, 1½-inch diameter slotted-PVC pipes were placed in each boring to permit extended groundwater level readings. Two extended groundwater measurements were obtained in each boring while the drilling crew was still on-site.

At the completion of each boring (or at the end of extended groundwater measurements in B-0909 and B-0911), each boring was backfilled with cement-bentonite grout.

<u>Recording of Field Data</u>

In the field, the following procedures and specific duties were performed by a Staff Engineer from our office:

i. examined all samples recovered from the borings;
ii. cleaned soil samples of cuttings and preserved representative portions in airtight glass jars;
iii. made seepage observations and measured the water levels in the borings;
iv. prepared a log of each boring;
v. made hand-penetrometer measurements in soil samples exhibiting cohesion;
vi. provided liaison between the field personnel and the Project Manager so that the field investigation could be modified in the event that unexpected subsurface conditions were encountered; and
vii. obtained extended groundwater measurements

At the completion of drilling, all samples were transported to the BBCM laboratory for further examination and testing

LABORATORY TESTING

Index Testing

In the lab, visual identifications were performed on all soil samples obtained from Borings B-0904 through B-0911, and on select representative soil samples from these borings, natural moisture content (ASTM D2216), liquid and plastic limits (BBCM adjustment to ASTM D4318), and grain size distributions (ASTM D422) were determined. The results of these and other tests permit an evaluation of the strength, compressibility and permeability characteristics of the soils encountered at this site.

The results of the moisture content testing and of the liquid and plastic limits are graphically displayed on the individual boring logs presented as Plates 5 through 17 in Appendix A. A summary of laboratory test results are presented as Plates 1 through 4 in Appendix B. The results of all grain size analyses are also displayed graphically and presented as Plates 5 through 31 in Appendix B. Soils described in this report have been classified basically in accordance with the Unified Soil Classification System, but this system has been augmented by the use of special adjectives to designate the approximate percentages of minor soil components. Definitions of these special adjectives and an explanation of the symbols and terms used on the boring logs are presented on Plate 4 of Appendix A.

A statistical summary of index testing for all layers which a significant number of index testing was performed is presented in Table 1. For a comprehensive summary of all index testing and grain size analyses results, see the parameter justification in Appendix C.

Table 1: Summary of Index Values

Cohesive Embankment Fill

Statistic	MC	LL	PL	PI	CF
Sample Size	9 9 9			9	7
Minimum	21 44	24		20	31.7
Maximum	28 57	31		30	38.6
Mean	23.8 51.	1 26	1	25.0	35.5
Median	24 50	25		24	35.9
Mode	24 50	27		23	N/A
Standard Deviation	2.2	4.0	2.2	3.3	2.7

Natural Cohesive Soil

Statistic	MC	LL	PL	PI	CF
Sample Size	7	8 8		8 8	
Minimum 19		32	16	15	22.8
Maximum 27		54	26	28	42.2
Mean	22.9	44.0 21	8	22.3 35	0
Median	22	45.5 23		23 37.4	
Mode 22		32	23	27	N/A
Standard Deviation	2.5	8.4 3.5		5.2 7.4	

Specialty Testing

In addition to the above index test s, two thr ee-point isotropically consolidated-undrained (CU) triaxial she ar tests (ASTM D476 7), and on e flex-wall permeability test were performed on undisturbed soil samples obtained from Shelby Tube sampling. One CU test was p erformed on the embankment fill, and one on the natural cohesive soil. It should be noted that the CU series performed on the fou ndation soil was repre sentative of the lowest blow count material encountered for this layer. The permeability test was performed on the emb ankment fill . Results of all laboratory testing are included in Appendix B including laboratory logs of Shelby tubes (Plate s 32 throug h 34), triaxial test resu lts (Plates 35 through 38), and th e flex-wall permeability test result (Plate 39).

GENERAL SUBSURFACE CONDITIONS

Borings B-0904, 0906, 0907, and 0909 were performed through the crest of the embankment of the ash pond complex. Borings B-0905, 0908, 0910, and 0911 were performed at the toe of the embankment. At three location s, a crest and toe boring were completed to develop cross-sections. At one location (B-0911), the boring was combined with a boring from the August 2009 investigation (B-0903) to devel op a cross-section. At the final location (B-0906), only an embankment boring was completed. The subsurface profile developed between these borings is denoted as Sections A, B, C, D, and E in Ta ble 2. The crest of the embankment is currently used to ga in access to the ash po nd complex to monitor the ponds. All of the crest boring s, except B-0906, were completed after an additional 3 f eet of fill w as placed on top of the embankments in November 2009. Boring B-0906 was completed befor e the pla cement of the additional fill and therefore the boring elevation is estimated on the boring log.

Cross Sections

The final cross-sect ions depicted in this report were de veloped based on the subsurface conditions encountered in the borings, surv ey and topographic data provided by AEP, and available historical data. The ground surface elevation at each boring was submitted by AEP as a result of surveying completed after the investigation The profile of the inboard and outboard slope was created using recent topographical info rmation provided by AEP. This information was evidently generated at a time that the ash ponds were empty.

The development of each section an d why it was selected for analysis is detailed below. Tabl e 2 summarizes the borings used to develop the cr oss-sections. The cross-sect ions are shown with general subsurface conditions on Plate 3 of Appendix A.

Table 2: Cross-Section Data

Cross-Section	Location	Crest Boring	Toe Boring
Section A	East Embankment - North Pond	B-0904	B-0905
Section B	South Embankment - North Pond	B-0906	N/A
Section C	East Embankment - South Pond	B-0907	B-0908
Section D	South Embankment - South Pond	B-0909	B-0910
Section E	West Embankment - South Pond	B-0903	B-0911

At the time of the site reconnaissance performed on November 17, 2009. the ash ponds were inactive, and there was no sign of a water level inside the pond. This was a result of the plant having been shut down for an extended period of time prior to our arrival. For the purposes of the analysis, it will be assumed that the ash pond water level is 3 feet below the crest of the embankment, as this is the maximum height permitted. Due to the similarities present in the five cross-sections developed, only the two that were deemed the most critical for stability and seepage were analyzed further.

Stratigraphy

Based on the descriptions of the samples recovered in the borings and laboratory testing, the subsurface stratigraphy can generally be described in descending order as follows:

Crest Borings

Borings B-0904, 0906, 0907, and 0909 were performed through the crest of the embankment, and encountered between 17.5 and 18.7 feet of cohesive fill that predominantly consisted of a very-stiff to hard brown and dark-brown mottled with gray silty clay. Hand penetrometer measurements ranged between 1.5-4.5+ tsf. The percent passing the 200 sieve for tested samples ranged between 95 and 98. The material predominantly was plastic and classified as a Fat Clay (CH) or a Lean Clay (CL) under the Unified Soil Classification System.

Beneath the cohesive embankment fill, all four crest borings encountered a layer of very-stiff to hard brown mottled with gray silty clay with thicknesses between 2.3 and 10.0 feet. Hand penetrometer measurements ranged between 2.25-4.5+ tsf. The percent passing the 200 sieve for tested samples of this stratum varied between 94 and 99. The material was predominantly plastic and classified as a Lean Clay, or a Fat Clay (CH) under the Unified Soil Classification System. Boring B-0907 and B-0909 encountered a medium-stiff to stiff brown mottled with gray silty clay with some fine to coarse sand underlying the natural very-stiff to hard silty clay layer. This layer became very-soft to soft in B-0907. The thicknesses of this layer varied between 2.8 and 6.3 feet and the hand penetrometer measurements ranged between 0.1-1.75 tsf. The percent passing the 200 sieve was 56 in the only sieve analysis for this layer. The material predominantly was plastic and classified as a Sandy Lean Clay (CL) under the Unified Soil Classification System.

Underlying the natural cohesive soils in B-0904, 0906, 0907, and 0909 was a granular layer consisting of either medium-dense to dense brown fine to coarse sand with some fine gravel, or medium-dense to dense brown fine to coarse gravel with some fine sand. The thicknesses of this layer ranged between 7.5 and 11.2 feet and N-60 values (corrected for 60% energy) ranged from 15 to 48 with an average of 29. The percent passing the 200 sieve ranged between 13.1 and 24.3. Three of the four crest borings terminated in this layer at depths between 35 and 37.5 feet. B-0904 terminated at a depth of 25 feet after penetrating 0.6 feet into a hard gray silty clay layer.

Toe Borings

Borings B-0905, 0908, 0910, and 0911 were completed at the toe of the ash pond embankment near the elevation of the natural ground surface. Boring B-0910 encountered 2.4 feet of fill that was loose brown fine to coarse sand "and" silty clay with an N-60 value (corrected for 60% energy) of 4. Boring B-0911 encountered fill that consisted of 2.5 feet of very-stiff to hard brown mottled with gray silty clay with asphalt fragments. Hand penetrometer measurements ranged between 3.5 and 4.0 tsf. Borings B-0905, 0908, and 0911 encountered between 2.5 and 10.0 feet of very-stiff to hard brown mottled with gray silty clay. Hand penetrometer measurements were recorded between 2.0 and 4.0 tsf. The percent passing the 200 sieve ranged between 78 and 98. The material predominantly was plastic and classified as a Lean Clay or Lean Clay with Sand (CL), or a Fat Clay (CH) under the Unified Soil Classification System. Borings B-0908 and 0910 encountered between 3.3 and 3.5 feet of medium-stiff becoming very soft brown mottled with gray silty clay with little to some fine to coarse sand. Hand penetrometer measurements were recorded between 0.1 and 1.5 tsf. The material predominantly was plastic and classified as a Lean Clay (CL) under the Unified Soil Classification System.

Underlying the layers of natural cohesive soil is a granular zone that varies in thickness between 7.0 and 20.5 feet. This layer is generally described as either a medium-dense to dense brown fine to coarse gravel with some to "and" fine to coarse sand, or a medium-dense to very-dense brown fine to coarse sand with little to some fine to coarse gravel. N-60 values (corrected for 60% energy) for this layer ranged between 10 and 66 with an average of 29 (spoon refusal was met in B-0905, S-5). The percent passing the 200 sieve ranged between 13.1 and 24.3. All of the toe borings except B-0905 were terminated in this granular zone at depths of either 20 feet (B-0910 and B-0911) or 30 feet (B-0908).

B-0905 penetrated 4.5 feet into a layer of hard gray clayey silt with some fine to coarse sand before terminating at a depth of 20 feet. Hand penetrometer measurements were 4.5+ tsf. The percent passing the 200 sieve was 63. The material predominantly was plastic and classified as a Sandy Lean Clay (CL) under the Unified Soil Classification System. This material was also encountered in B-0904, which is the crest boring that coincides with B-0905.

For detailed description of the stratigraphy, including the presence of minor variations and inclusions, the logs of the individual borings should be examined in conjunction with the summaries above.

Groundwater

Groundwater observations were made as each boring was advanced and measurements were made at the completion of drilling. The groundwater observations are graphically displayed on the boring logs and also noted at the bottom of the log. Extended groundwater measurements, summarized in Table 3, were made in two borings through the use of a 1½-inch diameter slotted-PVC pipe p laced in the bo ring upon completion. Water lev el measure ments were obtained during the dur ation of the drilling before being backfilled with cement-bentonite grout upon completion of the other borings. Initial water level readings fro m the monitoring well installed at the active ash pond (MW-0903S) is also shown in Table 3. No addition al readings from the wells have bee n provided to BBCM since the installation of the wells. For reference, the Scioto River is locat ed to the west of the ash pond co mplex and maintains an ordinary low water level of approximately Elevation 670 feet. As previously noted , the a sh p onds were inactive at the time of this investigation.

Table 3: Extended Groundwater Elevation Measurements

Boring	Ground Surface Elevation	Water Depths*			
		First Encountered	At Completion	11/20/09	11/23/09
B-0909	692.81	664.31		668.01	666.01
B-0911	679.36	665.86	665.36	668.56	667.26
Information obtained in August 2009 from B-0903 (active pond):				8/24/09	8/27/09
MW-0903S	690.3	668.1		667.9	668.0

*Note: The ponds were inactive during this investigation. No water was observed within 2 feet of the ash surface adjacent to the inboard slope.

SEEPAGE AND STABILITY ANALYSIS

Embankment dams must exhibit ad equate factors of safet y against a slope stability failure for static and seismic cond itions. As part of this project, BBCM considered areas o n the pond embankments the appeared to be the most critical to analyze for stability. Sections C and D were each developed by performi ng borings through both the crest and outboard toe of the embankment. The following sections of t his report discuss the analyses that were performed, explain the rationale supporting parameter selection and present the results.

Although two separate cross-sections (Section C and Section D) were analyzed, the parameters selected to represent th e permeability and strength of the different fill layers were kept the same. Although there are minor differences b etween the embankmen t fill, it is be lieved that there is insufficient evidence to support delin eating the f ill between the sect ions. For th is reason, the permeability and shear strength par ameters used to represe nt the embankment fill were based on the totality of test data available across the entire site.

The natural cohesive soils underlying the pond embankments are also slightly variable. As with the embankment fill, it is difficult to justif y developing spe cific parameters for a given cross-section, as the properties of this str atum are expected to vary over sh ort distance s. As such, the paramet ers used to represent the natural cohesive soil were base d on the tot ality of test data available across the entire site.

Methodology

The seepag e and stab ility analyses were perfo rmed for the existing P icway Plant Ash Pond embankments with the aid of th e computer program Slide (Version 5.0) de veloped b y Rocscience, Inc. The program performs 2- D limit equilibr ium slope stability ana lyses and steady-state unsaturated groundwater analysis; the latter using the finite element method. Pore pressure values produced from the seepage analysis are used in the slope stability computations for each model.

Static and seismic slope stability analyses were performed on the outboard embankment slopes for Cross-Sections C and D using Spencer's method (Spencer, 1973) with a deterministic approach. The method provides solutions for given cross sections based on limit equilibrium theory. The critical slip surfaces corresponding to the lowest factor-of-safety is shown in the graphical output. Seismic slope stability analyses were performed based on a pseudo-static slope stability approach. Stability calculations were performed in general accordance with the US Army Corps of Engineer's Engineering Manual 1110-2-1902 entitled *Slope Stability*.

Seepage Analysis

The location of the piezometric level within the embankments was estimated in consideration of the maximum allowable water level for the ponds. It is typical practice to rely on a combination of actual groundwater measurements from piezometers and seepage analysis results to develop a phreatic surface for stability analyses. However, for the Picway ash ponds, groundwater readings obtained during the investigation are not considered representative of full pool conditions, as the pond was inactive during the investigation and there was no sign of water at or near the surface of the ash. For this reason, the phreatic surface within the embankments used with the stability analyses was principally based on the results of finite element seepage analyses.

Hydraulic Properties

Permeability values assigned to the model layers are shown in Table 4 below. The cohesive embankment fill was modeled with anisotropic permeability functions. The horizontal permeability (k_h) of the cohesive embankment fill was taken as either 5 or 10 times (both conditions were examined) the vertical permeability (k_v) to best model the stratification of the soil as a result of compacting the fill in horizontal lifts (Casagrande, 1937). A permeability test performed on an undisturbed sample obtained in the cohesive fill yielded an average vertical permeability of $1.83x10^{-8}$ cm/sec. The natural cohesive soil and sand and gravel layers were assigned isotropic permeability functions.

Table 4: Permeability Values

Material Description	Permeability		Reference
	k_v (cm/sec)	k_h / k_v	
Cohesive Embankment Fill	$5x10^{-8}$	5 or 10	Flex-Wall Permeability Test
General Fill (Section D only)	$5x10^{-5}$		Typical Values
Natural Cohesive Soil	$5x10^{-8}$	1	Holtz and Kovacs (1981)
Sand and Gravel	$5x10^{-3}$	1	Grain Size Correlation

Hydraulic Boundary Conditions

The following boundary conditions were assigned to the finite element based models.

-Section C and Section D

- A 'Constant Head' boundary of 690' was used to represent the level of water in the ash pond. This level maintains the required 3 feet of freeboard on the inboard slope.
- A 'Constant Head' bou ndary of 67 0' was used to represent the low water level i n the nearby Scioto River and was placed on the downstream end of each model.
- A 'No-Flow' boundary was placed on the bottom of the model at Elevation 630.
- A 'No-Flow' boundary was also placed on the upstream end of the model. On the upstream side, the flow is assumed to become predominantly downward near the middle of the pond.
- 'Unknown' boundary conditions were set on the remainder of the exterior boundaries t o allow the program free dom to cal culate values at these locations. These locations include the downstream slope face and the downstream ground surface.

Finite Element Discretization and Mesh

The following steps were performed during the development of the seepage model:

- 6 Noded Triangles were used to generate the finite ele ment mesh for the models (Graphical printouts included in Appendix D).
- The density of nodes was manually increased to minimize the number of 'Poor Quality Elements based on the Mesh Quality function available in Slide.

Poor quality elements were defined as elements with one of the following characteristics:

- Maximum side length to minimum side length ratio greater than 10.
- Minimum interior angle less than 20 degrees.
- Maximum interior angle greater than 120 degrees.

Seepage Analysis Models and Results

Graphical output from the seepage analyses for Sections C and D are presented in Appendix D. No attempts were made to calibrate the models to observed field conditions, as the ponds were inactive and the measured water le vels in the borings likely do not ref lect typical active pond levels. The models did produce slightly abnormal phreatic surface shapes.

As previously discussed , the compa cted fill li kely exhibits an anisotr opic permeability possibly as large as 10:1 for k_h:k_v. To this end, BBCM investigated the sha pe and location of the phreatic surface when employing tow different permeability ratios. When a ratio of 10:1 was used, the p hreatic surface approached very close to the exterior slope of the emb ankment for Section C. Changing the ratio to 5:1 resulted in a phreatic surface that does not approach the edge of the exterior slope. The two dike co ndition surveys completed did not reveal any seepage ar eas on the exterior slope, leadin g to the likelihood that the actual anisotropic permeability ratio is closer to 5:1 r ather than 10:1. However, as the 10:1 ratio r epresents a more conservative scenario, the subsequent stability analyses modeled the embankment with a 10:1 ratio. Plates 4 and 5 of Appendix D show the impro vement in the seepage and stability of the embankment by altering the anisotropic characteristics.

Stability Analyses

Shear Strength Parameters

In order to perform slope stability analyses, it was necessary to estimate appropriate unit weight and strength paramete rs to represent the vari ous soil layers. The shear strength and unit weight values used for the slope stability an alyses were based on a combination of the laboratory index test r esults, triaxial shear te st result s, published v alues and engineering judgment, and are intended to be representative of long-term conditions. As previously indicated, t he soil spe cimen used for the CU series performed o n the foundation soils represented the lowest blow count material encountered for this layer. To estimate the effective friction angl e of the cohesive emb ankment fill and natural cohesive soil, several correlation methods were exa mined. The mode or med ian (if mod e does not exist) values from the statistical a nalysis for liquid li mit, plasticity in dex, and clay sized fra ction (per cent finer tha n 0.002 mm) were used in the correlations. Table 5 lists the design strength parameters used for static analyses for ea ch stratum. Supporting calculations for the development of these strength values are presented in the *Slope Stability Shear Strength and Permeability Parameter Justification* section of Appendix C.

Table 5: Strength Values for Static Steady-State Conditions:

Material Description	γ_{wet} (pcf)	Strength		Reference
		φ'	c' (psf)	
Cohesive Embankment Fill	130	30°	200	CU Triaxial Test (BBCM, 2009) and Index Testing Correlations
General Fill (Section D only)	120	28°	0	Index Testing Correlations (Stark et al. 2005)
Natural Cohesive Soil	120	28°	0	CU Triaxial Test (BBCM, 2009) and Index Testing Correlations
Sand and Gravel	115	35°	0	SPT and Grain Size Correlations

In addition to the static steady-state stability analyses, strength parameters were developed for use with the pseudo-static seismic analyses. With respect to seismic loa ding, it is believed that the cohesive embankment fill and natural cohesive soils may exhibit an undrained response. As the ponds have been in place for an extended period of time, the cohesive fill and natural cohesive so ils have co me to equilibrium under the presen t steady-sta te seepage conditions. Therefore, the shear strength envelope used in the analysis was calculated based on the results of the "R" test, as recommended in the Army Corps of Engineer's Manual 1110-2-1906 "Laboratory Soils Testing," and suggested by Duncan and Wright in their 2005 publication. This is essentially the slope and y intercept of the CU strength values. The sand and gravel stratum will maintain drainage during a seismic event, as such, drained strength values were used for seismic loading. Table 6 lists the design strength parameters used for pseudo-static analyses for each stratum.

Table 6: Strength Values for Seismic Conditions:

Material Description	γ_{wet} (pcf)	Strength		Reference
		φ	c (psf)	
Cohesive Embankment Fill	130	22°	400	CU Triaxial Test (BBCM, 2009)
General Fill (Section D only)	120	14° 200		Index Testing Correlations (Stark et al. 2005)
Natural Cohesive Soil	120	10°	500	CU Triaxial Test (BBCM, 2009)
Sand and Gravel	115	35° 0		SPT and Grain Size Correlations

A rapid drawdown analysis was also completed for the ash pond embankments. It is the understanding of BBCM that the ponds are typically filled with ash which would tend to support the inboard slopes. However, on an occasional basis, during times of ash removal and subsequent re-filling, a full pool of water could be established and a rapid drawdown scenario could occur if it were suddenly emptied. Additionally, the pond does not receive storm water runoff from the surrounding area and the amount of water in the pond is controlled by the plant personnel. For these reasons, while not impossible, a large scale rapid drawdown event with unsupported interior slopes is unlikely. Notwithstanding, a rapid drawdown analysis was completed using the conventional method whereby the phreatic surface is positioned at the ground surface and extending up the inboard embankment slope to the normal pool elevation. Drained strength parameters are used in this scenario. The drawdown level for the analysis was considered to occur from the normal operating pool El. 690 down to the natural ground surface on the inboard side of the embankment as determined from the topographical information provided by AEP.

Analyses and Results

Static and seismic analyses were performed on each section to determine the factor of safety against rotational failure for the inboard and outboard slopes using drained soil strength parameters. Rapid drawdown was investigated for the inboard slope only. The graphical computer output for these analyses has been included with this report in Appendix D.

Seismic analyses were performed for both inboard and outboard slopes using a pseudostatic analysis with a horizontal seismic coefficient of 0.06g. This coefficient was determined from the 2008 USGS National Seismic Hazard Maps for the "Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years". This map is provided as Plate 18 of Appendix A.

Graphical results of the slope stability analysis for seismic conditions are shown in Appendix D. Table 7 summarizes the lowest factors of safety determined for each analysis case.

Table 7: Stability Analysis Summary:

Analysis Case	Computed FS			
	Outboard Slopes		Inboard Slopes	
	Section C	Section D	Section C	Section D
Static (Steady-State Seepage)	1.53 1.54		2.51	4.15
Pseudo-Static 1.54		1.48	2.16	2.96
Rapid Drawdown	N/A	N/A	1.13[a] 1.24	

[a] Assumes inboard slope will be maintained at a 2H:1V or flatter when ash excavation occurs.

The critical failure surfaces were located through a deterministic search, with no limitations on failure surface location. The results are based on the highest pool level permitted for the ponds (Elevation 690 – 3 feet of freeboard on the inboard slope).

According to the topographical information provided, the inboard embankment slope at Section C is steep which results in a low computed factor of safety for the rapid drawdown case However, since the ash provides support for the inboard slope, the only way to create this scenario is to completely remove the ash from the inboard embankment slope AEP has indicated that when ash is excavated from the pond, the interior embankments are maintained at a 2H:1V slope or flatter. With this understanding, BBCM completed an analysis where a 2H:1V slope is maintained on the inboard slope after excavating the ash from the pond Based on this geometry, a factor of safety of 1.13 was computed for rapid drawdown conditions.

As can be seen in the profile of Section D, the south embankment on the south pond is over-steepened and shallow sloughs have been observed at this location. As was noted by BBCM in the previous condition survey (March 2009), the outboard slope of this embankment should be re-graded. BBCM understands that subsequent to our March 2009 inspection visit, an attempt has been made to regrade the slope back to original design grades with a sidehill fill, however proper benching techniques were not used and the fill material flowed down the slope. To this end, it is important that additional steps be taken to stabilize this area.

CONCLUSIONS

As part of this report, BBCM examined the stability of the outboard embankment slopes at 2 locations under steady-state seepage and seismic loading conditions using the results of 11 soil borings (8 with this investigation, 3 with a previous investigation). The analyses suggest that at the two cross-sections examined, the embankments exhibit adequate factors of safety relative to those recommended by the US Army Corps of Engineers (COE) for existing facilities, with the exception of the issues previously discussed.

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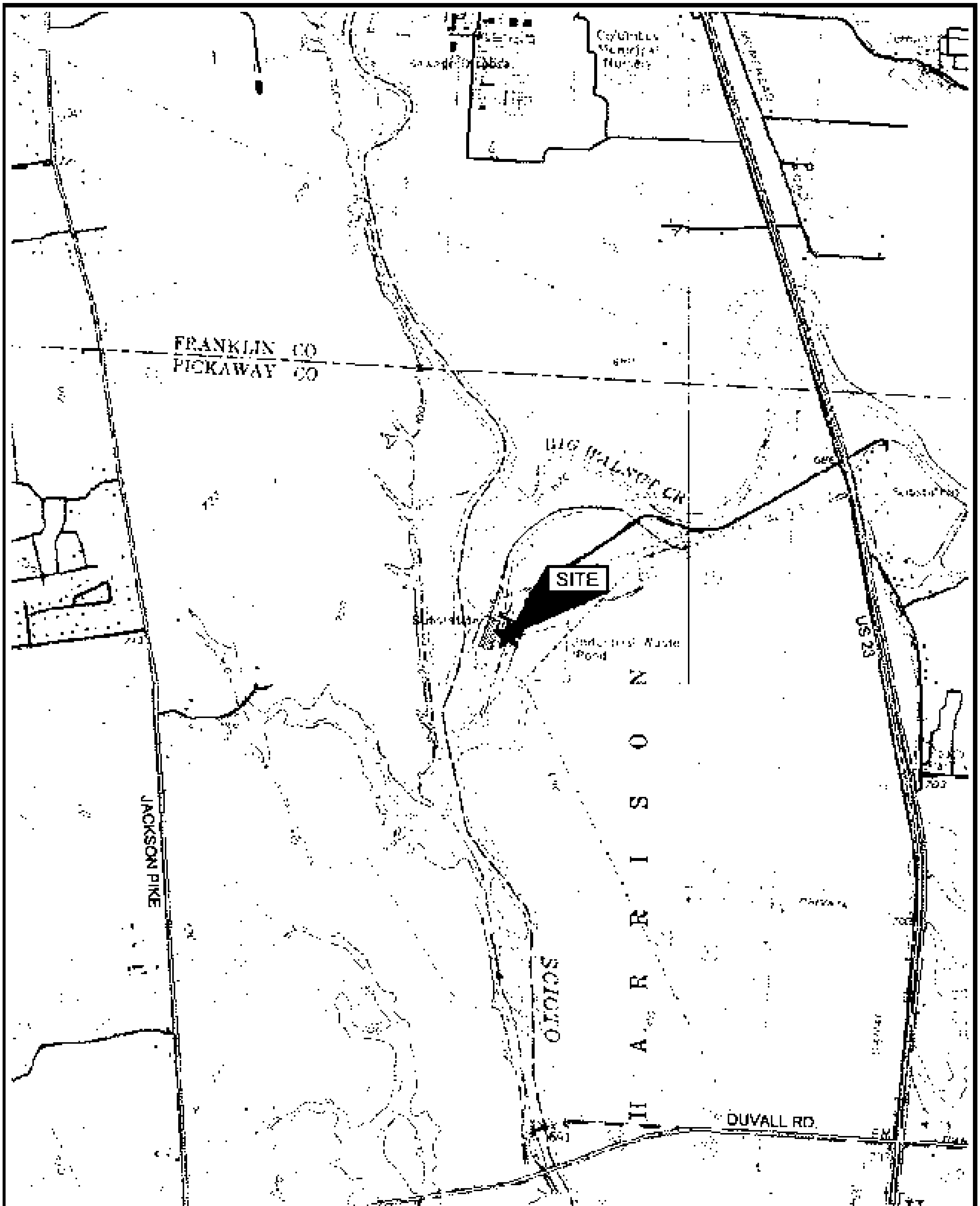
APPENDIX A

Site Investigation



USGS Mapping:
Lockbourne Quad

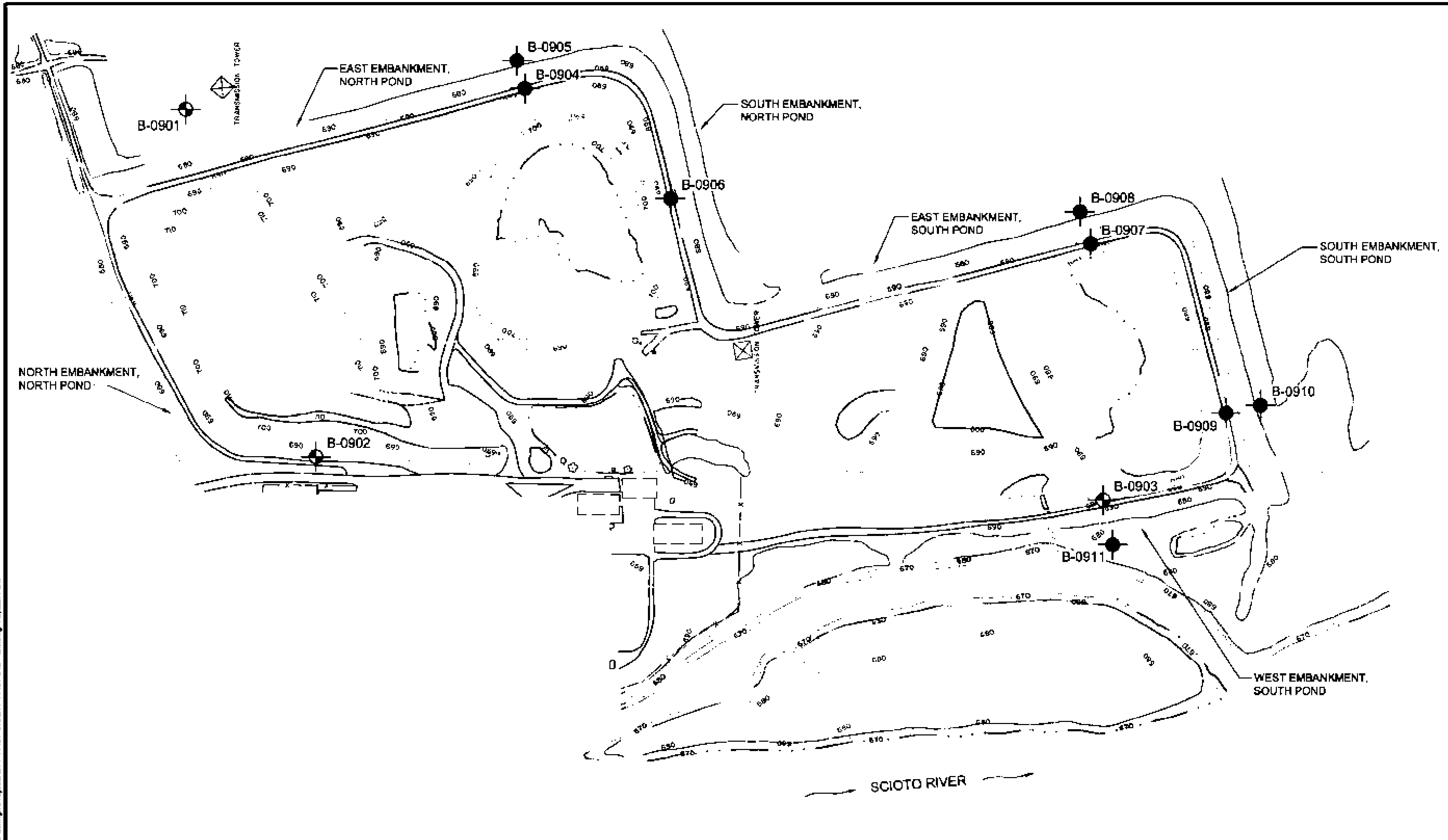
VICINITY MAP

AEP Picway Plant Ash Pond Dike Evaluation
Lockbourne, Ohio

BBCM

Project: 011-11497-019	Drawn By: TJM
Drawing Date: 1-7-2010	Approved By: JDR
Last Updated: 1-7-2010	Scale: 1" = 2000' 1:1

PLATE 1



0 200 400
SCALE IN FEET

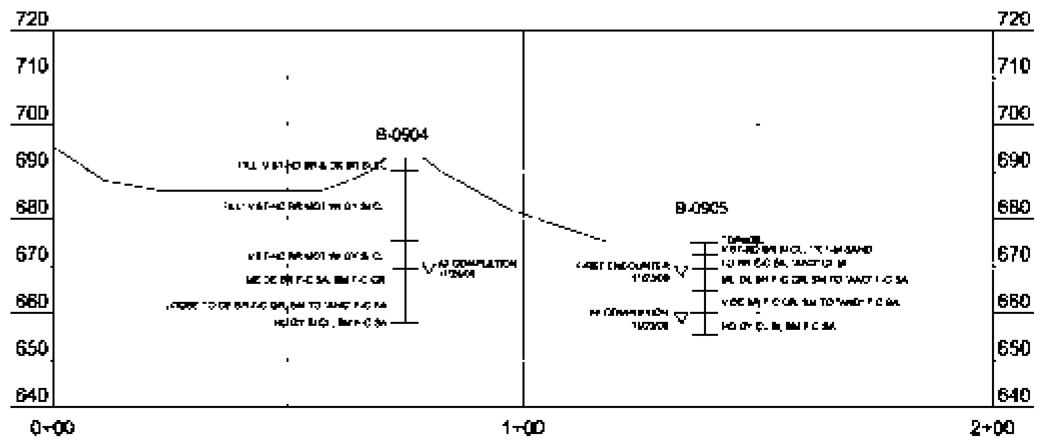
LEGEND

B-0901 BORING NUMBER AND LOCATION
BBCM AUGUST 2009 SUBSURFACE INVESTIGATION

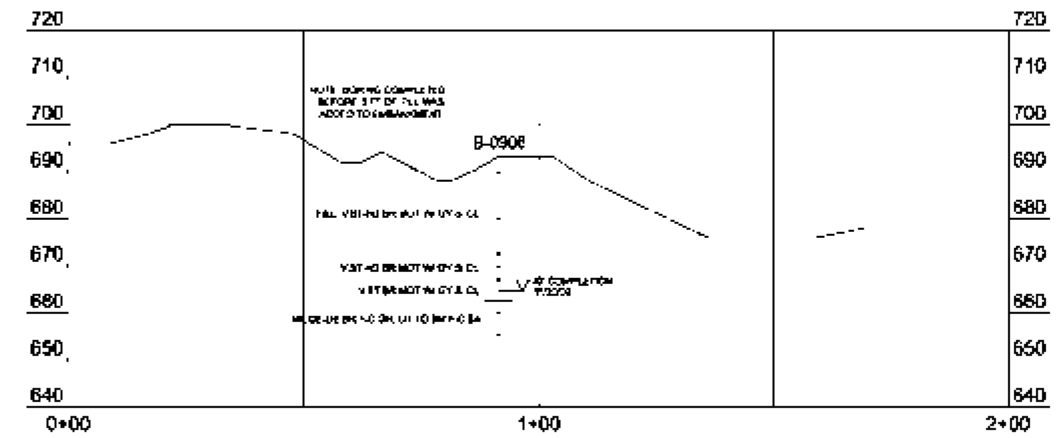
B-0904 BORING NUMBER AND LOCATION
BBCM NOVEMBER 2009 SUBSURFACE INVESTIGATION

PLAN OF BORINGS		
AEP Picway Plant Ash Pond Dike Evaluation Lockbourne, Ohio		BBCM
Project: 011-11497-019	Drawn By: TJM	
Drawing Date: 1-7-2010	Approved By: JDR	
Last Updated: 2-9-2010	Scale: 1" = 200'	1:1

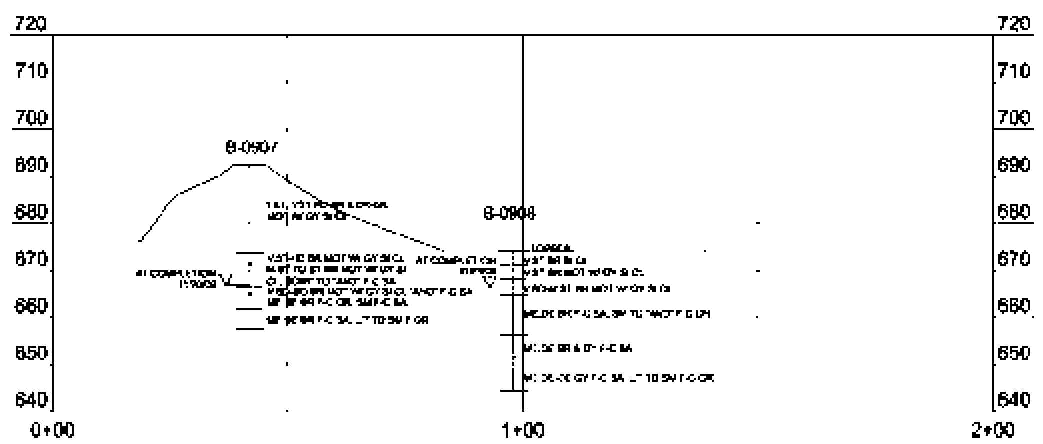
PLATE 2



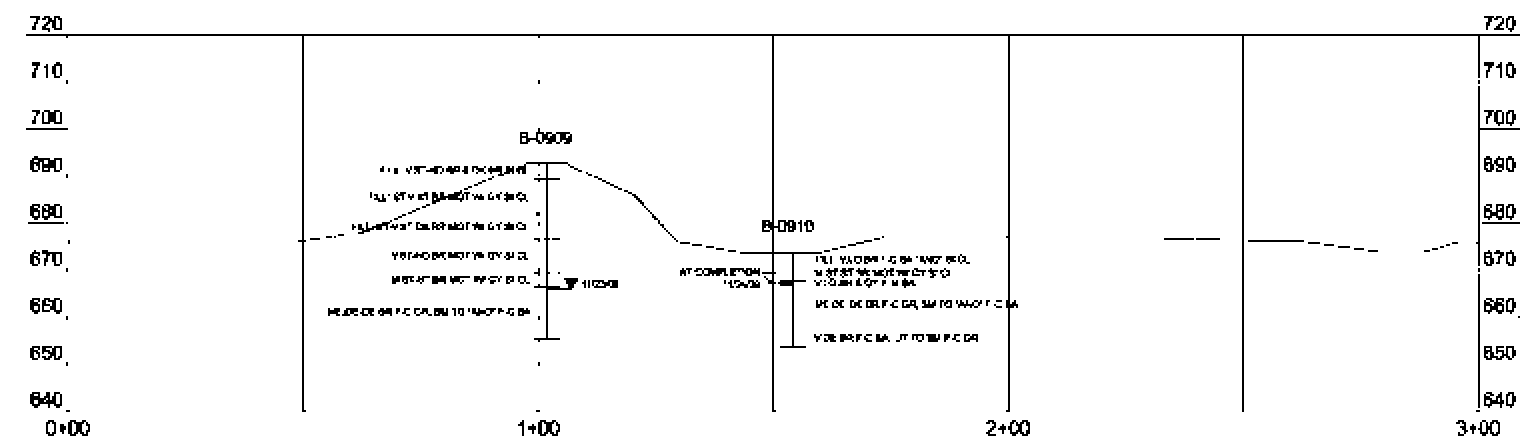
SECTION A
B-0904 & B-0905



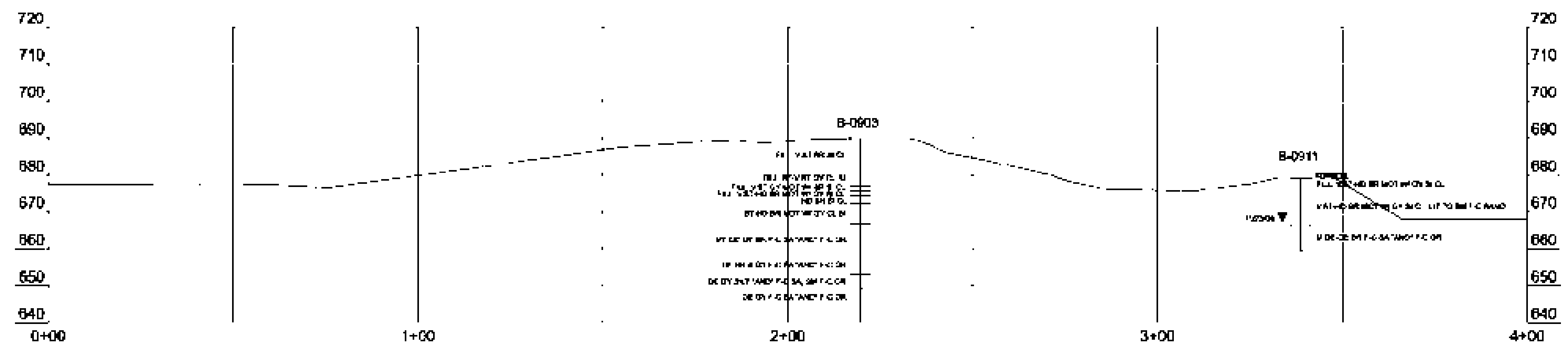
SECTION B
B-0906



SECTION C
B-0907 & B-0908



SECTION D
B-0909 & B-0910



SECTION E
B-0903 & B-0911

SCALE IN FEET
0 20 40

LEGEND

6/30/09 ▼	OBSERVATION WELL READING: ELEVATION AND DATE
6/14/09 ▽	WATER ENCOUNTERED DURING DRILLING
V.SO / SO	SOFT / VERY SOFT
M.ST	M. STIFF
ST / V.ST	STIFF / VERY STIFF
HD	HARD
V.LO / LO	VERY LOOSE / LOOSE
M.DE	MEDIUM DENSE
DE / V.DE	DENSE / VERY DENSE

PROJECT NUMBER:	011-11497-019	DRAWN BY:	TJM
DRAWING DATE:	1-7-2010	ENGINEER:	JDR
LAST UPDATED:	1-7-2010	APPROVED BY:	MCR
		SCALE:	1" = 20'

BBCM

A.E.P.
PICWAY PLANT
LOCKBOURNE OHIO

ASH POND
INVESTIGATION
SECTIONS

DWG NO PLATE 3

AEP AMERICAN ELECTRIC POWER
AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

AEPPIP000045

EXPLANATION OF SYMBOLS AND TERMS USED ON BORING LOGS FOR SAMPLING AND DESCRIPTION OF SOIL

SAMPLING DATA

- Blocked-in "SAMPLES" column indicates sample was attempted and re covered within this depth interval.

- Sample was attempted within this interval but not recovered.

2/5/9 - The number of blows required for each 6-inch increment of penetration of a "Standard" 2-inch O.D. split-barrel sampler, d riven a dist ance of 18 inches by a 140-pou nd hammer freely falling 30 inches. The raw "blowcount" or "N" is equal to the sum of the second and third 6-inch increments of penetration. Addition of one of the following symbols indicates the use of a split-barrel other than the 2" O.D. sampler:

- 2S - 2½"O.D split-barrel sampler
- 3S - 3" O.D. split-barrel sampler

N_{60} - Corrected Blowcount = [(BBCM Drill Rod Energy Ratio) / (0.60 Standard)] X N_{raw}

P - Shelby tube sampler, 3" O.D., hydraulically pushed.

R - Refusal of sampler in very-hard or dense soil, or on a resistant surface.

50-2" - Number of blows (50) t o drive a split-barrel sa mpler a cert ain number of inches (2), other than the normal 6-inch increment.

SD - Split-barrel sampler (S) advanced by weight of drill rods (D).

SH - Split-barrel sampler (S) advanced by combined weight of rods and drive Hammer (H).

SOIL DESCRIPTIONS

All soils have been classified basica lly in accordance with the Unified Soil Classification System, but this sy stem has been augmented by the use of special a djectives to designate t he approximate percentages of minor components, as follows:

Adjective	Percent by Weight
trace	1 to 10
little	11 to 20
some	21 to 35
"and"	36 to 50

The following terms are used to describe density and consistency of soils:

Term (Granular Soils)	Blows per foot (N_{60})
Very-loose	Less than 5
Loose	5 to 10
Medium-dense	11 to 30
Dense	31 to 50
Very-dense	Over 50

Term (Cohesive Soils)	Qu (tsf)
Very-soft	Less than 0.25
Soft	0.25 to 0.5
Medium-stiff	0.5 to 1.0
Stiff	1.0 to 2.0
Very-stiff	2.0 to 4.0
Hard	Over 4.0

LOG OF BORING NO. B-0904
AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCKBOURNE, OHIO

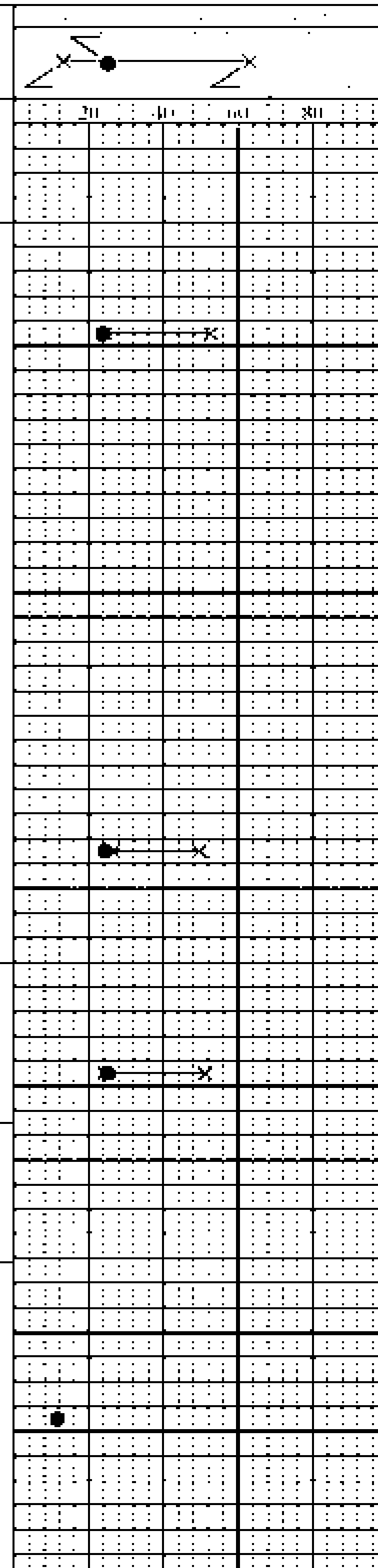
BBCM

LOCATION: See Plate 2 of Appendix A ELEVATION: 692.85 DATE: 11/24/09

DRILLING METHOD: 3-1/4" I.D. Hollow-stem Auger COMPLETION DEPTH: 35.0'

SAMPLER(S): 2" O.D. Split-barrel Sampler

ELEV.	DEPTH (FEET)	SAMPLE NUMBER	SAMPLE EFFORT	N	SAMPLE REC %	DESCRIPTION	TEST RESULTS
	0	1	3 / 8 / 7	21	67	FILL: Very-stiff to hard brown and dark-brown silty clay, little fine to coarse sand, little fine gravel, few roots, damp.	H 4.5
690.4		2	3 / 5 / 7	17	67	FILL: Very-stiff to hard-brown mottled with gray silty clay, trace fine to coarse sand, contains occasional roots, damp.	H 3.05-4.5
	5	3	3 / 5 / 6	15	73		H 2.75
		4	2 / 4 / 3	10	53		H 2.75-3.5
		5	2 / 2 / 5	10	60		H 2.75
		6	1 / 3 / 5	11	73		H 2.75-3.75
	10	7	2 / 5 / 8	18	80		H 2.75-4.5
		8	2 / 4 / 5	12	87		H 2.25-3.5
		9A			100		H 2.25
		9B	1 / 2 / 5	10	69		H 2.75
	15	10	3 / 8 / 9	19	73		H 3.25-4.0 G
		11	4 / 5 / 6	15	100		H 3.0-3.25
675.4		12	2 / 5 / 7	17	100	Very-stiff to hard dark-brown mottled with brown and gray silty clay, trace fine to medium sand, damp.	H 2.75
	20	13	2 / 6 / 8	19	100		H 3.25-4.0 G
672.1		14A			100	Very-stiff brown mottled with gray silty clay, trace fine to medium sand, damp.	H 3.25
		14B	3 / 5 / 4	12	100		H 3.25
669.3		15A			100	Loose to medium-dense brown fine to coarse sand, some fine to coarse gravel, little to some silt, trace clay, wet.	H 2.75
	25	15B	2 / 2 / 4	8	71		
		16	2 / 6 / 12	25	73		G
664.2		17	7 / 11 / 13	33	87	Dense brown fine to coarse gravel, some to "and" fine to coarse sand, little silt, wet.	
	30						



WATER LEVEL: ∇ 23.6 (First Encounter, 11/24/09); ▼ 24.6 (At Completion, 11/24/09)

Drill Rod Energy Ratio: 0.83
Last Calibration Date: 10/13/09
Drill Rig Number: D50

LOG OF BORING NO. B-0904
AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCKBOURNE, OHIO

BBCM

LOCATION: See Plate 2 of Appendix A | ELEVATION: 692.85 | DATE: 11/24/09

DRILLING METHOD: 3-1/4" I.D. Hollow-stem Auger | COMPLETION DEPTH: 35.0'

SAMPLER(S): 2" O.D. Split-barrel Sampler

ELEV.	DEPTH (FEET)	SAMPLE NUMBER	SAMPLE EFFORT	N	SAMPLE REC %	DESCRIPTION	TEST RESULTS
	30					Dense brown fine to coarse gravel, some to "and" fine to coarse sand, little silt, wet.	
		18	5 / 12 / 13	35	100		
658.4		19A	8 / 11 / 13	33	100		
657.2	35	19B			17	Hard gray silty clay, some fine to coarse sand, trace fine gravel, moist.	H 4.5
						- Groundwater encountered at 23.6 feet. - Upon completion, hole was backfilled with cement-bentonite grout.	
	40						
	45						
	50						
	55						
	60						

Chart scale: 20 40 60 80

WATER LEVEL	23.6	24.6
WATER NOTE	First Encounter	At Completion
DATE	11/24/09	11/24/09

Drill Rod Energy Ratio: 0.83
Last Calibration Date: 10/13/09
Drill Rig Number: D50

LOG OF BORING NO. B-0905
AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCKBOURNE, OHIO

BBCM

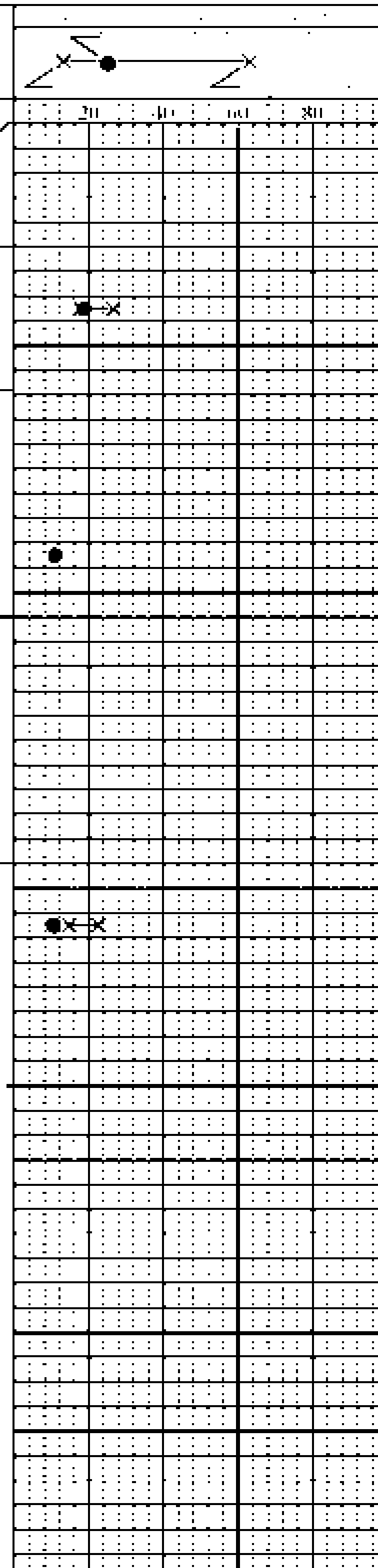
LOCATION: See Plate 2 of Appendix A — ELEVATION: 675.20 — DATE: 11/23/09

DRILLING METHOD: 3-1/4" I.D. Hollow-stem Auger — COMPLETION DEPTH: 20.0'

SAMPLER(S): 2" O.D. Split-barrel Sampler

ELEV.	DEPTH FEET	SAMPLE NUMBER	SAMPLE EFFORT	N	SAMPLE REC %	DESCRIPTION	TEST RESULTS
674.7	0					TOPSOIL - 6 INCHES	
672.2		1	3 / 5 / 5	14	60	Very-stiff to hard brown silty clay, trace fine to medium sand, slightly organic, damp.	H 3.25-4.0
669.7	5	2	2 / 3 / 4	8	73	Loose brown fine to coarse sand, "and" clayey silt, moist.	H 1.25-1.5, G
664.7	10	3	2 / 3 / 6	12	47	Medium-dense brown fine to coarse gravel some to "and" fine to coarse sand, little silt, trace clay, wet.	
		4	4 / 8 / 9	24	67		G
659.7	15	5	7 / 17 / 50-2"R		100	Very-dense brown fine to coarse gravel, some to "and" fine to coarse sand, little silt, wet.	
		6	20 / 21 / 27	66	13		
655.2	20	7	8 / 12 / 18	42	87	Hard gray clayey silt, some fine to coarse sand, trace fine gravel, damp.	H 4.5, G
		8	8 / 12 / 16	39	100		H 4.5

- Encountered seepage at 6.8'
- Upon completion hole was backfilled with cement-bentonite grout.



WATER LEVEL:	7.5	17.5
WATER NOTE:	First Encounter	At Completion
DATE:	11/23/09	11/23/09

Drill Rod Energy Ratio: 0.83
Last Calibration Date: 10/13/09
Drill Rig Number: D50

JOB: 011-11497-019 — PLATE 7

LOG OF BORING NO. B-0906
AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCKBOURNE, OHIO

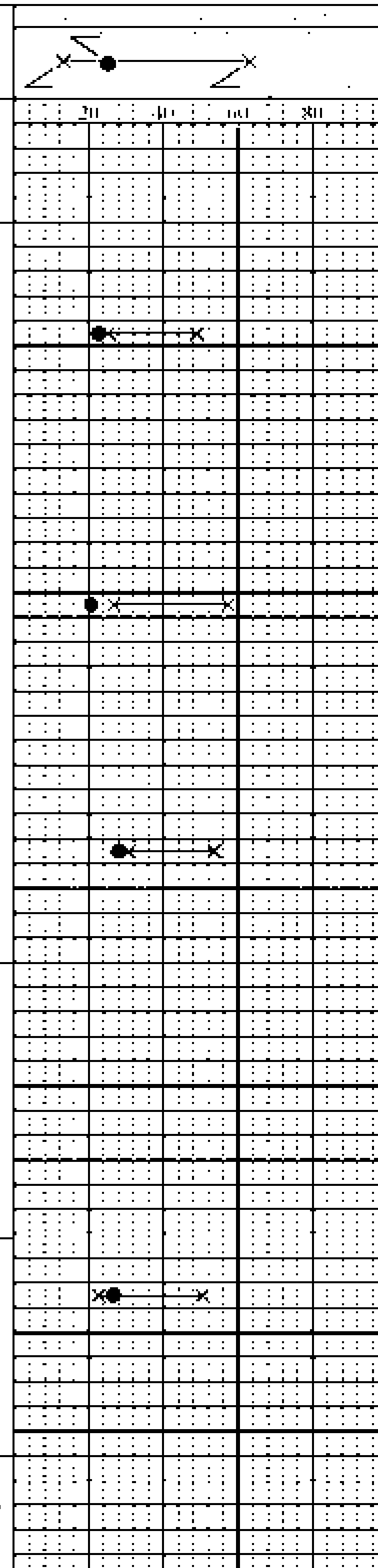
BBCM

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **690** DATE: **11/20/09**

DRILLING METHOD: **3-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **35.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

ELEV.	DEPTH FEET	SAMPLE NUMBER	SAMPLE EFFORT	N	SAMPLE REC %	DESCRIPTION	TEST RESULTS
	0	1	5 5 6	15	47	FILL: Hard dark-brown silty clay, trace fine to coarse sand, few roots, damp	H 4.5
687.5		2	3 4 5	12	60	FILL: Very-stiff to hard brown mottled with gray silty clay, trace fine to coarse sand, damp	H 4.0
	5	3	3 5 8	18	60		H 4.05-4.5 G
		4	4 7 11	25	73		H 4.5
		5	P		92		H 3.25
	10	6	5 7 10	24	100		H 4.5
		7	2 5 6	15	100		H 2.75-4.0
		8	2 7 9	22	100		H 4.0
	15	9	2 5 8	18	100		H 3.5 G
		10	8 11 12	32	100		H 3.5-4.0
672.5		11A	4	15	100		H 3.5-4.0
		11B	5 6		75	Very-stiff to hard brown mottled with gray silty clay, trace fine to medium sand, damp	H 3.5-4.0
		12	1 2 7	12	100		H 3.5-4.0
	20						
		13	P		100		H 4.5
666.0		14	2 5 5	14	100	Very-stiff brown mottled with gray silty clay, trace fine to coarse sand, trace fine gravel, moist	H 2.25-2.75 G
	25	15	2 3 9	17	47		H 2.25-2.5
662.5		16	3 5 13	25	47	Medium-dense to dense brown fine to coarse gravel, little to some fine to coarse sand, little silt, wet	
	30						



WATER LEVEL: ▽ 27.5 ▼ 25.4

WATER NOTE: First Encounter At Completion

DATE: 11/20/09 11/20/09

Drill Rod Energy Ratio: 0.83

Last Calibration Date: 10/13/09

Drill Rig Number: D50

LOG OF BORING NO. B-0906
AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCKBOURNE, OHIO

BBCM

LOCATION: See Plate 2 of Appendix A — ELEVATION: 690 — DATE: 11/20/09

DRILLING METHOD: 3-1/4" I.D. Hollow-stem Auger — COMPLETION DEPTH: 35.0'

SAMPLER(S): 2" O.D. Split-barrel Sampler

ELEV.	DEPTH FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N	SAMPLE REC %	DESCRIPTION	TEST RESULTS
	30	17		9 / 13 / 15	30	60	Medium-dense to dense brown fine to coarse gravel, little to some fine to coarse sand, little silt, wet.	G
		18		9 / 12 / 14	26	73		
655.0	35						- Encountered seepage at 26.7'. - Upon completion hole was backfilled with cement bentonite grout.	
	40							
	45							
	50							
	55							
	60							

WATER LEVEL: ▽ 27.5 — ▼ 25.4

WATER NOTE: First Encounter — At Completion

DATE: 11/20/09 — 11/20/09

Drill Rod Energy Ratio: 0.83

Last Calibration Date: 10/13/09

Drill Rig Number: D50

LOG OF BORING NO. B-0907
AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCKBOURNE, OHIO

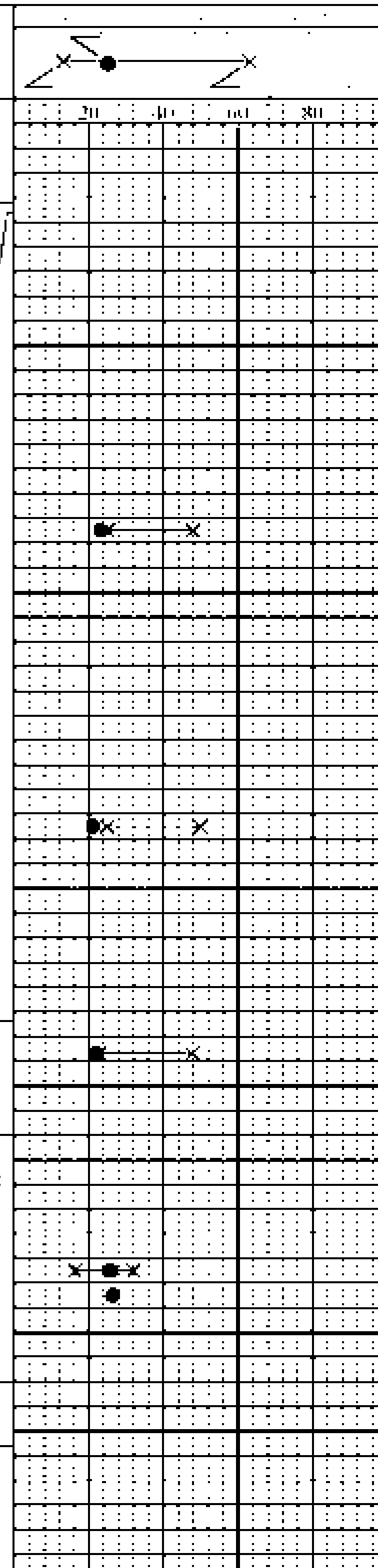
BBCM

LOCATION: See Plate 2 of Appendix A — ELEVATION: 692.38 — DATE: 11/19/09 - 11/20/09

DRILLING METHOD: 3-1/4" I.D. Hollow-stem Auger — COMPLETION DEPTH: 35.0'

SAMPLER(S): 2" O.D. Split-barrel Sampler

ELEV.	DEPTH (FEET)	SAMPLE NUMBER	SAMPLE EFFORT	N_{60}	SAMPLE REC %	DESCRIPTION	TEST RESULTS
	0					FILL: Very-stiff dark-brown mottled with gray silty clay, trace fine to coarse sand, damp.	
690.3		1A	3 9 9	25	100		HP 3.25
690.1		1B			50	FILL: Medium-dense gray fine gravel, little fine to coarse sand, trace silt, dry.	
		2A	3 4 5	12	100	FILL: Very-stiff to hard brown and dark-brown mottled with gray silty clay, trace fine to coarse sand, damp.	HP 2.5
		2B			70		HP 2.5-2.75
	5	3	P		27		HP 2.5
		4	3 3 4	10	93		HP 3.5-4.0
		5	3 4 6	14	100		HP 2.75-3.25
	10	6	3 5 9	19	100		G HP 3.5-4.0
		7	3 4 7	15	93		HP 3.25-3.75
		8	2 4 8	17	100		HP 3.25-3.75
	15	9	2 8 10	25	100		HP 4.5 G
		10	13 14 12	36	100		HP 3.5
		11	4 5 7	17	100		HP 2.5-3.5
673.7		12A	3 5 8	18	100		HP 2.25
		12B			100	Very-stiff to hard brown mottled with gray silty clay, damp.	HP 3.5-4.5 G
	20						
671.4		13	P		75	Medium-stiff to stiff brown mottled with gray silty clay, some to "and" fine to coarse sand, trace fine gravel, moist.	
	25	14	P				G HP 0.75-1.75 P
666.4		15A	WH WH 1	1	100	Very-soft to soft brown mottled with gray silty clay "and" fine to coarse sand, wet.	HP 0.1-0.5
665.1		15B			100	Medium-dense to dense brown fine to coarse gravel, some fine to coarse sand, little silt, wet.	
		16	2 4 7	15	33		
	30						G



WATER LEVEL:	▽ 27.3	▼ 25.5
WATER NOTE:	First Encounter	At Completion
DATE:	11/20/09	11/20/09

Drill Rod Energy Ratio: 0.83
Last Calibration Date: 10/13/09
Drill Rig Number: D50

LOG OF BORING NO. B-0907
AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCKBOURNE, OHIO

BBCM

LOCATION: See Plate 2 of Appendix A ELEVATION: 692.38 DATE: 11/19/09 - 11/20/09
DRILLING METHOD: 3-1/4" I.D. Hollow-stem Auger COMPLETION DEPTH: 35.0'
SAMPLER(S): 2" O.D. Split-barrel Sampler

ELEV.	DEPTH FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N	SAMPLE REC %	DESCRIPTION	TEST RESULTS
662.9	30							
		17		8 10 11	29	27	Medium-dense to dense brown fine to coarse sand, little to some fine gravel, little silt, wet.	
		18		19 13 10	32	40		
657.4	35							
							- Encountered seepage at 26.0'. - Upon completion hole was backfilled with cement-bentonite grout.	
	40							
	45							
	50							
	55							
	60							

WATER LEVEL: ∇ 27.3 ▼ 25.5
WATER NOTE: First Encounter / At Completion
DATE: 11/20/09 / 11/20/09

Drill Rod Energy Ratio: 0.83
Last Calibration Date: 10/13/09
Drill Rig Number: D50

JOB: 011-11497-019 PLATE 11

LOG OF BORING NO. B-0908
AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCKBOURNE, OHIO

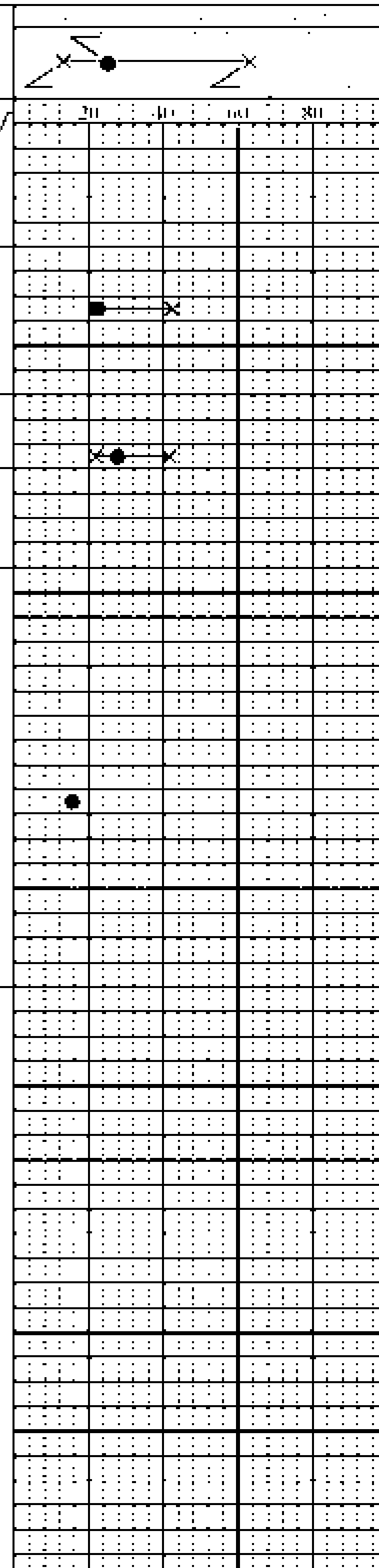
BBCM

LOCATION: See Plate 2 of Appendix A ELEVATION: 674.25 DATE: 11/23/09

DRILLING METHOD: 3-1/4" I.D. Hollow-stem Auger COMPLETION DEPTH: 30.0'

SAMPLER(S): 2" O.D. Split-barrel Sampler

ELEV.	DEPTH FEET	SAMPLE NUMBER	SAMPLE EFFORT	N	SAMPLE REC %	DESCRIPTION	TEST RESULTS
674.3	0					TOPSOIL - 4 INCHES	
671.3		1	2 2 3	7	53	Very-stiff brown silty clay, little fine to coarse sand, few roots, damp.	HP 2.5
668.3	5	2	2 4 7	15	93	Very-stiff brown mottled with gray silty clay, trace fine to medium sand, damp.	HP 2.5-3.25, G
666.8		3	1 P 1 3	6	100	Soft to medium-stiff brown mottled with gray silty clay, some fine to coarse sand, wet.	HP 0.3-0.75, G
664.8		4A	WH 1	3	100	Very-soft to soft brown mottled with gray silty clay, trace fine to coarse sand, wet.	HP 0.1-0.25
	10	4B	1		100	Medium-dense brown fine to coarse sand, some to "and" fine to coarse gravel, trace to little silt, wet.	
		5	5 6 6	17	60		
	15	6	4 5 9	19	93		G
656.3		7	4 3 5	11	80		
	20	8	5 3 4	10	40	Medium-dense brown and gray fine to coarse sand, little fine to coarse gravel, trace silt, wet	
651.3		9	1 3 5	11	27		
	25	10	4 10 11	29	67	Medium-dense to dense gray fine to coarse sand, little to some fine to coarse gravel, trace to little silt, wet.	G
		11	15 16 11	37	53		
644.3	30	12	4 14 12	36	73		



WATER LEVEL:	∇ 6.9	▼ 8.0
WATER NOTE:	First Encounter	At Completion
DATE:	11/23/09	11/23/09

Drill Rod Energy Ratio: 0.83
Last Calibration Date: 10/13/09
Drill Rig Number: D50

JOB: 011-11497-019 -CONTINUED- PLATE 12

LOG OF BORING NO. B-0908
AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCKBOURNE, OHIO

BBCM

LOCATION: See Plate 2 of Appendix A | ELEVATION: 674.25 | DATE: 11/23/09

DRILLING METHOD: 3-1/4" I.D. Hollow-stem Auger | COMPLETION DEPTH: 30.0'

SAMPLER(S): 2" O.D. Split-barrel Sampler

ELEV.	DEPTH FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N	SAMPLE REC %	DESCRIPTION	20 40 60 80	TEST RESULTS
	30						- Encountered seepage at 6.3'. - Hole was backfilled with cement-bentonite grout upon completion. - Shelby tube Sample 13 obtained from offset boring.		
	35								
	40								
	45								
	50								
	55								
	60								

WATER LEVEL:	6.9	8.0
WATER NOTE:	First Encounter	At Completion
DATE:	11/23/09	11/23/09

Drill Rod Energy Ratio: 0.83
Last Calibration Date: 10/13/09
Drill Rig Number: D50

JOB: 011-11497-019 | PLATE 13

LOG OF BORING NO. B-0909
AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCKBOURNE, OHIO

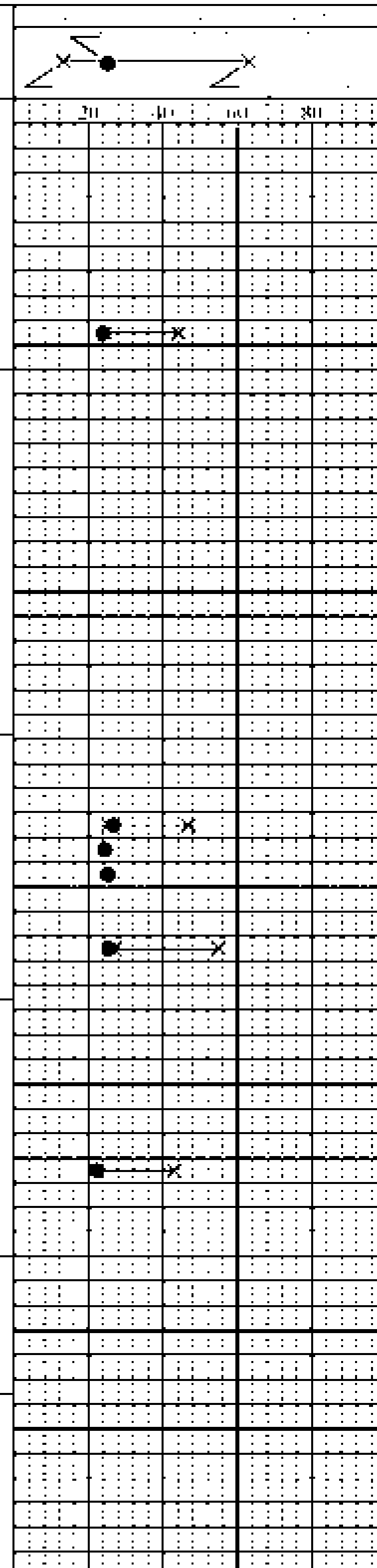
BBCM

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **692.81** DATE: **11/19/09**

DRILLING METHOD: **3-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **37.5'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

ELEV.	DEPTH FEET	SAMPLE NUMBER	SAMPLE EFFORT	N	SAMPLE REC %	DESCRIPTION	TEST RESULTS
	0	1	6-9-9	25	80	FILL: Very-stiff to hard brown and dark-brown silty clay, trace fine to coarse sand, trace fine gravel, few roots, damp.	H 4.5
		2	1-3-5	11	40		H 3.0-3.8
687.3	5	3	1-2-4	8	60		H 2.25 G
		4	2-4-6	14	53	FILL: Stiff to very-stiff brown mottled with gray silty clay, trace fine to coarse sand, trace to little fine gravel, damp.	H 2.75-3.25
		5	2-3-4	10	93		H 1.5-2.25
	10	6	P		54		H 2.75
		7	3-4-6	14	73		H 3.75
679.3		8A	3	11	100		H 3.75
		8B	4-4		73	FILL: Stiff to very-stiff dark brown mottled with gray silty clay, trace fine to coarse sand, damp.	H 1.75-2.25
	15	9	P		100		H 3.25 G I
		10	3-6-9	21	100		H 3.5-3.75 G
674.3		11A	2	17	100		H 3.75
		11B	5-7			Very-stiff to hard brown mottled with gray silty clay, trace fine to coarse sand, damp.	H 3.25-3.5
	20	12	7-8-8	22	100		H 3.25-3.5
		13	3-4-5	12	100		H 3.35-4.5 G
669.3		14A	1-2	6	100	Medium-stiff to stiff brown mottled with gray silty clay, some fine to coarse sand, trace fine gravel, interbedded with fine sand and silt seams, wet.	H 1.5-1.75
	25	14B	2		100		
666.3		15A	3	15	100		H 0.5
		15B	4-7		58	Medium-dense to dense brown fine to coarse gravel, some to "and" fine to coarse sand, trace to little silt, wet.	
		16	7-19-16	48	60		
	30						



WATER LEVEL	28.5	26.8
WATER NOTE	First Encounter	Inside PVC
DATE	11/19/09	11/23/09

Drill Rod Energy Ratio: 0.83
Last Calibration Date: 10/13/09
Drill Rig Number: D50

LOG OF BORING NO. B-0909
AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCKBOURNE, OHIO

BBCM

LOCATION: See Plate 2 of Appendix A | ELEVATION: 692.81 | DATE: 11/19/09

DRILLING METHOD: 3-1/4" I.D. Hollow-stem Auger | COMPLETION DEPTH: 37.5'

SAMPLER(S): 2" O.D. Split-barrel Sampler

ELEV.	DEPTH FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N	SAMPLE REC %	DESCRIPTION	TEST RESULTS
	30						Medium-dense to dense brown fine to coarse gravel, some to "and" fine to coarse sand, trace to little silt, wet.	
		17		5 / 7 / 13	28	53		
		18		6 / 13 / 16	40	73		
	35							
		19		4 / 16 / 13	40	47		
655.3								
	40						- Encountered seepage at 24.6'. - Installed 40' of 1-1/2" diameter slotted PVC, stick up was 3.5'. - Upon obtaining extended groundwater measurements, hole was backfilled with cement-bentonite grout on 11/23/09. - Extended groundwater measurements: 11/20/09 - 24.8 feet B.G.S. 11/23/09 - 26.8 feet B.G.S.	
	45							
	50							
	55							
	60							

WATER LEVEL	28.5	26.8
WATER NOTE	First Encounter	Inside PVC
DATE	11/19/09	11/23/09

Drill Rod Energy Ratio: 0.83
Last Calibration Date: 10/13/09
Drill Rig Number: D50

LOG OF BORING NO. B-0910
AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCKBOURNE, OHIO

BBCM

LOCATION: See Plate 2 of Appendix A | ELEVATION: 673.68 | DATE: 11/24/09

DRILLING METHOD: 3-1/4" I.D. Hollow-stem Auger | COMPLETION DEPTH: 20.0'

SAMPLER(S): 2" O.D. Split-barrel Sampler

ELEV.	DEPTH FEET	SAMPLE NUMBER	SAMPLE EFFORT	N	SAMPLE REC %	DESCRIPTION	TEST RESULTS
673.4	0					TOPSOIL - 4 INCHES	
671.2		1	1 / 2 / 1	4	60	FILL: Very-loose brown fine to coarse sand "and" silty clay, trace fine gravel, damp.	
667.9	5	2	P		95	Medium-stiff to stiff brown mottled with gray silty clay, some to "and" fine to coarse sand, moist	LL: 75-15
667.3		3A / 3B	WH / WH / 2	2	10 / 17	Very-loose brown and gray fine to medium sand, trace coarse sand, trace fine gravel, "and" silty clay, wet.	
	10	4	8 / 11 / 12	32	53	Medium-dense to dense brown fine to coarse gravel, some to "and" fine to coarse sand, little silt, trace clay, wet.	G
		5	8 / 9 / 11	28	80		
657.7	15	6	12 / 16 / 12	30	60		
		7	11 / 16 / 20	50	87	Very-dense brown fine to coarse sand, little to some fine to coarse gravel, trace to little silt, wet	
653.7	20	8	32 / 25 / 22	65	27		
	25					- Encountered seepage at 6.7'. - Upon completion, hole was backfilled with cement-bentonite grout.	
	30						

Chart scale: 20, 40, 60, 80

WATER LEVEL	▽ 8.0	▼ 6.5
WATER NOTE	First Encounter	At Completion
DATE	11/24/09	11/24/09

Drill Rod Energy Ratio: 0.83
Last Calibration Date: 10/13/09
Drill Rig Number: D50

JOB: 011-11497-019

LOG OF BORING NO. B-0911
AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCKBOURNE, OHIO

BBCM

LOCATION: See Plate 2 of Appendix A ELEVATION: 679.36 DATE: 11/19/09

DRILLING METHOD: 3-1/4" I.D. Hollow-stem Auger COMPLETION DEPTH: 20.0'

SAMPLER(S): 2" O.D. Split-barrel Sampler

ELEV.	DEPTH FEET	SAMPLE NUMBER	SAMPLE EFFORT	N60	SAMPLE REC %	DESCRIPTION	TEST RESULTS
678.9	0					TOPSOIL - 6 INCHES	
		1	4 / 5 / 5	14	53	FILL: Very-stiff to hard dark-brown mottled with gray silty clay, trace fine to coarse sand, trace fine gravel (asphalt fragments), damp.	H 3.5-4.0
676.4		2	2 / 6 / 9	21	93	Very-stiff to hard brown mottled with gray silty clay, little to some fine to coarse sand, damp becoming wet.	H 3.5-4.5 G
	5	3	P		42		
		4	2 / 4 / 8	12	80		H 2.0-3.0 G
	10	5A / 5B	2 / 2 / 2	6	20		H 2.25-3.25
666.4		6	2 / 4 / 9	18	53	Medium-dense to dense brown fine to coarse sand "and" fine to coarse gravel, little silt, wet.	
	15	7	5 / 11 / 15	36	73		G
		8	9 / 7 / 8	21	40		
659.4	20						
	25						
	30						

- Encountered seepage at 11.7'.
- 1-1/2" diameter slotted PVC pip was placed in hole, stick-up was 1.9 feet.
- Upon obtaining extended groundwater measurements hole was backfilled with cement bentonite grout on 11/24/09
- Extended groundwater measurements:
11/20/09 - 10.8 feet B.G.S.
11/24/09 - 12.1 feet B.G.S.

WATER LEVEL:	▽ 13.5	▼ 12.0
WATER NOTE:	First Encounter	Inside PVC
DATE:	11/19/09	11/24/09

Drill Rod Energy Ratio: 0.83
Last Calibration Date: 10/13/09
Drill Rig Number: D50

JOB: 011-11497-019 PLATE 17

USGS National Seismic Hazard Maps - 2008

Peak Horizontal Acceleration with 2% Probability of Exceedence in 50 Years

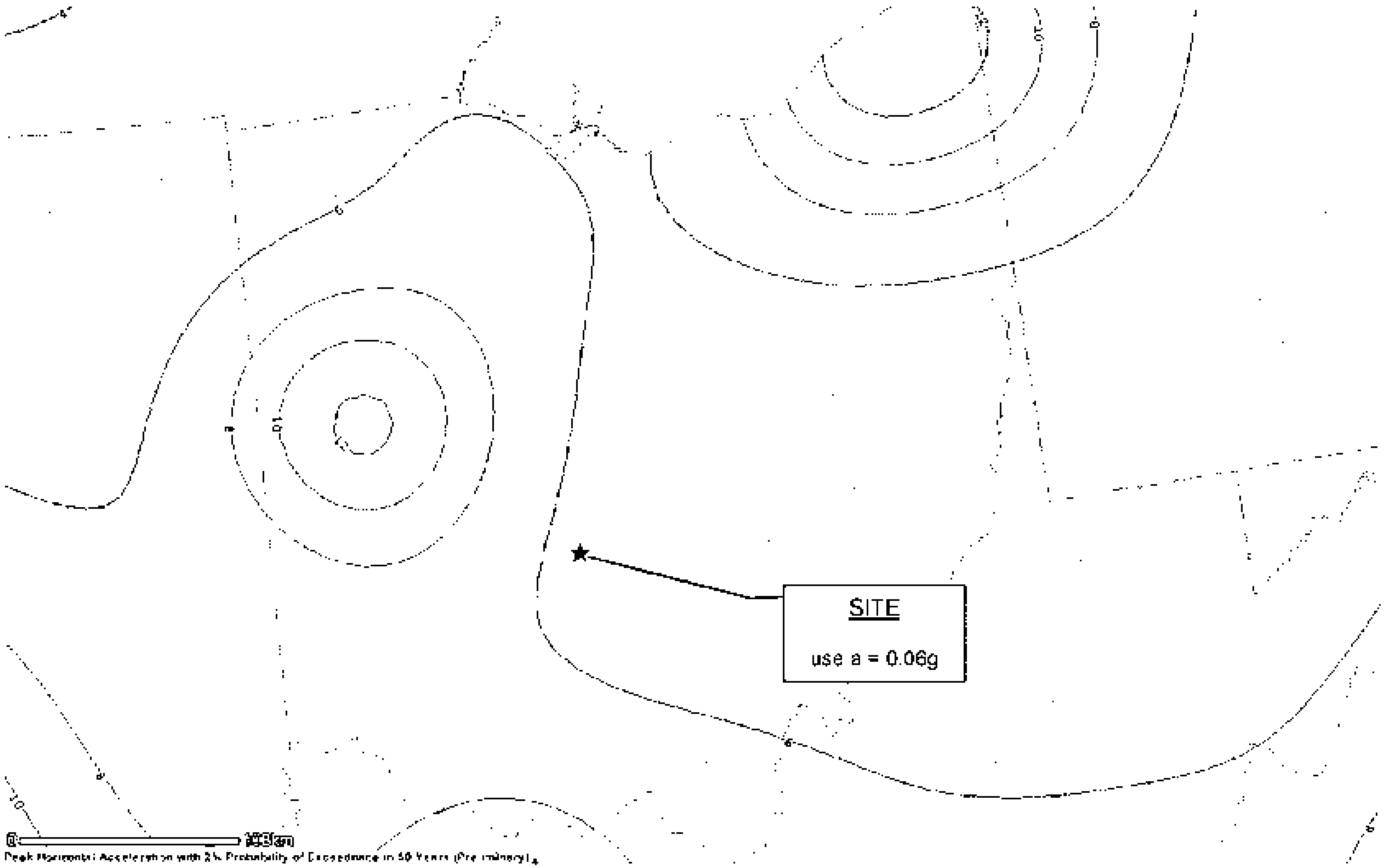


PLATE 13

APPENDIX B

Laboratory Testing

PLATE 1

SUMMARY OF LABORATORY TEST RESULTS

BORING	Grnt Id.	MC	LL	PL	PI	GRADATION: Sieve	GRADATION: Hydrometer short	GRADATION: Hydrometer long	COMPACTION: standard	COMPACTION: modified	TRIAXIAL: uncons undrain	TRIAXIAL: consolid undrain	TRIAXIAL: w/ pores	TRIAXIAL: drained	DIRECT SHEAR: drained	DIRECT SHEAR: undrain	DIRECT SHEAR: residual	UNCONFIN	COMPRESS	CONSOLID.	SPECIFIC GRAVITY	UNIT DRY WEIGHT	REMOLDED	PERMEABILITY: cohesive	PERMEABILITY: non cohes	PERMEABILITY: rigid wall	PERMEABILITY: flexible wall	RELATIVE DENSITY	L O I	ROCK CORE	SHELBY TUBE	C B R
		%	%	%	%																	PCF						%	%			
B-0904	4.75	24	53	24	29																											
B-0904	15.25	25	50	27	23	*		*																								
B-0904	19.75	25	51	24	27	*		*																								
B-0904	26.75	12				*		*																								
B-0905	4.25	19	27	18	9	*		*																								
B-0905	9.25	11				*		*																								
B-0905	16.75	10	23	15	8	*		*																								
B-0906	4.75	23	49	25	24	*		*																								
B-0906	10.25	21	57	27	30																											
B-0906	15.25	28	54	31	23	*		*																								
B-0906	24.25	27	50	23	27	*		*																								
B-0906	31.75					*																										
B-0907	8.75	23	48	25	23	*		*																								
B-0907	14.75	21	50	25	25	*		*																								
B-0907	19.35	22	48	23	25	*		*																								
B-0907	23.75		32	16	16	*		*				*																				
B-0907	24.25											*								*												
B-0907	29.25					*																										
B-0908	4.25	22	42	23	19	*		*																								
B-0908	7.25		42	22	20	*		*																								

* SEE INDIVIDUAL TEST CURVES

BBCM
SOLUTIONS TO BUILD ON

TESTING SUMMARY - STANDARD

PROJECT AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION LOCKBOURNE, OHIO
JOB NO. 011-11497-019 DATE 1/6/10

SUMMARY OF LABORATORY TEST RESULTS

BORING	G'nt Id.	MC %	LL %	PL %	PI %	Gradation: Sieve	Gradation: Hydrometer Short	Gradation: Hydrometer Long	Compaction: Standard	Compaction: Modified	Triaxial: Unconsolidated Undrained	Triaxial: Consolidated Undrained	Triaxial: Consolidated Undrained w/ Pores	Triaxial: Drained	Direct Shear: Drained	Direct Shear: Undrained	Direct Shear: Residual	Unconfined Compress	Consolid.	Specific Gravity	Unit Weight Dry PCF	Remolded	Permeability: Constant	Permeability: Non-Constant	Permeability: Rigid Wall	Permeability: Flexible Wall	Relative Density %	L.O.I. %	Rock Core	Shelby Tube	CBR
B-0908	14.25	15				*		*																							
B-0908	24.25					*																									
B-0909	4.75	24	44	24	20	*		*																							
B-0909	14.75		47	25	22	*		*																							
B-0909	15.25																														
B-0909	15.75																														
B-0909	17.25	25	55	27	28	*		*																							
B-0909	21.75	22	43	22	21	*		*																							
B-0910	9.25	16				*		*																							
B-0911	4.25	23	54	26	28	*		*																							
B-0911	9.25	19	32	17	15	*		*																							
B-0911	16.75					*																									

* SEE INDIVIDUAL TEST CURVES

BBCM
SOLUTIONS TO BUILD ON

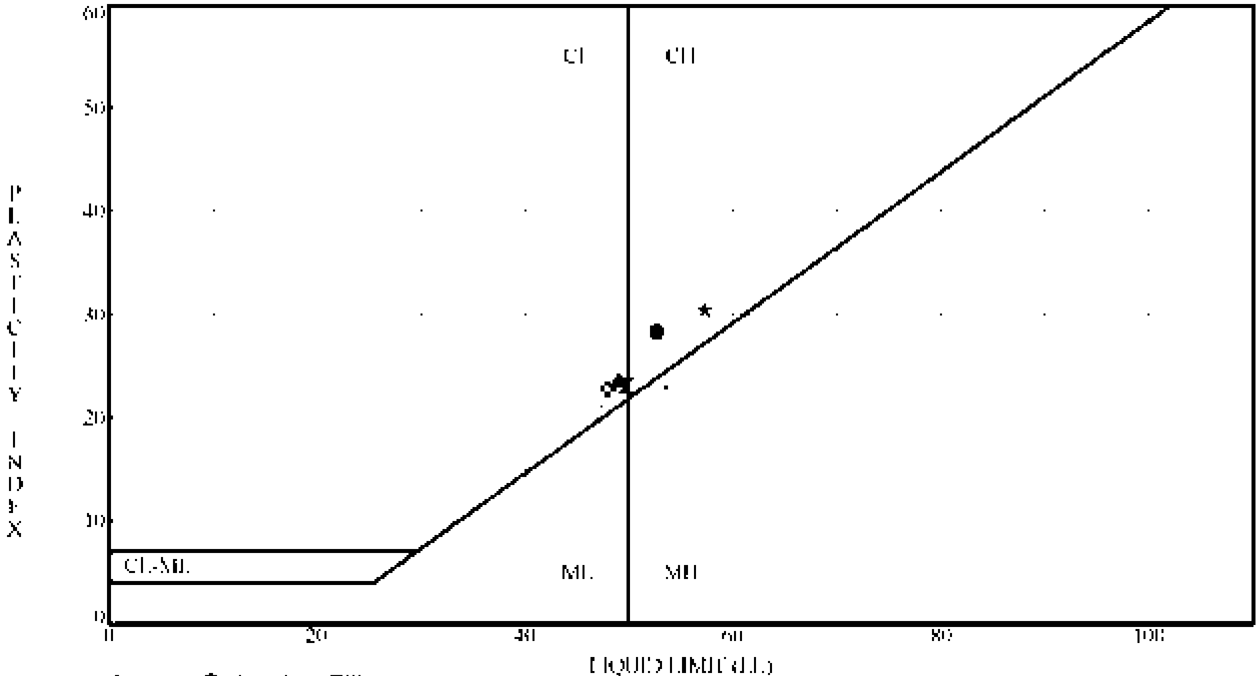
TESTING SUMMARY - STANDARD

PROJECT AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION LOCKBOURNE, OHIO
JOB NO. 011-11497-019 DATE 1/6/10

PLATE 2

ATTERBERG LIMITS' RESULTS

BBCM



Layer: Cohesive Fill

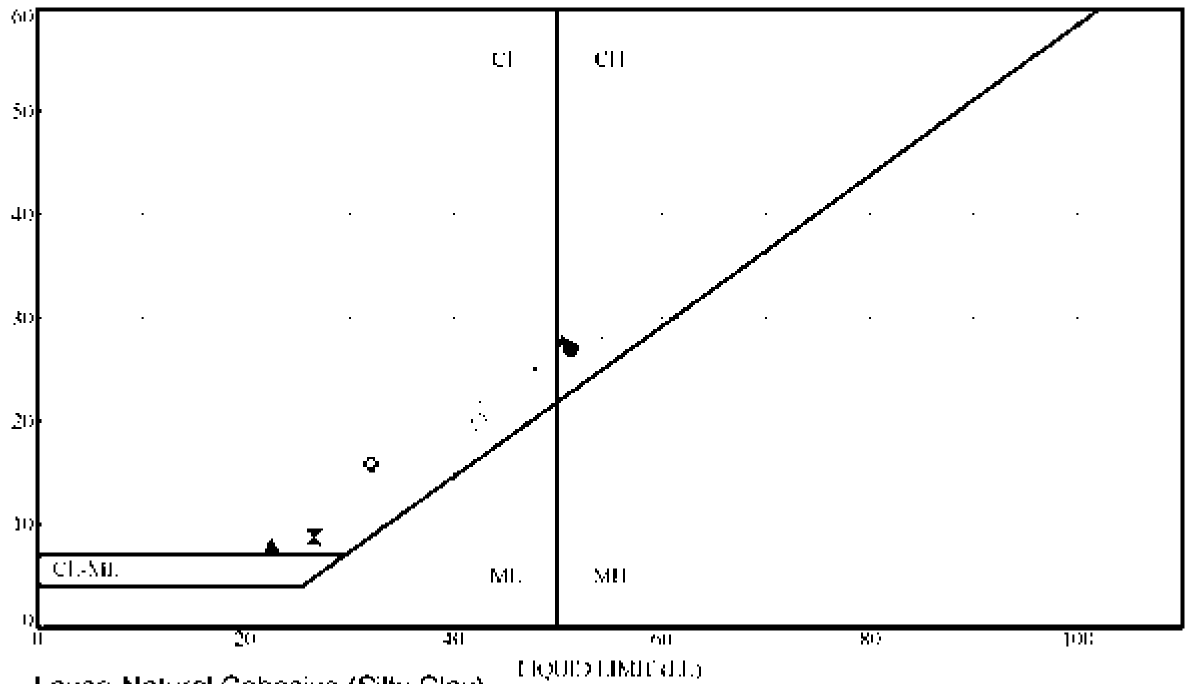
	Specimen Id.	Depth	MC	LL	PL	PI	Fines	ASTM Classification
●	B-0904	4.75	24	53	24	29		
⧗	B-0904	15.25	25	50	27	23	97.6	FAT CLAY CH
▲	B-0906	4.75	23	49	25	24	96.5	LEAN CLAY CL
★	B-0906	10.25	21	57	27	30		
•	B-0906	15.25	28	54	31	23	97.8	ELASTIC SILT MH
✪	B-0907	8.75	23	48	25	23	96.7	LEAN CLAY CL
	B-0907	14.75	21	50	25	25	96.2	FAT CLAY CH
	B-0909	4.75	24	44	24	20	95.0	LEAN CLAY CL
	B-0909	14.75		47	25	22	93.7	LEAN CLAY CL

PROJECT AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION LOCKBOURNE, OHIO
JOB NO. 011-11497-019 DATE 1/6/10

PLATE 3

ATTERBERG LIMITS' RESULTS

BBCM

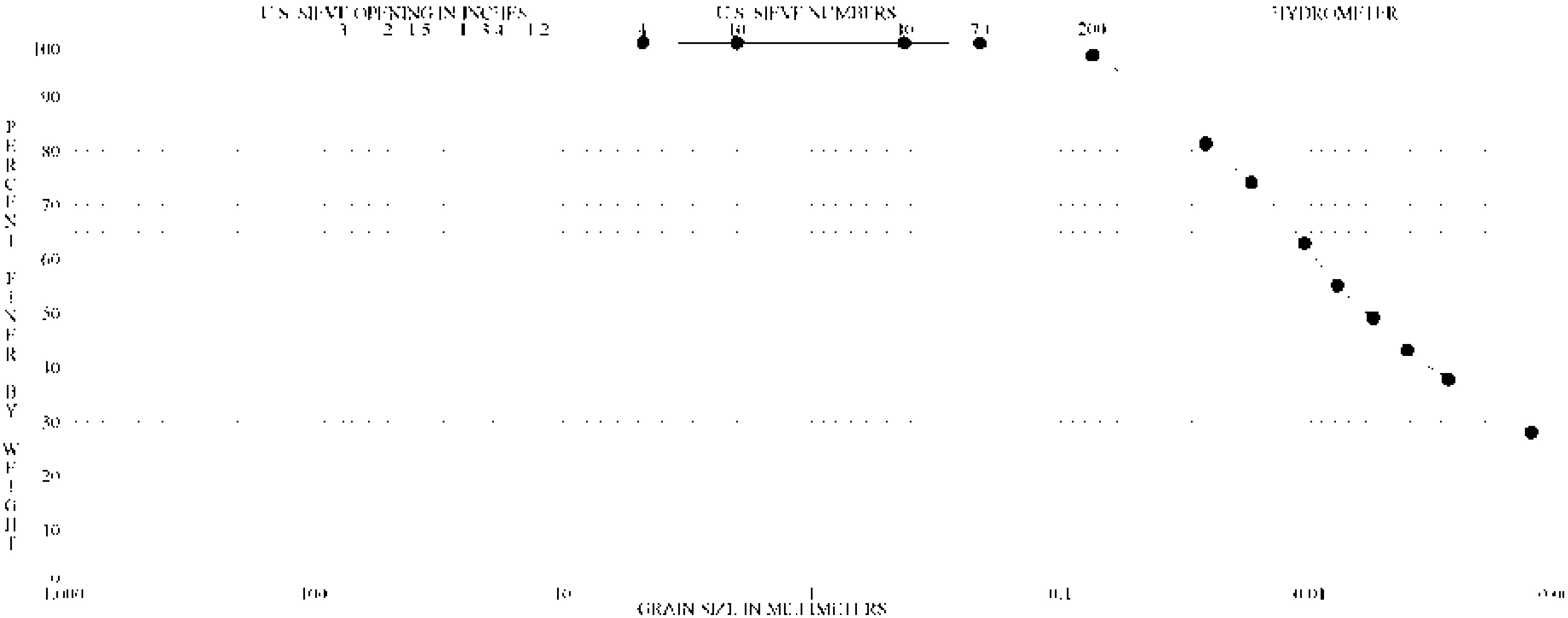


Layer: Natural Cohesive (Silty Clay)

	Specimen Id.	Depth	MC	LL	PL	PI	Fines	ASTM Classification
●	B-0904	19.75	25	51	24	27	98.5	FAT CLAY CH
⧗	B-0905	4.25	19	27	18	9	48.9	CLAYEY SAND SC
▲	B-0905	16.75	10	23	15	8	61.8	SANDY LEAN CLAY CL
★	B-0906	24.25	27	50	23	27	95.7	FAT CLAY CH
•	B-0907	19.35	22	48	23	25	99.1	LEAN CLAY CL
✪	B-0907	23.75		32	16	16	56.1	SANDY LEAN CLAY CL
	B-0908	4.25	22	42	23	19	94.9	LEAN CLAY CL
	B-0908	7.25		42	22	20	90.0	LEAN CLAY CL
	B-0909	21.75	22	43	22	21	97.4	LEAN CLAY CL
	B-0911	4.25	23	54	26	28	98.5	FAT CLAY CH
	B-0911	9.25	19	32	17	15	78.2	LEAN CLAY with SAND CL

PROJECT AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION LOCKBOURNE, OHIO
JOB NO. 011-11497-019 DATE 1/6/10

PLATE 4



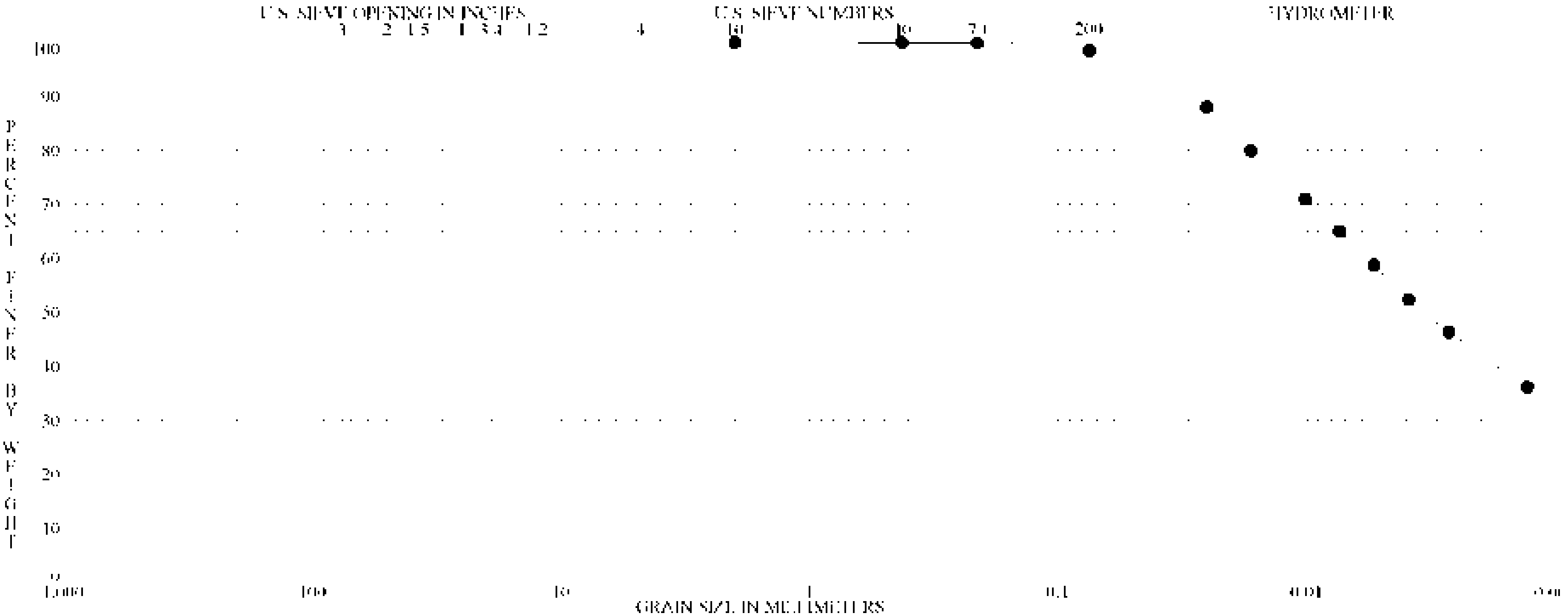
Specimen Identification - Depth			Classification	MC%	LL	PL	PI	UWW	UDW
● B-0904	S-10	14.5' to 15.6'	FILL : Dark-brown mottled with brown and gray silty clay, trace fine to coarse sand. FAT CLAY CH	25	50	27	23		

Specimen Identification - Depth			D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● B-0904	S-10	14.5' to 15.6'	4.7500	0.0633	0.0094	0.0059		0.0	2.4	64.1	33.6

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019
DATE: 1/6/10

PLATE 5



Specimen Identification - Depth			Classification	MC%	LL	PL	PI	Cc	Cu
● B-0904	S-13	19.0' to 20.5'	Dark-brown mottled with brown and gray silty clay, trace fine to medium sand. FAT CLAY CH	25	51	24	27		

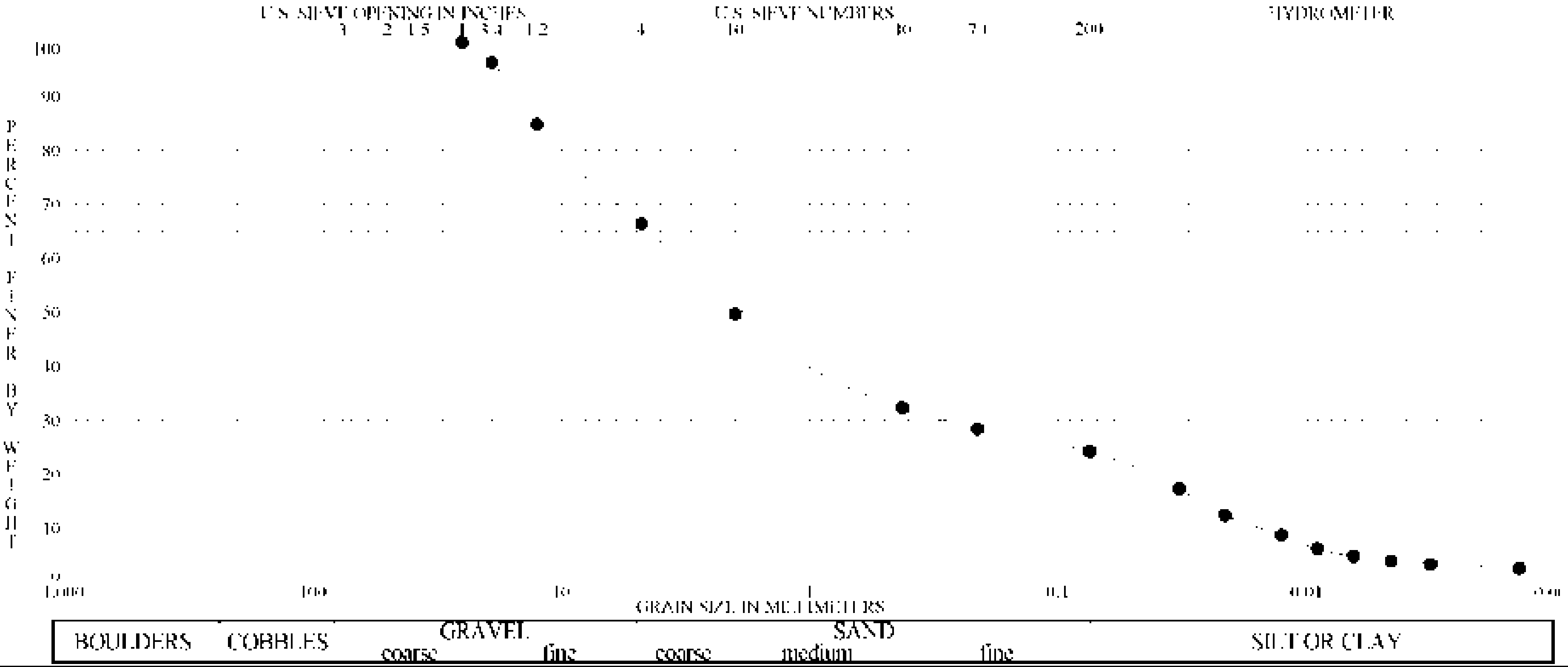
Specimen Identification - Depth			D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● B-0904	S-13	19.0' to 20.5'	2.0000	0.0519	0.0058	0.0034		0.00	1.47	56.34	42.19

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019
DATE: 1/6/10

PLATE 6

BBCM



Specimen Identification - Depth			Classification	MC%	LL	PL	PI	Cc	Cu
● B-0904	S-16	26.0' to 27.1'	Brown fine to coarse sand, some fine to coarse gravel, some silt, trace clay.	12				1.509	224.050

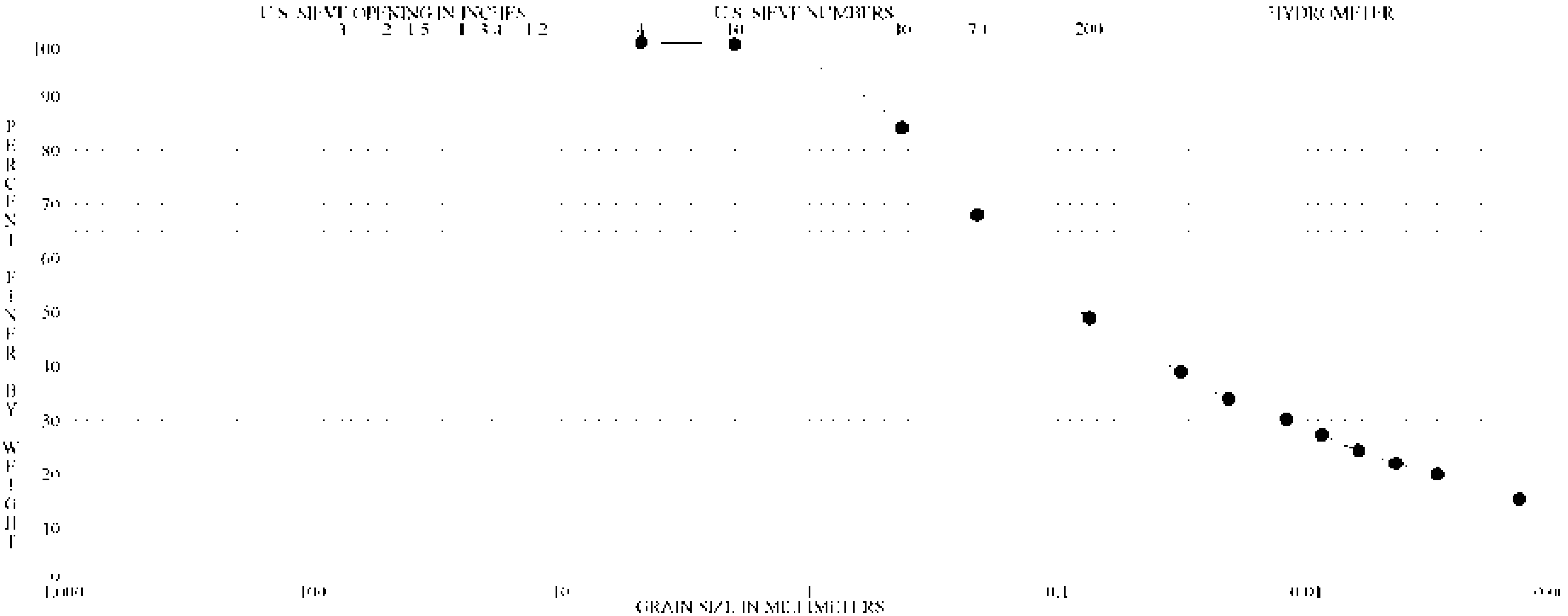
Specimen Identification - Depth			D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● B-0904	S-16	26.0' to 27.1'	25.0000	18.0899	3.4093	2.0301	0.0152	33.60	42.12	21.33	2.94

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019
DATE: 1/6/10

PLATE 7

BBCM



BOULDERS	COBBLES	GRAVEL coarse	GRAVEL fine	SAND coarse	SAND medium	SAND fine	SILT OR CLAY

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	B-0905 S-2 3.5' to 4.6'	Brown fine to coarse sand, "and" clayey silt.	19	27	18	9		

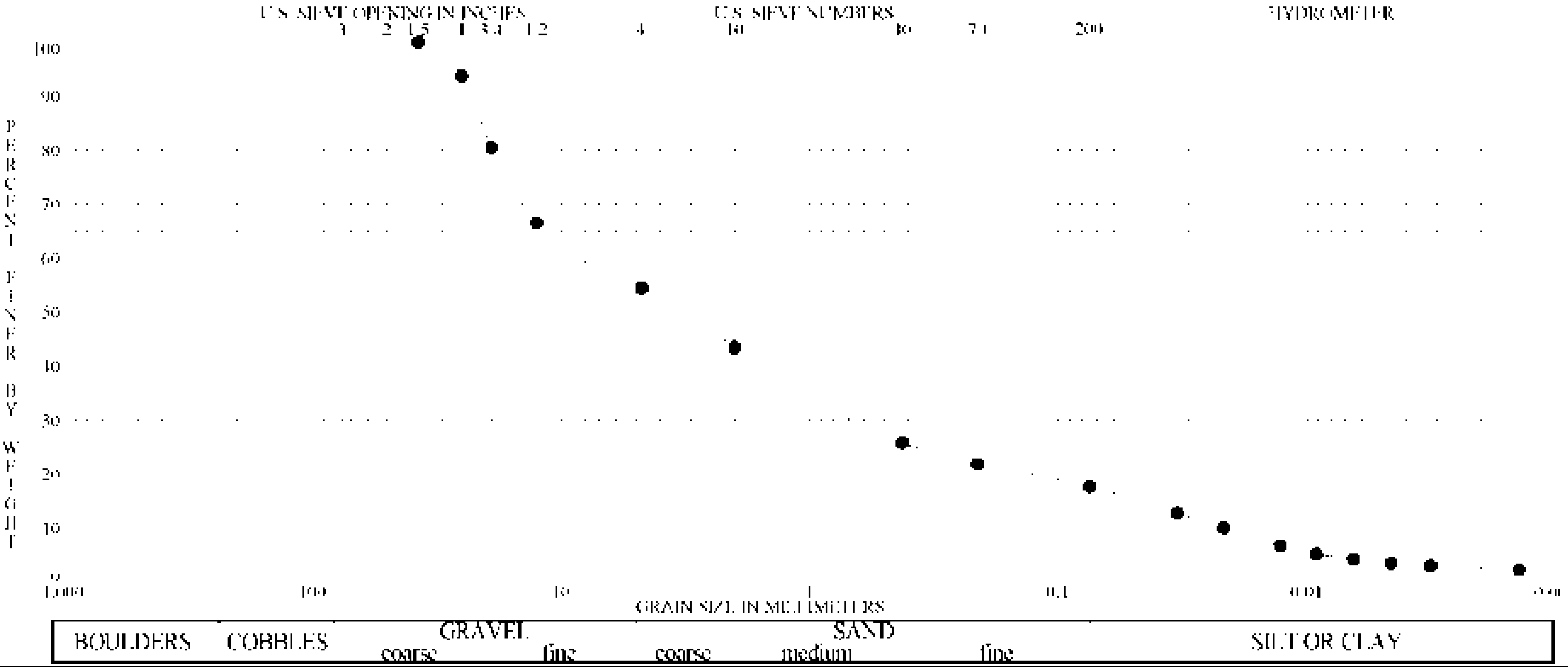
CLAYEY SAND SC

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	B-0905 S-2 3.5' to 4.6'	4.7500	1.2525	0.1370	0.0795		0.00	51.06	31.40	17.54

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019
DATE: 1/6/10

PLATE 8



Specimen Identification - Depth			Classification	MC%	LL	PL	PI	Cc	Cu
● B-0905	S-4	8.5' to 9.5'	**Brown fine to coarse gravel, "and" fine to coarse sand, little silt, trace clay.**	11				2.341	343.007

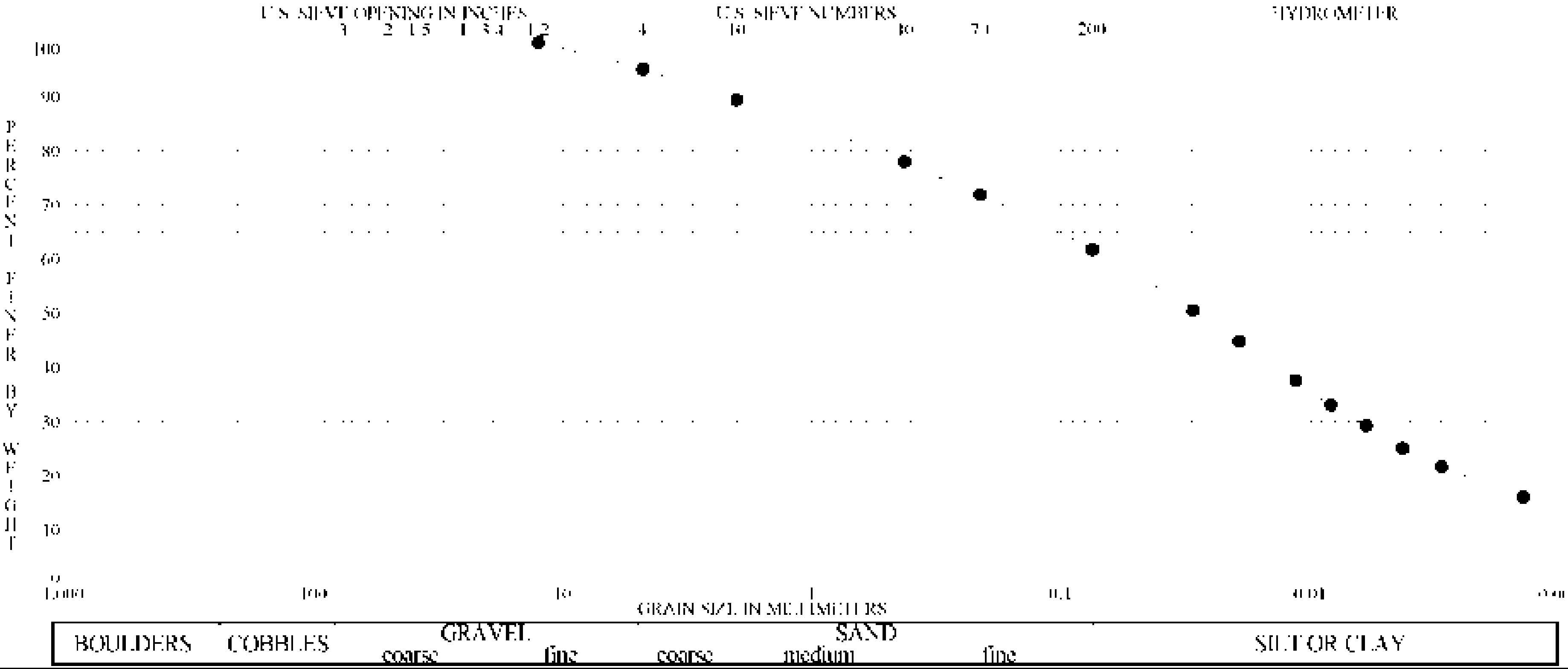
Specimen Identification - Depth			D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● B-0905	S-4	8.5' to 9.5'	37.5000	27.1372	7.3722	3.3319	0.0215	45.47	36.77	15.12	2.64

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019
DATE: 1/6/10

PLATE 9

BBCM



Specimen Identification - Depth			Classification	MC%	LL	PL	PI	Cc	Cu
● B-0905	S-7	16.0' to 17.3'	Gray clayey silt, some fine to coarse sand, trace fine gravel.	10	23	15	8		

SANDY LEAN CLAY CL

Specimen Identification - Depth			D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● B-0905	S-7	16.0' to 17.3'	12.5000	4.6797	0.0648	0.0284		4.90	33.34	43.03	18.73

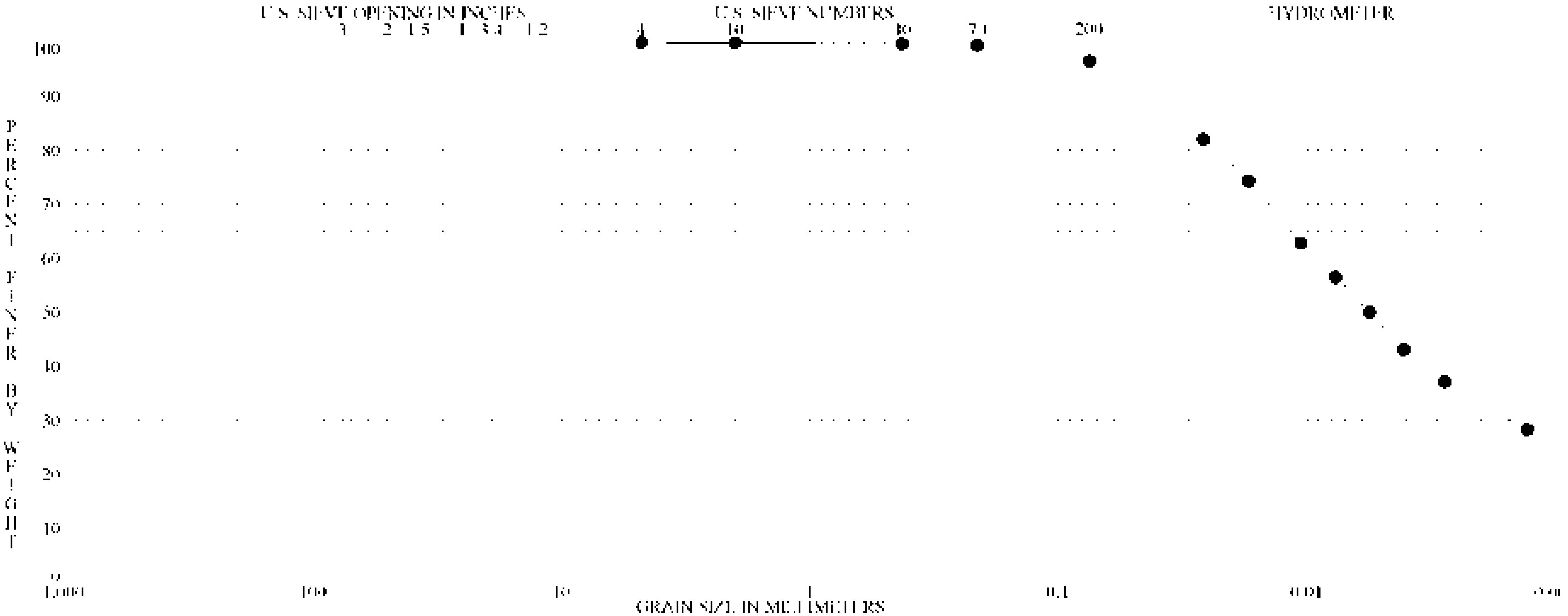
ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019 DATE: 1/6/10

PLATE 10

PLATE 11

BBCM



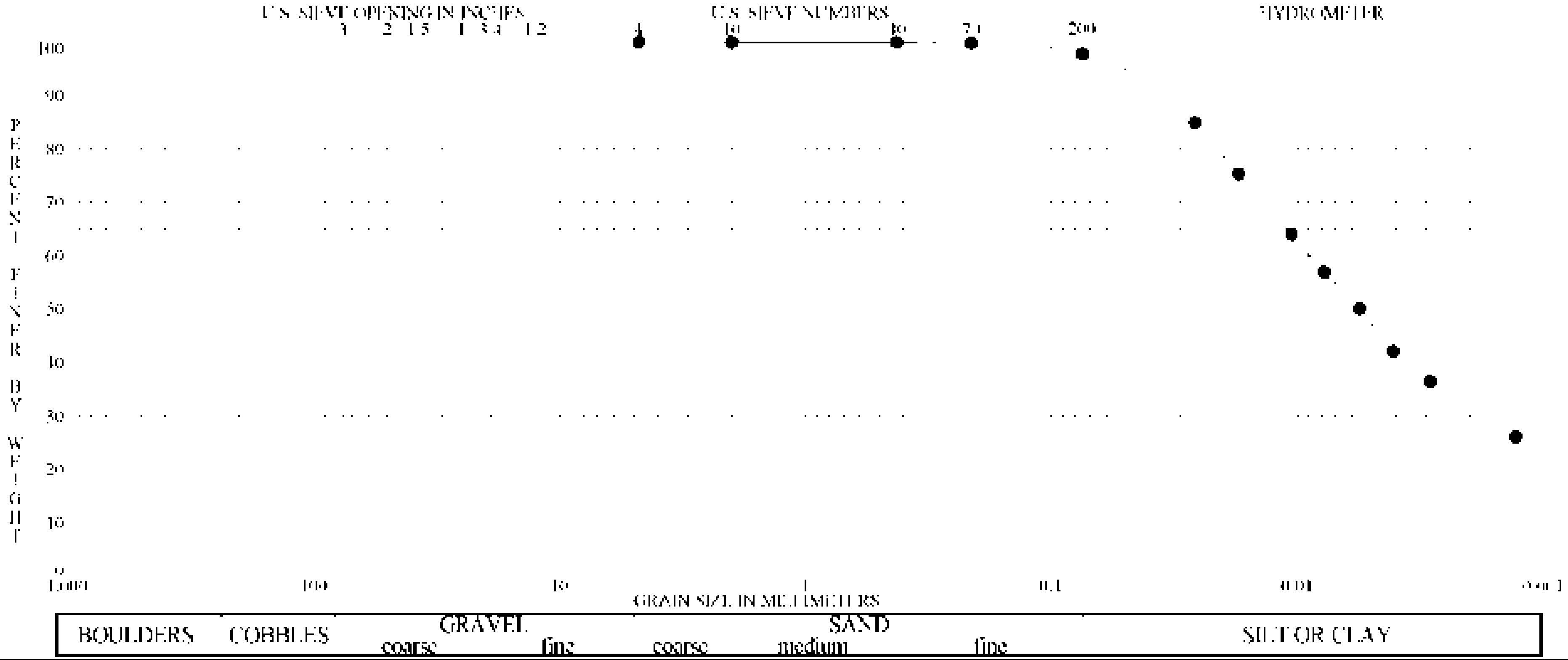
	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	UWW	UDW
●	B-0906 S-3 4.0' to 4.9'	FILL : Brown silty clay, trace fine to coarse sand.	23	49	25	24		
⧗								
▲		LEAN CLAY CL						
★								
•								

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	B-0906 S-3 4.0' to 4.9'	4.7500	0.0672	0.0092	0.0056		0.0	3.5	63.2	33.3
⧗										
▲										
★										
•										

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019
DATE: 1/6/10

BBCM



Specimen Identification - Depth			Classification	MC%	LL	PL	PI	UWW	UDW
● B-0906	S-9	14.0' to 15.5'	FILL : Dark-brown mottled with brown and gray silty clay, trace fine to coarse sand.	28	54	31	23		

(/S67,& 6,L7 0+

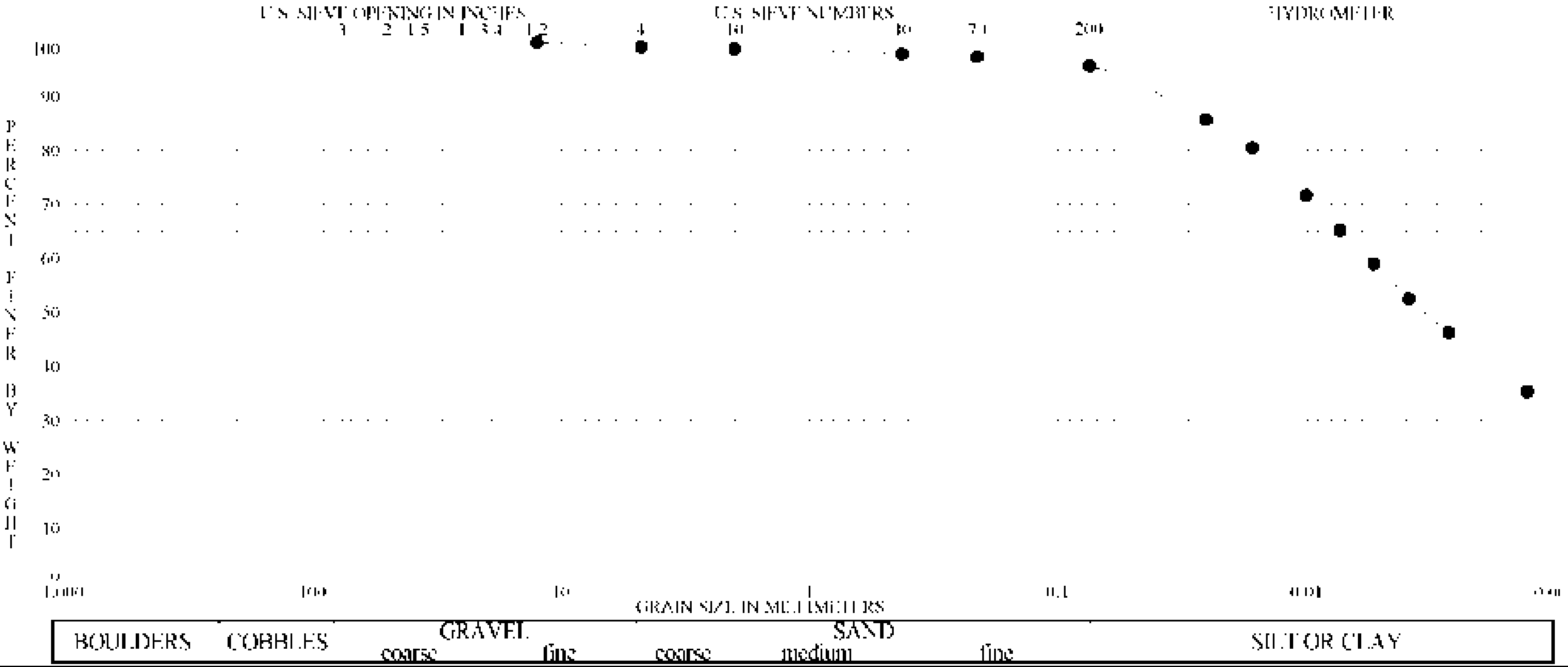
Specimen Identification - Depth			D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● B-0906	S-9	14.0' to 15.5'	4.7500	0.0597	0.0089	0.0056		0.0	2.2	66.0	31.7

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019 DATE 1/6/10

PLATE 12

BBCM



Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● B-0906 S-14 23.5' to 25.0'	**Brown mottled with gray silty clay, trace fine to coarse sand, trace fine gravel.** **FAT CLAY CH**	27	50	23	27		

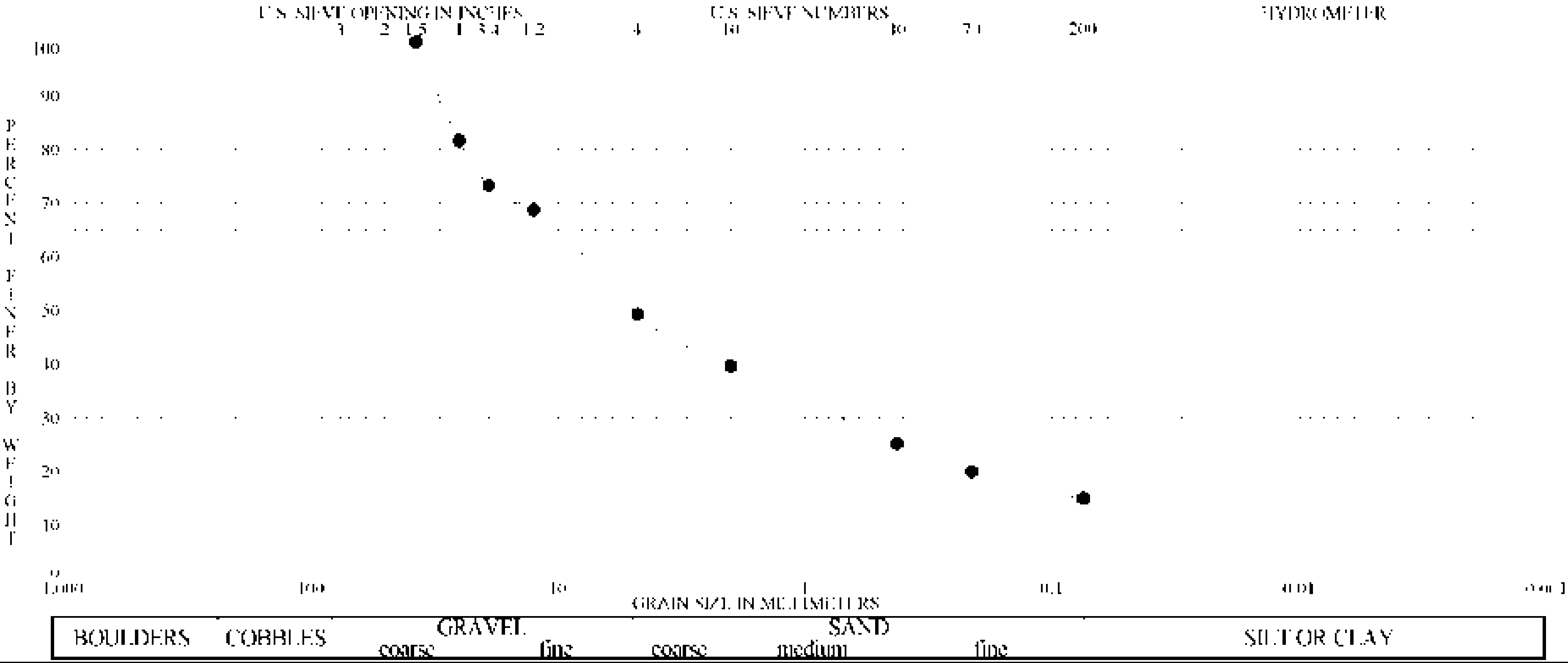
Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● B-0906 S-14 23.5' to 25.0'	12.5000	0.0695	0.0057	0.0034		0.79	3.52	53.86	41.83

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019
DATE: 1/6/10

PLATE 13

BBCM



Specimen Identification - Depth			Classification	MC%	LL	PL	PI	Cc	Cu
● B-0906	S-17	31.0' to 31.9'	Brown fine to coarse gravel, some fine to coarse sand, little silt.						

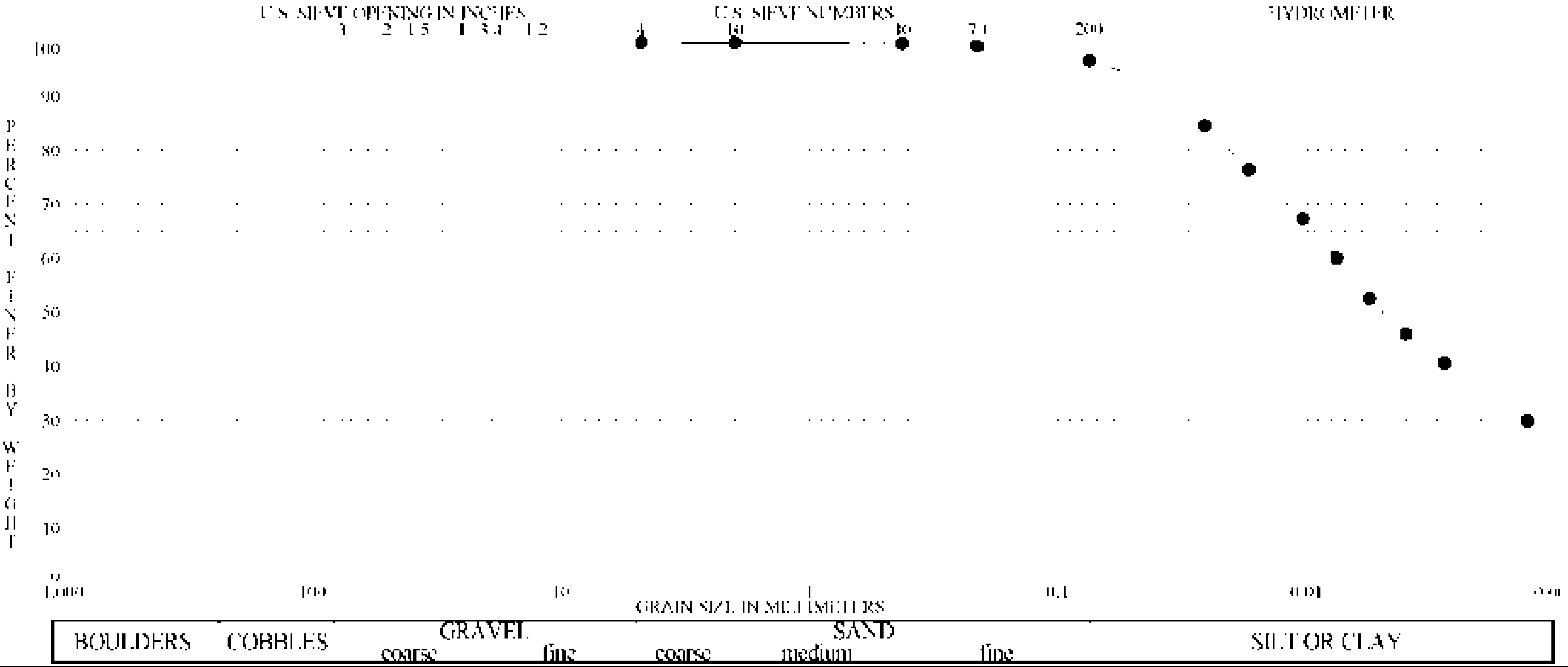
Specimen Identification - Depth			D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● B-0906	S-17	31.0' to 31.9'	37.5000	33.5671	8.0779	4.9085		50.66	34.41	14.93	

ASTM D422 GRADATION CURVE

PROJECT AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION LOCKBOURNE, OHIO
JOB NO. 011-11497-019 DATE 1/6/10

PLATE 14

BBCM



	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	UWW	UDW
●	B-0907 S-5 8.0' to 9.5'	**FILL : Brown and dark-brown mottled with gray silty clay, trace fine to coarse sand.** **LEAN CLAY CL**	23	48	25	23		
⧗								
▲								
★								
•								

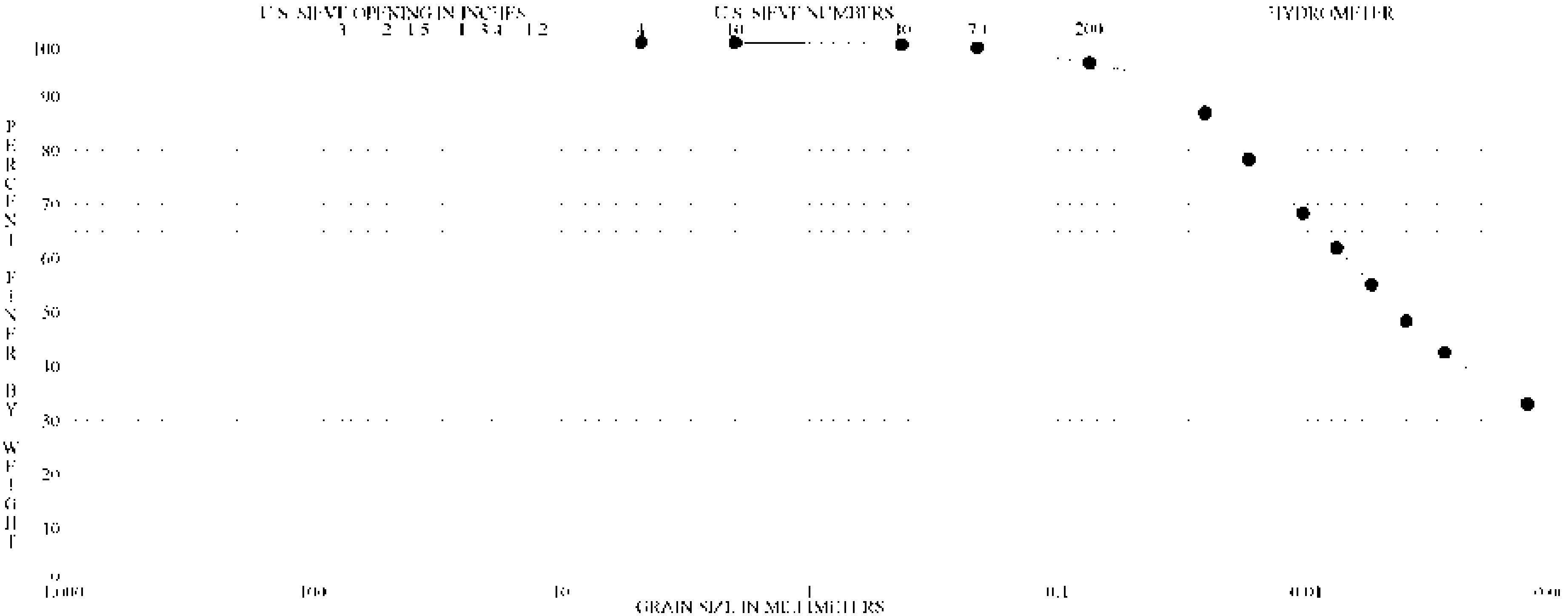
	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	B-0907 S-5 8.0' to 9.5'	4.7500	0.0647	0.0076	0.0049		0.0	3.3	60.8	35.9
⧗										
▲										
★										
•										

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019
DATE: 1/6/10

PLATE 15

BBCM



BOULDERS	COBBLES	GRAVEL coarse	GRAVEL fine	SAND coarse	SAND medium	SAND fine	SILT OR CLAY

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	UWW	UDW
●	B-0907 S-9 14.0' to 15.5'	FILL : Dark-brown mottled with brown and gray silty clay, trace fine to coarse sand. FAT CLAY CH	21	50	25	25		
⧗								
▲								
★								
•								

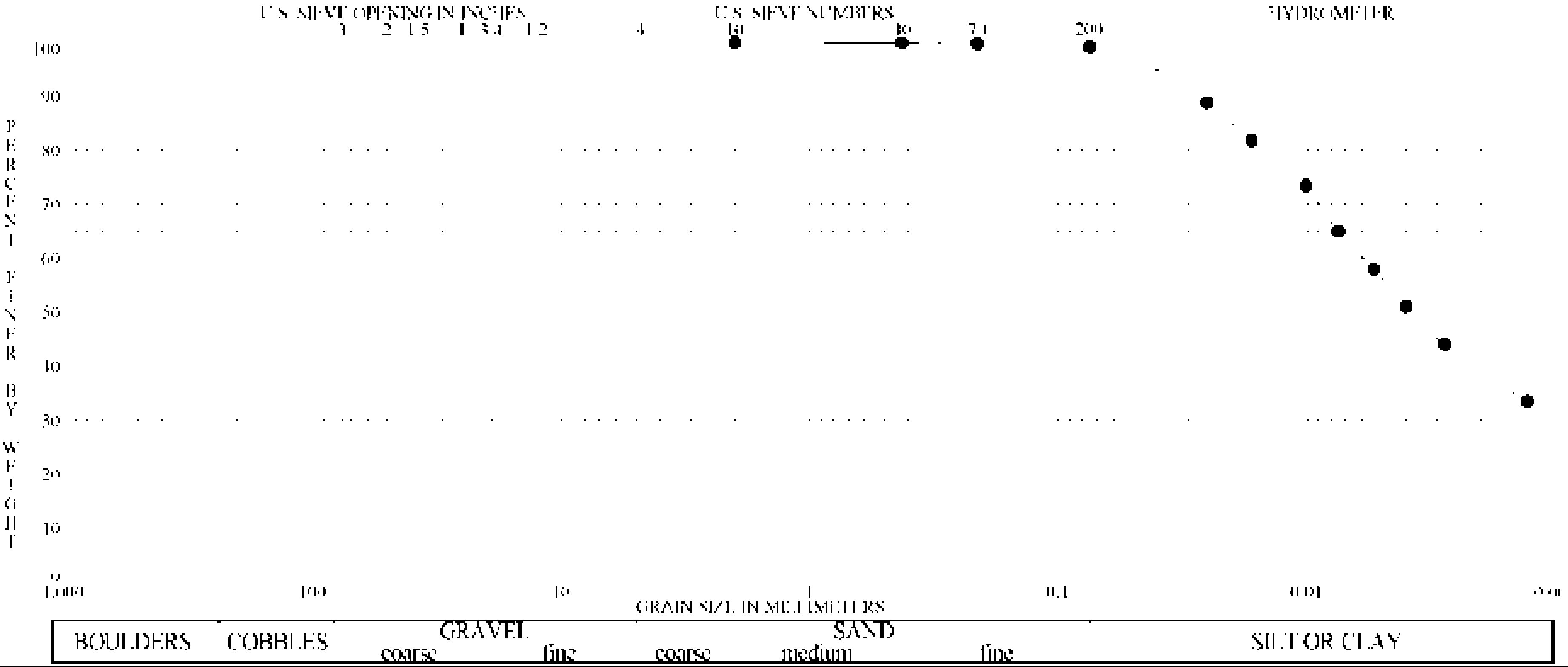
	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	B-0907 S-9 14.0' to 15.5'	4.7500	0.0651	0.0069	0.0043		0.0	3.8	57.8	38.4
⧗										
▲										
★										
•										

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019 DATE: 1/6/10

PLATE 16

BBCM



Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● B-0907 S-12B 18.7' to 20.0'	**Brown mottled with gray silty clay, trace fine to medium sand.**	22	48	23	25		

LEAN CLAY CL

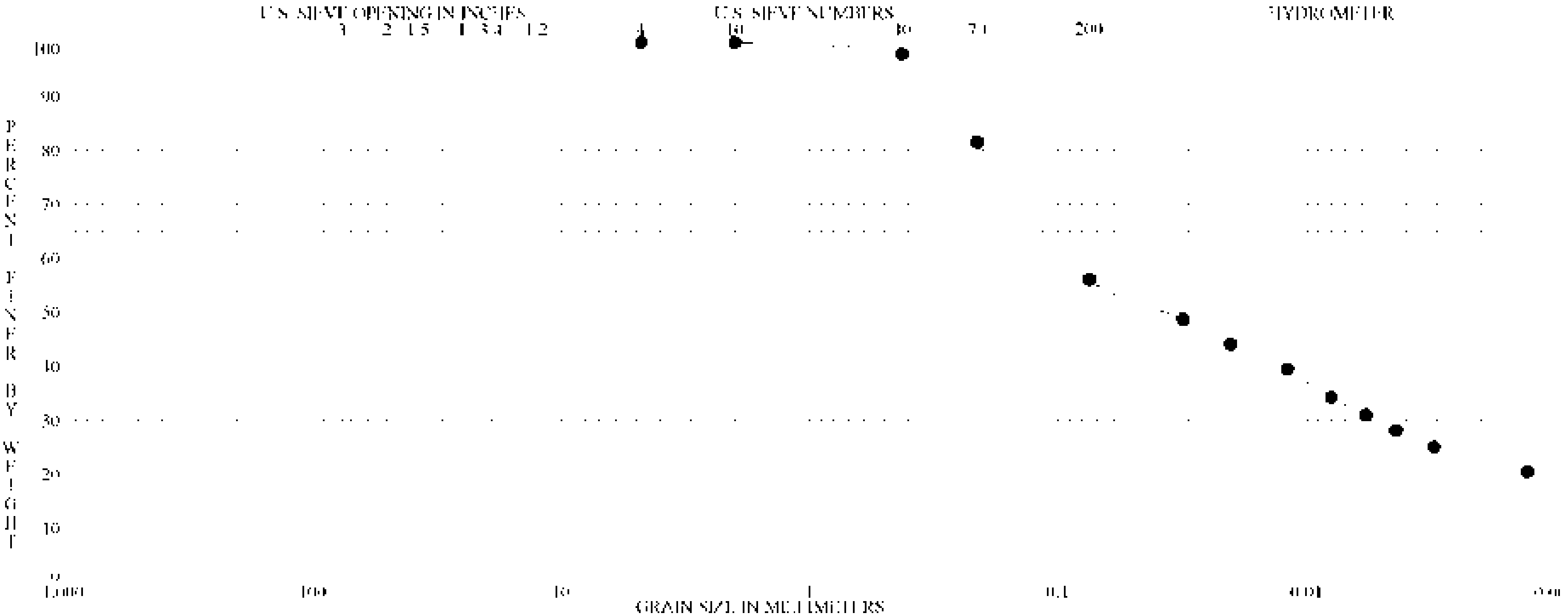
Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● B-0907 S-12B 18.7' to 20.0'	2.0000	0.0484	0.0059	0.0038		0.00	0.85	59.66	39.49

PLATE 17

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019
DATE: 1/6/10

BBCM



BOULDERS	COBBLES	GRAVEL coarse	GRAVEL fine	SAND coarse	SAND medium	SAND fine	SILT OR CLAY

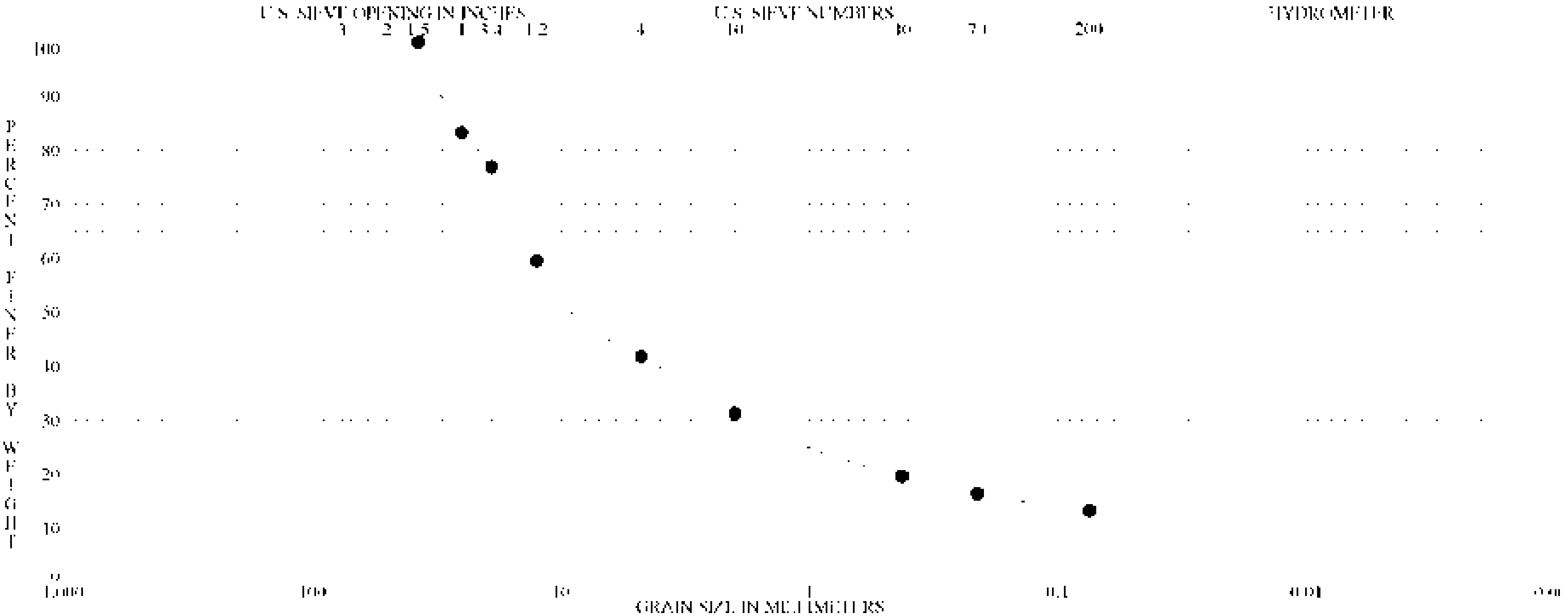
Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● B-0907 S-14 II 23.5' to 25.2'	Medium-stiff to stiff brown mottled with gray silty clay, some to "and" fine to coarse sand, trace fine gravel. SANDY LEAN CLAY CL		32	16	16		

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● B-0907 S-14 II 23.5' to 25.2'	4.7500	0.3759	0.0879	0.0366		0.00	43.88	33.33	22.79

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019
DATE: 1/6/10

PLATE 18



BOULDERS	COBBLES	GRAVEL coarse	GRAVEL fine	SAND coarse	SAND medium	SAND fine	SILT OR CLAY

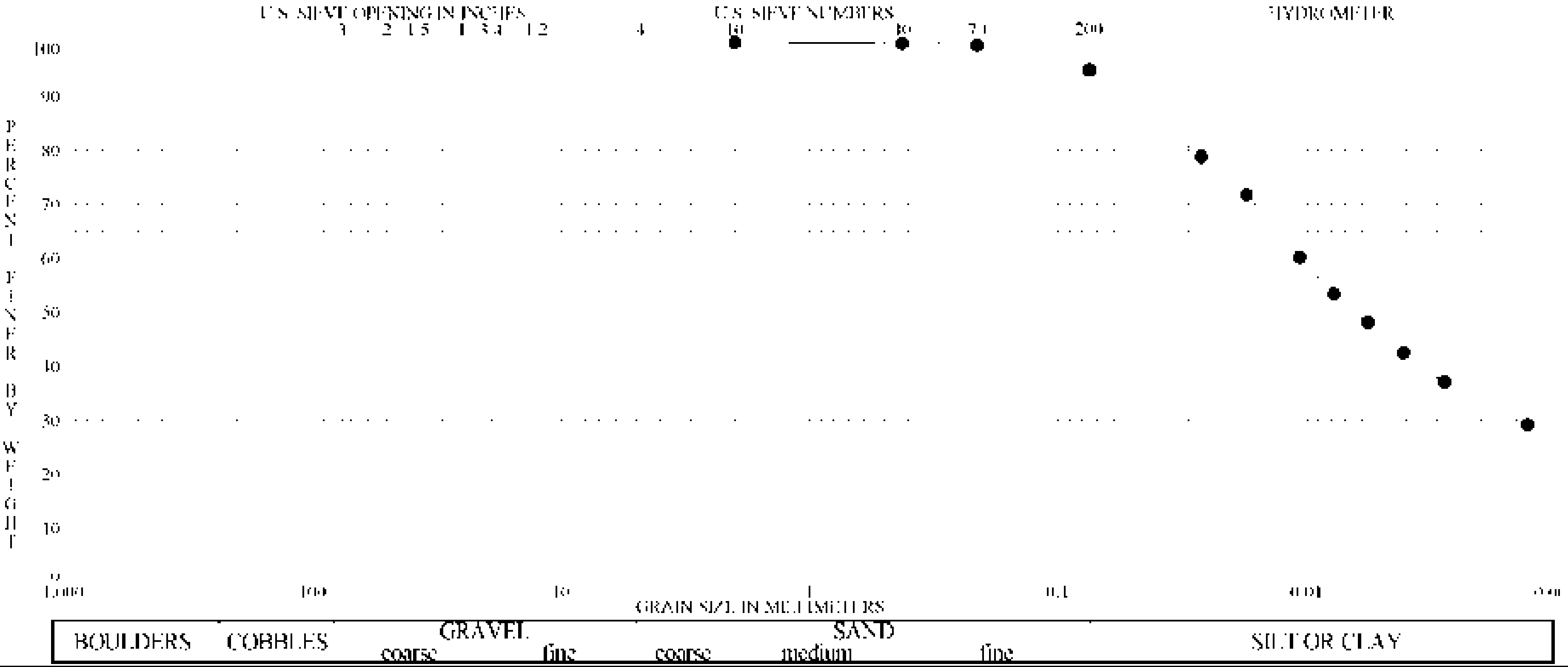
Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● B-0907 S-16 28.5' to 29.0'	**Brown fine to coarse gravel, some fine to coarse sand, little silt.**						

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● B-0907 S-16 28.5' to 29.0'	37.5000	33.2121	12.6420	7.4203		58.15	28.55	13.30	

ASTM D422 **GRADATION CURVE**

PROJECT AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION LOCKBOURNE, OHIO
JOB NO. 011-11497-019 DATE 1/6/10

PLATE 19



Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● B-0908 S-2 3.5' to 4.9'	**Brown mottled with gray silty clay, trace fine to medium sand.**	22	42	23	19		
	LEAN CLAY CL						

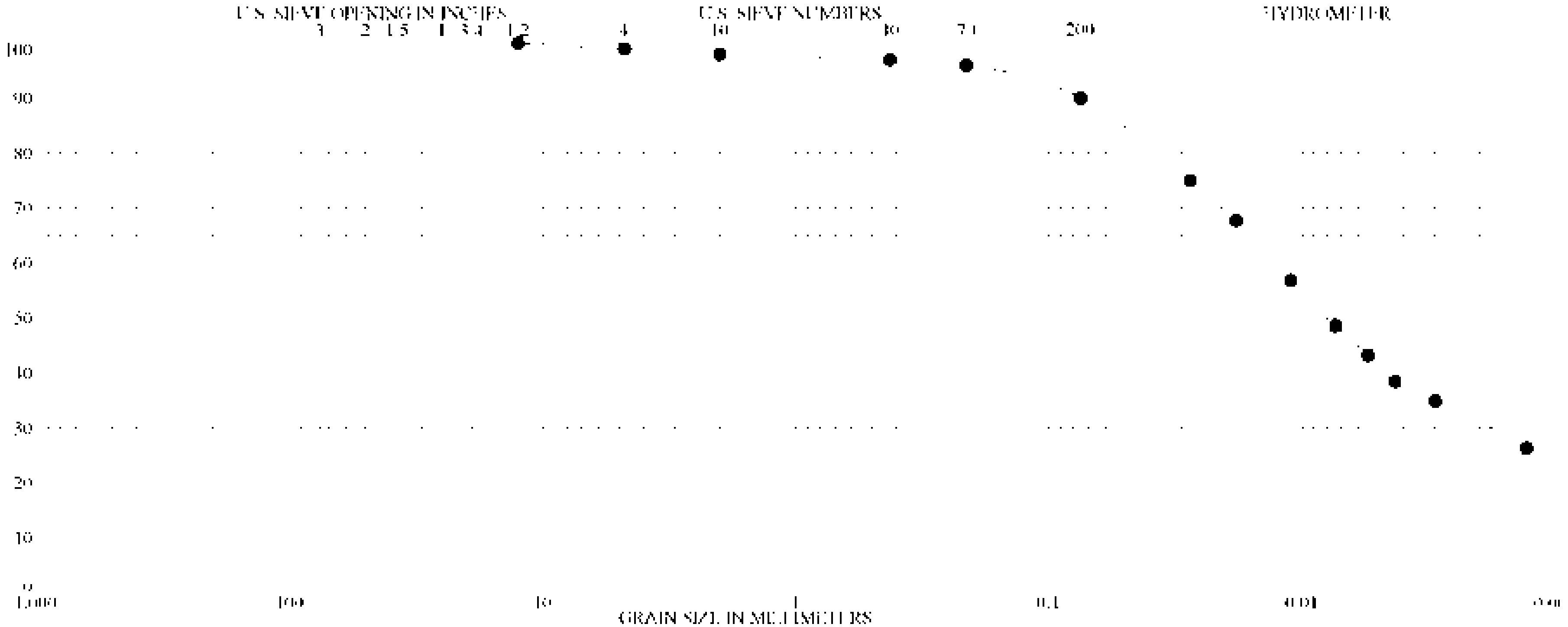
Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● B-0908 S-2 3.5' to 4.9'	2.0000	0.0765	0.0106	0.0064		0.00	5.09	61.25	33.67

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019
DATE: 1/6/10

PLATE 20

BBCM



BOULDERS	COBBLES	GRAVEL coarse	GRAVEL fine	SAND coarse	SAND medium	SAND fine	SILT OR CLAY

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	B-0908 S-13 II 6.5' to 8.1'	Very-soft to soft brown mottled with gray silty clay, little fine to coarse sand, trace fine gravel. LEAN CLAY CL		42	22	20		

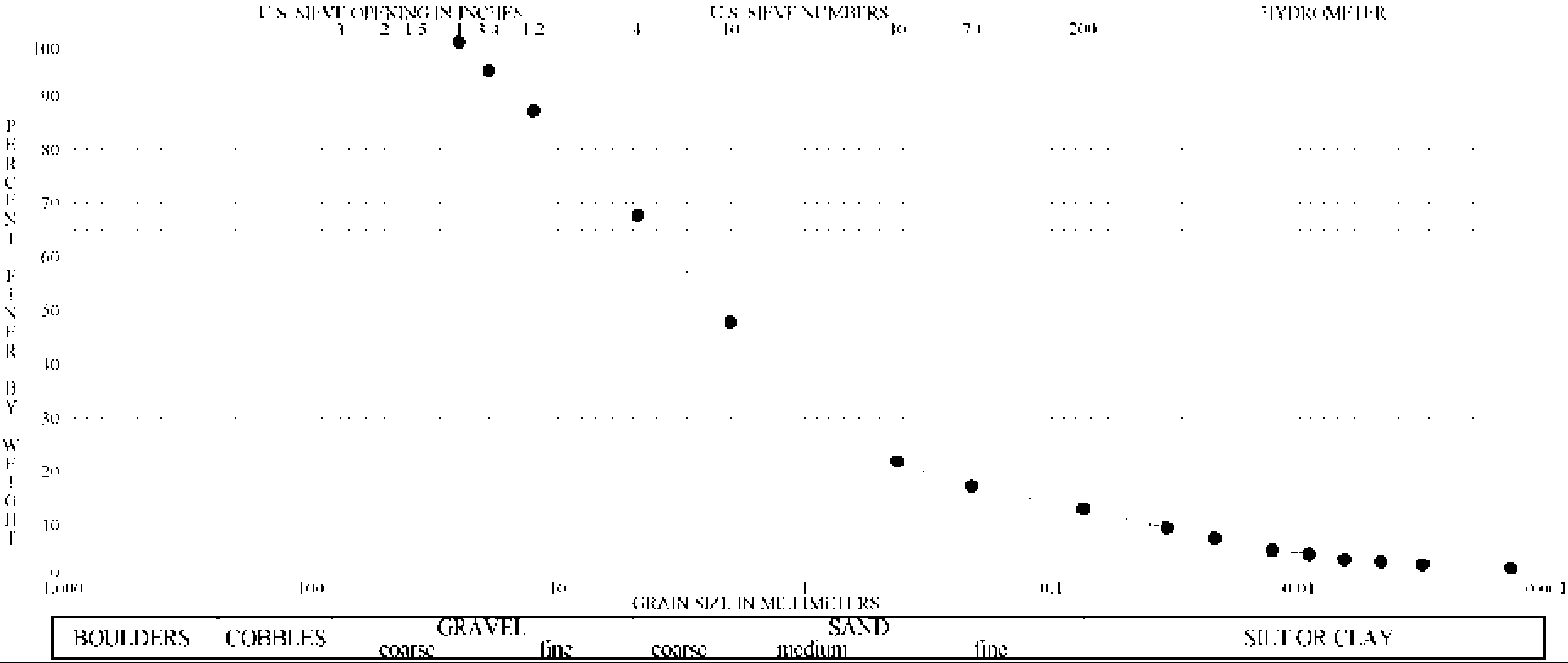
	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	B-0908 S-13 II 6.5' to 8.1'	12.5000	0.1783	0.0128	0.0079		1.00	9.00	59.25	30.75

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019
DATE: 1/6/10

PLATE 21

BBCM



	Specimen Identification - Depth			Classification	MC%	LL	PL	PI	Cc	Cu
●	B-0908	S-6	13.5' to 14.4'	**Brown fine to coarse sand, some fine to coarse gravel, little silt, trace clay.**	15				3.622	88.047

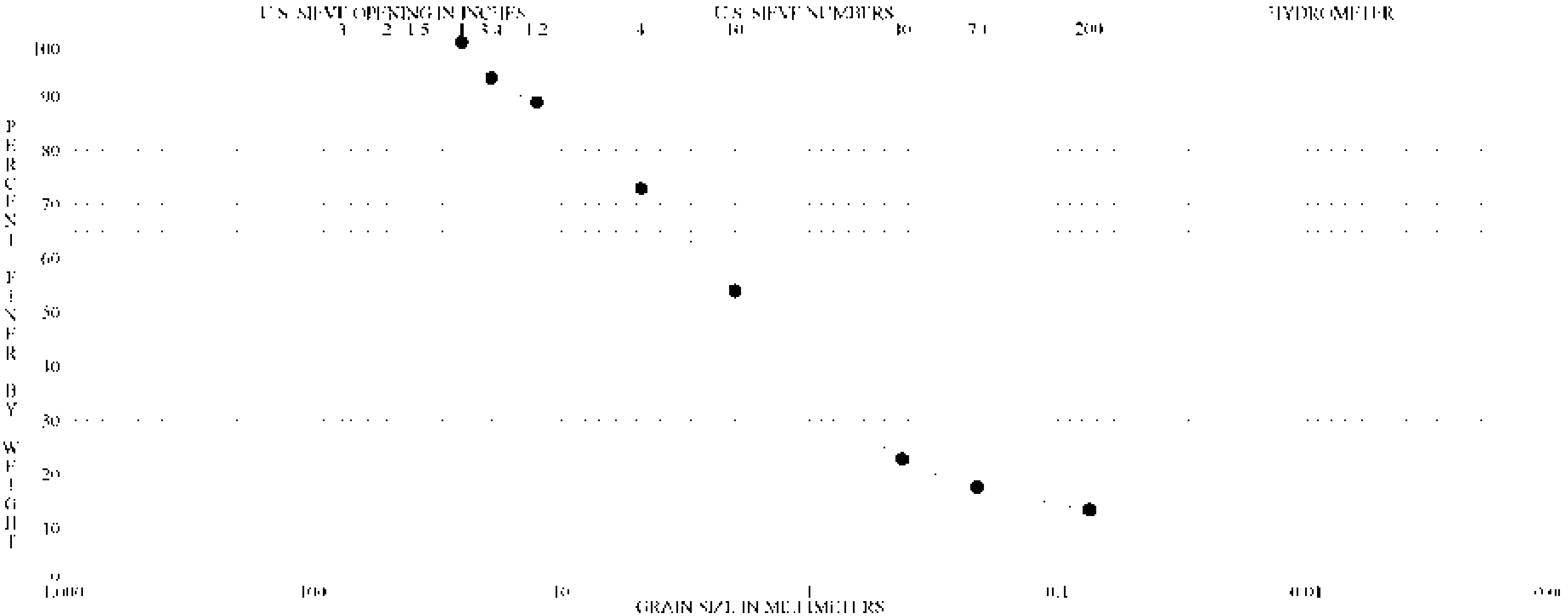
	Specimen Identification - Depth			D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	B-0908	S-6	13.5' to 14.4'	25.0000	19.3244	3.3945	2.1999	0.0386	32.25	54.70	10.77	2.28

ASTM D422 **GRADATION CURVE**

PROJECT	AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION	LOCKBOURNE, OHIO
JOB NO.	011-11497-019
DATE	1/6/10

PLATE 22

BBCM



Specimen Identification - Depth				Classification	MC%	LL	PL	PI	Cc	Cu
●	B-0908	S-10	23.5' to 24.5'	**Gray fine to coarse sand, some fine to coarse gravel, little silt.**						

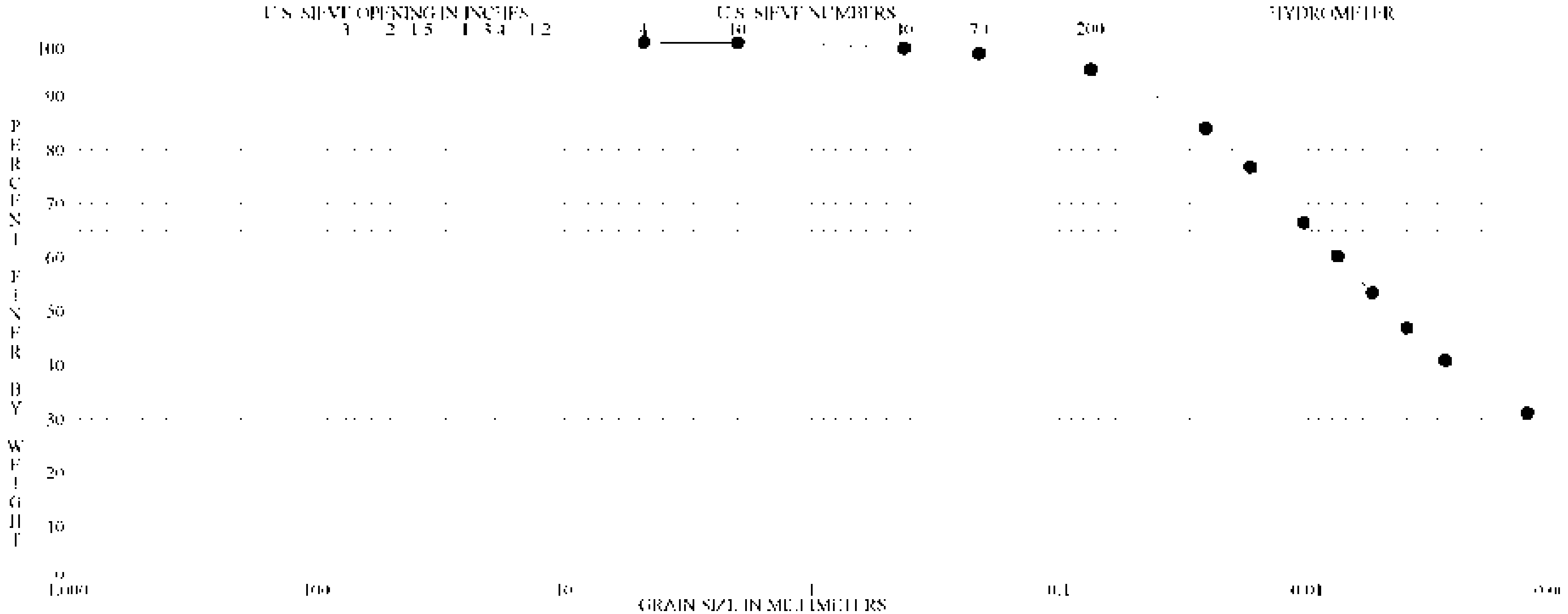
Specimen Identification - Depth				D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	B-0908	S-10	23.5' to 24.5'	25.0000	20.3037	2.6368	1.6443		27.07	59.53	13.41	

ASTM D422 **GRADATION CURVE**

PROJECT	AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION	LOCKBOURNE, OHIO
JOB NO.	011-11497-019
DATE	1/6/10

PLATE 23

BBCM



BOULDERS	COBBLES	GRAVEL coarse	GRAVEL fine	SAND coarse	SAND medium	SAND fine	SILT OR CLAY

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	B-0909 S-3 4.0' to 4.9'	**FILL: Brown mottled with gray silty clay, trace fine to coarse sand, few roots.**	**24**	**44**	**24**	**20**		

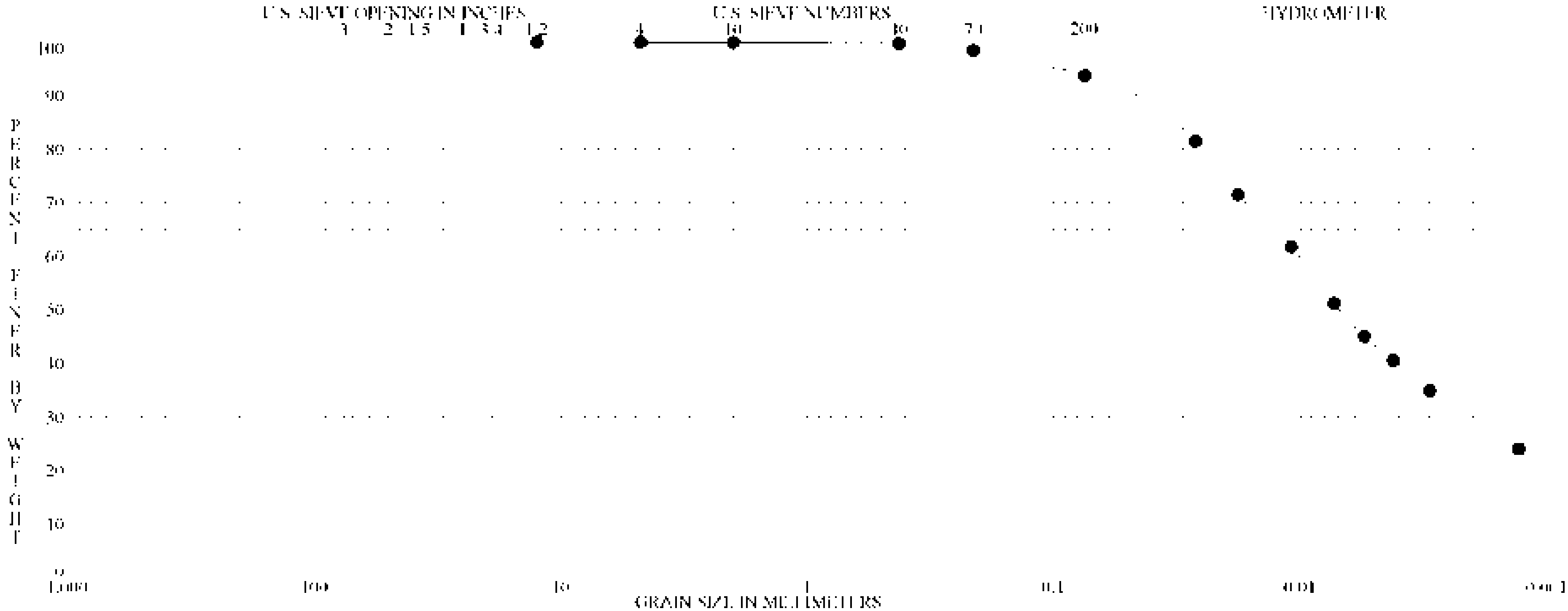
LEAN CLAY CL

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	B-0909 S-3 4.0' to 4.9'	4.7500	0.0760	0.0075	0.0046		0.00	5.04	58.30	36.66

ASTM D422 **GRADATION CURVE**

PROJECT AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION LOCKBOURNE, OHIO
JOB NO. 011-11497-019 DATE 1/6/10

PLATE 24



Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● B-0909 S-9 1 14.5' to 16.5'	FILL: Stiff to hard brown mottled with gray silty clay, trace fine to coarse sand, trace fine gravel. LEAN CLAY CL		47	25	22		

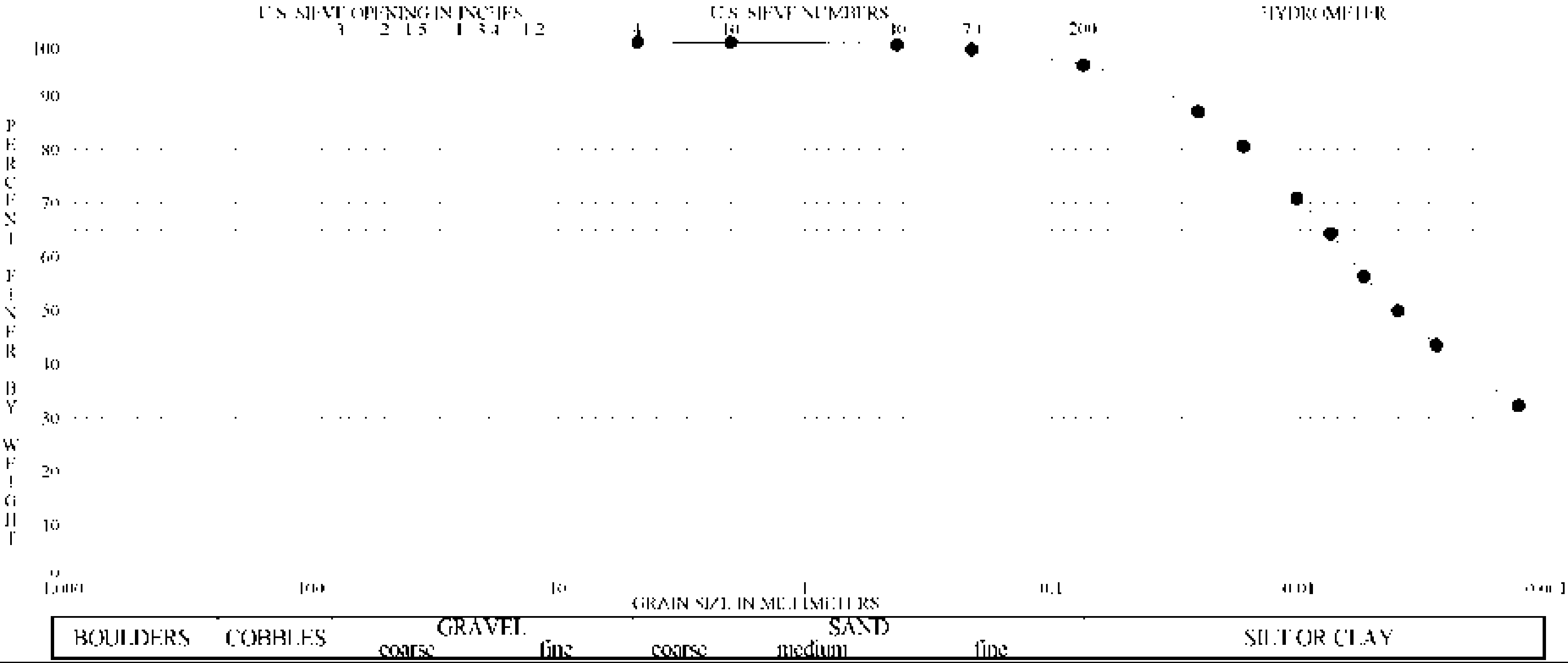
Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● B-0909 S-9 1 14.5' to 16.5'	12.5000	0.0994	0.0102	0.0069		0.02	6.26	64.07	29.65

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019
DATE: 1/6/10

PLATE 25

BBCM



Specimen Identification - Depth			Classification	MC%	LL	PL	PI	UWW	UDW
● B-0909	S-10	16.5' to 18.0'	FILL : Dark-brown mottled with gray silty clay, trace fine to coarse sand. FAT CLAY CH	25	55	27	28		

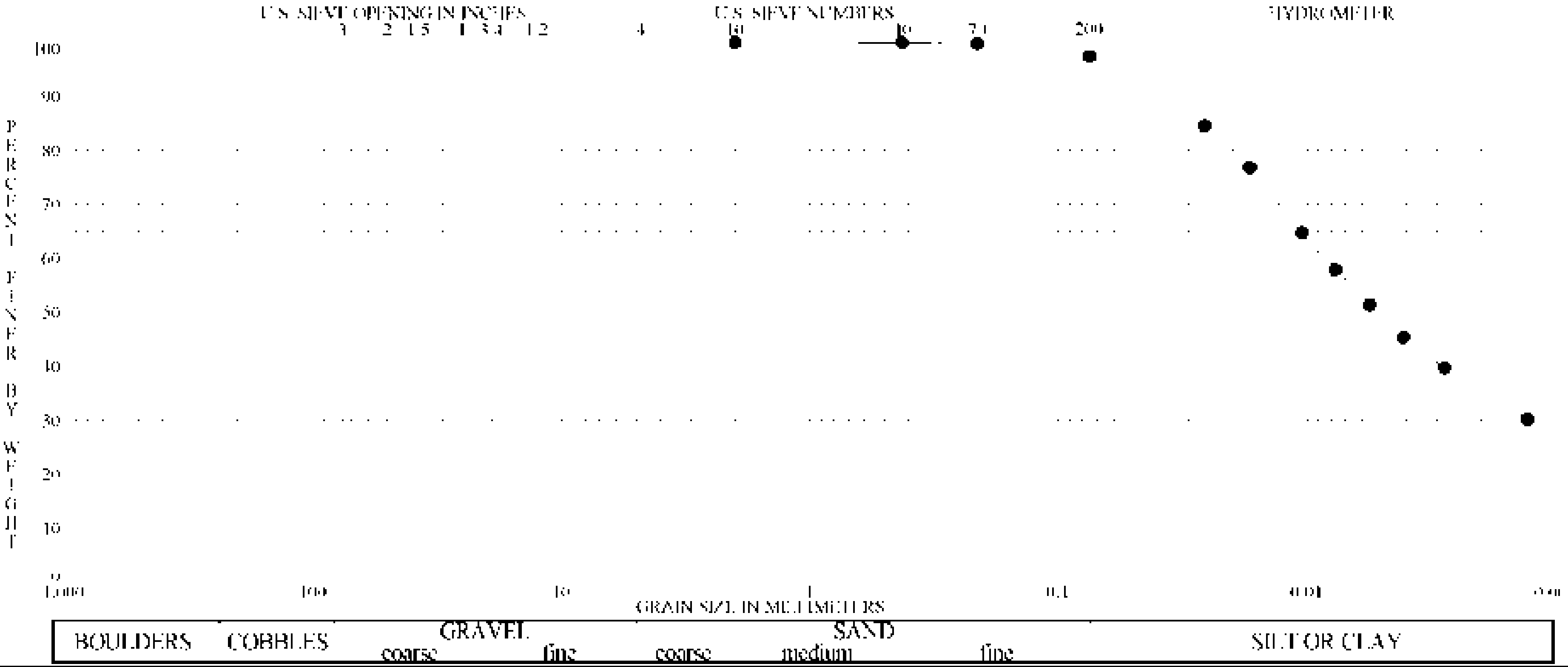
Specimen Identification - Depth			D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● B-0909	S-10	16.5' to 18.0'	4.7500	0.0681	0.0063	0.0040		0.0	4.2	57.2	38.6

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019
DATE: 1/6/10

PLATE 26

BBCM



Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● B-0909 S-13 21.0' to 22.5'	**Brown mottled with gray silty clay, trace fine to medium sand.**	22	43	22	21		

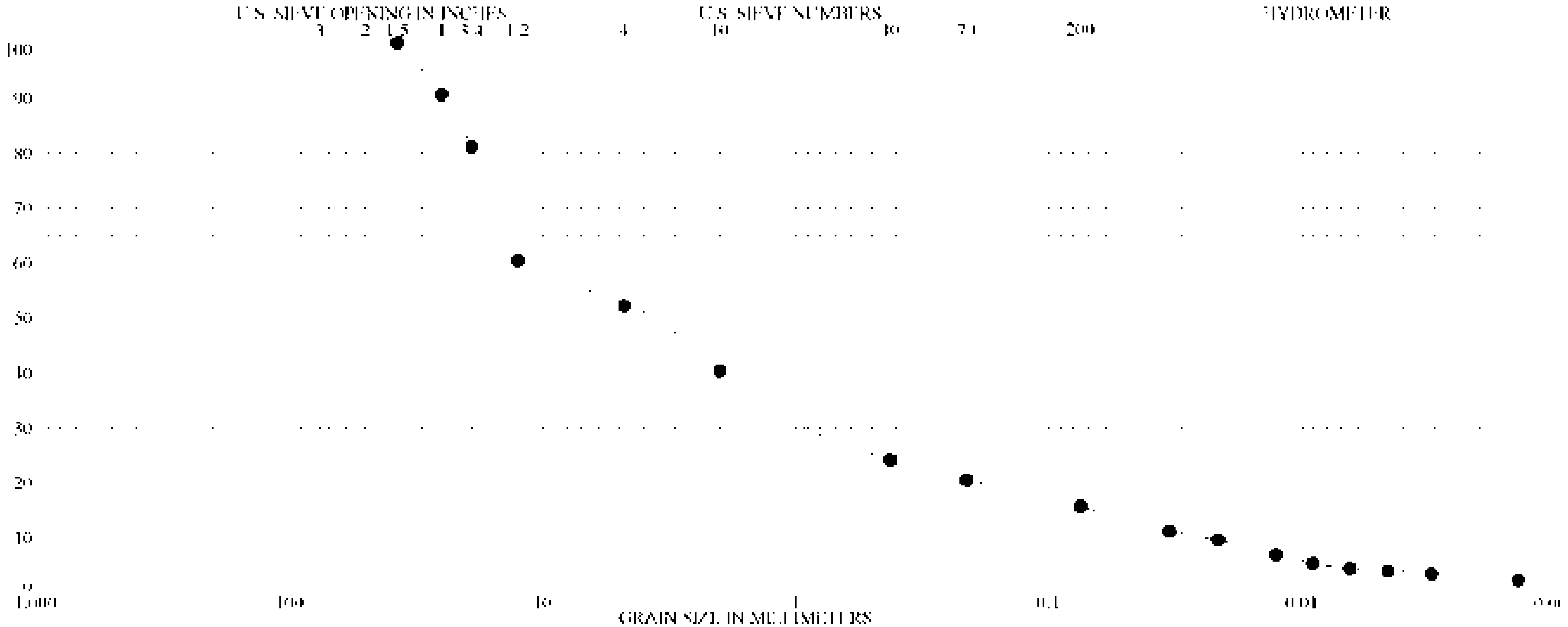
LEAN CLAY CL

Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● B-0909 S-13 21.0' to 22.5'	2.0000	0.0613	0.0085	0.0052		0.00	2.57	61.85	35.58

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019
DATE: 1/6/10

PLATE 27



BOULDERS	COBBLES	GRAVEL coarse	GRAVEL fine	SAND coarse	SAND medium	SAND fine	SILT OR CLAY

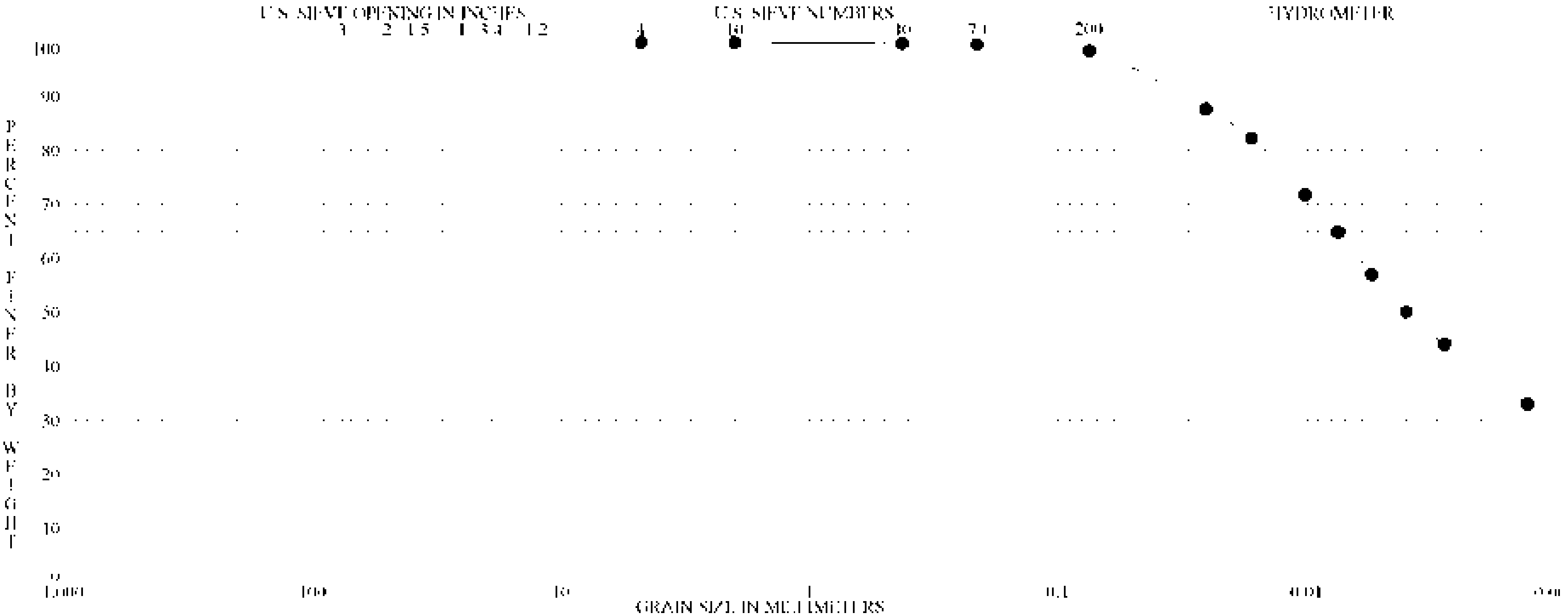
	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	B-0910 S-4 8.5' to 9.3'	**Brown fine to coarse gravel, "and" fine to coarse sand, little silt, trace clay.**	16				1.906	489.154

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	B-0910 S-4 8.5' to 9.3'	37.5000	30.1704	11.8653	4.0350	0.0243	47.77	36.54	12.89	2.81

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019
DATE: 1/6/10

PLATE 28



BOULDERS	COBBLES	GRAVEL coarse	GRAVEL fine	SAND coarse	SAND medium	SAND fine	SILT OR CLAY

	Specimen Identification - Depth			Classification	MC%	LL	PL	PI	Cc	Cu
●	B-0911	S-2	3.5' to 4.4'	**Brown mottled with gray silty clay, trace fine to coarse sand.**	23	54	26	28		

FAT CLAY CH

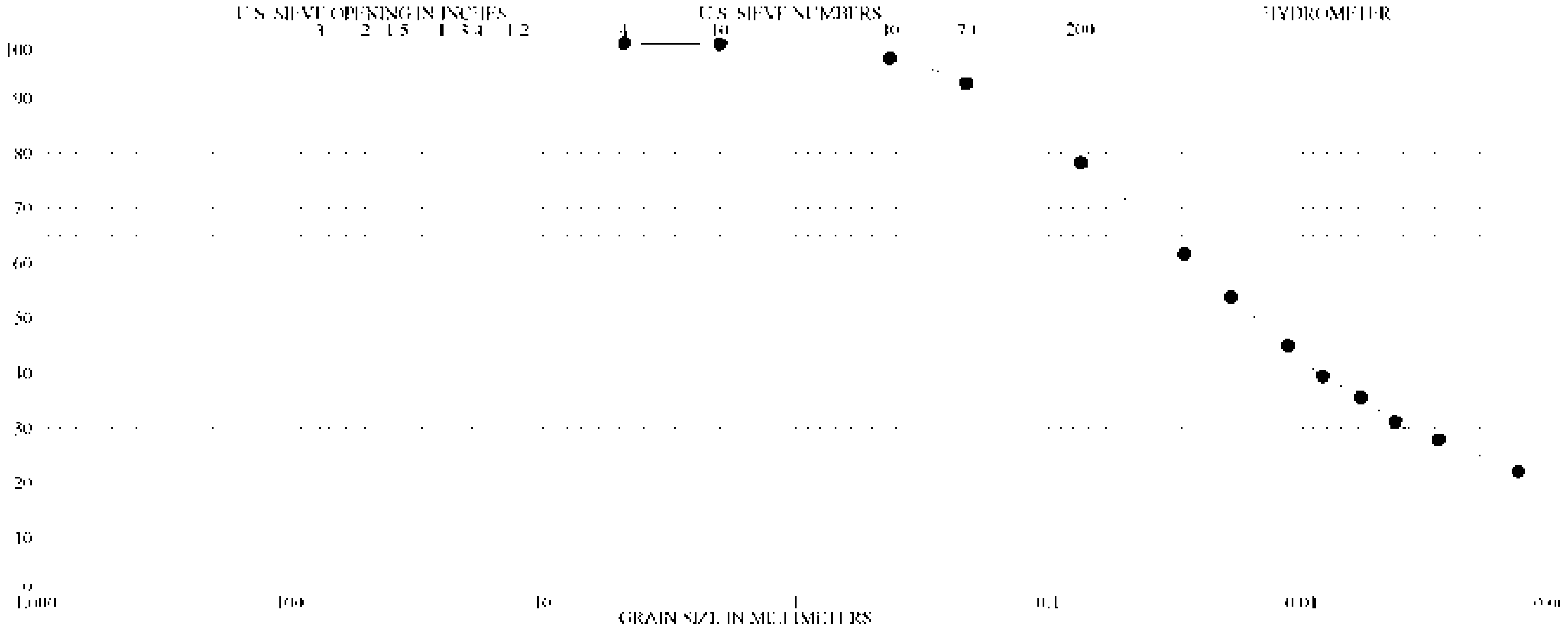
	Specimen Identification - Depth			D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	B-0911	S-2	3.5' to 4.4'	4.7500	0.0529	0.0062	0.0040		0.00	1.54	59.19	39.27

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019
DATE: 1/6/10

PLATE 29

BBCM



BOULDERS	COBBLES	GRAVEL coarse	GRAVEL fine	SAND coarse	SAND medium	SAND fine	SILT OR CLAY

Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● B-0911 S-4 8.5' to 9.7'	Brown mottled with gray silty clay, some fine to coarse sand.	19	32	17	15		
	LEAN CLAY with SAND CL						

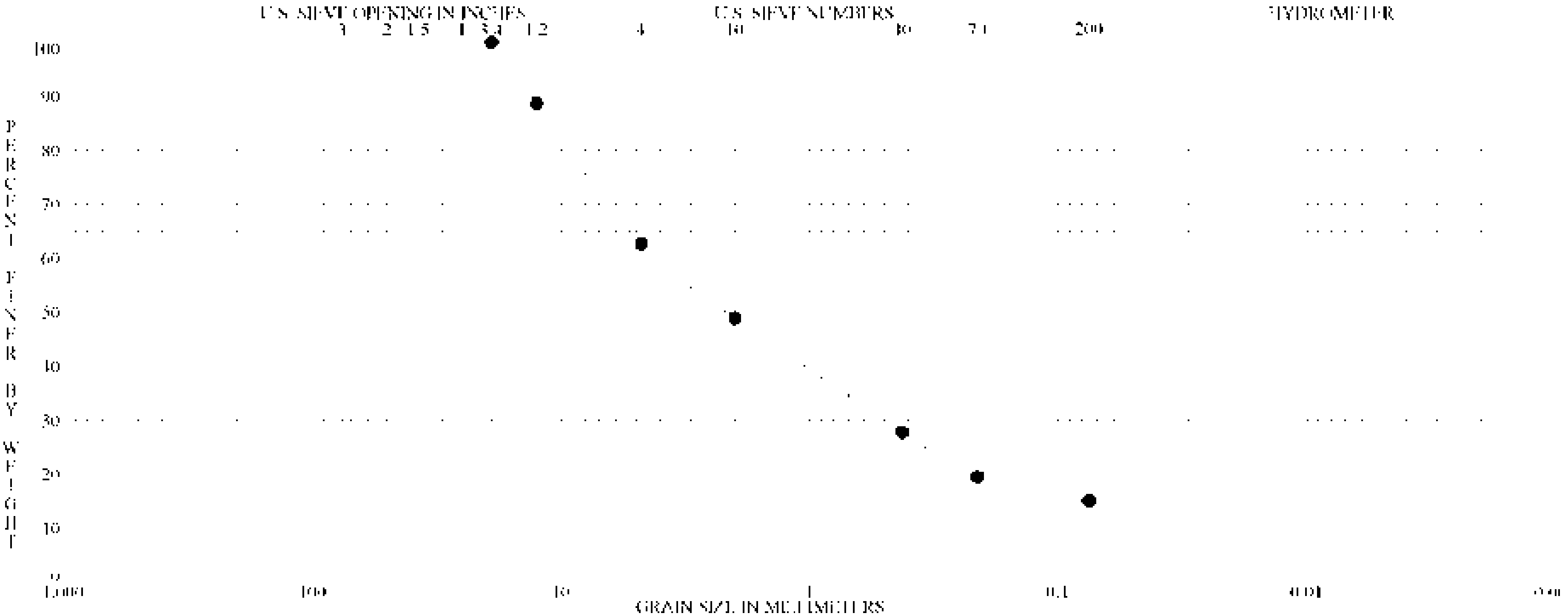
Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● B-0911 S-4 8.5' to 9.7'	4.7500	0.3013	0.0266	0.0153		0.00	21.76	53.28	24.96

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019
DATE: 1/6/10

PLATE 30

BBCM



Specimen Identification - Depth			Classification	MC%	LL	PL	PI	Cc	Cu
● B-0911	S-7	16.0' to 17.1'	Brown fine to coarse sand, "and" fine gravel, little silt.						

Specimen Identification - Depth			D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● B-0911	S-7	16.0' to 17.1'	19.0000	15.7878	4.0150	2.1443		37.32	47.61	15.07	

ASTM D422 **GRADATION CURVE**

PROJECT: AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION: LOCKBOURNE, OHIO
JOB NO.: 011-11497-019
DATE: 1/6/10

PLATE 31

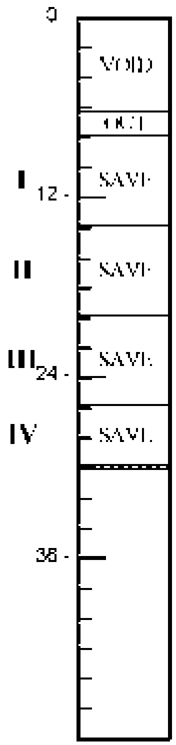
JOB NUMBER :	011-11497-019
PROJECT :	AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION :	LOCKBOURNE, OHIO

BBCM

LABORATORY LOG OF SHELBY TUBES

Boring : B-0906 Sample : 5

Depth : 7.5' to 9.5' Recovery : 22.00"



disturbed - discarded

FILL - Hard brown mottled with gray silty clay, trace fine to coarse sand, trace fine gravel

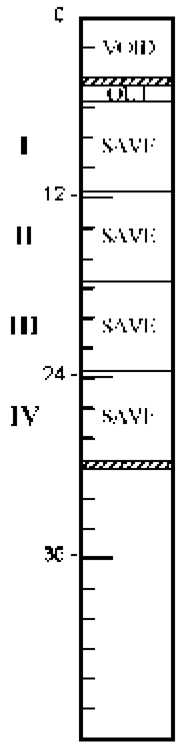
H 4.5

NOTE
1. Section II has horizontal crack
2. film of wax only at top

30.00" tube

Boring : B-0906 Sample : 13

Depth : 21.5' to 23.5' Recovery : 24.00"



disturbed - discarded

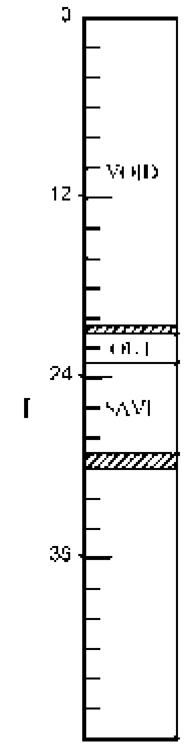
Very-stiff brown mottled with gray silty clay, trace fine to coarse sand

H 2.75-3.75

30.00" tube

Boring : B-0907 Sample : 3

Depth : 4.5' to 5.2' Recovery : 6.50"



disturbed - discarded

FILL - Hard brown mottled with gray silty clay, trace fine to coarse sand, trace fine gravel

H 4.5

3.00" tube

LEGEND

- Consolidation, Incremental
- C R S - Consolidation, C R S
- P P - Permeability, Vertical / Horizontal
- Swelling, Test
- Wax
- Unconfined Compression Test
- Triaxial Compression Test

H - Hand Penetrometer (tsf)	SL - Shrinkage Limit
Ds - Direct Shear	POR - Porosity
LOI - Loss on Ignition	UDW - Unit Dry Weight
AL - Atterberg Limits	MC - Moisture Content
MA - Sieve/Hydrometer	D_R - Relative Density
SG - Specific Gravity	S - Sieve

PLATE 32

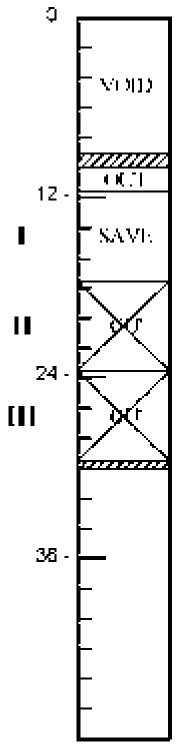
JOB NUMBER : 011-11497-019
PROJECT : AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION : LOCKBOURNE, OHIO

BBCM

LABORATORY LOG OF SHELBY TUBES

Boring : B-0907 Sample : 14

Depth : 23.5' to 25.2' Recovery : 18.00"



disturbed - discarded

Medium-stiff to stiff brown mottled with gray silty clay, some to "and" fine to coarse sand, trace fine gravel

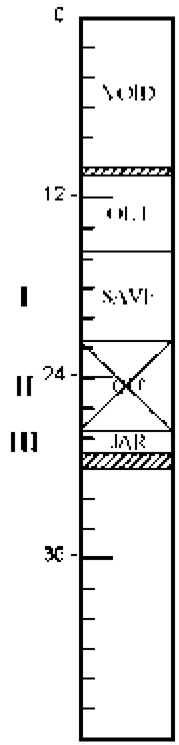
H 0.75-1.75

NOTE: AL/MA on representative sample from Sections II and III

30.00" tube

Boring : B-0908 Sample : 13

Depth : 6.5' to 8.1' Recovery : 13.50"



disturbed - discarded

Very-soft to soft brown mottled with gray silty clay, little fine to coarse sand, trace fine gravel.

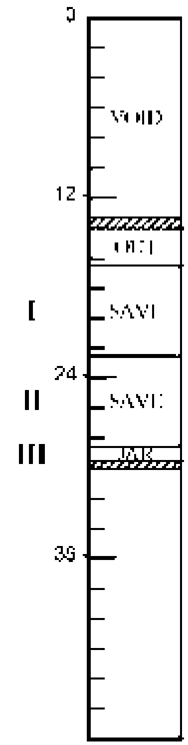
H 0.0-0.5

NOTE: AL/MA on Section II

30.00" tube

Boring : B-0909 Sample : 6

Depth : 9.0' to 10.4' Recovery : 13.00"



disturbed - discarded

FILL: Very-stiff brown mottled with dark-brown and gray silty clay, trace fine to coarse sand.

30.00" tube

LEGEND

- Consolidation, Incremental
- Swelling, Test
- Wax
- C R S - Consolidation, C R S
- P P - Permeability, Vertical / Horizontal
- Unconfined Compression Test
- Triaxial Compression Test

H - Hand Penetrometer (tsf)
Ds - Direct Shear
LOI - Loss on Ignition
AL - Atterberg Limits
MA - Sieve/Hydrometer
SG - Specific Gravity

SL - Shrinkage Limit
POR - Porosity
UDW - Unit Dry Weight
MC - Moisture Content
D_R - Relative Density
S - Sieve

PLATE 33

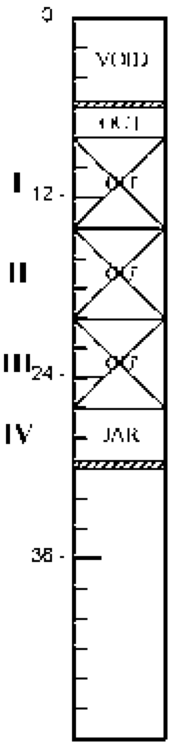
JOB NUMBER : 011-11497-019
PROJECT : AEP PICWAY PLANT ASH POND DIKE EVALUATION
LOCATION : LOCKBOURNE, OHIO

BBCM

LABORATORY LOG OF SHELBY TUBES

Boring : B-0909 Sample : 9

Depth : 14.5' to 16.5' Recovery : 21.50"



disturbed - discarded

FILL - Stiff to hard brown mottled with gray silty clay, trace fine to coarse sand

H 3.25

H 4.5

H 1.75

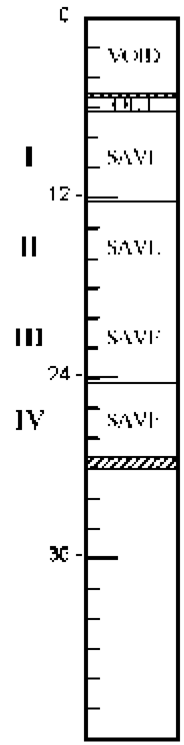
H 4.25

NOTE 1 - AL/MA on representative sample from Sections I, II and III
NOTE 2 - Permeability performed on Section I

30.00" tube

Boring : B-0910 Sample : 2

Depth : 3.5' to 5.5' Recovery : 23.00"



disturbed - discarded

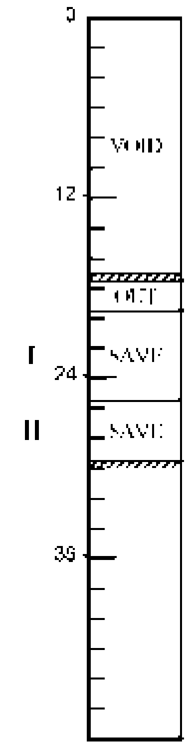
Stiff brown mottled with gray silty clay, some to "and" fine to coarse sand

H 1.25-1.50

30.00" tube

Boring : B-0911 Sample : 3

Depth : 5.5' to 6.6' Recovery : 10.00"



disturbed - discarded

Hard brown mottled with gray silty clay, trace fine to coarse sand, contains silt seams

H 4.25-4.5

30.00" tube

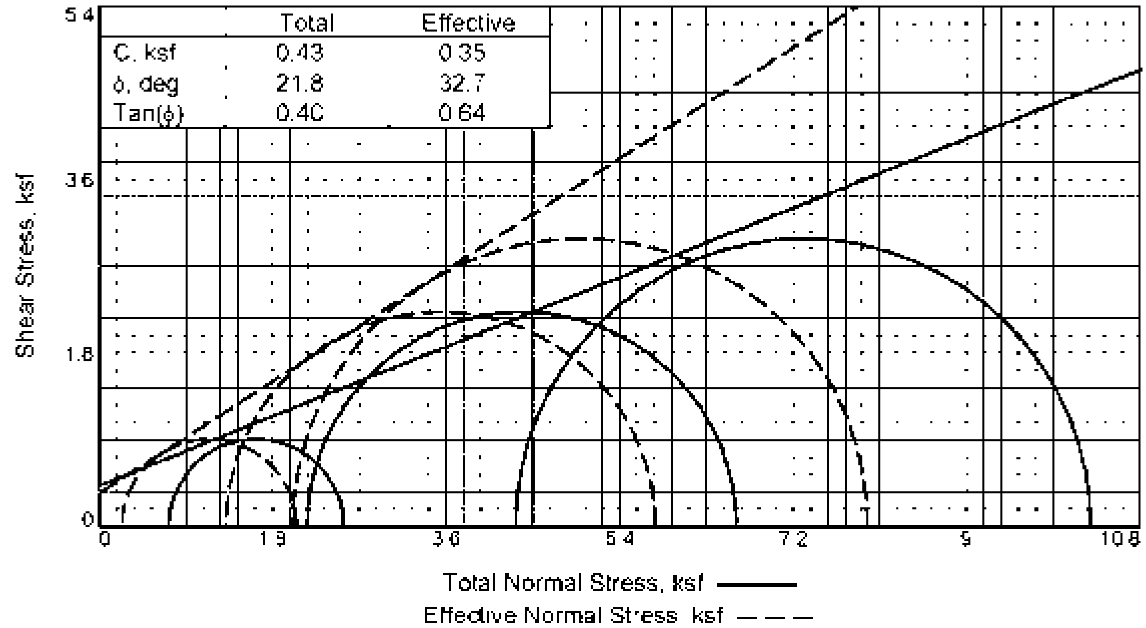
LEGEND

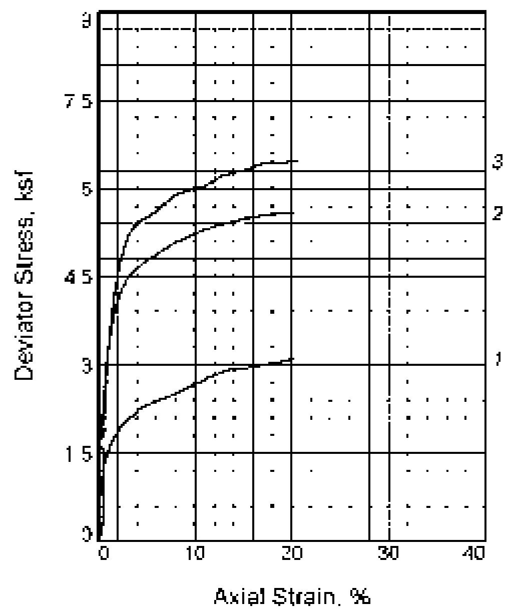
- Consolidation, Incremental
- Swelling, Test
- Wax
- C R S - Consolidation, C R S
- P P - Permeability, Vertical / Horizontal
- Unconfined Compression Test
- Triaxial Compression Test

H - Hand Penetrometer (tsf)	SL - Shrinkage Limit
Ds - Direct Shear	POR - Porosity
LOI - Loss on Ignition	UDW - Unit Dry Weight
AL - Atterberg Limits	MC - Moisture Content
MA - Sieve/Hydrometer	D_R - Relative Density
SG - Specific Gravity	S - Sieve

PLATE 34

	Total	Effective
C, ksf	0.43	0.35
ϕ, deg	21.8	32.7
Tan(ϕ)	0.40	0.64





Sample No.		1	2	3
Initial	Water Content, %	26.7	24.4	25.2
	Dry Density, pcf	93.2	98.1	96.0
	Saturation, %	89.2	91.7	90.3
	Void Ratio	0.8093	0.7176	0.7549
	Diameter, in.	2.89	2.89	2.88
	Height, in.	5.59	5.59	5.58
At Test	Water Content, %	28.3	24.9	25.5
	Dry Density, pcf	94.3	100.4	100.1
	Saturation, %	97.1	99.1	100.7
	Void Ratio	0.7868	0.6781	0.6837
	Diameter, in.	2.88	2.87	2.85
	Height, in.	5.54	5.53	5.47
Strain rate, %/min.		0.02	0.02	0.02
Back Pressure, tsf		4.320	4.320	4.320
Cell Pressure, tsf		4.680	5.400	6.480
Fail. Stress, ksf		1.82	4.45	5.97
Total Pore Pr., ksf		9.13	9.48	10.95
Ult. Stress, ksf		3.11	5.59	6.48
Total Pore Pr., ksf		8.18	8.37	9.48
$\bar{\sigma}_1$ Failure, ksf		2.05	5.77	7.98
$\bar{\sigma}_3$ Failure, ksf		0.23	1.32	2.01

Type of Test:
CU with Pore Pressures

Sample Type: Shelby Tube

Description: FILL: Stiff to hard brown mottled with gray silty clay, trace fine to

LL= 47 **PL=** 25 **PI=** 22

Assumed Specific Gravity= 2.7

Remarks:

Figure 1

Client: AEP

Project: AEP PICWAY PLANT ASH POND DIKE EVALUATION

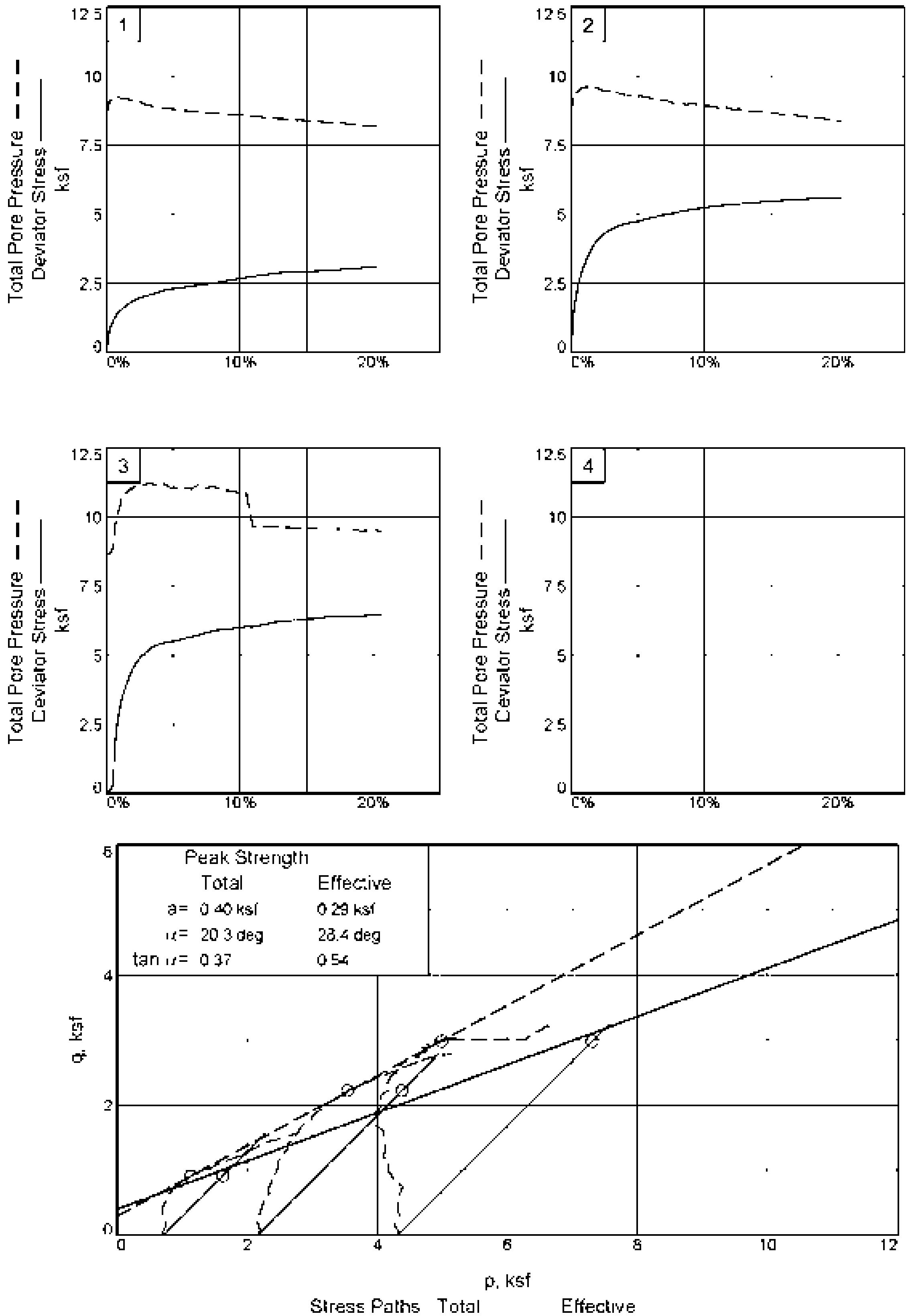
Location: B-0909

Sample Number: S-9 LILIII

Proj. No.: 011.11497.019 **Date Sampled:** 12/23/09

TRIAXIAL SHEAR TEST REPORT
BBC&M Engineering, Inc.
Dublin, Ohio

Tested By: PJM **Checked By:** JJ PLATE 35



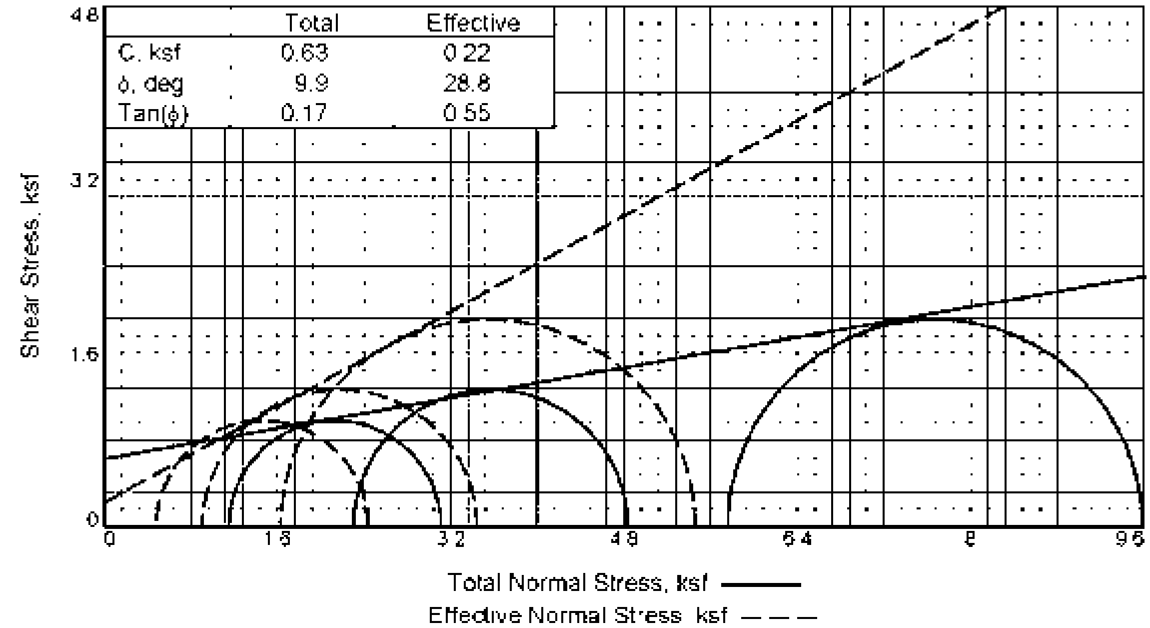
Client: AEP

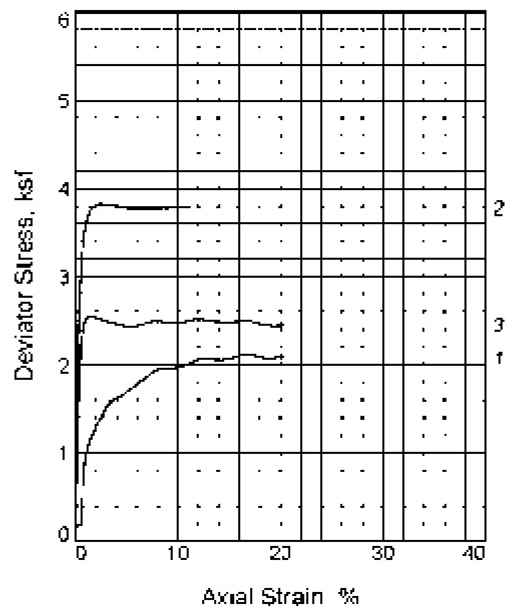
Project: AEP PICWAY PLANT ASH POND DIKE EVALUATION

Location: B-0909 **Depth:** 14.5' to 16.5' **Sample Number:** S-9 1,II,III

Project No.: 011.11497.019 Figure 2 **BBC&M Engineering, Inc.**

Tested By: PJM **Checked By:** JJ PLATE 36





	Sample No.	1	2	3
Initial	Water Content, %	27.7	25.7	26.5
	Dry Density, pcf	95.8	98.0	96.0
	Saturation, %	98.5	96.5	94.7
	Void Ratio	0.7587	0.7201	0.7554
	Diameter, in.	2.88	2.89	2.89
	Height, in.	5.59	5.58	5.59
At Test	Water Content, %	26.3	23.7	25.9
	Dry Density, pcf	99.4	101.9	99.6
	Saturation, %	102.0	97.9	101.0
	Void Ratio	0.6963	0.6539	0.6921
	Diameter, in.	2.85	2.87	2.87
	Height, in.	5.51	5.45	5.49
	Strain rate, %/min.	0.02	0.02	0.02
	Back Pressure, tsf	2.880	4.320	2.880
	Cell Pressure, tsf	3.456	7.200	4.032
	Fail. Stress, ksf	1.96	3.83	2.53
	Total Pore Pr., ksf	6.43	12.77	7.16
	Ult. Stress, ksf	2.09	3.79	2.46
	Total Pore Pr., ksf	6.28	12.92	7.21
	$\bar{\sigma}_1$ Failure, ksf	2.44	5.46	3.44
	$\bar{\sigma}_3$ Failure, ksf	0.48	1.63	0.91

Type of Test:
CU with Pore Pressures
Sample Type: Shelby Tube
Description: Very-soft to soft brown mottled with gray silty clay, some fine to coarse
LL= 32 **PL=** 16 **PI=** 16
Assumed Specific Gravity= 2.7
Remarks:

Figure 1

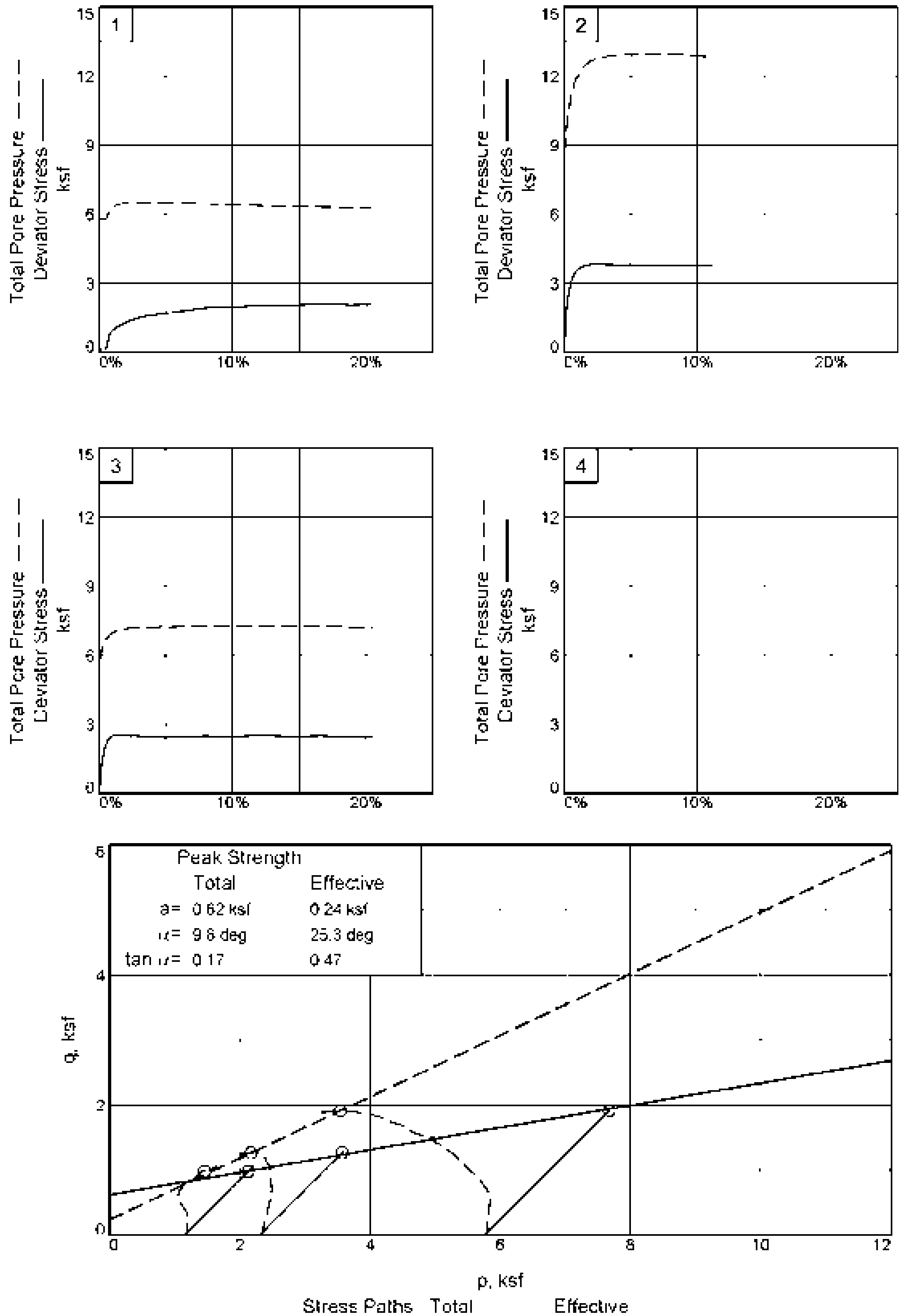
Client: AEP

Project: AEP PICWAY PLANT ASH POND DIKE EVALUATION
Location: B-0907, B-0908
Sample Number: S-14, S-13
Proj. No.: 011.11497.019 **Date Sampled:** 12/23/09

TRIAXIAL SHEAR TEST REPORT
BBC&M Engineering, Inc.
Dublin, Ohio

PLATE 37

Tested By: PJM/JJ **Checked By:** JJ



Client: AEP

Project: AEP PICWAY PLANT ASH POND DIKE EVALUATION

Location: B-0907, B-0908 **Sample Number:** S-14, S-13

Project No.: 011.11497.019 Figure 2

BBC&M Engineering, Inc.

Tested By: PJM/JJ **Checked By:** JJ

PLATE 38

PERMEABILITY TEST DATA AND COMPUTATION SHEET

((ASTM D-5084) FALLING HEAD, METHOD C)

BBCM
SOLUTIONS TO BUILD ON

Job Number	011.11497.019	Date	1/5-6/2010	Maximum Dry Density	
Project Name	AEP Picway Plant Ash Pond MW	Boring	B-0909	Optimum Moisture Content	
Project Location	Lockbourne, Ohio	Sample	S-9 Section I	% Compaction	
Tested By	PJM	Depth	14.5' to 16.5'	Optimum +/-	
Remarks				Natural	X
Material				Remolded	

Sample

Initial Length	5.5940 in = 14.209 cm
Final Ave. Length (L)	5.5700 in = 14.148 cm
Diameter	2.8575 in = 7.26 cm
Area (A)	6.347 sq in = 40.94 sq cm
Volume (V)	35.503 cu in = 580.14 cu cm
Wet Wt.	1134.71 grams
Unit Wet Wt.	115.04 pcf
Unit Dry Wt.	89.09 pcf

Test Conditions

Chamber Pressure	60 psi
Back Pressure	58 psi
Confining Pressure	4 psi
Temp. @ Start	17.0 °C
Temp. @ End	16.5 °C
Average Temp.	16.5 °C
B Parameter	0.95

Moisture Content

	Before Test	After Test
Pan No.	4	4
Wet Wt. + Pan	1134.71	1149.18
Dry Wt. + Pan	854.80	854.80
Wt. of Pan	0.00	0.00
Wt. of Dry Soil	854.80	854.06
Wt. of Water	339.82	253.09
% Moisture	26.80	29.80
% SATURATION	69.25	95.09

S.G. (est.) = 2.7000

Pipette Pressures During Test

Top Pipette	60 psi	= 4220.3 cm
Bottom Pipette	58 psi	= 4079.6 cm

Pipette

Area (a) 0.3435 sq in = 0.8725 sq cm

Calculations

$$k = \frac{a \cdot L}{2 \cdot A \cdot \Delta t} \ln\left(\frac{h_1}{h_2}\right)$$

where k = Hydraulic Conductivity; a = Pipette Cross-Sectional Area; L = Length of Sample; A = Sample Cross-Sectional Area; Δt = Time Interval $t_2 - t_1$; h_1 = Head Loss Across Permeameter/Specimen at t_1; h_2 = Head Loss Across Permeameter/Specimen at t_2; ln = Natural Logarithm (Base e = 2.71828)

Date	Time Readings	Time Interval Δt Seconds	Top Pipette cc	Hydraulic Head Headwater H_1 cm	Bottom Pipette cc	Hydraulic Head Tailwater H_2 cm	Head Loss $h = H_1 - H_2$ cm	$\ln(h_1/h_2)$	Temp. Corr. Permeability k cm/sec
1/5/2010	11:53 AM	0.00	45.00	4091.16	5.50	4090.84	159.68	-	-
1/5/2010	12:54 PM	3,660	45.30	4091.22	6.00	4090.73	159.50	0.00091	3.532E-08
1/5/2010	1:57 PM	3,780	45.10	4091.33	6.65	4090.61	159.33	0.00091	2.311E-08
1/5/2010	2:57 PM	3,600	45.00	4091.39	6.70	4090.61	159.22	0.00061	2.370E-08
1/5/2010	3:56 PM	3,960	45.00	4091.45	6.75	4090.55	159.10	0.00081	2.321E-08
1/6/2010	8:50 AM	60,840	42.50	4092.02	7.20	4090.03	158.01	0.00547	1.306E-08

Time Weighted Average, k [cm/sec] = 1.849E-08

APPENDIX C

Slope Stability Shear Strength

Parameter Justification

Determine strength parameters for subsurface and embankment soils at AEP Pleasy Plant:

1) Only drained strengths will be considered in analysis (except for seismic loading)
2) An additional 3 ft of fill was added to the top of the embankment in Nov 2009, previous to subsurface investigations.
3) At the time of the subsurface investigation, all ponds were inactive as the plant was not operating at the time. The water surface on the inboard slope of the pond was not visible. Therefore, analysis assumes a water level that maintains a 3 ft freeboard (highest permitted level)
4) The following conditions will be considered:
   a.) Long term steady state
   b.) Seismic event
   c.) Rapid Drawdown
5) End of construction (short term-undrained conditions) will not be considered.

- Drained Strength Parameters

- For embankment fill and natural cohesive layers, estimate the effective angle of internal friction (ϕ') from the following methods:

1) Correlations to LL, clay sized fraction, and effective stress developed by Stark et al. (1996) for fully softened friction angle.

2) Relationship between ϕ' and P.I. (Terzaghi, Peck & Mesri)

3) ĀCU Triaxial Test

   i.) Natural Cohesive Soil - B-0907 (S-14), B-0908 (S-13)
   ii.) Embankment Fill - B-0909, S-9

4) For fill soils, estimate drained strength values from NAVFAC Design Manual 7.2 using Table 1, Typical properties of compacted soils

PLATE 1

- For granular foundation lay s (sand + gravel), estimate ϕ' bas d on SPT correla ions nd grain-size analysis.

1) $\phi' = \sqrt{15.4(N_{60})} + 20°$ (Hatanaka & Uchida, 1996)

2) N vs ϕ table from Peck, Hanson, and Thornburn, 1953.

3) Compare methods 1) and 2) w/ typical values published by Schroeder et al.

+ Undrained strength parameters

- Necessary in order to determine strengths during a seismic event.

- Both the embankment fill and natural cohesive soils are expected to exhibit undrained strengths in a seismic event

- Undrained strengths will be determined by:

) Results of CU triaxial tests on embankment fill and natural cohesive soils.

PLATE 2

BBCM
SOLUTIONS TO BUILD ON
Cincinnati (513) 771-8471
Cleveland (216) 901-1000
Columbus (614) 793-2226
Dayton (937) 424-1011

Project/Proposal No. 011-11497-019 Calculated By JDR Date 12/31/09
Project/Proposal Name Picway Dike Evaluation Checked By .... Date 1/25/1.
Subject Strength + Perm. Parameters Sheet 3 of 10

- Permeability

Embankment Fill:
- Permeability will be based on flex wall permeability test completed on sample from:
B-0909 S-9 Sect. 1 Depth 19.0 [illegible] Ft
In order to account for permeability on a macro scale, use permeability higher than [illegible] and consider [illegible]

Natural Cohesive Soils:
- Estimate permeability based on typical published values considering both soil descriptions and grain-size analyses.

Granular Foundation Layers:
- Estimate permeability using typical published values based on relative density and grain size analyses.
- use GeoSyntec (1991) method published in FHWA GEC No 5

PLATE 3

Layer: Embankment Fill

Note:
i) This layer is drained in the long-term analysis
ii) Undrained strength values are needed in the event of a RDD or seismic event.

Description: Vst-hd br mot w/ gy si cl, tr f-c sa

Hand Penetrometer Results: 1.75-4.5+ (See Table)

- Drained Strength Parameter Estimates:

1) Correlation to Stark charts:

$\sigma'_{v0} \approx$ 50 kPa (middle of embankment)
$\approx$ 100 kPa (bottom of embankment)

$\phi' = 25°$ (See correlation this appendix)

2) ϕ' vs PI (Terzaghi, Peck, + Mesri, 1996)

$\phi' = 29°$ (See correlation this appendix)

3) 3-pt CU Triaxial Test:

B-0909 S-4 Depth: 14.5'-16.5'

$\phi' = 32.7°$ $c' = 350$ psf

4) NAVFAC Table:

Inorganic clays of low to medium plasticity

$\phi' = 28°$, $c' = 270$ psf

Considering all available information, design strength of the embankment fill in a drained condition is:

$\phi' = 30°$ $c' = 200$ psf

PLATE 4

Layer Embankment Fill (cont)

- Undrained Strength Parameters

1) CU Triaxial Test:

B-0909 S-9 Depth: 14.5-16.5'

$\phi = 21.8°$ c = 430 psf

Per United States Society on Dams (USSD) "Strength of Materials for Embankment Dams" - Feb 2007
- NRCS Practice for Steady Seepage w/ seismic forces.

→ use 80% of CU shear strength for impervious soils

21.8 (0.80) = 17.4° 430 (0.8) = 344 psf

Therefore, undrained strengths of the embankment fill used in this analysis are:

$\phi = 17°$	c = 340 psf

- Permeability

- Flex wall permeability test performed on

S-9 III in B-0909 Depth: 14.5'-16.5'
Description: Fill St-hd br mo w/ gy silt, tr f-c sa

Results: $k_v = 1.83 \times 10^{-8}$ cm/s

For design, use $k_v = 5 \times 10^{-8}$ cm/s to account for seepage on a macro scale. Also, use $k_h / k_v = 10$ for seepage analysis due to construction in lifts.
(CASAGRANDE, 1961)

Job Number: 911.11497.019
Job Name: AEP Pleasy Plant Dike Evaluation

Layer: Cohesive Embankment Fill

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Effective Particle Size, mm						%Fines	%Clay	Atterberg Limits			
														d_{85}	d_{60}	d_{50}	d_{30}	d_{10}	Cu	<#200 sieve	<0.005 mm	MC	LL	PL	PI
B-0504	1	692.85	Fill: Vst-hd br & dk br gr cl w/ fe sa, d/ gr, fe rts	1	691.85	24.6	4.5+	15	21	125	1692.4	76.7	2064												
B-0504	2	692.85	Fill: Vst-hd br mot w/ gy si cl, li f-c sa, cont rts	2.5	690.35	24.6	3.75-4.5	12	17	312.5	1696.0	81.2	2064												
B-0504	3	692.85	Fill: Vst-hd br mot w/ gy si cl, li fe sa	4	688.85	24.6	2.75	11	15	500	1780.56	85.68	2064									24	51	24	27
B-0504	4	692.85	Fill: Vst-hd br mot w/ gy si cl, li fe sa	5.5	687.35	24.6	2.75-3.5	7	15	687.5	1883.16	90.17	2064												
B-0504	5	692.85	Fill: Vst-hd br mot w/ gy si cl, li fe sa	7	685.85	24.6	2.75	7	15	875	1978.8	94.8	2064												
B-0504	6	692.85	Fill: Vst-hd br mot w/ gy si cl, li fe sa	8.5	684.35	24.6	2.75-3.75	8	11	1062.5	2070.4	98.1	2064												
B-0504	7	692.85	Fill: Vst-hd br mot w/ gy si cl, li fe sa	10	682.85	24.8	3.25-4.5	13	15	1250	2164.0	100.6	2065												
B-0504	8	692.85	Fill: Vst-hd br mot w/ gy si cl, li fe sa	11.5	681.35	24.8	3.25-3.5	6	12	1437.5	2257.6	108.1	2065												
B-0504	9	692.85	Fill: Vst-hd br mot w/ gy si cl, li fe sa	13	679.85	24.9	2.25-2.75	7	10	1625	2351.2	112.6	2066												
B-0504	10	692.85	Fill: Vst-hd br mot w/ gy si cl, li fe sa	14.5	678.35	24.5	3.25-4.0	14	15	1812.5	2444.8	117.1	2066	0.305	0.0659					97.84	31.59	25	50	27	23
B-0504	11	692.85	Fill: Vst-hd br mot w/ gy si cl, li fe sa	16	676.85	24.5	3.0-3.25	11	15	2000	2538.4	121.5	2066												
B-0506	1	690	Fill: Hd dk br si cl, li f-c sa, fe rts	1	689	25.4	4.5+	11	15	125	1652.4	79.1	2064												
B-0506	2	690	Fill: Vst-hd br mot w/ gy si cl, li f-c sa	2.5	687.5	25.4	4	9	12	312.5	1746.0	83.5	2064												
B-0506	3	690	Fill: Vst-hd br mot w/ gy si cl, li f-c sa	4	686	25.4	4.0-4.5	13	10	500	1839.6	88.1	2064	0.009	0.006					96.50	33.31	23	49	25	24
B-0506	4	690	Fill: Vst-hd br mot w/ gy si cl, li f-c sa	5.5	684.5	25.4	4.5+	18	25	687.5	1933.2	92.5	2064												
B-0506	5	690	Fill: Vst-hd br mot w/ gy si cl, li f-c sa, tr gr	7.5	682.5	25.4	3.75			937.5	2026.8	96.5	2065												
B-0506	6	690	Fill: Vst-hd br mot w/ gy si cl, li f-c sa	9.5	680.5	25.4	4.5+	17	24	1187.5	2120.8	104.5	2065									31	57	27	30
B-0506	7	690	Fill: Vst-hd br mot w/ gy si cl, li f-c sa	11	679	25.4	2.75-4.0	11	15	1375	2214.4	109.0	2065												
B-0506	8	690	Fill: Vst-hd br mot w/ gy si cl, li f-c sa	12.5	677.5	25.4	3.5	16	22	1562.5	2370.9	113.5	2065												
B-0506	9	690	Fill: Vst-hd br mot w/ gy si cl, li f-c sa	14	676	25.4	3.5-4.0	13	18	1750	2463.5	118.0	2066	0.309	0.026					97.75	31.73	28	54	31	23
B-0506	10	690	Fill: Vst-hd br mot w/ gy si cl, li f-c sa	15.5	674.5	25.4	3.5-4.0	20	32	1937.5	2557.2	122.4	2066												
B-0907	1A	692.38	Fill: Vst dk br mot w/ gy si cl, li f-c sa	1	691.38	25.5	3.25	18	25	125	1658.7	76.4	2064												
B-0907	2	692.38	Fill: Vst-hd br & dk br mot w/ gy si cl, li f-c sa	2.5	689.88	25.5	2.5	9	12	312.5	1752.3	83.9	2064												
B-0907	3	692.38	Fill: Vst-hd br & dk br mot w/ gy si cl, li f-c sa	4.5	687.88	25.5	2.75-3.25			562.5	1847.1	88.9	2064												
B-0907	4	692.38	Fill: Vst-hd br & dk br mot w/ gy si cl, li f-c sa	6.5	685.88	25.5	3.5-4.0	7	10	812.5	2001.9	95.3	2064												
B-0907	5	692.38	Fill: Vst-hd br & dk br mot w/ gy si cl, li f-c sa	8	684.38	25.5	2.75-3.25	13	24	1000	2096.5	100.3	2064	0.308	0.025					96.67	35.41	27	48	25	23
B-0907	6	692.38	Fill: Vst-hd br & dk br mot w/ gy si cl, li f-c sa	9.5	682.88	25.5	3.75-4.0	24	38	1187.5	2185.1	104.8	2065												
B-0907	7	692.38	Fill: Vst-hd br & dk br mot w/ gy si cl, li f-c sa	11	681.38	25.5	3.25-3.75	11	15	1375	2270.7	109.3	2065												
B-0907	8	692.38	Fill: Vst-hd br & dk br mot w/ gy si cl, li f-c sa	12.5	679.88	25.5	3.25-3.75	12	17	1562.5	2376.3	113.8	2065												
B-0907	9	692.38	Fill: Vst-hd br & dk br mot w/ gy si cl, li f-c sa	14	678.38	25.5	4.5+	15	25	1750	2459.9	118.3	2065	0.307	0.004					95.32	38.40	21	50	25	25
B-0907	10	692.38	Fill: Vst-hd br & dk br mot w/ gy si cl, li f-c sa	15.5	676.88	25.5	3.5	26	38	1937.5	2553.5	122.7	2065												
B-0907	11	692.38	Fill: Vst-hd br & dk br mot w/ gy si cl, li f-c sa	17	675.38	25.5	2.5-3.5	12	17	2125	2647.1	127.2	2066												
B-0909	1	692.81	Fill: Vst-hd br & dk br si cl, li f-c sa, tr f gr, fe rts	1	691.81	28.5	4.5+	18	25	125	1646.5	88.4	2064												
B-0909	2	692.81	Fill: Vst-hd br & dk br si cl, li f-c sa, tr f gr, fe rts	2.5	690.31	28.5	3.0-3.5	8	11	312.5	1840.1	92.9	2064												
B-0909	3	692.81	Fill: Vst-hd br & dk br si cl, li f-c sa, tr f gr, fe rts	4	688.81	28.5	2.25	6	8	500	2033.7	97.4	2064	0.005	0.005					94.90	35.65	24	44	24	20

PLATE 6

B-0909	4	692.81	Fill: Si-vsl br mol w/ gy sl cl, tr f-c sa, 5 ... gr	5.5	687.31	28.5	3.75-3.35	10	14	687.5	2157.3	101.9	2084												
B-0909	5	692.81	Fill: Si-vsl br mol w/ gy sl cl, tr f-c sa, ... gr	7	685.81	28.4	1.5-2.25	7	10	575	2220.9	108.3	2084												
B-0909	6	692.81	Fill: Vsl br mol w/ dk br & gy ...	9	683.81	28.5	3.75			1125	2345.7	112.3	2084												
B-0909	7	692.81	Fill: Si-vsl br mol w/ gy sl cl, tr f-c sa, ... gr	11	681.81	29.5	3.75	10	14	1375	2470.5	118.3	2085												
B-0909	8	692.81	Fill: Si-vsl dk br mol w/ gy snd, ...	12.5	680.31	28.5	1.75-3.75	5	11	1562.5	2564.1	122.8	2085												
B-0909	9	692.81	Fill: Si-nd br mol w/ gy sl cl, tr f-c sa	14.5	678.31	28.5	1.75-4.5			1812.5	2688.9	128.7	2085												
B-0909	10	692.81	Fill: Si-vsl dk br mol w/ gy snd, ...	16.5	676.31	28.5	3.5-3.75	15	21	2062.5	2813.7	134.7	2085	0.006	0.004					95.79	98.69	25	55	27	28
B-0909	11A	692.81	Fill: Si-vsl dk br mol w/ gy snd, ...	18	674.81	28.5	2.75	12	17	2250	2907.3	139.2	2085												
B-0917	1	675.56	Fill: Vsl hd dk br mol w/ gy snd, ...	1	678.56	14	3.5-4.0	10	14	125	938.0	44.9	2055												
						Averages		12.2	16.9																

Number in Statistical Sample	7	7	9	9	9	9
Minimum	95.0	31.7	21.0	44.0	24.0	20.0
Maximum	97.6	38.8	28.9	57.0	31.0	30.0
Mean	96.5	35.5	25.8	51.1	26.1	25.0
Median	96.5	35.8	24.0	50.0	25.0	24.0
Mode	#N/A	#N/A	24	52	27	23
Std Dev	0.9933517	2.6572046	2.16567	4.01308	2.23475	3.31662

Laboratory Testing
Permeability test on cohesive fill
Sample: B-0909, S-9, 14.5 - 16.5 ft
k = 1.83E-08 cm/s
CU Triaxial Test
Sample: B-0909, S-9, 14.5 - 16.5 ft
Description: Fill: Si-hd br mol w/ gy si cl, tr f-c sa
c' = 350 psf
φ' = 32.7 degrees
c = 470 psf
φ = 21.8 degrees

Key
GWT Ground Water Table
Elevation Feet above Mean Sea Level
N Standard Penetration Test (blows per foot)
N_{60} Standard Penetration Test for 60 percent energy ratio (blows per foot)
σ_v Normal Stress
σ'_{vo} Effective Normal Stress (in tsf)
P_a Atmospheric Pressure (2116.2 psf at Sea Level)
D_r Relative Density

d_{60} Effective particle size for 60 percent passing
d_{50} Effective particle size for 50 percent passing
d_{30} Effective particle size for 30 percent passing
d_{15} Effective particle size for 15 percent passing
d_{10} Effective particle size for 10 percent passing
Cu Uniformity Coefficient (d_{60}/d_{10})

PLATE 7

BBCM
SOLUTIONS TO BUILD ON

DRAINED SHEAR STRENGTH PARAMETER CORRELATION

Project No: 011.11497.019
Project: AEP Picway Plant Dike Evaluation

Reference:
Drained Shear Strength Parameters for Analysis of Landslides. Timothy D. Stark; Hangseok Choi; and Sean McCone. Journal of Geotechnical Engineering, May 2005. pp 575 - 588

Purpose:
Estimate effective stress, or drained, shear strength parameters of cohesive soils through emperical correlations using laboratory index testing and the effective normal stress. Secant residual and secant fully soffened friction angles can be estimated from charts developed by Stark et al.

Laboratory Data

Soil Layer: Cohesive Embankment Fill

Statistical Results from 4 Borings

	MC	LL	PL	PI	% Passing #200 Sieve (.075 mm)	Clay Sized Fraction (.002 mm)
Number in Statistical Sample	9	9	9	9	7	7
Minimum	21	44	24	20	94.96	31.73
Maximum	28	57	31	30	97.78	38.63
Mean	24	51	26	25	97	35
Median	24	50	25	24	96.5	35.91
Mode	24	50	27	23	#N/A	#N/A
Std Dev	2	4	2	3	1	3
Design Value	-	50	-	-	-	35

Adjustment Factor for ASTM Derived Values

$$\frac{\textit{ball-milled derived LL}}{\textit{ASTM derived LL}} = .003\ (\textit{ASTM derived LL}) + 1.23$$

LL_{ASTM} = 50
LL_{BM} = 69.0

$$\frac{\textit{ball-milled derived CF}}{\textit{ASTM derived CF}} = 0.0003\ (\textit{ASTM derived CF})2 - 0.037(\textit{ASTM derived CF}) + 2.254$$

CF_{ASTM} = 35
CF_{BM} = 46.4

where: LL = Liquid Limit
CF = Clay-sized Fraction

BBCM
SOLUTIONS TO BUILD ON

DRAINED SHEAR STRENGTH PARAMETER CORRELATION

Soil Layer: Cohesive Embankment Fill

LL_{BM} = 69.0

CF_{BM} = 46.4

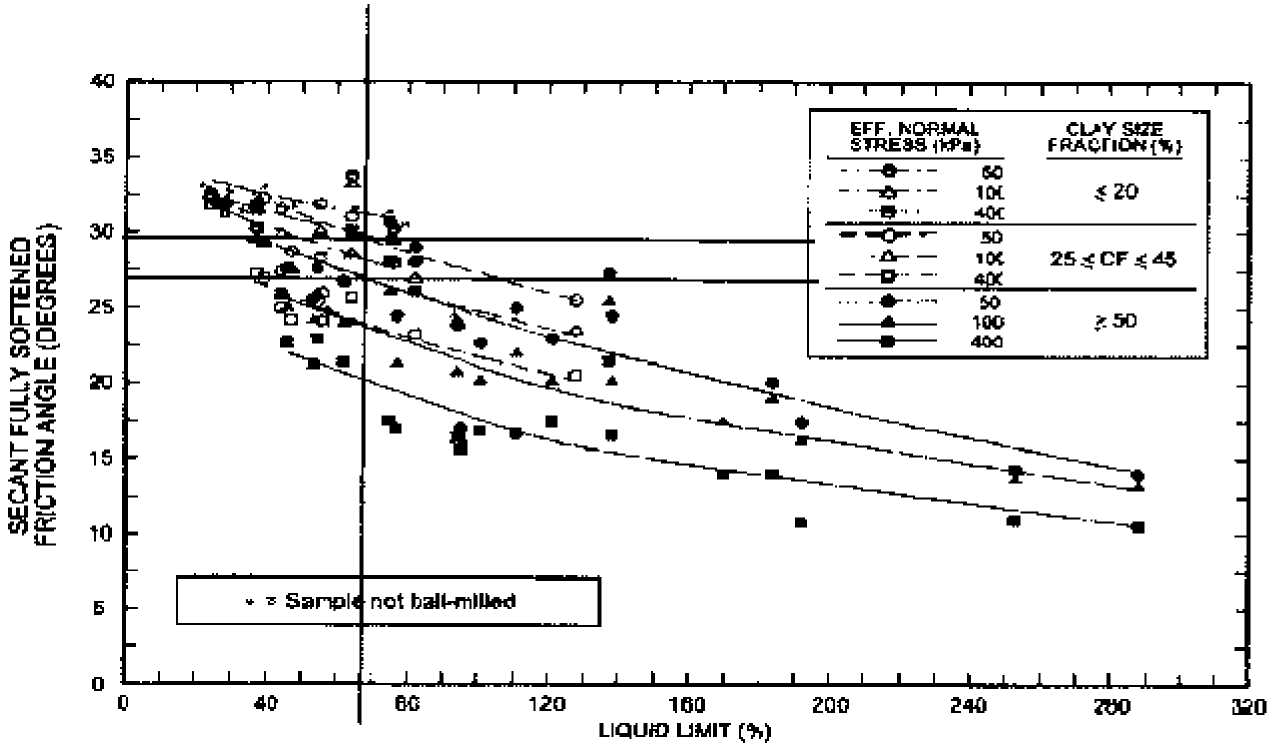


Fig. 5. Secant fully softened friction angle relationships with liquid limit, clay-size fraction, and effective normal stress

Secant Fully Softened Friction Angle

Clay Sized Fraction, %	Effective Normal Stress: 50 kPa	Effective Normal Stress: 100 kPa
24 ≤CF ≤45	29°	27°
≥50	-	-

Depth	σv' (kPa)
9	56
18	112

Design Value	28°

BBCM SOLUTIONS TO BUILD ON

DRAINED SHEAR STRENGTH PARAMETER CORRELATION

Method: Terzhagi, Peck, and Mesri, 1996
Source: FHWA GEC No 5: pg 165

Equation: Graphic

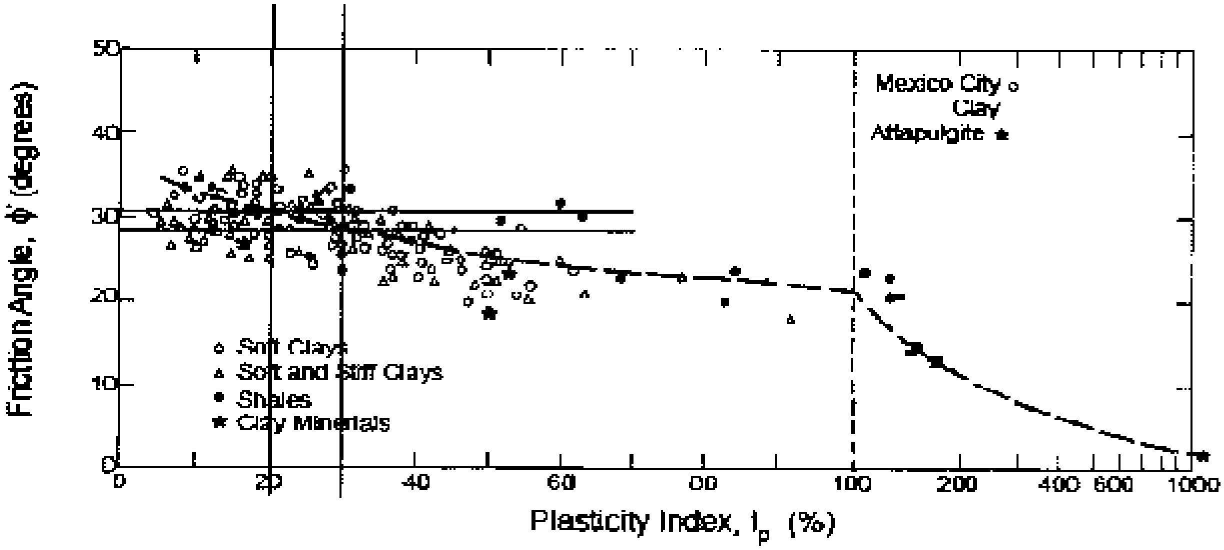


Figure 74. Relationship between φ' and PI (Terzaghi, Peck, and Mesri, 1996).

Layer: Cohesive Embankment Fill

Boring	Sample	*PI*	*φ'*
B-0904	3	29	28.0
B-0904	10	23	30.0
B-0906	3	24	29.5
B-0906	6	30	28.0
B-0906	9	23	30.0
B-0907	5	23	30.0
B-0907	9	25	29.0
B-0909	3	20	30.5
B-0909	10	28	28.5

Minimum	28
Maximum	31
Average	29.3

BBCM SOLUTIONS TO BUILD ON

TYPICAL PROPERTIES OF COMPACTED SOILS

Layer: Cohesive Embankment Fill

Source: NAVFAC Design Manual 7.02, September, 1986, Page 38

Group Symbol	Soil Type	Range of Maximum Dry Unit Weight, pcf	Range of Optimum Moisture, Percent	Typical Value of Compression: At 1.4 tsf (20 psi)	Typical Value of Compression: At 3.6 tsf (50 psi)	Typical Strength Characteristics: Cohesion (as compacted) psf	Typical Strength Characteristics: Cohesion (saturated) psf	Typical Strength Characteristics: φ (Effective Stress Envelope Degrees)	Typical Strength Characteristics: Tan φ	Typical Coefficient of Permeability ft./min.	Range of CBR Values	Range of Subgrade Modulus k lbs/cu in.
				Percent of Original Height								
GW	Well graded clean gravels, gravel-sand mixtures.	125 - 135	11 - 8	0.3	0.6	0	0	>38	>0.79	5 x 10^{-2}	40 - 80	300 - 500
GP	Poorly graded clean gravels, gravel-sand mix	115 - 125	14 - 11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30 - 60	250 - 400
GM	Silty gravels, poorly graded gravel-sand-silt.	120 - 135	12 - 8	0.5	1.1	.....	.....	>34	>0.67	>10^{-6}	20 - 60	100 - 400
GC	Clayey gravels, poorly graded gravel-sand-clay.	115 - 130	14 - 9	0.7	1.6	.....	.....	>31	>0.60	>10^{-7}	20 - 40	100 - 300
SW	Well graded clean sands, gravelly sands.	110 - 130	16 - 9	0.6	1.2	0	0	38	0.79	>10^{-3}	20 - 40	200 - 300
SP	Poorly graded clean sands, sand-gravel mix.	100 - 120	21 - 12	0.8	1.4	0	0	37	0.74	>10^{-3}	10 - 40	200 - 300
SM	Silty sands, poorly graded sand-silt mix.	110 - 125	16 - 11	0.8	1.6	1050	420	34	0.67	5 x >10^{-5}	10 - 40	100 - 300
SM-SC	Sand-silt clay mix with slightly plastic fines.	110 - 130	15 - 11	0.8	1.4	1050	300	33	0.66	2 x >10^{-6}	5 - 30	100 - 300
SC	Clayey sands, poorly graded sand-clay-mix.	105 - 125	19 - 11	1.1	2.2	1550	230	31	0.60	5 x >10^{-7}	5 - 20	100 - 300
ML	Inorganic silts and clayey silts.	95 - 120	24 - 12	0.9	1.7	1400	190	32	0.62	>10^{-5}	15 or less	100 - 200
ML-CL	Mixture of inorganic silt and clay.	100 - 120	22 - 12	1.0	2.2	1350	460	32	0.62	5 x >10^{-7}	.....	
CL	Inorganic clays of low to medium plasticity.	95 - 120	24 - 12	1.3	2.5	1800	270	28	0.54	>10^{-7}	15 or less	50 - 200
OL	Organic silts and silt-clays, low plasticity.	80 - 100	33 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	50 - 100
MH	Inorganic clayey silts, elastic silts.	70 - 95	40 - 24	2.0	3.8	1500	420	25	0.47	5 x >10^{-7}	10 or less	50 - 100
CH	Inorganic clays of high plasticity	75 - 105	36 - 19	2.6	3.9	2150	230	19	0.35	>10^{-7}	15 or less	50 - 150
OH	Organic clays and silty clays	65 - 100	45 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	25 - 100

Notes:

1. All properties are for condition of "Standard Proctor" maximum density, except values of k and CBR which are for "modified Proctor" maximum density.
2. Typical strength characteristics are for effective strength envelopes and are obtained from USBR data.
3. Compression values are for vertical loading with complete lateral confinement.
4. (>) indicates that typical property is greater than the value shown. (..) indicates insufficient data available for an estimate.

PLATE 11

Layer: Natural Cohesive Soil

Note:
1.) This layer is drained in the long-term analysis.
2.) Undrained strength values are needed in the event of a RDD or seismic event.

Description: St - vst or med w/ gy s, cl, lit to sm f-c sa
* Some medium-stiff, soft, or very-soft layers were encountered. They were limited in size and typically occured in the soil directly above the granular layers. They typically had thicknesses of 3-5 ft. The lab testing for these soft soils have been incorporated into this layer.

Hand Penetrometer Results: 0.1-4.5+ (See Table)
Avg = 2.3 tsf

- Drained Strength Parameter Estimates

1) Correlation to Stark Charts

CF_{SM} 47.9 (See correlation this appendix)

25 ≤ CF ≤ 45 Φ' = 27.5°
CF ≥ 50 Φ' = 24.5°

Φ' = 26°

2) Φ' vs PI (Terzaghi, Peck, & Mesri, (1996))

Φ' = 30° (See correlation this appendix)

3) 3-pt CU Triaxial Test

B-0907 S-14
B-0908 S-13
Φ' = 29.8° c' = 220 psf

Considering all the above information design parameters are

Φ' = 28° c' = 0 psf

PLATE 12

Layer Natural Cohesive Soil (cont.)

- undrained Strength Parameters

i) CU Triaxial Test:

B-0907, S-14
B-0908, S-13
$\phi = 9.9°$ c = 630 psf

Per United States Society on Dams (USSD) "Strength of Materials for Embankment Dams" - Feb. 2007
→ Use 80% of CU shear strength for impervious soils
9.9° (0.8) = 7.9° 630 (0.8) = 504 psf

Therefore, undrained strengt. of th natural cohesive soil used in this analysis are:

ϕ = 8°	c = 500 psf

- Permeabili...

Use typical value from Holtz and Kovacs (1981)

$k_v = 5 \times 10^{-8}$ cm/s

Use $k_h/k_v = 1$

Grain-size analyses for this layer displayed very high clay content (35-40%) and very little sand.

PLATE 13

Job Number [illegible]
Job Name [illegible]

[illegible]

Number in Statistical Sample	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Minimum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Maximum	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mean	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Median	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mode	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Std Dev	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

PLATE 14

SOLUTIONS TO BUILD ON

DRAINED SHEAR STRENGTH PARAMETER CORRELATION

Project No: 011.11497.019
Project: AEP Picway Plant Dike Evaluation

Reference:
Drained Shear Strength Parameters for Analysis of Landslides. Timothy D. Stark; Hangseok Choi; and Sean McCone. Journal of Geotechnical Engineering, May 2005. pp 575 - 588

Purpose:
Estimate effective stress, or drained, shear strength parameters of cohesive soils through emperical correlations using laboratory index testing and the effective normal stress. Secant residual and secant fully softened friction angles can be estimated from charts developed by Stark et al.

Laboratory Data

Soil Layer: Natural Cohesive

Statistical Results from 8 Borings

	MC	LL	PL	PI	% Passing #200 Sieve (.075 mm)	Clay Sized Fraction (.002 mm)
Number in Statistical Sample	7	8	8	8	8	8
Minimum	19	32	16	15	56.12	22.79
Maximum	27	54	26	28	99.15	42.19
Mean	23	44	22	22	90	35
Median	22	45.5	23	23	96.56	37.425
Mode	22	32	23	27	#N/A	#N/A
Std Dev	3	8	3	5	15	7
Design Value	-	45	-	-	-	37

Adjustment Factor for ASTM Derived Values

$$\frac{\text{ball-milled derived LL}}{\text{ASTM derived LL}} = .003\,(\text{ASTM derived LL}) + 1.23$$

LL_{ASTM} = 45
LL_{BM} = 61.4

$$\frac{\text{ball-milled derived CF}}{\text{ASTM derived CF}} = 0.0003\,(\text{ASTM derived CF})2 - 0.037(\text{ASTM derived CF}) + 2.254$$

CF_{ASTM} = 37
CF_{BM} = 47.9

where: LL = Liquid Limit
CF = Clay-sized Fraction

Soil Layer: Natural Cohesive

LL_{BM} = 61.4

CF_{BM} = 47.9

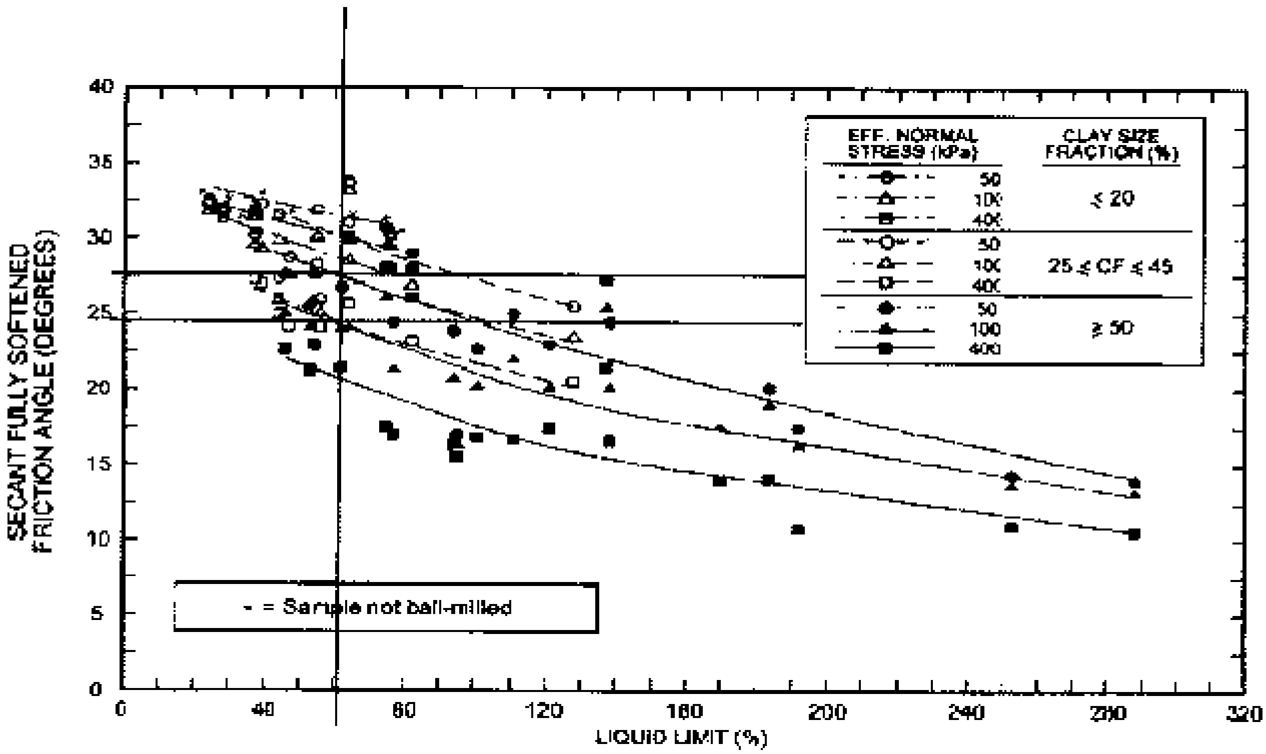


Fig. 5. Secant fully softened friction angle relationships with liquid limit, clay-size fraction, and effective normal stress

Secant Fully Softened Friction Angle

Clay Sized Fraction, %	Effective Normal Stress: 50 kPa	Effective Normal Stress: 100 kPa
24 ≤CF ≤45	-	27.5°
≥50	-	24.5°

Design Value	26°

Natural Clay has effective normal stress between 100 - 200 kPa

DRAINED SHEAR STRENGTH PARAMETER CORRELATION

Method: Terzhagi, Peck, and Mesri, 1996
Source: FHWA GEC No 5: pg 165

Equation: Graphic

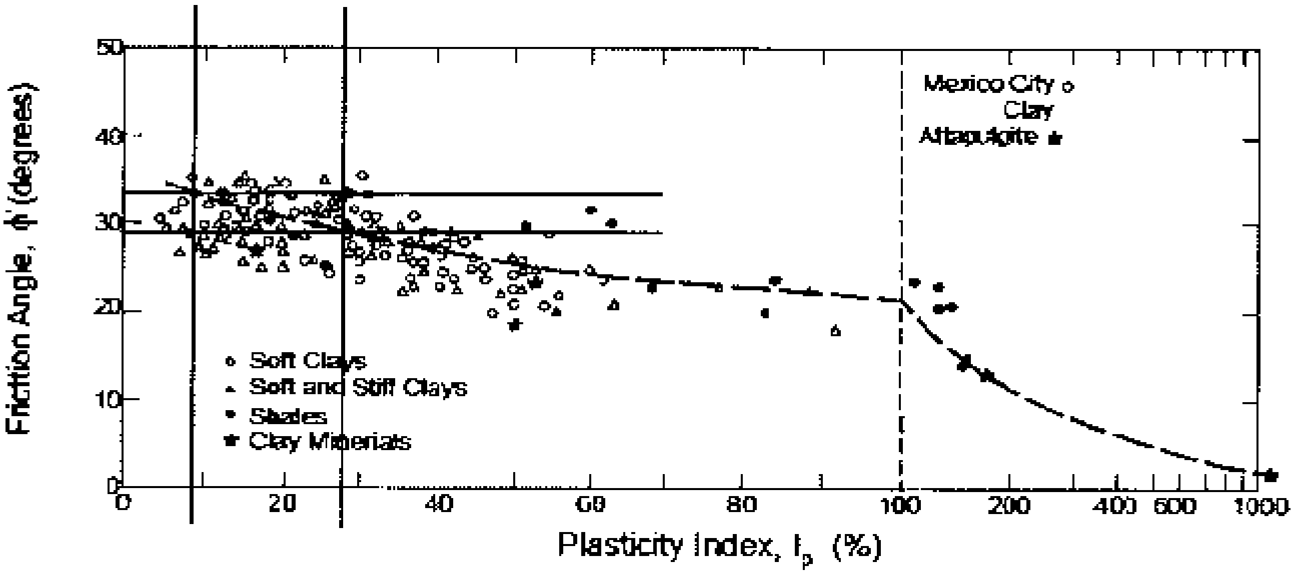


Figure 74. Relationship between ϕ' and PI (Terzaghi, Peck, and Mesri, 1996).

Layer: Natural Cohesive

Boring	Sample	*PI*	*ϕ'*
B-0904	13	27	29.0
B-0906	14	27	29.0
B-0907	12B	25	29.5
B-0908	2	19	30.0
B-0909	13	21	29.8
B-0911	2	28	29.0
B-0911	4	15	31.0

Minimum	29
Maximum	31
Average	30

BBCM
SOLUTIONS TO BUILD ON

RANGE OF HYDRAULIC CONDUCTIVITY BASED ON SOIL TYPE

Method: Holtz and Kovacs, 1981 (after Casagrande)
Source: FHWA GEC No 5: pg 184

Equation: Graphic
Soil Layer: Alluvium

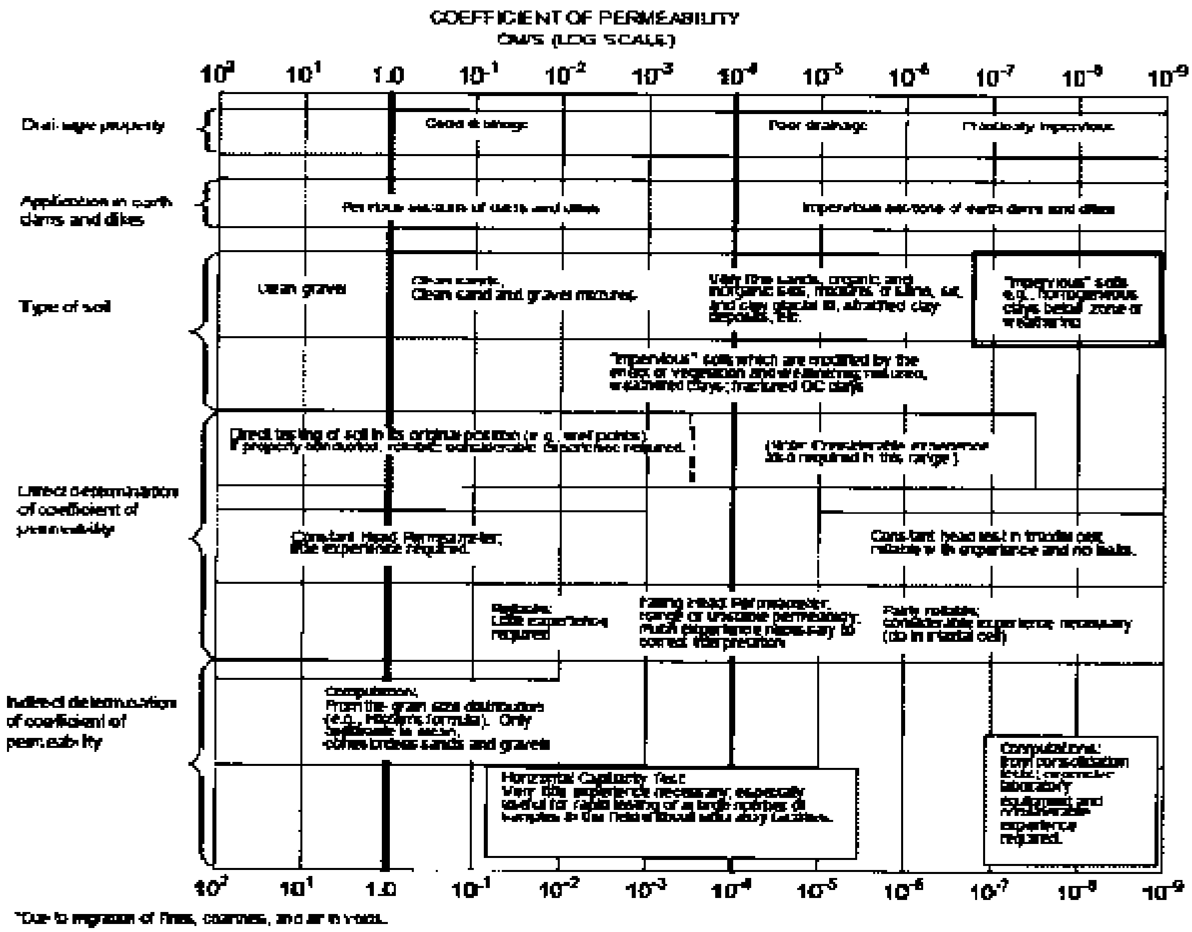


Figure 90. Range of hydraulic conductivity values based on soil type.

Layer: Sand and Gravel

Note:
This layer is a freely-draining granular material and therefore, only drained strength parameters will be considered.

Description: Me-de to de gy f-c sa, lit to sm f-c gr, lit si
OR
Me-de to de gy f-c gr, sm to "and" f-c sa, lit si

N_{60} Values:

Max: 66
Min: 8
Avg: 30
Mode: 36

- Drained Strength Parameters:

1.) Hatanaka & Uchida (1996)

$\phi' = 40°$ (See correlation this appendix)

2.) Peck, Hanson, and Thornburn (1953)

$\phi' = 35°$ (See correlation this appendix)

3.) Schroeder et al.

N_{60} (avg) = 30 $\phi' = 36°$ (See correlation, this appendix)

Considering these methods, design strength for the sand and gravel layer:

$\phi' = 35°$, $c' = 0$

PLATE 19

BBCM SOLUTIONS TO BUILD ON
Cincinnati (513) 771-8471
Cleveland (216) 901-1000
Columbus (614) 793-2226
Dayton (937) 424-1011

Project/Proposal No. GH-11997-019 Calculated By JDR Date 12/31/09
Project/Proposal Name Picway Dike Eval. Checked By CK Date 1/25/10
Subject Strength + Perm. Parameters Sheet 8 of

Layer: Sand and Gravel (cont.)

- Permeability

) GeoSyntec (1991)

$k_s = 1 \times 10^{-3}$ cm/s (See Correlation this appendix)

- Based off d_{15} values from grain-size analyses

Considering the results of the grain-size analyses and available information on grain-size analysis, use

$k_v = 1 \times 10^{-3}$ cm/s $= 3.28 \times 10^{-5}$ ft/s

PLATE 20

Layer: Clayey Silt (B-0904 & B-0905)

Note:

i.) This layer will be assumed to be drained for all analyses due to high sand content

Description: Gy cl si, sm f-c sa, tr f gr

Hand Penetrometer Results = 4.5+

B-0904 (34.4 - 35.0'); B-0905 (15.5 - 20')

S-19B
No Testing

S-7
33.3% Sand, 43% Silt, 18.7% Clay
MC = 10%, LL = 23, PL = 15, PI = 8

S-8
No testing

- Drained Strength Parameter Estimates

1) Stark Charts

CF ≤ 20

σ_{vo}'	Φ'
50	33°
100	32°
400	31°

2) Terzaghi, Peck, & Mesri (1996)

PI = 8, $\Phi' = 34°$

Design Strength Parameters:

Use $c' = 0, \quad \Phi' = 32°$

PLATE 21

Job Number: 011-11497-019
Job Name: AEP Pirway Plant Dike Evaluation

Layer: Sand and Gravel

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Effective Particle Size, mm						%Fines
													d_{60}	d_{50}	d_{30}	d_{15}	d_{10}	Cu	#200 Sieve
B-0904	15B	692.85	Me-de br f-c gr, sm to "and" f-c sa, lit si, wet	23.6	669.25	24.6	6	8	2060	3012.6	144.2	2066							
B-0904	16	692.85	Me-de br f-c gr, sm to "and" f-c sa, lit si, wet	25	666.85	24.6	18	25	3250	3162.4	151.4	2066	3.409	2.030	0.300	0.028	0.015	224.299	24.27
B-0904	17	692.85	Me-de br f-c gr, sm to "and" f-c sa, lit si, wet	28.5	664.35	24.6	24	33	3582.5	3318.4	158.9	2068							
B-0904	18	692.85	Me-de br f-c gr, sm to "and" f-c sa, lit si, wet	31	661.85	24.6	25	35	3875	3474.4	166.4	2068							
B-0904	19A	692.85	Me-de br f-c gr, sm to "and" f-c sa, lit si, wet	33.5	659.35	24.6	24	33	4167.5	3630.4	173.8	2068							
B-0905	2	675.2	Lo br f-c sa "and" cl si	3.5	671.7	7.5	6	8	437.5	687.9	32.9	2065							
B-0905	3	675.2	Me-de br f-c gr, sm to "and" f-c sa, lit si, tr c, wet	6	669.2	7.5	8	12	750	843.9	40.4	2066							
B-0905	4	675.2	Me-de br f-c gr, sm to "and" f-c sa, lit si, tr c, wet	8.5	666.7	7.5	17	24	1062.5	999.9	47.9	2066	7.372	3.332	0.750	0.050	0.022	342.893	17.76
B-0905	5	675.2	V-de br f-c gr, sm to "and" f-c sa, lit si	11	664.2	7.5	50	100	1375	1155.9	55.3	2066							
B-0905	6	675.2	V-de br f-c gr, sm to "and" f-c sa, lit cl	13.5	661.7	7.5	48	66	1687.5	1311.9	62.8	2066							
B-0906	16	690	Me-de-de br f-c gr, lit to sm f-c sa, lit si	28.5	661.5	25.4	18	25	3562.5	3368.4	161.3	2060							
B-0906	17	690	Me-de-de br f-c gr, lit to sm f-c sa, lit si	31	659	25.4	26	39	3875	3524.4	168.8	2066	6.078	4.809	0.700	0.075			14.93
B-0906	18	690	Me-de-de br f-c gr, lit to sm f-c sa, lit si	33.5	656.5	25.4	26	36	4187.5	3680.4	176.2	2066							
B-0907	15	692.38	Me-de br f-c gr, sm f-c sa, lit si	28.5	663.88	25.5	11	15	3562.5	3374.7	161.6	2066	12.642	7.420	1.900	0.150			13.3
B-0907	17	692.38	Me-de br f-c sa, lit to sm f gr, lit si	31	661.38	25.5	21	29	3875	3530.7	169.1	2066							
B-0907	18	692.38	Me-de br f-c sa, lit to sm f gr, lit si	33.5	658.88	25.5	23	32	4187.5	3686.7	176.5	2066							
B-0908	5	674.25	Me-de br f-c sa, sm to "and" f-c gr, tr to lit si	11	663.25	6	12	17	1375	1187.2	56.8	2066							
B-0908	6	674.25	Me-de br f-c sa, sm to "and" f-c gr, tr to lit si	13.5	660.75	8	14	19	1687.5	1343.2	64.3	2066	3.395	2.200	0.800	0.140	0.039		13.05
B-0908	7	674.25	Me-de br f-c sa, sm to "and" f-c gr, tr to lit si	16	658.25	8	6	11	2000	1499.2	71.8	2066							
B-0908	8	674.25	Me-de br & gy f-c sa, lit f-c gr, lit si	18.5	655.75	8	7	10	2312.5	1655.2	79.3	2067							
B-0908	9	674.25	Me-de br & gy f-c sa, lit f-c gr, tr si	21	653.25	8	8	11	2625	1811.2	86.7	2067							
B-0908	10	674.25	Me-de lo de gy f-c sa, lit to sm f-c gr, tr to lit si	23.5	650.75	8	21	29	2937.5	1967.2	94.2	2067	2.637	1.644	0.700	0.120			13.41
B-0908	11	674.25	Me-de lo de gy f-c sa, lit to sm f-c gr, tr to lit si	26	648.25	8	27	37	3250	2123.2	101.7	2067							
B-0908	12	674.25	Me-de lo de gy f-c sa, lit to sm f-c gr, tr to lit si	28.5	645.75	8	26	38	3562.5	2279.2	109.1	2067							
B-0909	15B	692.81	Me-de lo de br f-c gr, sm to "and" f-c sa, tr to lit si	26.3	666.51	28.5	11	15	3287.5	3425.2	164.0	2068							
B-0909	16	692.81	Me-de lo de br f-c gr, sm to "and" f-c sa, tr to lit si	28.5	664.31	28.5	35	46	3562.5	3562.5	170.6	2068							

PLATE 22

B-0909	17	692.81	Me-de to de br f-c gr, sm to "and" f-c sa, tr to lt si	31	661.81	28.5	20	28	3875	3718.5	178.0	2066							
B-0909	18	692.81	Me-de to de br f-c gr, sm to "and" f-c sa, tr to lt s	33.5	659.31	28.5	29	40	4187.5	3874.5	185.5	2066							
B-0909	19	692.81	Me-de to de br f-c gr, sm to "and" f-c sa, tr to lt s	36	656.81	28.5	29	40	4500	4030.5	193.0	2066							
B-0910	4	673.68	Me-de to de br f-c gr, sm to "and" f-c sa, lt si, tr cl	8.5	665.18	6.5	23	32	1062.5	937.3	44.9	2066	11.865	4.035	0.600	0.070	0.024		15.7
B-0910	5	673.68	Me-de to de br f-c gr, sm to "and" f-c sa, lt si, tr cl	11	662.68	6.5	20	28	1375	1093.3	52.3	2066							
B-0910	6	673.68	Me-de to de br f-c gr, sm to "and" f-c sa, lt si, tr cl	13.5	660.18	6.5	26	39	1687.5	1249.3	59.8	2066							
B-0911	6	679.36	Me-de to de br f-c sa "and" f-c gr, lt si	13.5	665.86	14	13	18	1687.5	1718.6	82.3	2066							
B-0911	7	679.36	Me-de to de br f-c sa "and" f-c gr, lit si	16	663.36	14	16	30	2000	1874.8	89.8	2066	4.015	2.144	0.400	0.075			15.07
B-0911	8	679.36	Me-de to de br f-c sa "and" f-c gr, lit si	18.5	660.86	14	15	21	2312.5	2030.8	97.2	2066							
							Min. N60 =	8											
							Max. N60 =	66											
							Avg. N60 =	30											
							N60 Mode =	38											
													8	8	8	8	4		8
													2.6	1.6	0.3	0.0	0.0		13.1
													12.6	7.4	1.9	0.2	0.0		24.3
													6.7	3.5	0.8	0.1	0.0		15.9
													5.7	2.8	0.7	0.1	0.0		15.0
													#N/A	#N/A	0.7	0.075	#N/A		#N/A
													3.93068	1.95628	0.48697	0.04355	0.00889		3.7082608

Key

GWT	Ground Water Table
Elevation	Feet above Mean Sea Level
N	Standard Penetration Test (blows per foot)
N_{60}	Standard Penetration Test for 60 percent engergy ratio (blows per foot)
σ_v	Normal Stress
σ'_{vo}	Effective Normal Stress (In situ)
P_a	Atmospheric Pressure (2110.2 psf at Sea Level)
D_r	Relative Density

d_{60}	Effective particle size for 60 percent passing
d_{50}	Effective particle size for 50 percent passing
d_{30}	Effective particle size for 30 percent passing
d_{15}	Effective particle size for 15 percent passing
d_{10}	Effective particle size for 10 percent passing
C_u	Uniformity Coefficient (d_{60} / d_{10})

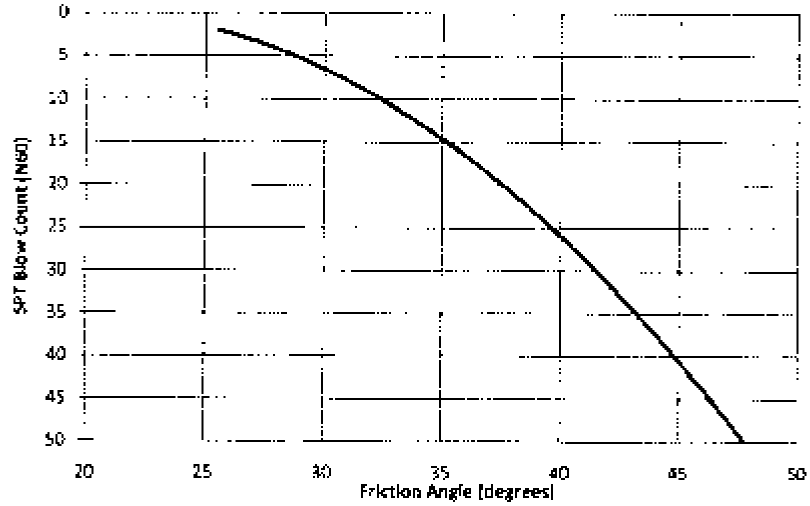
PLATE 23

BBCM
SOLUTIONS TO BUILD ON

SHEAR STRENGTH CORRELATION FOR COHESIONLESS SOILS

Method: Hatanaka and Uchida, 1996
Source: FHWA GEC No 5: Equation 72, pg 184

Equation: $\phi' = \sqrt{15.4(N_1)_{60}} + 20^\circ$



Layer: **Sand and Gravel**

Boring	*Sample*	N_{60}	ϕ'
B-0904	15B	8	31.1
B-0904	16	25	39.6
B-0904	17	33	42.5
B-0904	18	35	43.2
B-0904	19A	33	42.5
B-0905	2	8	31.1
B-0905	3	12	33.6
B-0905	4	24	39.2
B-0905	5	100	59.2
B-0905	6	66	51.9
B-0906	16	25	39.6
B-0906	17	39	44.5
B-0906	18	36	43.5
B-0907	16	15	35.2
B-0907	17	29	41.1
B-0907	18	32	42.2
B-0908	5	17	36.2
B-0908	6	19	37.1
B-0908	7	11	33.0
B-0908	8	10	32.4
B-0908	9	11	33.0
B-0908	10	29	41.1
B-0908	11	37	43.9
B-0908	12	36	43.5
B-0909	15B	15	35.2
B-0909	16	48	47.2
B-0909	17	28	40.8
B-0909	18	40	44.8
B-0909	19	40	44.8
B-0910	4	32	42.2
B-0910	5	28	40.8
B-0910	6	39	44.5
B-0911	6	18	36.6
B-0911	7	36	43.5
B-0911	8	21	38.0

Average 40.5

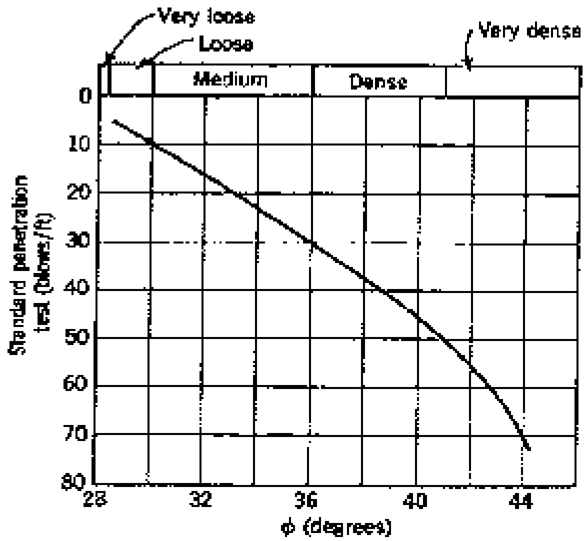
PLATE 24

BBCM
SOLUTIONS TO BUILD ON

SHEAR STRENGTH CORRELATION FOR COHESIONLESS SOILS

Method: Peck, Hanson, and Thornburn, 1953
Source: Lambe and Whitman, 1969. Figure 11.14

Equation Graphic



Layer: **Sand and Gravel**

Boring	Sample	N_{60}	φ'
B-0904	15B	8	29.0
B-0904	16	25	35.0
B-0904	17	33	36.5
B-0904	18	35	37.0
B-0904	19A	33	36.5
B-0905	2	8	29.0
B-0905	3	12	29 3
B-0905	4	24	34 0
B-0905	5	100	44.0
B-0905	6	66	43.3
B-0906	16	25	35.0
B-0906	17	39	38.5
B-0906	18	36	38 0
B-0907	16	15	31 8
B-0907	17	29	35 5
B-0907	18	32	36 5
B-0908	5	17	32 0
B 0908	6	10	33 0
D-0908	7	11	30.3
B-0908	8	10	30.0
B-0908	9	11	30.3
B-0908	10	29	35.5
B-0908	11	37	38.0
B-0908	12	36	37 7
B-0909	15B	15	31.8
B-0909	16	48	40.3
D-0909	17	28	35 5
B-0909	18	40	37.5
B-0909	19	40	37.5
B-0910	4	32	36 5
B-0910	5	28	35.5
B-0910	6	39	38.5
B-0911	6	18	32.3
B-0911	7	36	38.0
D-0911	8	21	33.2

Average 35.2

PLATE 25

BBCM
SOLUTIONS TO BUILD ON

SHEAR STRENGTH CORRELATION FOR COHESIONLESS SOILS

Method: Meyehoff, 1956
Source: FHWA GEC No 5: Equation 73, pg 184

State of Packing	Relative Density (%)	Standard Penetration Resistance, N (blows/300 mm)	Friction angle, φ' (°)
Very loose	<20	<4	< 30
Loose	20-40	4-10	30-35
Compact	40-60	10-30	35-40
Dense	60-80	30-50	40-45
Very dense	>80	>50	>45

Note: N = 15 + (N' - 15) / 2 for N' > 15 in saturated very fine or silty sand, where N' = measured blow count and N = blow count corrected for dynamic pore pressure effects during the SPT.

Method: Bowles, 1988
Source: Foundation Analysis and Design, 4th Ed. Table 3-4

Empirical values for ϕ, D_r, and unit weight of granular soils based on the SPT at about 6 m depth and normally consolidated

Description		Very loose	Loose	Medium	Dense	Very dense
Relative density D_r		0	0.15	0.35	0.65	0.85
SPT N'_{70}:	fine	1-2	3-6	7-15	16-30	?
	medium	2-3	4-7	8-20	21-40	> 40
	coarse	3-6	5-9	10-25	26-45	> 45
ϕ:	fine	26-28	28-30	30-34	33-38	
	medium	27-28	30-32	32-36	36-42	< 50
	coarse	28-30	30-34	33-40	40-50	
γ_{wet}, pcf		70-100†	90-115	110-130	110-140	130-150
(kN/m³)		(11-16)	(14-18)	(17-20)	(17-22)	(20-23)

† Excavated soil or material dumped from a truck will weigh 11 to 14 kN/m³ and must be quite dense to weigh much over 21 kN/m³. No existing soil has a D_r = 0.00 nor a value of 1.00—common ranges are from 0.3 to 0.7.

Method: Schroeder, Dickenson, and Warrington
Source: Soils In Construction, 5th Ed. Table 7.1

N60 (Avg) = 29.5
φ' = 35-36 ✓

TABLE 7.1 Relative Density of Cohesionless Soils

Relative Density Designation	γ moist (pcf)	*Approximate Relative Density, %*	*N_{60} Standard Penetration Resistance*	*Approximate Angle of Friction of Soil φ, degrees*
Very loose	?0 - 100	0-5	0-4	25-28
Loose	90 - 115	5-30	4-10	28-30
Medium	110 - 130	30-60	10-30	30-36
Dense	110 - 140	60-85	30-50	36-41
Very dense	130 - 150	>85	Over 50	>41

BBCM SOLUTIONS TO BUILD ON	RANGE OF HYDRAULIC CONDUCTIVITY BASED ON GRAIN SIZE

Method: Geosyntec
Source: FHWA GEC No 5: pg 184

Equation: Graphic

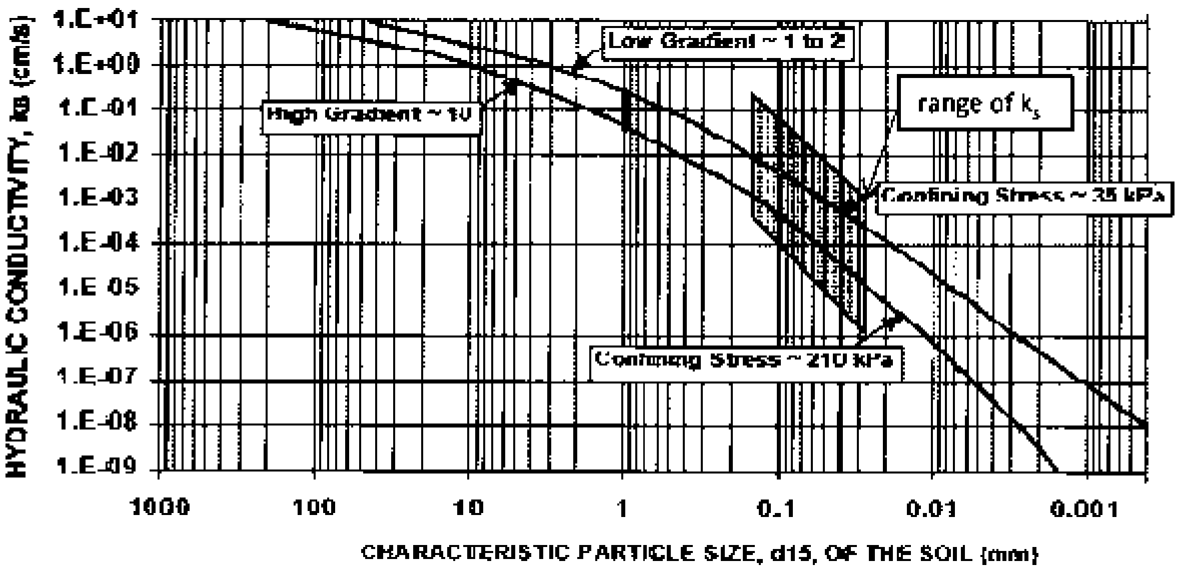


Figure 91. Range of hydraulic conductivity based on grain size (after GeoSyntec, 1991).

Layer: Sand and Gravel

Boring	Sample	d_{15}
B-0904	16	0.028
B-0905	4	0.050
B-0906	17	0.075
B-0907	16	0.150
B-0908	6	0.140
B-0908	10	0.120
B-0910	4	0.070
B-0911	7	0.075

Average: 0.089

use k_s = 1.0E-03 cm/s = 3.28E-05 ft/s

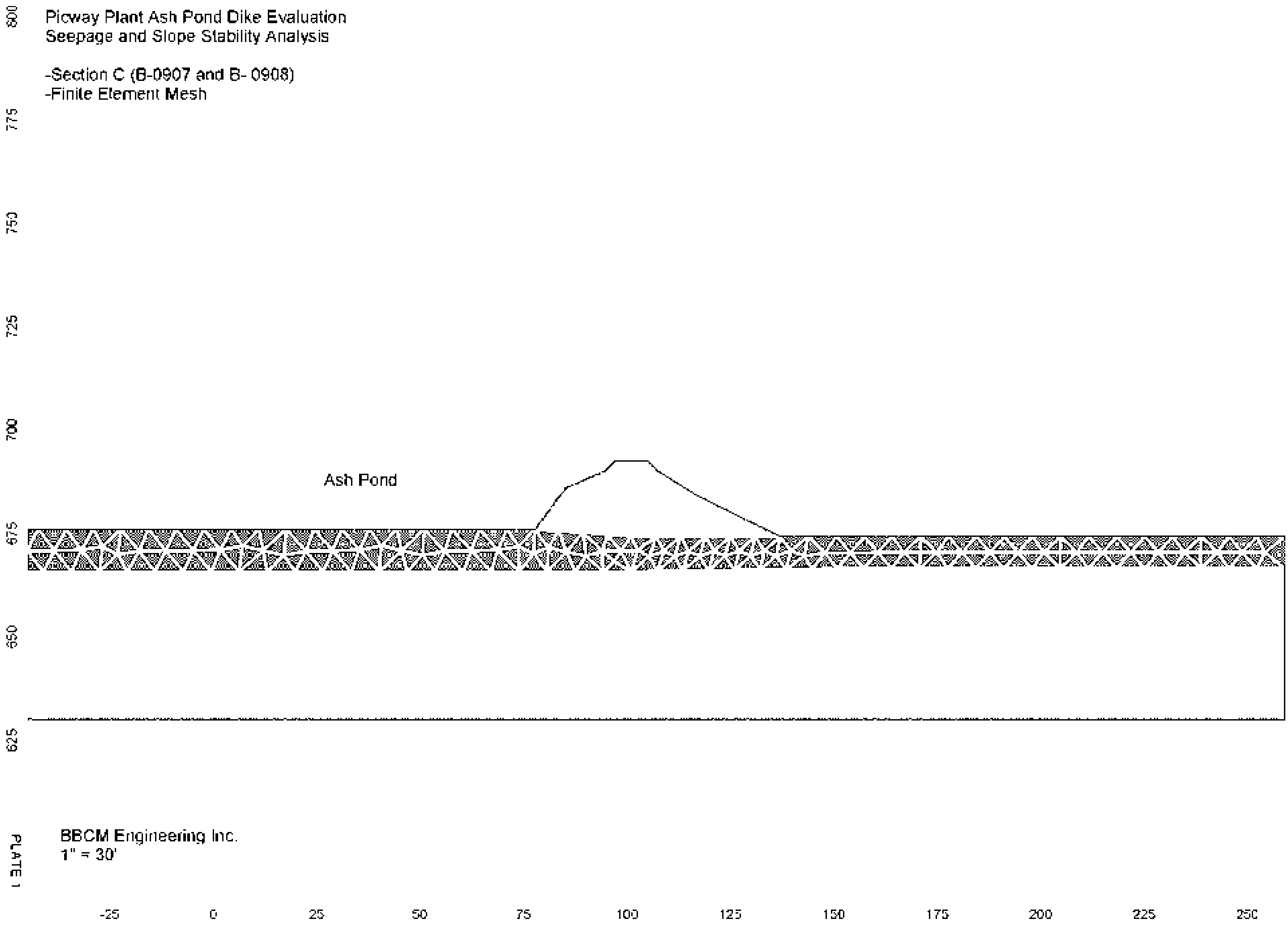
PLATE 27

APPENDIX D

Seepage and Slope Stability Analysis

Picway Plant Ash Pond Dike Evaluation
Seepage and Slope Stability Analysis

-Section C (B-0907 and B- 0908)
-Finite Element Mesh



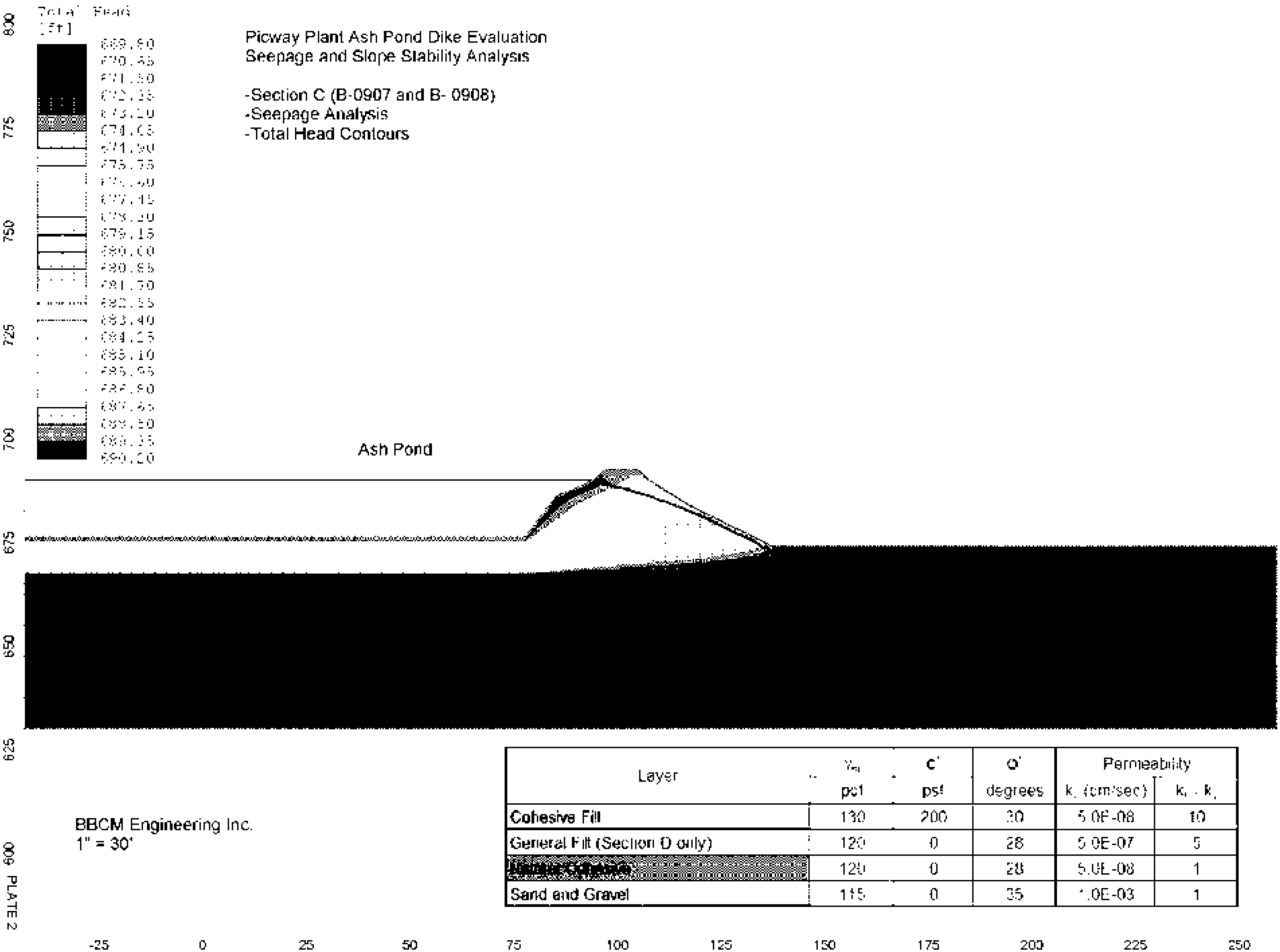
BBCM Engineering Inc.
1" = 30'

PLATE 1

AEPPIP000130

Picway Plant Ash Pond Dike Evaluation
Seepage and Slope Stability Analysis

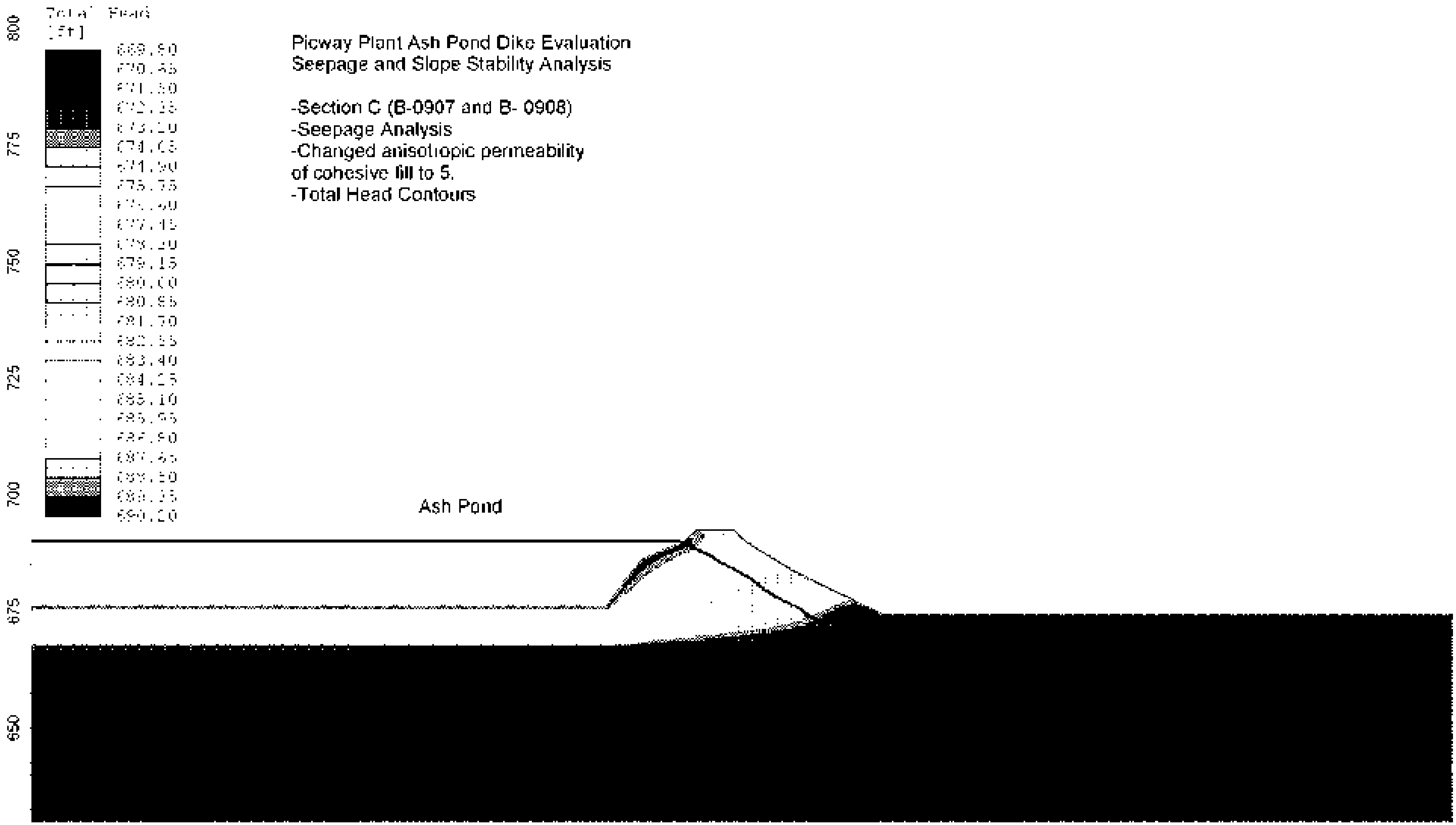
-Section C (B-0907 and B- 0908)
-Seepage Analysis
-Total Head Contours



Layer	γ_{sat} pcf	c' psf	φ' degrees	Permeability k_v (cm/sec)	k_h / k_v
Cohesive Fill	130	200	30	5.0E-08	10
General Fill (Section D only)	120	0	28	5.0E-07	5
[illegible]	120	0	28	5.0E-08	1
Sand and Gravel	115	0	35	1.0E-03	1

BBCM Engineering Inc.
1" = 30'

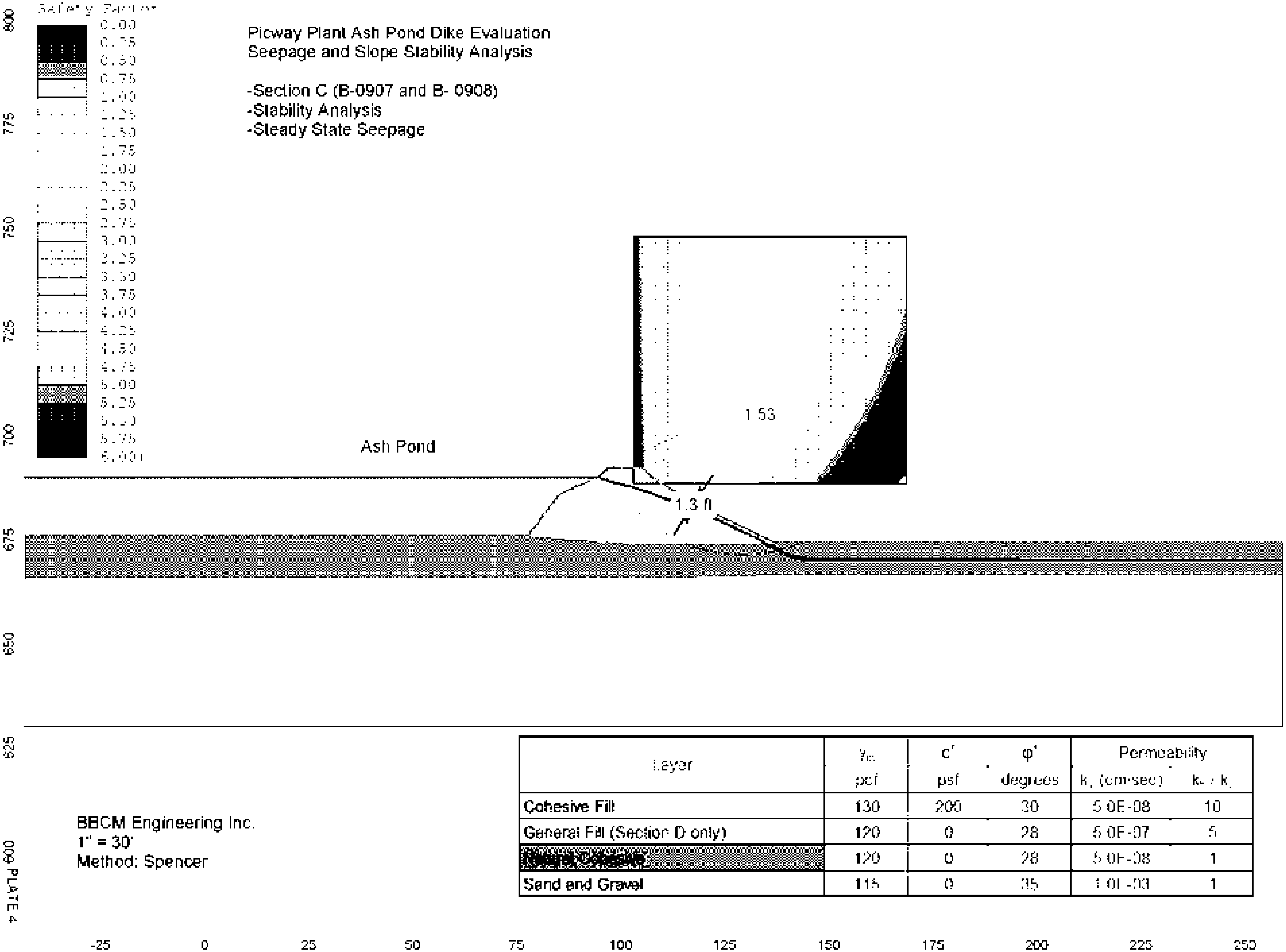
PLATE 2



Layer	γ_m	c'	φ'	Permeability	
	pcf	psf	degrees	k_v (cm/sec)	k_h / k_v
Cohesive Fill	130	200	30	5.0E-08	5
General Fill (Section D only)	120	0	28	5.0E-07	5
Natural Cohesive	120	0	28	5.0E-08	1
Sand and Gravel	115	0	35	1.0E-03	1

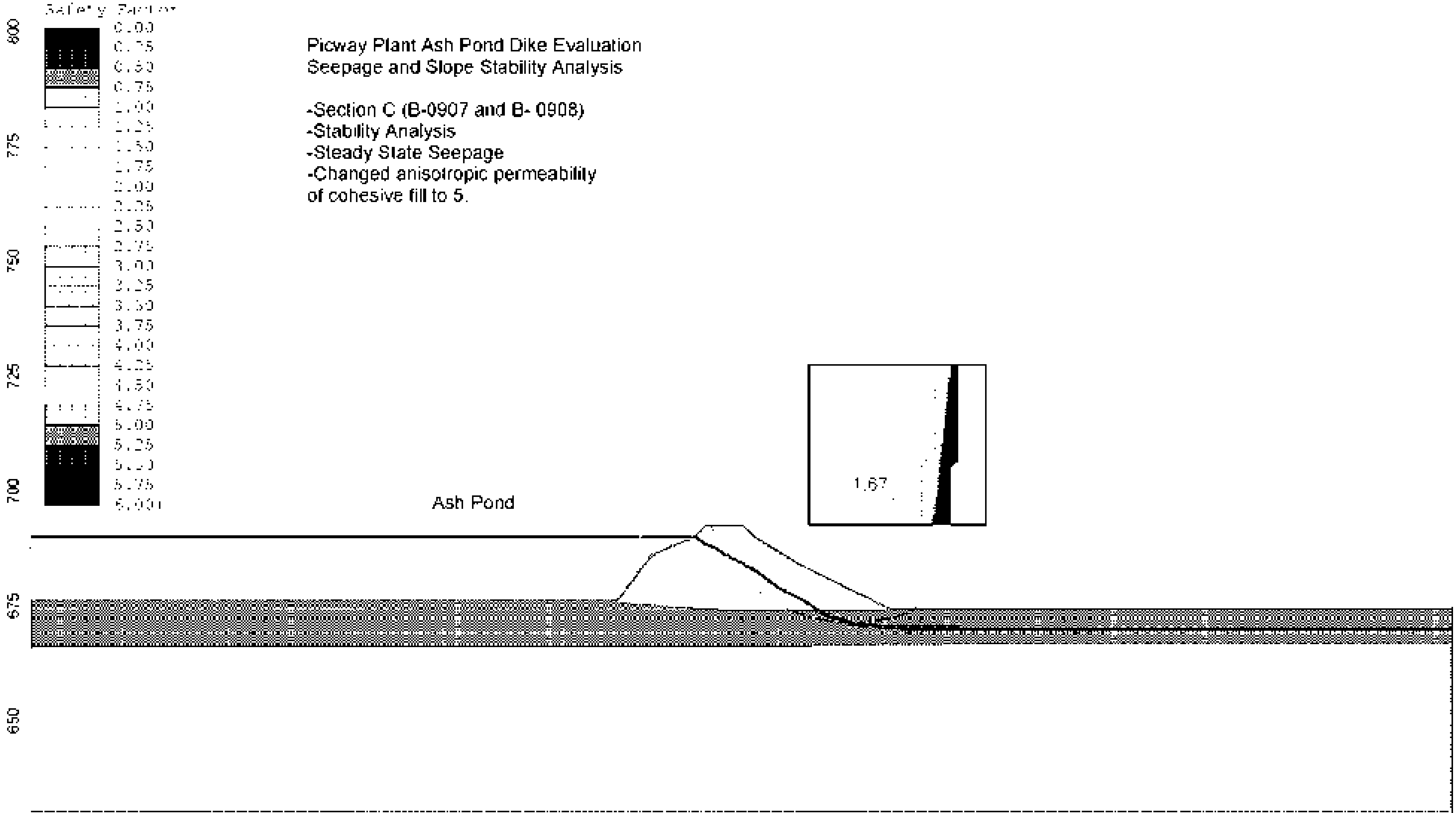
BBCM Engineering Inc.
1" = 30'

PLATE 3



Layer	γ_m	c'	φ'	Permeability	
	pcf	psf	degrees	k_h (cm/sec)	k_h/k_v
Cohesive Fill	130	200	30	5.0E-08	10
General Fill (Section D only)	120	0	28	5.0E-07	5
Natural Cohesive	120	0	28	5.0E-08	1
Sand and Gravel	115	0	35	1.0E-03	1

AEPPIP000133



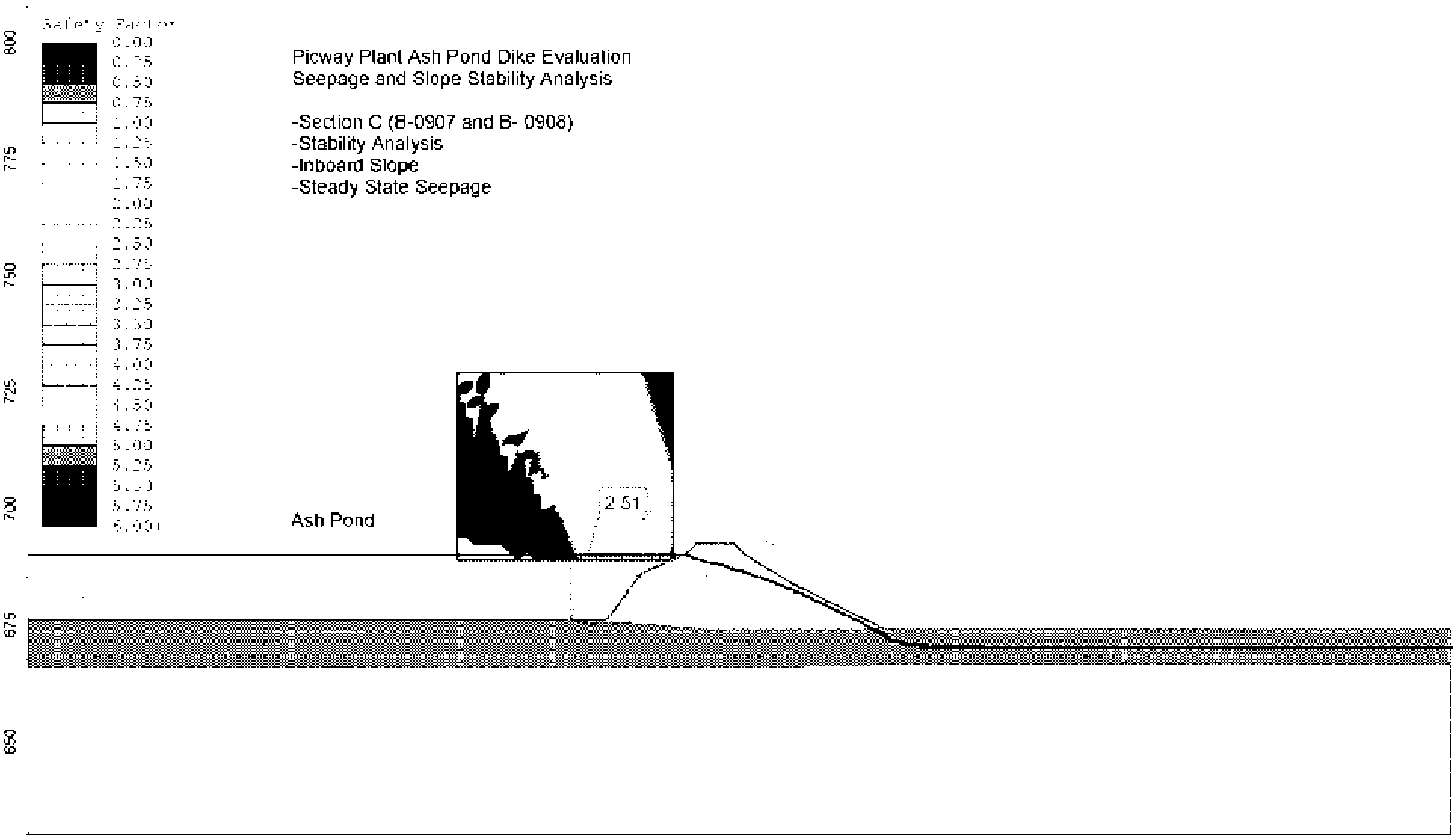
Layer	γ_m	c'	φ'	Permeability	
	pcf	psf	degrees	k_v (cm/sec)	k_h / k_v
Cohesive Fill	130	200	30	5.0E-08	5
General Fill (Section D only)	120	0	28	5.0E-07	5
Natural Cohesive	120	0	28	5.0E-08	1
Sand and Gravel	115	0	35	1.0E-03	1

BBCM Engineering Inc.
1" = 30'

600 PLATE 5

-25 0 25 50 75 100 125 150 175 200 225 250

AEPPIP000134

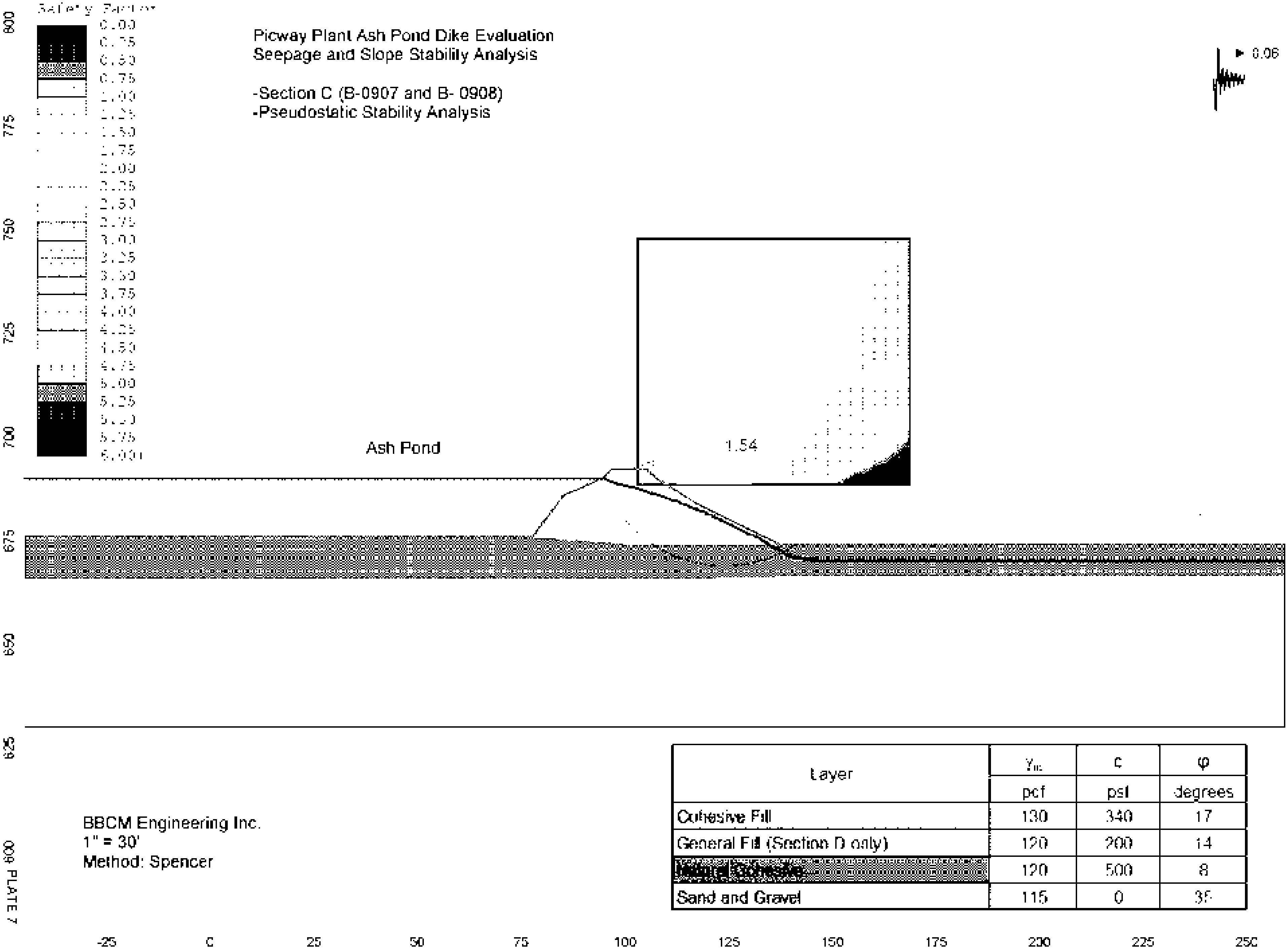


Layer	γ pcf	c' psf	φ' degrees	Permeability k_1 (cm/sec)	k_2/k_1
Cohesive Fill	130	200	30	5.0E-08	10
General Fill (Section D only)	120	0	28	5.0E-07	5
Natural Cohesive	120	0	28	5.0E-08	1
Sand and Gravel	115	0	35	1.0E-03	1

BBCM Engineering Inc.
1" = 30'
Method: Spencer

PLATE 5

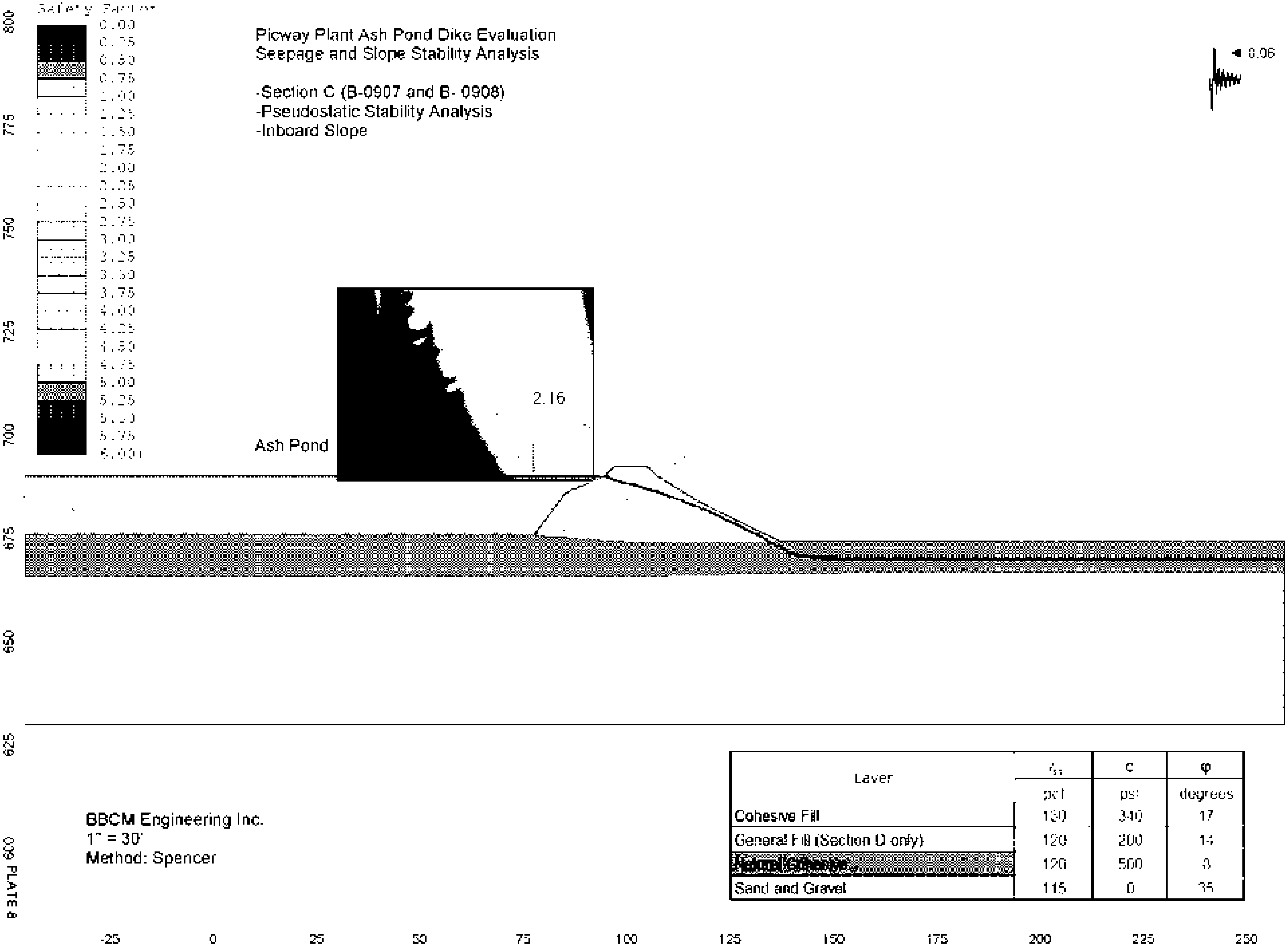
-25 0 25 50 75 100 125 150 175 200 225 250



Layer	γ_m	c	φ
	pcf	psf	degrees
Cohesive Fill	130	340	17
General Fill (Section D only)	120	200	14
Natural Cohesive	120	500	8
Sand and Gravel	115	0	35

Picway Plant Ash Pond Dike Evaluation
Seepage and Slope Stability Analysis

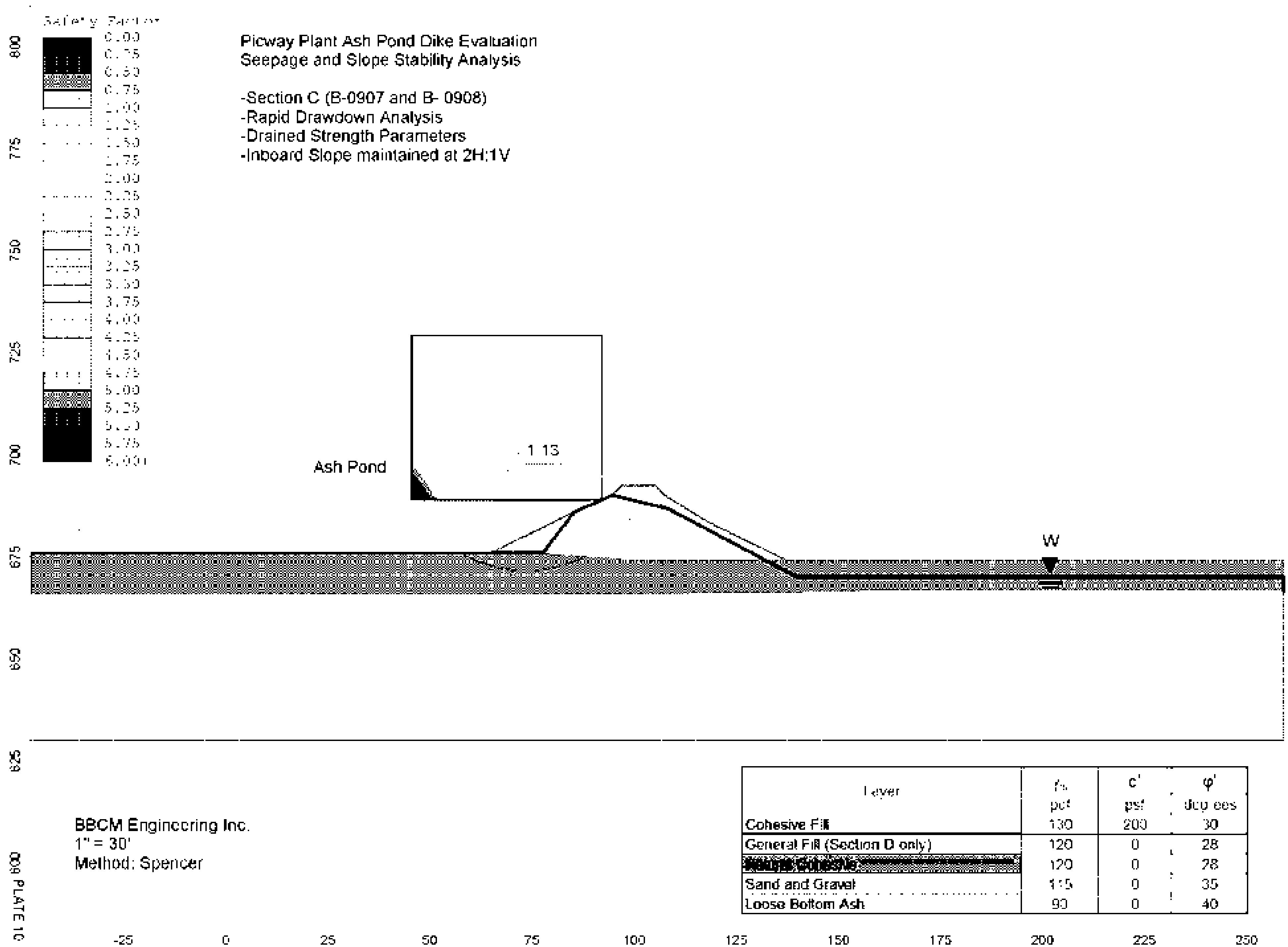
-Section C (B-0907 and B- 0908)
-Pseudostatic Stability Analysis
-Inboard Slope



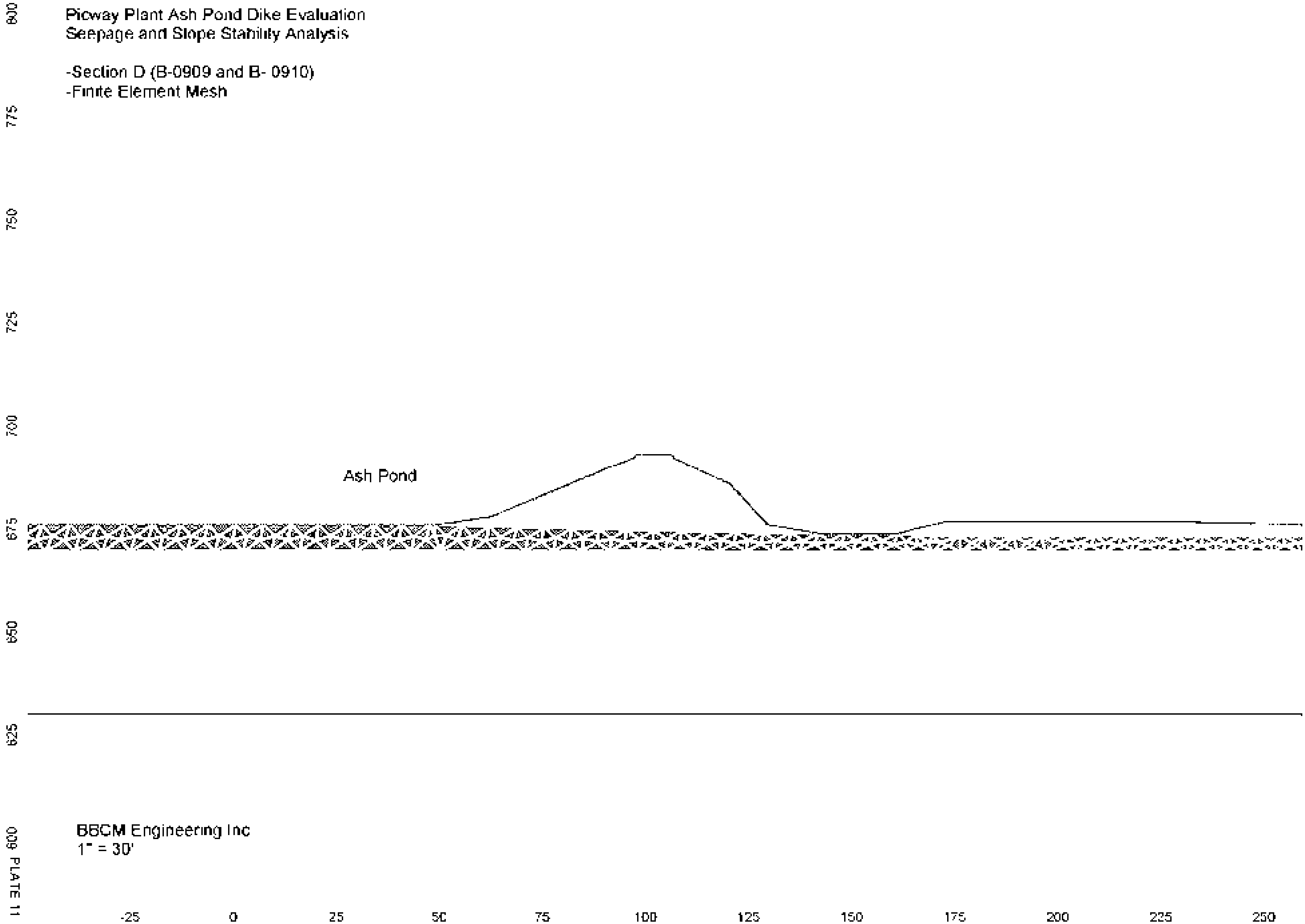
Layer	γ_{sat}	c	φ
	pcf	psf	degrees
Cohesive Fill	130	340	17
General Fill (Section D only)	120	200	14
Natural Cohesive	120	500	0
Sand and Gravel	115	0	35

BBCM Engineering Inc.
1" = 30'
Method: Spencer

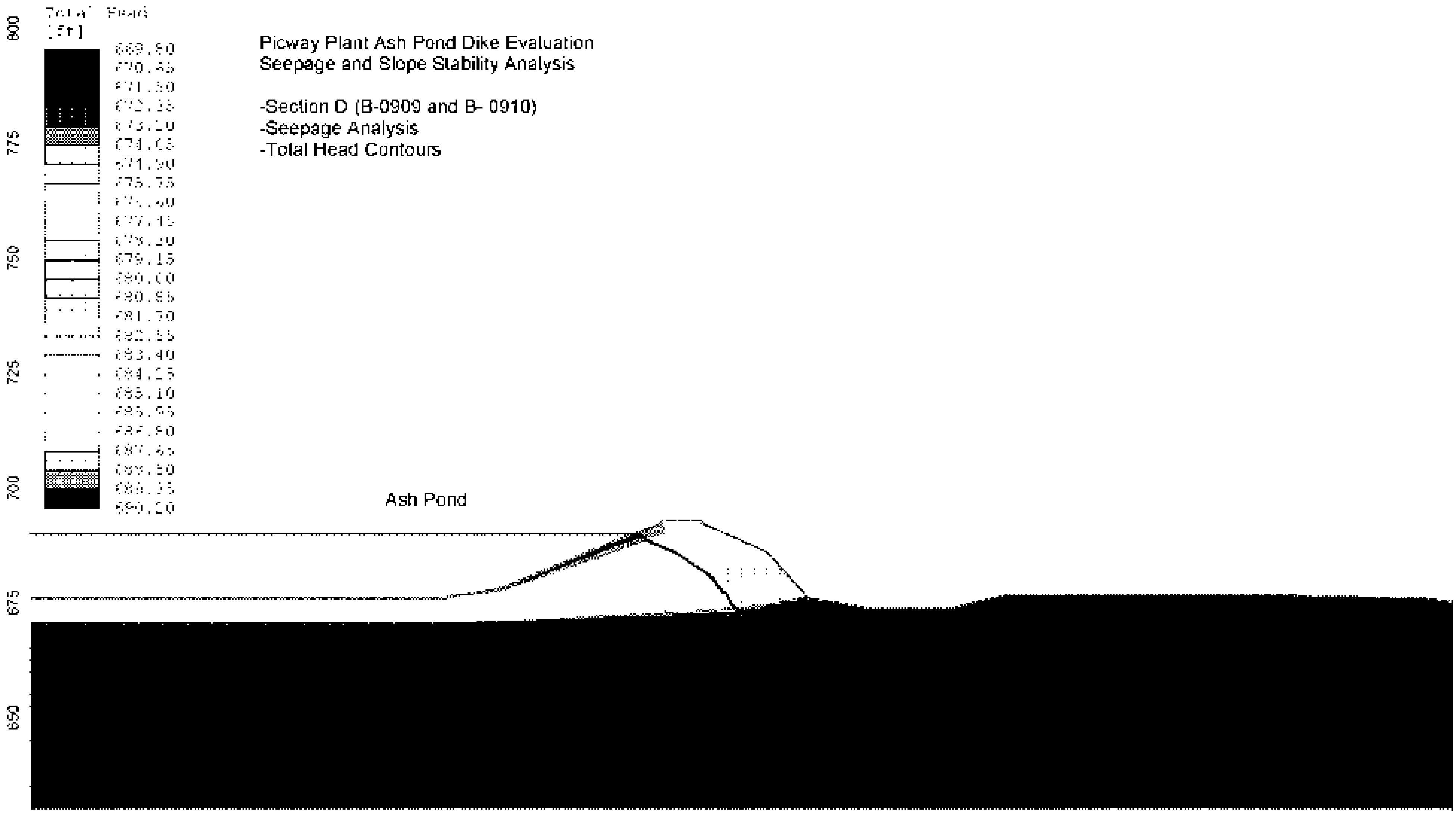
PLATE 8



Layer	γs pcf	c' psf	φ' degrees
Cohesive Fill	130	200	30
General Fill (Section D only)	120	0	28
Natural Cohesive	120	0	28
Sand and Gravel	115	0	35
Loose Bottom Ash	90	0	40



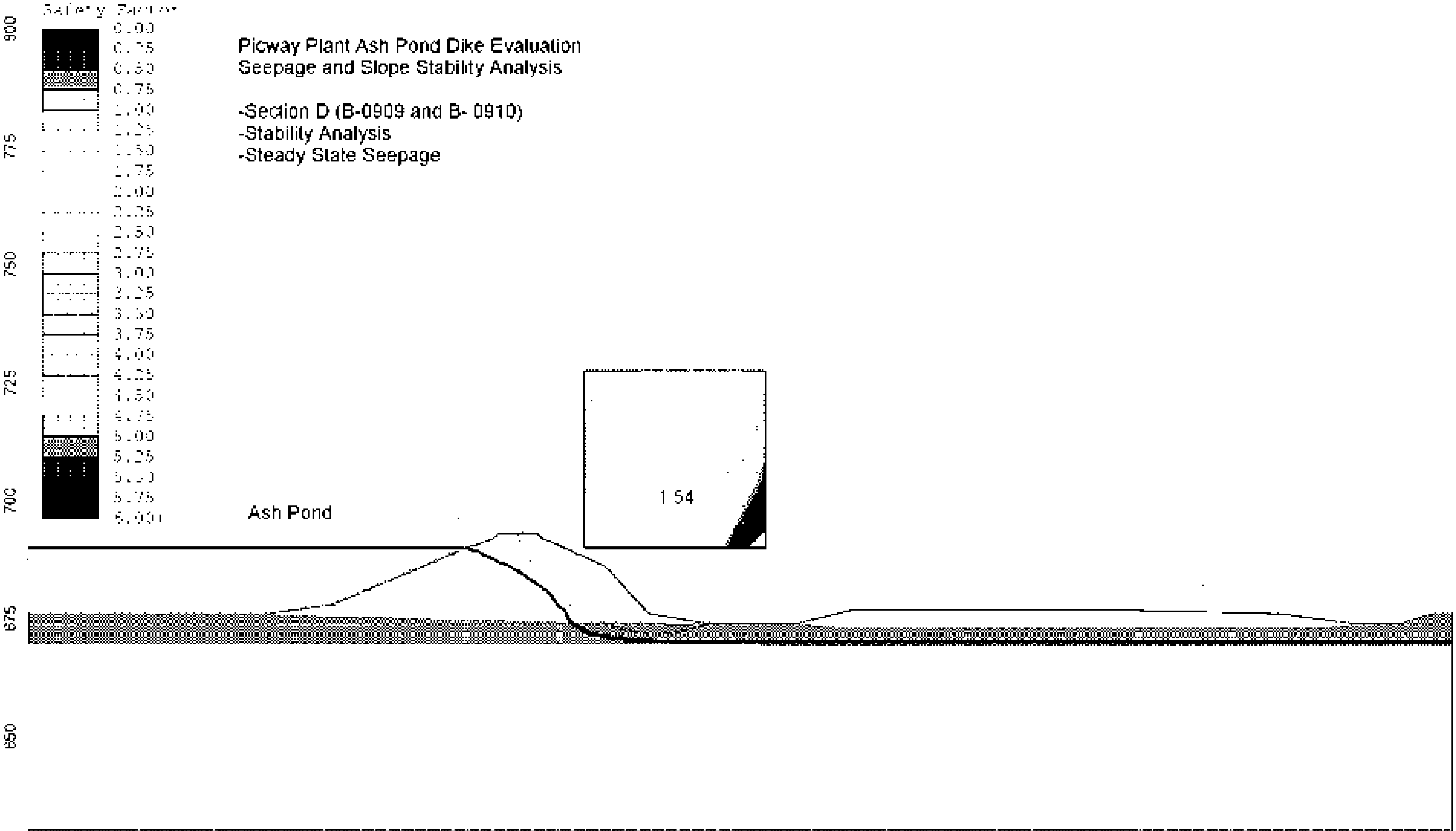
AEPPIP000139



BBCM Engineering Inc.
1" = 30'

Layer	γ_{sat}	c'	φ'	Permeability	
	pcf	psf	degrees	k (cm/sec)	k_h / k_v
Cohesive Fill	130	200	30	5.0E-08	10
General Fill (Section D only)	120	0	28	5.0E-07	5
Natural Cohesive	120	0	28	5.0E-08	1
Sand and Gravel	115	0	35	1.0E-03	1

PLATE 12

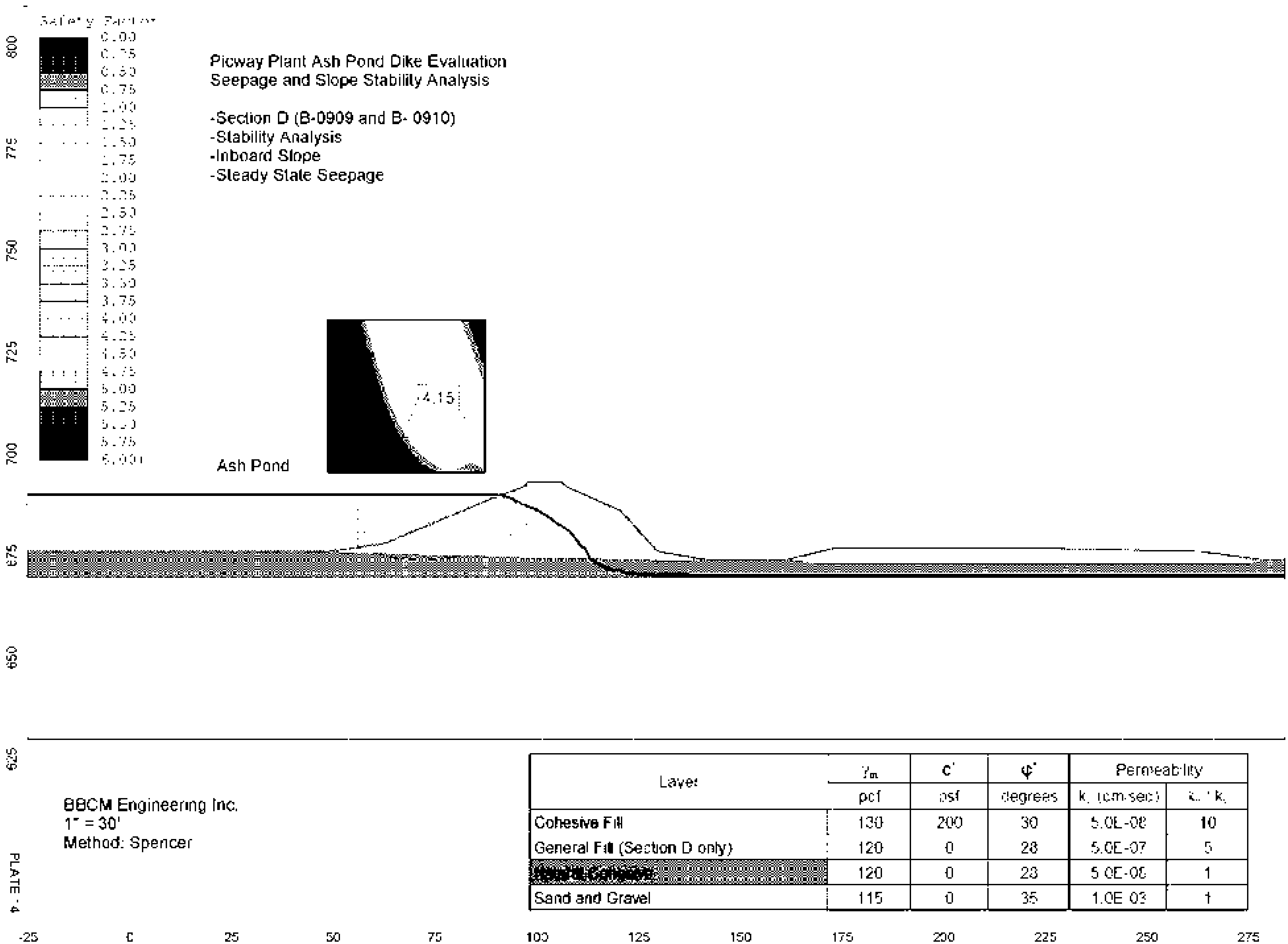


BBCM Engineering Inc.
1" = 30'
Method: Spencer

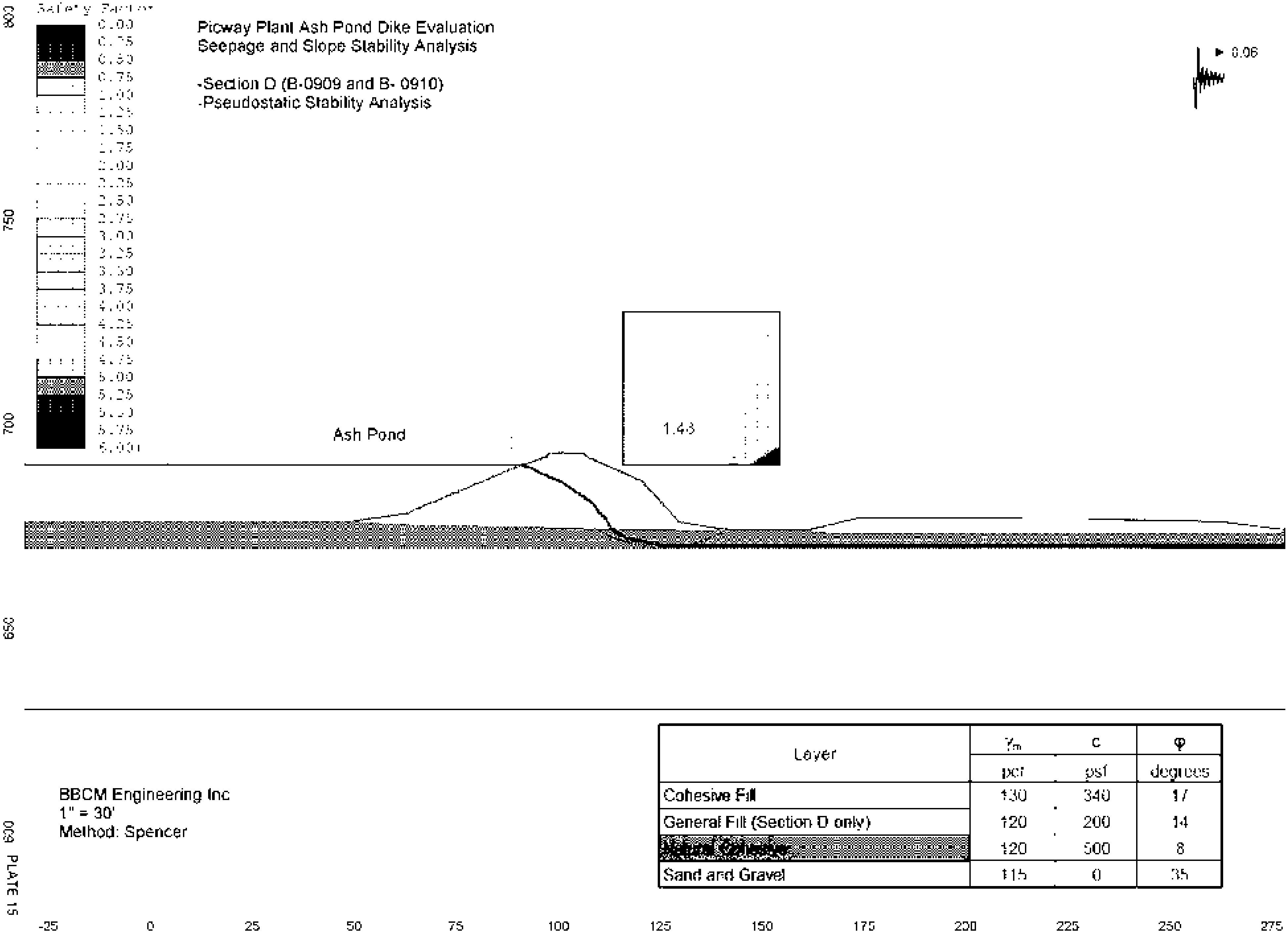
Layer	γ_m	c'	φ'	Permeability	
	pcf	psf	degrees	k_y (cm/sec)	k_x/k_y
Cohesive Fill	130	200	30	5.0E-08	10
General Fill (Section D only)	120	0	28	5.0E-07	5
Natural Cohesive	120	0	28	5.0E-08	1
Sand and Gravel	115	0	35	1.0E-03	1

PLATE 13

0 25 50 75 100 125 150 175 200 225 250 275 300

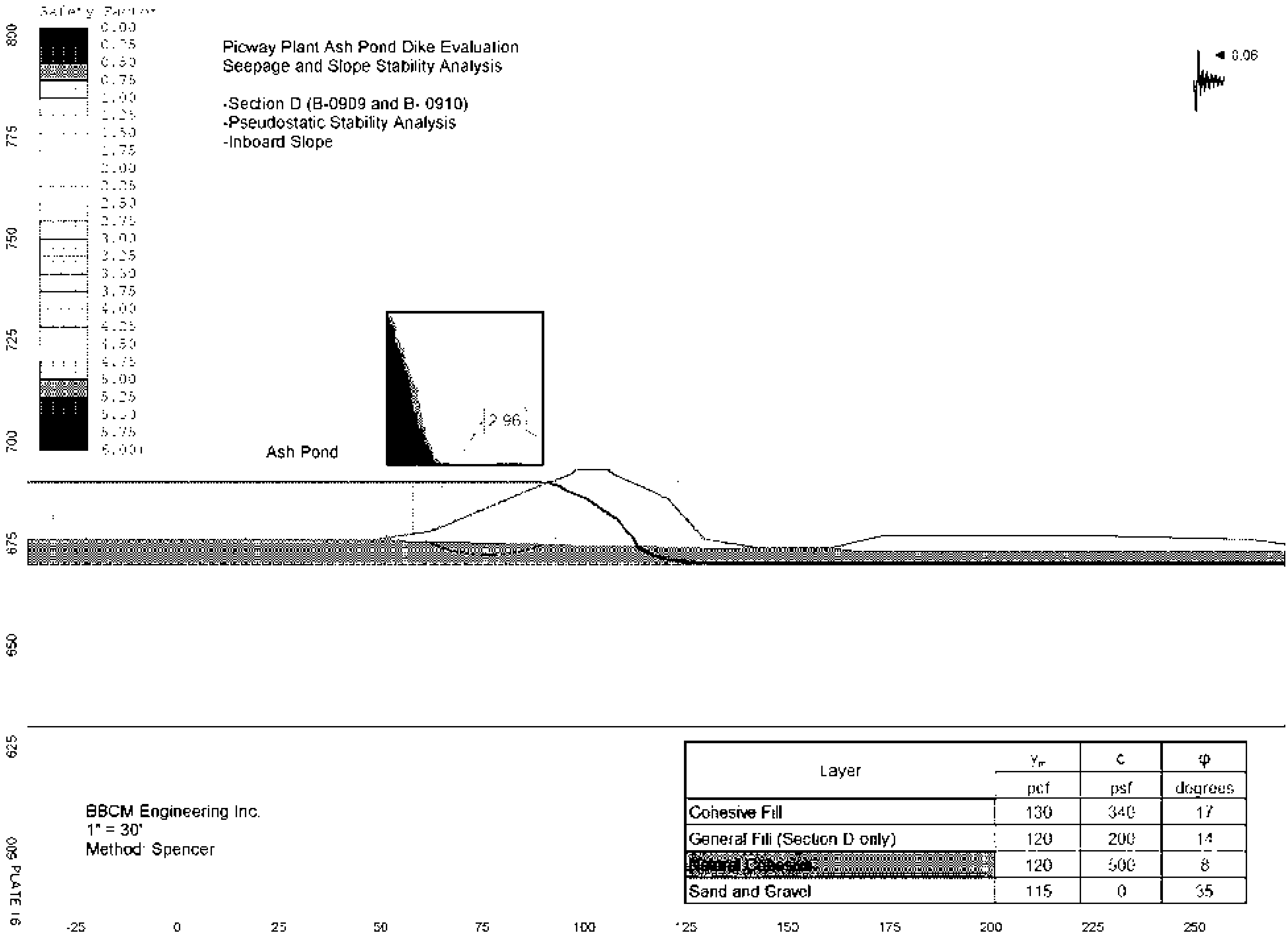


Layer	γ_m	c'	φ'	Permeability	
	pcf	psf	degrees	k_h (cm/sec)	k_h/k_v
Cohesive Fill	130	200	30	5.0E-08	10
General Fill (Section D only)	120	0	28	5.0E-07	5
Natural Cohesive	120	0	23	5.0E-06	1
Sand and Gravel	115	0	35	1.0E-03	1



Layer	γ_m	c	φ
	pcf	psf	degrees
Cohesive Fill	130	340	17
General Fill (Section D only)	120	200	14
Natural Cohesive	120	500	8
Sand and Gravel	115	0	35

PLATE 15



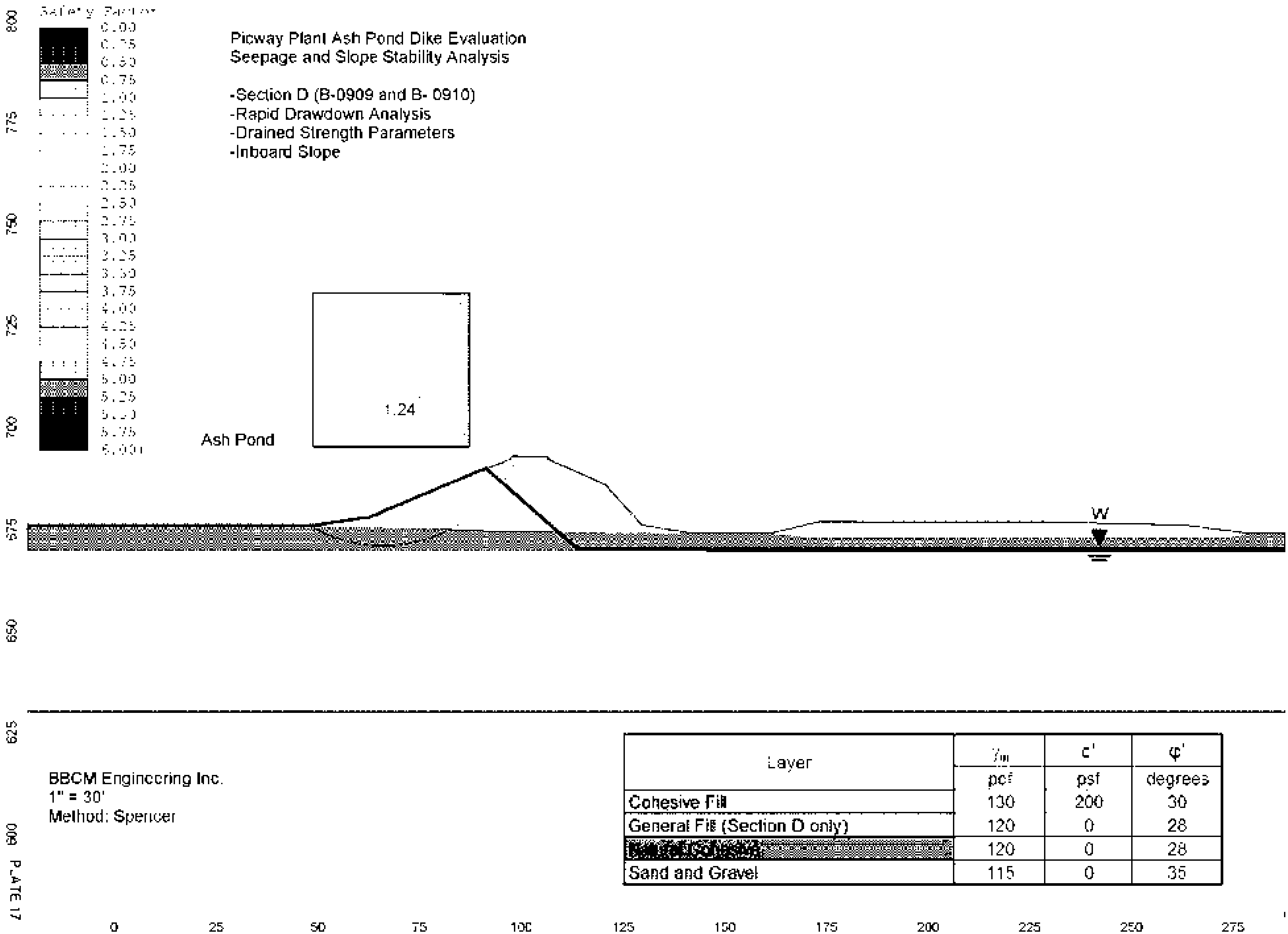
Picway Plant Ash Pond Dike Evaluation
Seepage and Slope Stability Analysis

-Section D (B-0909 and B- 0910)
-Pseudostatic Stability Analysis
-Inboard Slope

Layer	γ_m	c	φ
	pcf	psf	degrees
Cohesive Fill	130	340	17
General Fill (Section D only)	120	200	14
Natural Cohesive	120	500	8
Sand and Gravel	115	0	35

BBCM Engineering Inc.
1" = 30'
Method: Spencer

PLATE 16



Layer	γ_m	c'	φ'
	pcf	psf	degrees
Cohesive Fill	130	200	30
General Fill (Section D only)	120	0	28
Natural Cohesive	120	0	28
Sand and Gravel	115	0	35

APPENDIX E

August 2009 Investigation

Soil Boring and Monitoring Well Logs

LOG OF BORING NO. B-0901
AEP PICWAY PLANT ASH POND MONITORING WELLS
LOCKBOURNE, OHIO

BBCM

LOCATION N. 653,930: E. 1,826,464 (OH S) ELEVATION: 679.8 DATE 8/10/09 - 8/13/09
DRILLING METHOD 2-1/4" I.D. Hollow-stem Auger; 3-7/8" Tricone Bit COMPLETION DEPTH 97.1'
SAMPLER(S) 2" and 2-1/2" O.D. Split-barrel Samplers

ELEV.	DEPTH (FEET)	SAMPLE NUMBER	SAMPLE EFFORT	N	SAMPLE REC %	DESCRIPTION	TEST RESULTS
	0					TOPSOIL - 12 INCHES	
678.8 / 678.1		1	2 3 5 6	11	27	Very-stiff to hard brown clayey silt, trace fine to coarse sand, few roots, dry.	PP 3.8-4.5
		2	3 8 6 7	14	100	Very-stiff to hard brown silty clay, trace fine to coarse sand, few roots, dry.	PP 4.5
	5	3	3 4 7 10	15	93		PP 3.6-4.5
673.3		4A	2 4	15	100	Stiff to very-stiff brown silty clay, trace fine to coarse sand, damp becoming moist.	PP 2.7-3.4
		4B	7 8		73		PP 2.5-3.6
		5A	2 2	7	100		PP 1.2-1.9
		5B	3 4		77		PP 1.1-1.4
669.5	10	6A	2 2	7	100	Loose brown fine to coarse sand, little fine to coarse gravel, some silty clay, wet.	
		6B	3 5		50		
		7	5 2 3 4	7	13		
	15	8	10 12 7	26	80		
665.8		9	17 15 10 10	34	60	Loose brown and gray fine to coarse sand "and" fine to coarse gravel, little clayey silt, few cobbles, wet.	
660.8						Medium-dense to dense gray fine to coarse gravel "and" fine to coarse sand, little clayey silt, few cobbles, wet	
	20	10	5 12 18	41	33		
658.3		11	15 25 17	57	73	Dense gray fine to coarse gravel, some fine to coarse sand, trace silt, few to many cobbles, wet.	
655.8		12A	15 20	124	100	Hard gray clayey silt, some fine to coarse sand, little fine to coarse gravel, moist	
	25	12B	59 32		20		PP 4.5
		13	15 14 16 32	66	47		PP 4.5
		14	10 10 20 24 37 16	60	60		PP 4.0-4.5
	30						

WATER LEVEL
WATER NOTE
DATE:

Drill Rod Energy Ratio : 0.82
Last Calibration Date : 11/19/07
Drill Rig Number : D50

LOG OF BORING NO. B-0901
AEP PICWAY PLANT ASH POND MONITORING WELLS
LOCKBOURNE, OHIO

BBCM

LOCATION: N. 653,930; E. 1,826,464 (OH S) ELEVATION: 679.8 DATE: 8/10/09 - 8/13/09

DRILLING METHOD: 2-1/4" I.D. Hollow-stem Auger; 3-7/8" Tricone Bit COMPLETION DEPTH: 97.1'

SAMPLER(S): 2" and 2-1/2" O.D. Split-barrel Samplers

ELEV.	DEPTH (FT)	SAMPLE NUMBER	SAMPLE EFFORT	N	SAMPLE REC %	DESCRIPTION	TEST RESULTS
	30	15	25, 27, 35	71	100	Hard gray clayey silt, some fine to coarse sand, little fine to coarse gravel, moist	H 4.5
649.3		16	14, 21, 27, 32	66		Hard gray silty clay, some fine to coarse sand, little fine to coarse gravel, moist	H 4.0-4.5
	35	17	20, 26, 33, 42	81	53		H 4.0-4.5
644.3		18	12, 18, 25, 41	59	73	Very-stiff to hard gray silty clay, some fine sand, little medium to coarse sand, trace fine to coarse gravel, moist, contains fine to coarse sand seam at 41.5'.	H 4.5
		19	13, 19, 29, 35	66			H 4.5
	40	20	20, 25, 35, 41	82			H 3.5-4.5
		21	17, 27, 34, 50	83			H 4.5
	45	22	13, 22, 32, 40	74			H 4.5
		23	14, 19, 33, 39	71			H 4.5
		24	14, 23, 34, 51	78			H 4.5
629.8	50	25	13, 25, 36, 49	83		Hard gray silty clay, some fine to coarse gravel, little fine to coarse sand, moist.	H 4.5
		26	14, 22, 34, 47	77			H 4.5
		27A	15, 25, 34, 43	81			H 4.5
625.0	55	27B				Stiff to very-stiff gray and dark-gray silty clay, little fine to coarse sand, trace fine gravel, damp to moist, contains decayed wood fragments	
		27C					
		28	20, 25, 26, 32	70			H 2.0-3.5
		29A	8, 13, 18, 26	42			H 1.5-3.0
621.1		29B					H 1.0-2.5
		29C				Very-stiff becoming soft to medium-stiff gray clayey silt, some fine to medium sand, slightly	H 2.5-3.0
	60		10				

WATER LEVEL:
WATER NOTE:
DATE:

Drill Rod Energy Ratio: 0.82
Last Calibration Date: 11/19/07
Drill Rig Number: D50

LOG OF BORING NO. B-0901
AEP PICWAY PLANT ASH POND MONITORING WELLS
LOCKBOURNE, OHIO

BBCM

LOCATION N. 653,930: E. 1,826,464 (OH S) ELEVATION: 679.8 DATE 8/10/09 - 8/13/09

DRILLING METHOD 2-1/4" I.D. Hollow-stem Auger; 3-7/8" Tricone Bit COMPLETION DEPTH 97.1'

SAMPLER(S) 2" and 2-1/2" O.D. Split-barrel Samplers

ELEV.	DEPTH (FT)	SAMPLE NUMBER	SAMPLE EFFORT	N	SAMPLE REC %	DESCRIPTION	TEST RESULTS
	60	30A		70		organic, wet.	LL 0.5-2.0
619.6		30B	21			Soft gray silt, little clay, little fine to medium sand, slightly organic, contains fine to coarse sand seams, wet.	
		30C	32, 30				
617.6		31A	38			Very-dense gray fine to coarse sand, some fine to coarse gravel, wet.	
		31B	40	116			
		31C	45, 37				
		32A	35, 36	87			
	65	32B	28, 27				
614.3		33	16, 17, 22, 28	53	100	Dense gray silt, little clay, little fine to medium sand, contains fine to medium sand seams, wet	
612.0		34A	7, 30	141	100	Very-dense gray fine to coarse sand "and" fine to coarse gravel, little silt, slightly organic, wet.	
		34B	66, 68		59		
	70	35	32, 36, 45, 49	111	75		
		36	3, 10, 57, 48	92	40		
606.3		37	6, 20, 48, 52	93	67	Very-dense gray fine to coarse sand "and" fine to coarse gravel, little clayey silt, slightly organic, contains limestone fragments, cobbles, wet.	
	75	38	44, 80, 100, 72	246	87		
601.7		39A	81, 55	118	100	Dense to very-dense brown and gray silt, little clay, trace fine to medium sand, trace fine gravel, slightly organic, contains fine to medium sand seam, moist	
		39B	31, 32		20		
	80	40	20, 31, 36, 51	92			
		41	19, 29, 38, 49	92			
	85	42	18, 29, 32, 51	83			
		43	15, 20, 28, 33	60			
		44	14, 19, 25, 30, 8	60			
	90						

WATER LEVEL:
WATER NOTE:
DATE:

Drill Rod Energy Ratio : 0.82
Last Calibration Date : 11/19/07
Drill Rig Number : D50

LOG OF BORING NO. B-0901
AEP PICWAY PLANT ASH POND MONITORING WELLS
LOCKBOURNE, OHIO

BBCM

LOCATION N. 653,930; E. 1,826,464 (OH S) ELEVATION: 679.8 DATE 8/10/09 - 8/13/09

DRILLING METHOD 2-1/4" I.D. Hollow-stem Auger; 3-7/8" Tricone Bit COMPLETION DEPTH 97.1'

SAMPLER(S) 2" and 2-1/2" O.D. Split-barrel Samplers

ELEV.	DEPTH (FT)	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N	SAMPLE REC %	DESCRIPTION	TEST RESULTS
	90	45A			86	100		
588.8		45B		13 / 50		40	Black shale	
		46		50-2"R / 50-0"R				
585.8							Gray weathered shale.	
	95	47		50-4"R / 91		33		
582.7		48		50-2"R / 100-4"R		40		

- Encountered water at 10.3'.
- Sample from 18-20' was not attempted
- Casing advanced to 28.5'.
- Changed to mudrotary at 10'.
- Two monitoring wells (MW-0901S, MW-0901D) installed in offset holes. See separate well logs.
- Boring location and elevation surveyed by AEP. Datum: NAD 83/NGVD 29 OH S.
-N60 values determined from final two attempts.

WATER LEVEL
WATER NOTE
DATE:

Drill Rod Energy Ratio : 0.82
Last Calibration Date : 11/19/07
Drill Rig Number : D50

LOG OF BORING NO. B-0902
AEP PICWAY PLANT ASH POND MONITORING WELLS
LOCKBOURNE, OHIO

BBCM

LOCATION: N. 653,896; E. 1,825,698 (OH S) ELEVATION: 690.8 DATE: 8/21/09 - 8/25/09

DRILLING METHOD: 2-1/4" I.D. Hollow-stem Auger; 3-7/8" Tricone Bit COMPLETION DEPTH: 88.0'

SAMPLER(S): 2" and 2-1/2" O.D. Split-barrel Samplers

ELEV.	DEPTH (FEET)	SAMPLE NUMBER	SAMPLE EFFORT (blows)	N	SAMPLE REC %	DESCRIPTION	TEST RESULTS
	0	SH				Topsoil, contains fly ash, wet becoming dry.	
						FILL: Fly ash intermixed with silty clay, trace fine to coarse sand, trace fine gravel, dry.	
684.2	5	4	1, 1, 2, 3	4	20	FILL: Very-stiff brown silty clay, little fine to coarse sand, trace fine gravel, contains fly ash, dry.	El 2.5-3.0
682.1		5A	2				El 2.5-3.0
681.5		5B	8, 13	29		FILL: Medium-dense brown and gray fine to coarse gravel "and" fine to coarse sand, trace silty clay, damp.	
		5C	7				El 2.0-2.5
680.3	10	6A	2			FILL: Very-stiff brown mottled with gray silty clay, little fine to coarse sand, trace fine to coarse gravel, damp.	El 2.8-3.25
		6B	4	14			
		6C	6, 9				
678.5		7A	4		100	FILL: Very-stiff gray mottled with brown clayey silt, little fine to coarse sand, damp	
		7B	6, 7, 7	18	82	Very-stiff to hard brown silty clay, little fine to coarse sand, trace fine gravel, damp.	El 2.2-2.9
	15	8	3, 4, 10, 8	19	80		El 2.5-3.5
		9	1, 7, 10, 13	23	93		El 3.5-4.0
		10	4, 7, 9, 11	22			El 3.2-4.0
	20	11	4, 6, 7, 11	18	100		El 3.1-3.9
668.7		12A	2		100	Soft to medium-stiff brown mottled with gray silty clay, little fine to coarse sand, slightly organic, contains fine to medium sand seams, moist	El 1.5-1.9
		12B	4, 4, 6	11	100		El 1.0-1.5
		13A	1, 2	5	100		El 0.5-1.0
665.5	25	13B	2, 3		71	Loose to medium-dense brown fine to coarse sand "and" fine to coarse gravel, trace silt, wet.	
		14	3, 3, 5, 4	11	80		
		15	2, 1, 5, 6	8	67		
660.8	30						

WATER LEVEL: ▽ ▼

WATER NOTE:

DATE:

Drill Rod Energy Ratio: 0.82

Last Calibration Date: 11/19/07

Drill Rig Number: D50

LOG OF BORING NO. B-0902
AEP PICWAY PLANT ASH POND MONITORING WELLS
LOCKBOURNE, OHIO

BBCM

LOCATION N. 653,896; E. 1,825,698 (OH S) ELEVATION: 690.8 DATE 8/21/09 - 8/25/09
DRILLING METHOD 2-1/4" I.D. Hollow-stem Auger; 3-7/8" Tricone Bit COMPLETION DEPTH 88.0'
SAMPLER(S) 2" and 2-1/2" O.D. Split-barrel Samplers

ELEV	DEPTH (FT)	SAMPLE NUMBER	SAMPLE EFFORT	N	SAMPLE REC %	DESCRIPTION	TEST RESULTS
	30	16	6-8-10-12	25	80	Medium-dense to very-dense brown fine to coarse gravel "and" fine to coarse sand, trace silt, wet.	
656.8		17	12-21-28-35	67	33		
	35	18	21-27-36-46	86		Very-stiff to hard gray silty clay, some fine to coarse sand, little fine to coarse gravel, contains zones of dense gray fine to coarse sand, damp.	HP 4.5
		19	26-35-46-46	111	67		HP 4.5
		20	10-21-28-44	67	27		HP 2.5-2.8
	40	21A	11-21-24-33	62			HP 4.5
		21B					HP 4.5
		21C					
		21D			100		HP 4.5
		22A	19-26-42-56	93			
		22B			60		
		23A	19-15-16-20	42			
	45	23B					
		23C					HP 3.0-4.5
		24	14-21-34-47	75			HP 4.0-4.5
		25	7-13-16-25	40	87		HP 4.5
	50	26	9-15-26-30	56			HP 4.5
		27	13-16-21-35	51			HP 4.5
		28A	13-24-41-68	89	100		HP 4.5
635.6	55	28B			73	Very-dense gray fine to coarse gravel, little fine to coarse sand, some silty clay, wet.	
634.6		29A	11-21-29-37	68	100	Hard gray silty clay, some fine to coarse gravel, little fine to coarse sand, wet becoming damp	
		29B			94		HP 4.5
		30	16-24-36-58	82			HP 4.5
	60						

WATER LEVEL: ▽ ▼
WATER NOTE:
DATE:

Drill Rod Energy Ratio: 0.82
Last Calibration Date: 11/19/07
Drill Rig Number: D50

LOG OF BORING NO. B-0902
AEP PICWAY PLANT ASH POND MONITORING WELLS
LOCKBOURNE, OHIO

BBCM

LOCATION N. 653.896; E. 1,825,698 (OH S) ELEVATION: 690.8 DATE 8/21/09 - 8/25/09
DRILLING METHOD 2-1/4" I.D. Hollow-stem Auger; 3-7/8" Tricone Bit COMPLETION DEPTH 88.0'
SAMPLER(S) 2" and 2-1/2" O.D. Split-barrel Samplers

ELEV.	DEPTH (FEET)	SAMPLE NUMBER	SAMPLE EFFORT	N	SAMPLE REC %	DESCRIPTION	TEST RESULTS
	60	31A	13 22 29	70			H 4.5
629.5		31B	41			Hard gray clayey silt, some fine to coarse sand, little fine to medium gravel, moist	H 4.5
629.0		31C	9 19 34	72		Hard gray silty clay, some fine to coarse gravel, little fine to coarse sand, slightly organic, damp.	H 4.5
626.8	65	32	42				
		33	10 22 39 41	83		Hard gray silty clay, some fine to coarse gravel, little fine to coarse sand, contains shale fragments, damp.	
		34A	21 72 116	257	100		
623.1		34B	111		33	Dense gray silt, little fine to coarse sand, little gray clay, moist.	
		35	21 22 26 29	66			
620.3	70	36A	16 25	74	100	Dense dark-gray fine to coarse sand, little fine to coarse gravel, some silt, slightly organic, contains shale fragments, wet.	
		36B	29 36		60		
		37	14 30 30 73	90			
616.5		38A	28		100	Very-dense dark-gray fine to coarse sand "and" fine to coarse gravel, trace silt, slightly organic, wet, silt seam from 76.3' to 76.4'.	
	75	38B	46 61 54	146	88		
		39	23 50 51 56	138			
		40	32 40 54 59	128	100		
	80						
609.8		41	31 30 83 123	167		Very-dense dark-gray fine to coarse sand, cemented, some fine to coarse gravel, trace silt, contains limestone fragments, wet	
		42	79 89 94 109	250	87		
606.3		43A	97	254	100	Very-dense gray and brown fine to coarse sand "and" fine to coarse gravel, little silt, cobbles, wet.	
	85	43B	98 88 89		80		
		44	123 100-2"R		10		
603.8			200-2"R			Blue/gray shale.	
602.8							
	90					- See Notes On Following Page	

WATER LEVEL: ▽ ▼
WATER NOTE:
DATE:

Drill Rod Energy Ratio: 0.82
Last Calibration Date: 11/19/07
Drill Rig Number: D50

LOG OF BORING NO. B-0902
AEP PICWAY PLANT ASH POND MONITORING WELLS
LOCKBOURNE, OHIO

BBCM

LOCATION N. 653,896; E. 1,825,698 (OH S) ELEVATION 690.8 DATE 8/21/09 - 8/25/09

DRILLING METHOD 2-1/4" I.D. Hollow-stem Auger; 3-7/8" Tricone Bit COMPLETION DEPTH 88.0'

SAMPLER(S) 2" and 2-1/2" O.D. Split-barrel Samplers

ELEV.	DEPTH (FT)	SAMPLE NUMBER	SAMPLE	SAMPLE	EFFORT	N	SAMPLE REC %	DESCRIPTION	10 20 30 40	TEST RESULTS
	90							- Encountered water at 24.6', 70.5'. - Encountered cobbles at 33.0', 67.5', 84'. - Casing advanced to 25.5'. - Changed to mud rotary at 26.0'. - Two monitoring wells (MW-0902S, MW-0902D) installed in offset holes. See separate well logs. - Boring location and elevation surveyed by AEP. Datum NAD 83/NGVD 29 OH S. -N60 value determined from final two attempts.		
	95									
	100									
	105									
	110									
	115									
	120									

WATER LEVEL
WATER NOTE
DATE

Drill Rod Energy Ratio : 0.82
Last Calibration Date : 11/19/07
Drill Rig Number : D50

LOG OF BORING NO. B-0903
AEP PICWAY PLANT ASH POND MONITORING WELLS
LOCKBOURNE, OHIO

BBCM

LOCATION: N. 652,381; E. 1,825,113 (OH S) ELEVATION: 690.3 DATE: 8/17/09 - 8/20/09

DRILLING METHOD: 2-1/4" I.D. Hollow-stem Auger; 3-7/8" Tricone Bit COMPLETION DEPTH: 83.3'

SAMPLER(S): 2" and 2-1/2" O.D. Split-barrel Samplers

ELEV.	DEPTH (FT)	SAMPLE NUMBER	SAMPLE EFFORT	N	SAMPLE REC %	DESCRIPTION	TEST RESULTS
689.4						TOPSOIL - 11 INCHES	
		1	2, 5, 7, 7	16	7	FILL: Very-stiff brown silty clay, little fine to coarse sand, dry becoming damp, contains fly ash.	H 3.5-4.0
		2	13, 6, 8, 11	19	33		H 2.0-3.0
		3A	2		100		
	5	3B	4, 4, 6	4	17		H 2.25-3.25
		4A	2, 5	18	100		H 1.5-2.5
		4B	8, 13		25		H 1.5-2.5
681.3		5	4, 4, 5, 5	12	60	FILL: Stiff to very-stiff gray clayey silt, little fine to coarse sand, dry to damp, contains wood fragments.	H 1.5-2.5
	10	6	2, 3, 3, 4	8	87		H 1.5-3.0
		7A	2, 4	12	100		
677.0		7B	5, 6		71	FILL: Very-stiff gray mottled with brown silty clay, trace fine to coarse sand, damp, contains fly ash.	H 1.5-3.0
675.6		8A	2, 4	16	100		H 2.5-4.0
	15	8B	8, 15		31	FILL: Very-stiff to hard brown mottled with gray silty clay, trace fine to coarse sand, damp, contains fly ash.	H 2.5-4.0
674.3		9	5, 7, 9, 11	22	87	Hard brown silty clay, trace fine to coarse sand, damp	H 4.0-4.5
672.3		10	2, 2, 3, 4	7		Stiff to hard brown mottled with gray clayey silt, little fine to coarse sand, slightly organic, moist becoming wet.	
	20	11	1, 2, 2, 4	5			
		12	1, 1, 2, 3	4	53		
666.8	25	13	4, 6, 8, 13	19	53	Medium-dense to dense brown fine to coarse sand "and" fine to coarse gravel, little silt, wet.	
		14	13, 19, 15, 12	46	67		
	30		12, 10, 8, 11	25			

Chart scale: 10 20 30 40

WATER LEVEL:
WATER NOTE:
DATE:

Drill Rod Energy Ratio: 0.82
Last Calibration Date: 11/19/07
Drill Rig Number: D50

LOG OF BORING NO. B-0903
AEP PICWAY PLANT ASH POND MONITORING WELLS
LOCKBOURNE, OHIO

BBCM

LOCATION: N. 652,381; E. 1,825,113 (OH S) ELEVATION: 690.3 DATE: 8/17/09 - 8/20/09

DRILLING METHOD: 2-1/4" I.D. Hollow-stem Auger; 3-7/8" Tricone Bit COMPLETION DEPTH: 83.3'

SAMPLER(S): 2" and 2-1/2" O.D. Split-barrel Samplers

ELEV.	DESCRIPTION
	Medium-dense to dense brown fine to coarse sand "and" fine to coarse gravel, little silt, wet
658.0	Dense brown and gray fine to coarse sand "and" fine to coarse gravel, trace silt, wet
653.2	Dense gray silt "and" fine to coarse sand, some fine to coarse gravel, wet.
649.1	Dense gray fine to coarse sand "and" fine to coarse gravel, little silt, wet.
646.8	Dense gray silt, little fine to coarse sand, little fine to coarse gravel, wet.
645.3	Dense gray fine to coarse sand, some gray silt, becoming little fine to coarse gravel at 46.1', wet
643.5	Dense gray fine to coarse sand "and" fine to coarse gravel, trace to little silt, wet.
636.6	Dense gray silt, some fine to coarse sand, little fine to coarse gravel, contains many seams of dense fine to coarse sand, wet.

DEPTH (FEET)	SAMPLE NUMBER	SAMPLE EFFORT	N	SAMPLE REC %
30	15	8, 8, 5	18	47
	16	8, 11, 18, 21	53	40
35	17	25, 17, 22, 8	41	87
	18	21, 37, 110-4"R		33
	19	44, 55, 57	150	
40	20A	73, 45, 60	159	100
	20B	56, 85		75
	21	21, 53, 37	123	93
	22A	41, 19		100
	22B	31, 40	109	40
45	23	54, 22, 36, 40	104	
	24	10, 29, 33, 31	87	
50	25	33, 24, 28, 30	79	
	26A	36, 33		100
	26B	38, 41	108	58
	27A	40, 32		100
	27B	39, 49	120	85
55	28A	94, 21		
	28B	33	107	
	28C	45		
	28D	34		
	29	28, 44, 62	145	93
60	30A	91, 124, 76	153	100

TEST RESULTS: 10 20 30 40

WATER LEVEL:
WATER NOTE:
DATE:

Drill Rod Energy Ratio: 0.82
Last Calibration Date: 11/19/07
Drill Rig Number: D50

LOG OF BORING NO. B-0903
AEP PICWAY PLANT ASH POND MONITORING WELLS
LOCKBOURNE, OHIO

BBCM

LOCATION: N. 652,381; E. 1,825,113 (OH S) ELEVATION: 690.3 DATE: 8/17/09 - 8/20/09

DRILLING METHOD: 2-1/4" I.D. Hollow-stem Auger; 3-7/8" Tricone Bit COMPLETION DEPTH: 83.3'

SAMPLER(S): 2" and 2-1/2" O.D. Split-barrel Samplers

ELEV.	DEPTH (FT)	SAMPLE NUMBER	SAMPLE EFFORT	N60	SAMPLE REC %	DESCRIPTION	TEST RESULTS
629.5	60	30B	44		82		
		31	29, 30, 50, 80	109		Hard gray silty clay, little fine to coarse gravel, trace fine to coarse sand, becoming slightly organic at 66.0', damp to moist.	H 4.5
		32	15, 39, 45, 76	115			H 1.5
	65	33	11, 22, 41, 105	86			H 4.5
622.9		34A	24		100		H 4.5
		34B	40, 53, 59	127	94	Dense gray silt, trace fine to medium sand, damp to wet.	
	70	35	21, 43, 89, 100-3"R	180			
		36A	14, 28, 40	93	100		
617.8		36B	63		60	Dense gray fine to coarse sand, little to some fine to coarse gravel, trace silt, wet, contains flint fragments	
		37	26, 41, 92, 112	182			
	75	38	31, 39, 51, 63	123			
613.0		39A, 39B, 39C	39, 56, 71, 84	174		Dense gray fine to coarse sand, some fine to medium gravel, little silt, slightly organic, contains seams of hard brown and gray silty clay, wet.	H 4.5
		40A, 40B	33, 51	135			H 4.5
609.9	80	40C, 40D	48, 45			Gray weathered shale	
		41	15, 41, 115-3"R		53		
607.0		42	50-2"R, 100-4"R, 50-2"R		20		
	85						
	90						

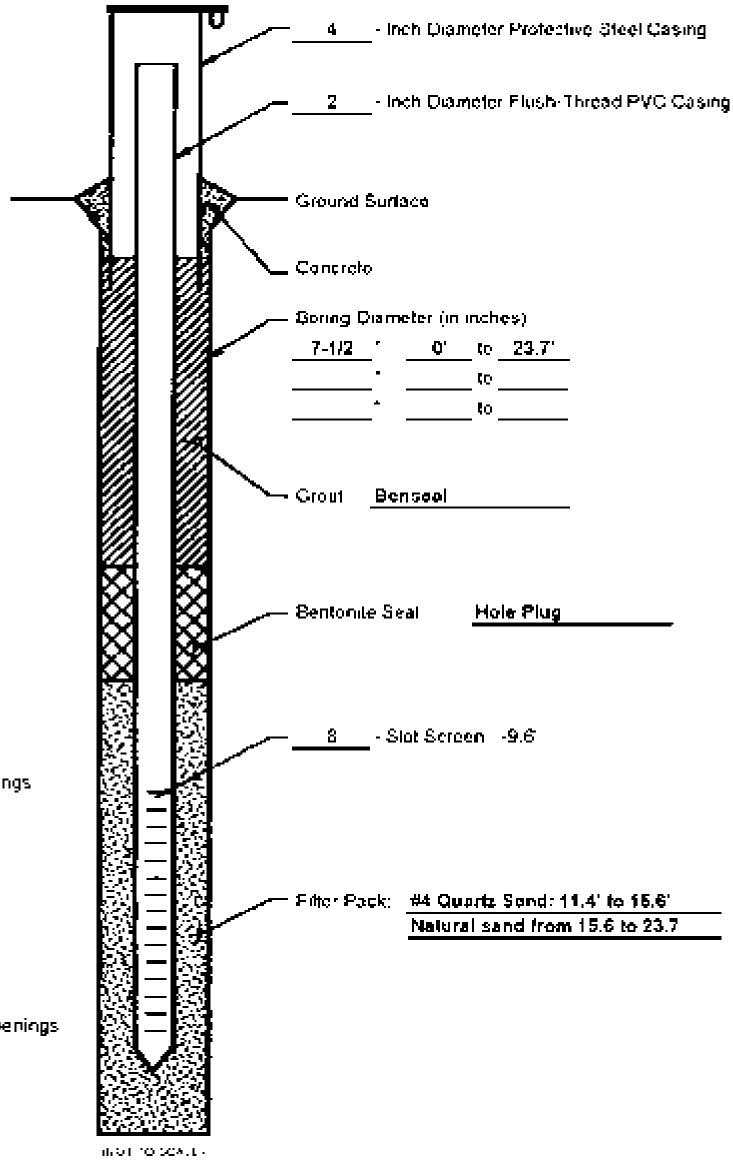
- Encountered sand lenses at 21.3' and 21.6', 22.6'.
- Encountered water at 22.2', 67'
- Encountered cobbles at 36'.
- Casing advanced to 40'.
- Changed to mud rotary at 28.0'.
- Monitoring well (MW-0903S) installed in offset hole. See separate well log.
- Boring location and elevation surveyed by AEP. Datum: NAD 83/NGVD 29 OH S.
- N60 value shown determined from final two attempts.

WATER LEVEL:
WATER NOTE:
DATE:

Drill Rod Energy Ratio: 0.82
Last Calibration Date: 11/19/07
Drill Rig Number: D50

BBCM
SOLUTIONS TO BUILD ON

Elevation (Feet above MSL)	Depth Below Ground Surface (Feet)	
681.5	+2.0	Top of Cover
681.2	+1.4	Top of PVC
679.8	0.0	Ground Surface
679.8	0.0	Top of Grout
670.5	9.3	Top of Bentonite
668.4	11.4	Top of Filter Pack
669.5	10.3	Top of Aquifer
666.4	13.4	Top of Screen Openings
656.8	23.0	Bottom of Screen Openings
656.4	23.4	Bottom of Well
	24.0	Bottom of Aquifer
656.1	23.7	Bottom of Boring



Water Elevation:	667.8	668.8	675.7	667.5	667.8	668.4	668.6
Date:	8/17/09	8/19/09	8/20/09	8/21/09	8/24/09	8/26/09	8/27/09

Well Development
- Between 8/19 measurement and 8/20, there was heavy rain in the area.
- 38 gallons was bailed out of well on 8/21 after measurement was taken.
- Top cover set in 3'x3' concrete pad. Protective steel bollards placed around concrete pad.
- Auquifer thickness determined in adjacent Boring B-901

Well Location
N 653,933.7 E 1,8256,463.2
Datum NAD83/NGVD29 OH S

WELL COMPLETION DIAGRAM

Project Name:
AEP Picway Plant Ash Pond Monitoring Wells

Project Location:
Lockbourne, Ohio

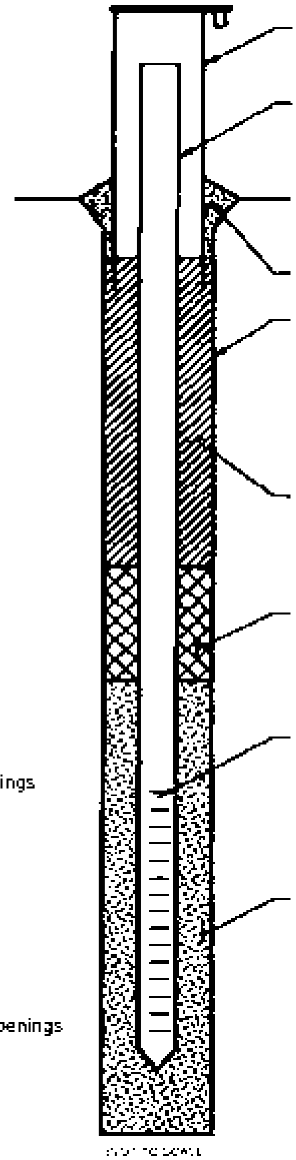
Project Number:
011-11497-019

Boring Number:
MW-0901S

Date Well Installed:
8/17/09

BBCM
SOLUTIONS TO BUILD ON

Elevation (Feet above MSL)	Depth Below Ground Surface (Feet)	
681.5	+1.7	Top of Cover
681.2	+1.4	Top of PVC
679.8	0.0	Ground Surface
679.8	0.0	Top of Grout
615.8	64.0	Top of Bentonite
613.5	66.3	Top of Filter Pack
612.0	67.8	Top of Aquifer
611.0	68.8	Top of Screen Openings
601.4	78.4	Bottom of Screen Openings
601.0	78.8	Bottom of Well
	78.1	Bottom of Aquifer
600.7	79.1	Bottom of Boring



Water Elevation:	642.8	668.0	668.5	663.1	664.7	660.7	651.9	662.6
Date:	8/18/09	8/19/09	8/20/09	8/21/09	8/24/09	8/26/09	8/26/09	8/27/09

Well Development
- Well was hand bailed until dry (~ 23 gallons) on 8/20. It returned to 16.8' on 8/21, approximately 18 hours later
- Bailed additional 5 gallons on 8/21
- Bailed additional 10 gallons on 8/26 (15 gallons total on 8/26)
- Second measurement on 8/26 was after bailing 10 gallons
- Measurement on 8/27 was 18 hours after bailing on 8/26.

Top cover set in 3'x3' concrete pad. Protective steel bollards placed around concrete pad

-Auquifer thickness determined in adjacent Boring B-0901

Well Location

N 653,927.2 E 1,826,462.6

Datum NAD83/NGVD29 OH S

WELL COMPLETION DIAGRAM

Project Name:
AEP Picway Plant Ash Pond Monitoring Wells

Project Location:
Lockbourne, Ohio

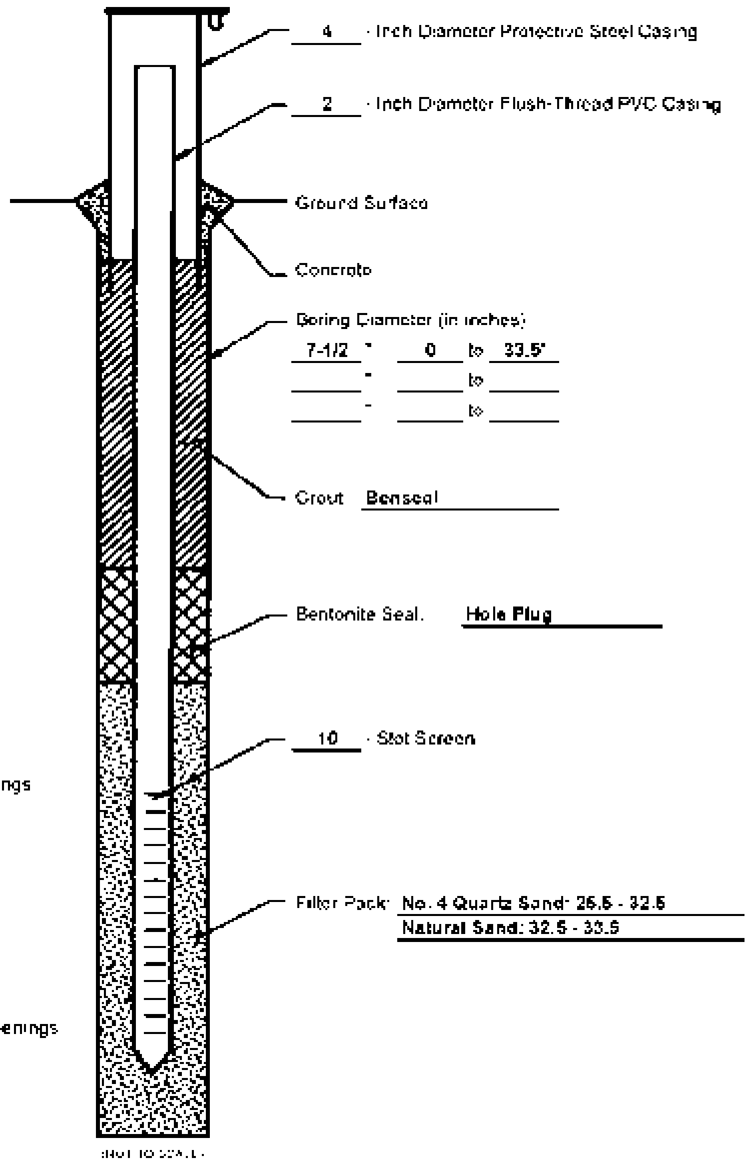
Project Number:
011-11497-019

Boring Number:
MW-0901D

Date Well Installed:
8/18/09

BBCM
SOLUTIONS TO BUILD ON

Elevation (Feet above MSL)	Depth Below Ground Surface (Feet)	
694.0	+3.2	Top of Cover
693.4	+2.6	Top of PVC
690.8	0.0	Ground Surface
690.8	0.0	Top of Grout
669.6	21.2	Top of Bentonite
666.0	24.8	Top of Filter Pack
666.2	24.6	Top of Aquifer
663.3	27.5	Top of Screen Openings
658.8	32.0	Bottom of Screen Openings
658.3	32.5	Bottom of Well
	33.5	Bottom of Aquifer
657.3	33.5	Bottom of Boring



Water Elevation:	661.9	665.7			
Date:	8/26/09	8/27/09			

Well Development
- Hand Bailed 2 gallons immediately after installation on 8/26. Water level dropped to about 6" from bottom of well
- Water clear on 8/27
- Top cover set in 3'x3' concrete pad. Protective steel bollards placed around concrete pad
Aquifer thickness determined in adjacent Boring B-0902

Well Location
N. 653,899.84 E. 1,825,700.7 6
Datum: NAD83/NGVD29 OH S

WELL COMPLETION DIAGRAM

Project Name:
AEP Picway Plant Ash Pond Monitoring Wells

Project Location:
Lockbourne, Ohio

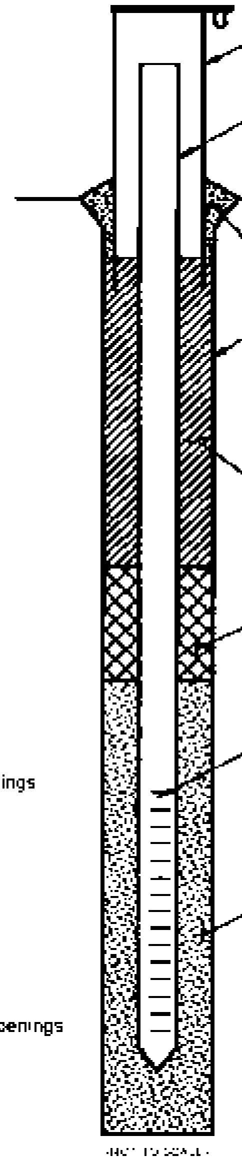
Project Number:
011-11497-019

Boring Number:
MW-0902S

Date Well Installed:
8/26/09

BBCM
SOLUTIONS TO BUILD ON

Elevation (Feet above MSL)	Depth Below Ground Surface (Feet)	
694.3	+3.5	Top of Cover
693.9	+3.1	Top of PVC
690.8	0.0	Ground Surface
690.8	0.0	Top of Grout
623.6	67.3	Top of Bentonite
621.6	69.3	Top of Filter Pack
620.3	70.5	Top of Aquifer
618.6	72.3	Top of Screen Openings
609.0	81.9	Bottom of Screen Openings
608.6	82.3	Bottom of Well
	87.0	Bottom of Aquifer
606.3	84.5	Bottom of Boring



Water Elevation	665.5	667.9	668.8		
Date	8/27/09	8/28/09	8/28/09		

Well Development:
- Hand Bailed approx. 75 gallons on 9/28. 2nd Measurement after bailing.
- Bailer could not be advanced below 50 feet, however weighted tape measure could be advanced to bottom of well.
- Top cover set in 3'x3' concrete pad. Protective steel bollards placed around concrete pad.
- Auquifer thickness determined in adjacent Boring B-0902

Well Location:
N 653,895.3 E 1,825,098.5
Datum: NAD83/NGVD29 OH S

WELL COMPLETION DIAGRAM

Project Name:
AEP Picway Plant Ash Pond Monitoring Wells

Project Location:
Lockbourne, Ohio

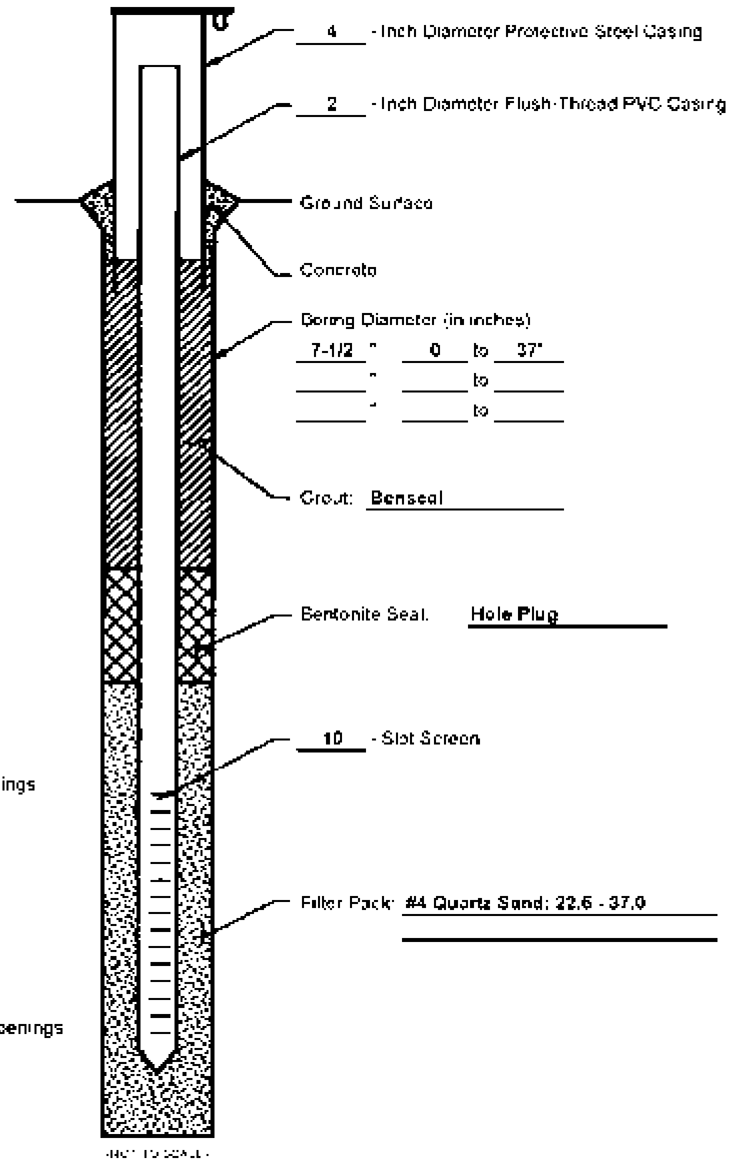
Project Number:
011-11497-019

Boring Number:
MW-0902D

Date Well Installed:
8/27/09

BBCM
SOLUTIONS TO BUILD ON

Elevation (Feet above MSL)	Depth Below Ground Surface (Feet)	
692.8	+2.5	Top of Cover
692.5	+2.2	Top of PVC
690.3	0.0	Ground Surface
689.8	0.5	Top of Grout
670.8	19.5	Top of Bentonite
667.8	22.5	Top of Filter Pack
672.3	18.0	Top of Aquifer
664.3	26.0	Top of Screen Openings
654.7	35.6	Bottom of Screen Openings
654.3	36.0	Bottom of Well
	60.8	Bottom of Aquifer
653.3	37.0	Bottom of Boring



Water Elevation	660.40	667.50	667.90	668.00	668.00
Date	8/21/09	8/21/09	8/24/09	8/26/09	8/27/09

Well Development:
-8/21 - Bailed 22 gallons of water (approx. 10 well volumes) out of well, water level stayed steady.
-Second measurement on 8/21 was immediately after well installation and before bailing.
-Top cover set in 3'x3' concrete pad. Protective steel bollards placed around concrete pad.
-Auquifer thickness determined in adjacent Boring B-0903

Well Location
N 652,381.2 E. 1,825,113.0
Datum: NAD83/NGVD29 OH S

WELL COMPLETION DIAGRAM

Project Name:
AEP Pirway Plant Ash Pond Monitoring Wells

Project Location:
Lockbourne, Ohio

Project Number:
011-11497-019

Boring Number:
MW-0903S

Date Well Installed:
8/21/09

HYDROLOGY / HYDRAULIC REPORT

ASH POND COMPLEX – File # 9630-001

PICWAY POWER PLANT
PICKAWAY COUNTY, OHIO

AEPSC DOCUMENT – GERS-11-013

PREPARED BY:

AMERICAN ELECTRIC POWER SERVICE CORPORATION
CIVIL ENGINEERING DEPARTMENT
GEOTECHNICAL ENGINEERING SECTION
1 RIVERSIDE PLAZA
COLUMBUS, OHIO 43215

PICWAY ASH POND COMPLEX
STORMWATER ANALYSIS
REPORT 1
SURFACE IMPOUNDMENT ASSESMENT

PICWAY POWER PLANT
PICKAWAY COUNTY, OHIO

PREPARED BY ________________ **DATE** 6/13/2011
Daniel W. Pizzino, P.E.

REVIEWED BY ________________ **DATE** 6/13/2011
Gary F. Zych, P.E.

APPROVED BY ________________ **DATE** 6/13/2011
Gary F. Zych, P.E.
Manager - Geotechnical Engineering

QA/QC DOCUMENT NO.
GERS-11-013

STATE OF OHIO
DANIEL
W.
PIZZINO
E-72784
REGISTERED
PROFESSIONAL ENGINEER

PROFESSIONAL ENGINEER
SEAL & SIGNATURE

Overview

Pieway Power Plant is an AEP owned coal fired electricity generating facility. Within the plant confines there is a diking system used to settle bottom ash and fly ash which is a product of coal burning electricity generation. The ash pond complex is an above ground reservoir system that is subdivided into two sections; the North Ash Pond and the South Ash Pond. A large portion of the North Ash Pond has been closed and capped. The remainder area of the North Ash Pond receives a very small amount of bottom ash and any rainfall that is not evaporated is infiltrated into the soil thus for the purpose of this study the North Ash Pond will be excluded from this analysis. The South Ash Pond that receives fly ash from the plant is divided into three internal cells (S1, S2 and S3). Refer to Exhibit 1 in Appendix A for a detailed map of the South Ash Pond. The diking system has been classified as a Class II structure and is under the jurisdiction the Ohio Department of Natural Resources (ODNR).

Purpose

The South Ash pond receives not only fly ash but rainfall as well. All rainfall captured by the pond system must be confined within it banks where it is slowly released by the outlet structure. Any overtopping of the pond's banks could cause failure of the diking system. The purpose of this stormwater analysis is to determine the hydraulic capacity of the diking system by analyzing the change in water surface elevation within South Ash Pond during an extreme weather event. The design flood for a Class II structure is the 6-hour, 0.5 Probable Maximum Flood (PMF). The 0.5 PMF is generated from the 50 percent Probable Maximum Precipitation (PMP) and is used in the analysis of this report.

Watershed Characteristics

The South Ash Pond is contained within an above ground diking system as shown on Exhibit 1 and Exhibit 2 of Appendix A. The entire pond is approximately 6.5 acres and is subdivided into three cells (S1, S2 and S3) by two splitter dikes and there is no sub-area outside the pond limits tributary to the pond. The three cells are interconnected by two overflow weirs at each splitter dike. There is a single outlet structure responsible for draining the entire pond located in cell S3. The outlet structure consists of riser pipe structure where surface water elevations are controlled by stop logs as shown on Exhibit 3 of Appendix A. The outlet structure discharges through a 30" pipe into a rip-rap lined channel that conveys water to the Clear Water Pond and ultimately to the Scioto River through the Clear Water Pond outlet structure. The Clear Water Pond has been excluded from this analysis The Clear Water Pond has been excluded from this analysis due to inflow being metered by the South Ash Pond outlet structure.

Hydrologic Analysis

The hydrologic parameters such as Time of Concentration (Tc) and Runoff Curve Numbers (CN) were determined using standard Natural Resources Conservation Service (NRCS) methodology. A minimum Tc of 5 minutes and a CN of 100 used assuming the pond had a wet surface and reflecting that only runoff within the banks of the pond will be detained. Analysis was conducted using Haestad Method's PondPack version v8i based on NRCS methodology. The PMP was estimated for this area to be 26.5 inches using the National Weather Service Hydrometeorological Report 51. As required the dike must be analyzed using the 50 percent of the PMP. This equates to a total rainfall event of 13.25 inches. The model used the NRCS Type II rainfall distribution with a 6 hour duration.

The model was created by assuming the most extreme operating conditions for the South Ash Pond. The outlet structure stop log elevation and consequently the normal pool elevations were set to 688 reflecting a maximum operating condition. At this operating condition the two weir structures connecting the 3 cells is inundated and therefore has no effect on the model. The model considered all three cells to be one pond since at elevation 688 they will be freely interconnected.

Existing Pond Characteristics

Refer to Exhibit 2 of Appendix A for more information.

Normal Pool – 688.00 (uppermost operating elevation)

Top of Bank – 693.00 (dike elevation)

Outlet Structure   stop log riser structure @ 688.00

Tailwater Control   30" outlet pipe with free outfall @ 681.00

Elevation-Area-Storage Table

	Basin	
Contour Elevation	Area	Cumulative Storage Volume
(ft)	(acre)	(ac-ft)
688	6.47	0
689	6.720	6.595
690	6.97	13.441

Results

The maximum water surface elevation reached during the 50% PMF is 688.71' which is below the top of bank elevation of 693.00'. The following is a summary of the results and the detailed output from the PondPack model has been included in Appendix B.

Storm Event: 13.25", 6-hour

Total Runoff Volume: 7.110 ac-ft

Peak Inflow: 34.78 ft^3/s

Peak Outflow: 9.41 ft^3/s

Maximum Storage Required: 4.667 ac-ft

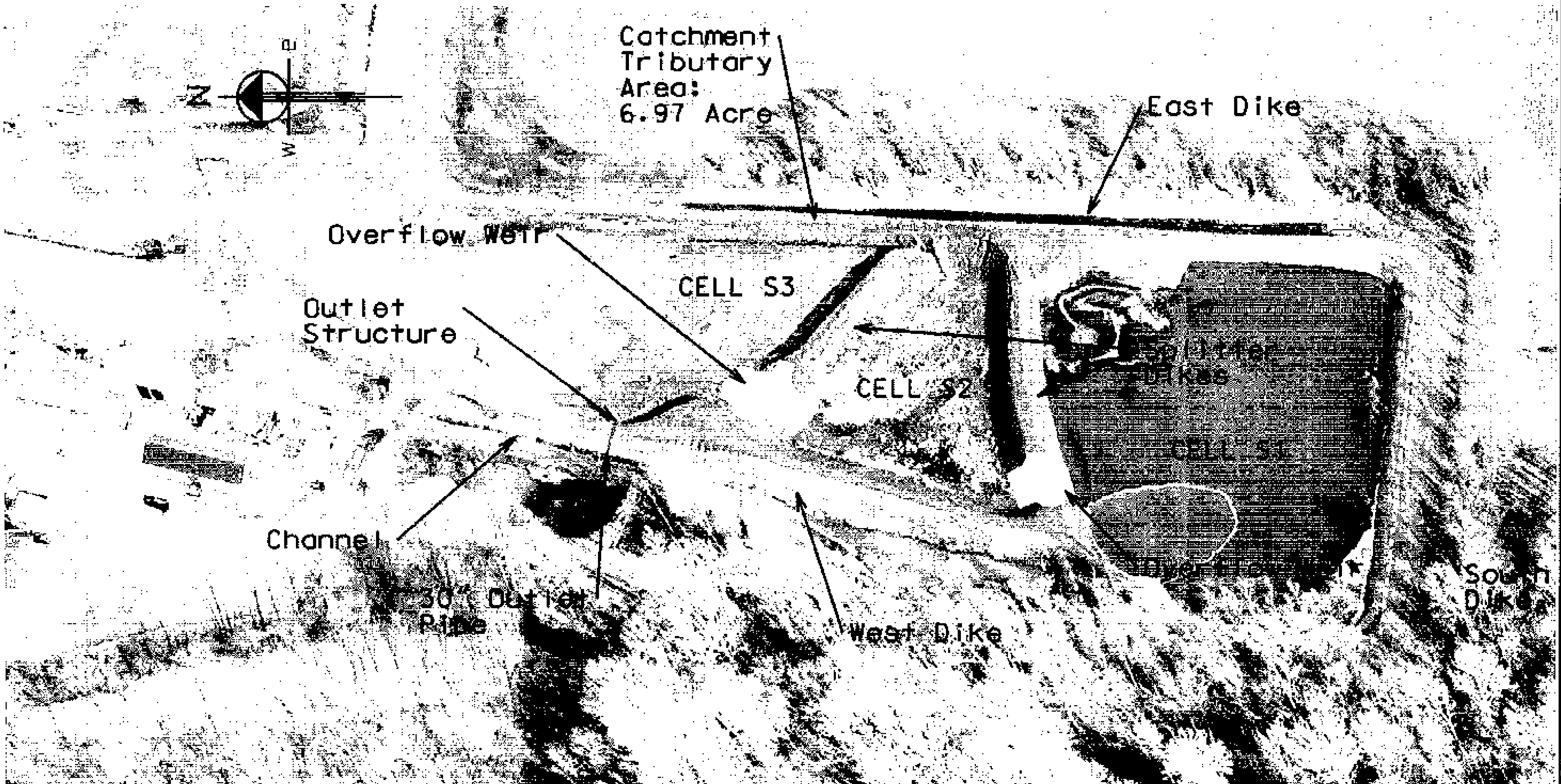
Maximum Water Surface Elevation: 688.71

Conclusion

The ash pond complex analysis has demonstrated that it is of adequate hydraulic capacity and storage. The ash pond complex can safely contain the design flood (50% PMF) without overtopping of the dike.

APPENDIX A

Exhibits



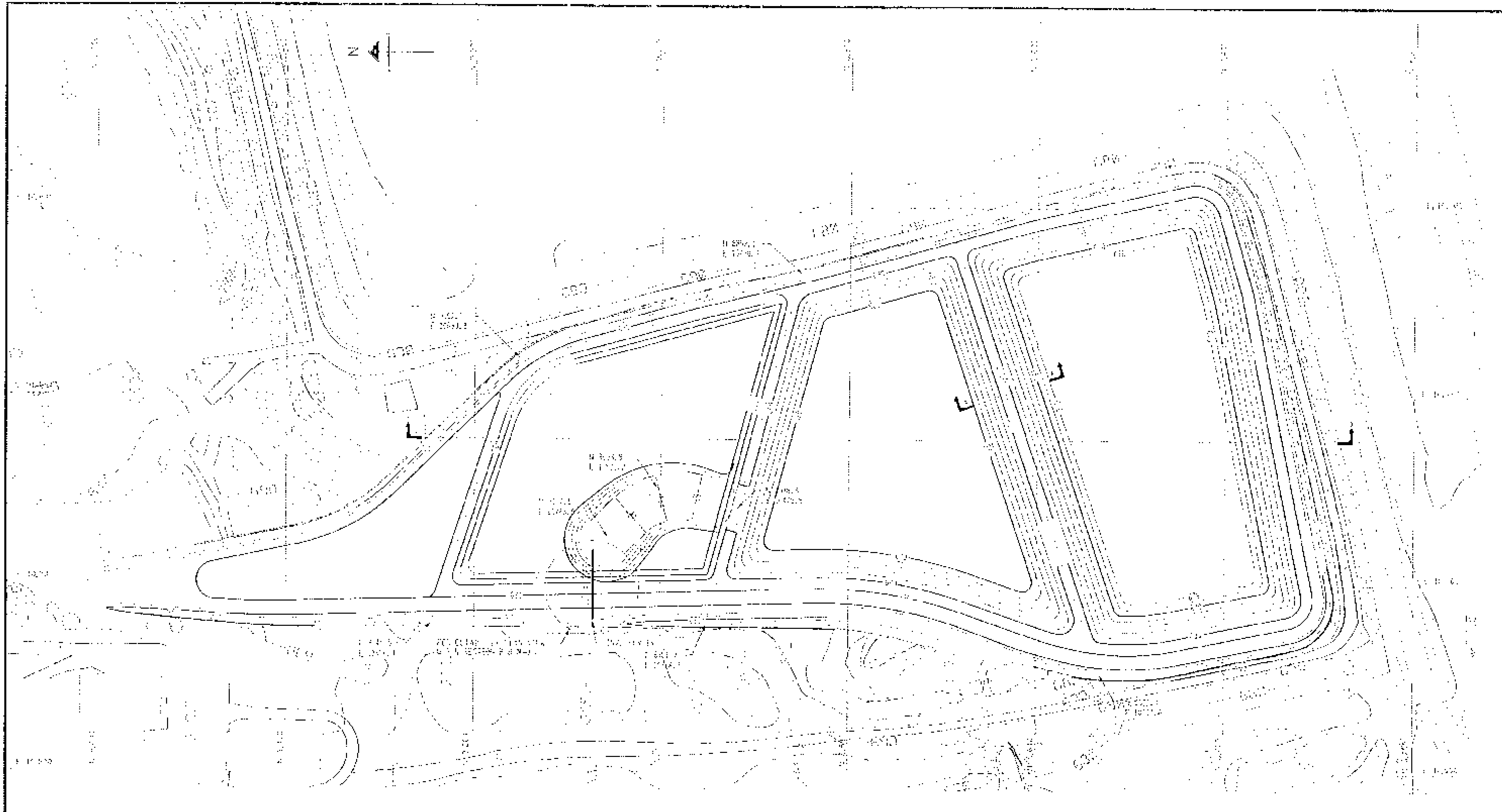
AEP OHIO

PICWAY POWER STATION

ASH POND DAM - EXHIBIT 1

AMERICAN ELECTRIC POWER

AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215



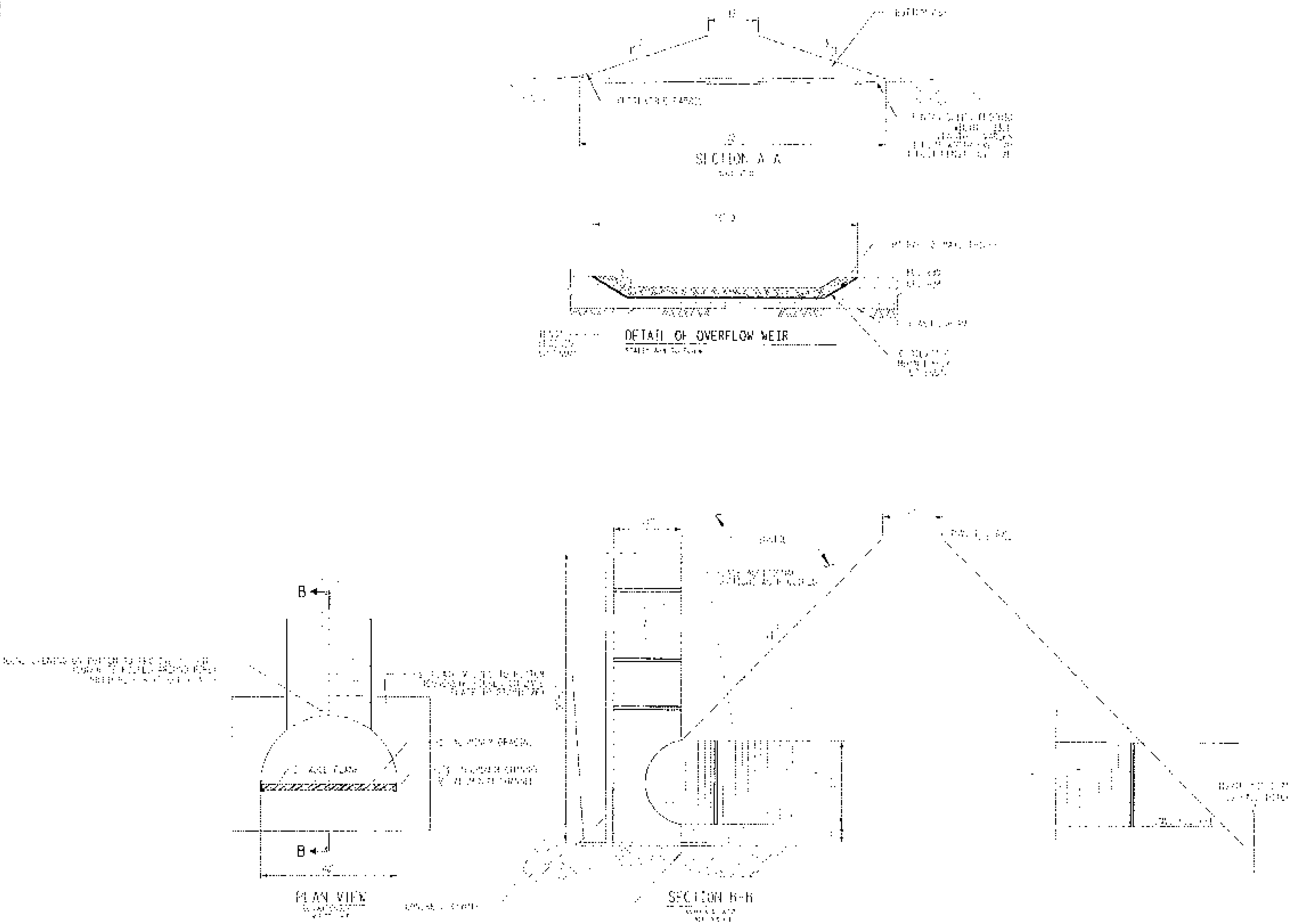
AEP OHIO

PICWAY POWER STATION

ASH POND DAM - EXHIBIT 2

AMERICAN ELECTRIC POWER

AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215



AEP OHIO

PICWAY POWER STATION

ASH POND DAM - EXHIBIT 3

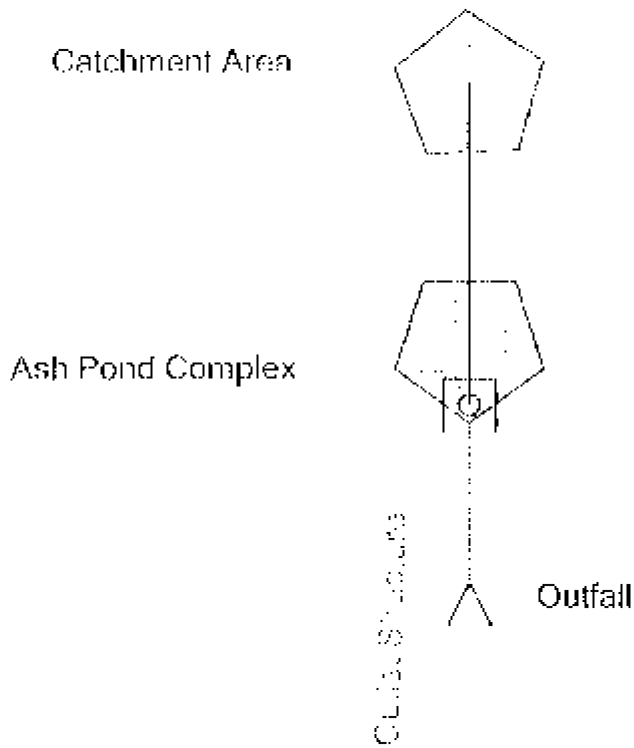
AMERICAN ELECTRIC POWER

AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

APPENDIX B

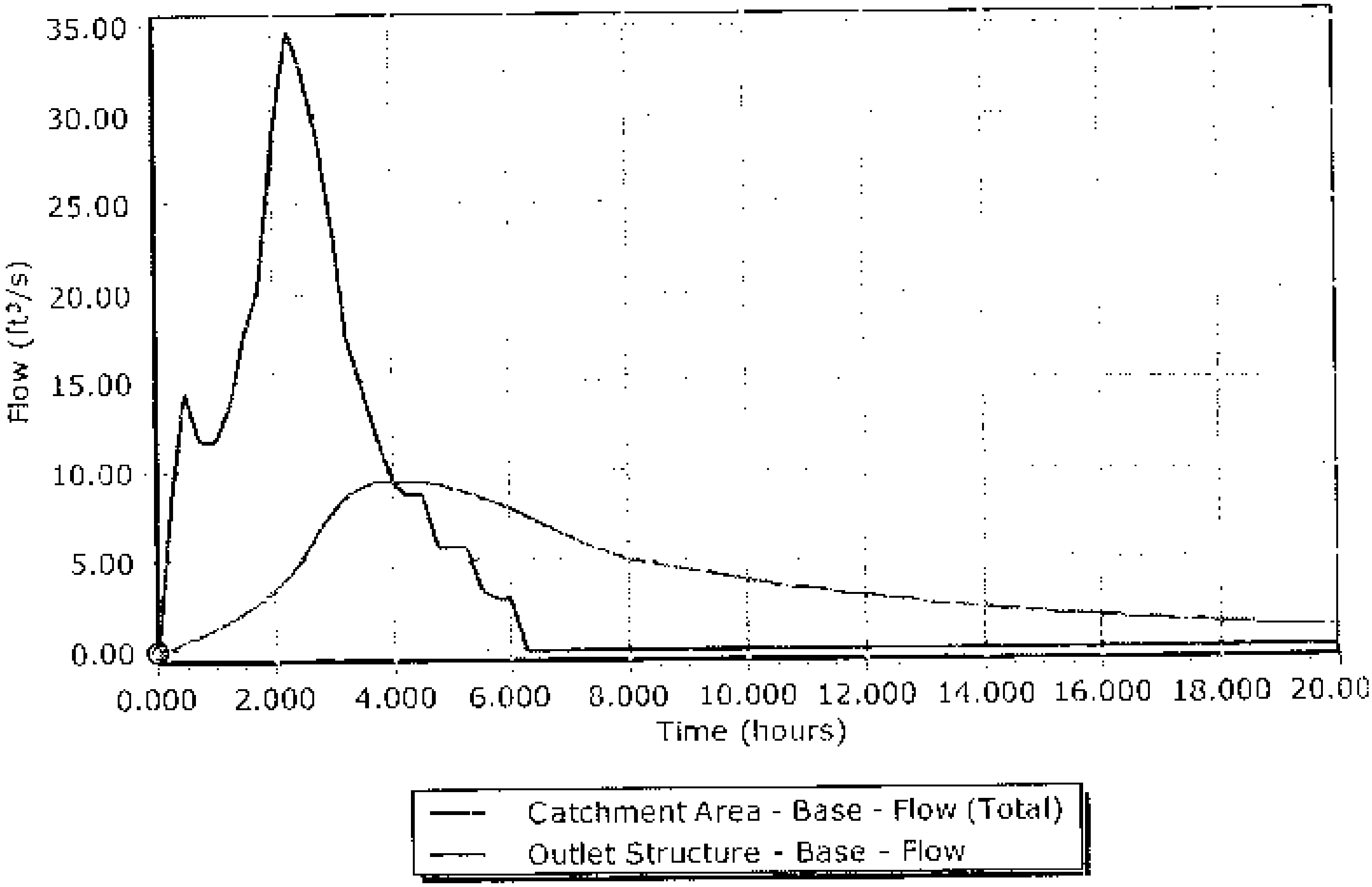
PondPack Output

Scenario: Base



AEPPIP000220

Graph - 1



35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Flow (ft³/s)
0.000
2.000
4.000
6.000
8.000
10.000
12.000
14.000
16.000
18.000
20.00
Time (hours)
Catchment Area - Base - Flow (Total)
Outlet Structure - Base - Flow

Project Summary	
Title	Picway Ash Pond Complex
Engineer	Daniel Pizzino
Company	American Electric Power
Date	5/18/2011

Notes

Table of Contents

Subsection: Master Network Summary

Catchments Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft³/s)
Catchment Area	Base	0	7.110	2.250	34.78

Node Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft³/s)
Outfall	Base	0	6.480	4.000	9.41

Pond Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft³/s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)
Ash Pond Complex (IN)	Base	0	7.110	2.250	34.78	(N/A)	(N/A)
Ash Pond Complex (OUT)	Base	0	6.480	4.000	9.41	688.71	4.667

AEPPIP000224

Storm Event	Half PMP
Return Event	0 years
Duration	20.000 hours
Depth	13.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	6.472 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	2.367 hours
Flow (Peak, Computed)	34.96 ft³/s
Output Increment	0.250 hours
Time to Flow (Peak Interpolated Output)	2.250 hours
Flow (Peak Interpolated Output)	34.78 ft³/s

Drainage Area

SCS CN (Composite)	100.000
Area (User Defined)	6.472 acres
Maximum Retention (Pervious)	0.0 in
Maximum Retention (Pervious, 20 percent)	0.0 in

Cumulative Runoff

Cumulative Runoff Depth (Pervious)	13.3 in
Runoff Volume (Pervious)	7.155 ac-ft

Hydrograph Volume (Area under Hydrograph curve)

Volume	7.110 ac-ft

SCS Unit Hydrograph Parameters

Time of Concentration (Composite)	0.083 hours
Computational Time Increment	0.011 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670
Unit peak, qp	68.00 ft³/s
Unit peak time, Tp	0.056 hours

AEPPIP000225

Subsection: Unit Hydrograph Summary | Return Event: 0 years
Label: Catchment Area | Storm Event: Half PMP

SCS Unit Hydrograph Parameters	
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	Half PMP
Return Event	0 years
Duration	20.000 hours
Depth	13.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	6.472 acres

HYDROGRAPH ORDINATES (ft³/s)
Output Time Increment = 0.250 hours
Time on left represents time for first value in each row.

Time (hours)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)
0.000	0.00	3.74	14.53	11.76	11.66
1.250	13.84	17.49	20.40	29.09	34.78
2.500	32.50	28.79	23.32	17.49	14.59
3.750	11.76	9.19	8.74	8.74	5.83
5.000	5.83	5.83	3.36	2.91	2.91
6.250	0.00	0.00	(N/A)	(N/A)	(N/A)

Subsection: Time vs. Elevation
Label: Ash Pond Complex (OUT)

Return Event: 0 years
Storm Event: Half PMP

Time vs. Elevation (ft)

Output Time increment = 0.250 hours
Time on left represents time for first value in each row.

Time (hours)	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)	Elevation (ft)
0.000	688.00	685.01	688.05	683.09	658.12
1.250	688.16	685.20	688.25	683.32	658.41
2.500	688.50	686.58	688.64	683.67	658.70
3.750	688.71	696.71	688.71	683.71	658.70
5.000	686.69	698.66	668.67	689.65	658.54
6.250	688.62	688.59	688.57	683.55	668.53
7.500	698.52	688.50	688.48	688.47	688.45
8.750	688.44	658.42	688.41	688.39	688.38
10.000	688.37	658.35	688.34	658.33	688.32
11.250	698.31	698.30	688.29	658.28	688.27
12.500	688.26	688.25	688.25	588.24	688.23
13.750	688.22	688.22	688.21	588.20	688.19
15.000	688.19	688.18	688.18	588.17	688.16
16.250	688.16	688.15	688.15	688.14	688.14
17.500	688.13	688.13	688.13	688.12	688.12
18.750	688.11	688.11	688.11	688.10	688.10
20.000	688.10	(N/A)	(N/A)	(N/A)	(N/A)

AEPPIP000228

Subsection: Time vs. Volume
Label: Ash Pond Complex

Return Event: 0 years
Storm Event: Half PMP

Time vs. Volume (ac-ft)

Output Time increment = 0.250 hours
Time on left represents time for first value in each row.

Time (hours)	Volume (ac-ft)	Volume (ac-ft)	Volume (ac-ft)	Volume (ac-ft)	Volume (ac-ft)
0.000	0.000	0.088	0.320	0.574	0.792
1.250	1.024	1.307	1.649	2.098	2.660
2.500	3.279	3.782	4.166	4.415	4.563
3.750	4.644	4.667	4.659	4.645	4.604
5.000	4.536	4.422	4.387	4.278	4.171
6.250	4.041	3.890	3.749	3.614	3.488
7.500	3.370	3.258	3.150	3.045	2.944
8.750	2.846	2.751	2.660	2.571	2.486
10.000	2.403	2.323	2.246	2.172	2.105
11.250	2.030	1.963	1.897	1.835	1.774
12.500	1.715	1.658	1.603	1.550	1.499
13.750	1.449	1.401	1.355	1.310	1.266
15.000	1.224	1.184	1.145	1.107	1.070
16.250	1.035	1.001	0.967	0.935	0.905
17.500	0.875	0.846	0.818	0.791	0.765
18.750	0.739	0.715	0.691	0.668	0.646
20.000	0.625	(N/A)	(N/A)	(N/A)	(N/A)

AEPPIP000229

Subsection: Elevation-Area Volume Curve
Label: Ash Pond Complex

Return Event: 0 years
Storm Event: Half PMP

Elevation (ft)	Planimeter (ft²)	Area (acres)	A1+A2+sqr (A1*A2) (acres)	Volume (ac-ft)	Volume (Total) (ac-ft)
688.00	0.0	6.472	0.000	0.000	0.000
690.00	0.0	6.972	20.161	13.441	13.441

Subsection: Outlet Input Data
Label: Composite Outlet Structure - 3

Return Event: 0 years
Storm Event: Half PMP

Requested Pond Water Surface Elevations	
Minimum (Headwater)	688.00 ft
Increment (Headwater)	0.50 ft
Maximum (Headwater)	690.00 ft

Outlet Connectivity

Structure Type	Outlet ID	Direction	Outfall	E1 (ft)	E2 (ft)
Inlet Box	Riser - 1	Forward	Culvert - 1	688.00	690.00
Culvert-Circular	Culvert - 1	Forward	TW	681.00	690.00
Tailwater Settings	Tailwater			(N/A)	(N/A)

Structure ID: Riser - 1 Structure Type: Inlet Box	
Number of Openings	1
Elevation	568.00 ft
Orifice Area	9.8 ft²
Orifice Coefficient	0.600
Weir Length	5.00 ft
Weir Coefficient	3.00 (ft^0.5)/s
K Reverse	1.000
Manning's n	0.000
Kev, Charged Riser	0.000
Weir Submergence	False
Orifice H to crest	False

Structure ID: Culvert - 1 Structure Type: Culvert-Circular	
Number of Barrels	1
Diameter	30.0 in
Length	60.00 ft
Length (Computed Barrel)	60.00 ft
Slope (Computed)	0.000 ft/ft

Outlet Control Data	
Manning's n	0.013
Ke	0.900
Kb	0.009
Kr	0.000
Convergence Tolerance	0.00 ft

Inlet Control Data	
Equation Form	Form 1
K	0.0340
M	1.5000
C	0.0553
Y	0.5400
T1 ratio (HW/D)	1.263
T2 ratio (HW/D)	1.425
Slope Correction Factor	0.500

AEPPIP000232

Use unsubmerged inlet control 0 equation below T1 elevation
Use submerged inlet control 0 equation above T2 elevation

In transition zone between unsubmerged and submerged inlet control,
interpolate between flows at T1 & T2..

T1 Elevation	684.16 ft	T1 Flow	27.16 ft³/s
T2 Elevation	684.56 ft	T2 Flow	31.05 ft³/s

Structure ID: TW
Structure Type: TW Setup, DS Channel

Tailwater Type	Free Outfall

Convergence Tolerances

Maximum Iterations	30
Tailwater Tolerance (Minimum)	0.01 ft
Tailwater Tolerance (Maximum)	0.50 ft
Headwater Tolerance (Minimum)	0.01 ft
Headwater Tolerance (Maximum)	0.50 ft
Flow Tolerance (Minimum)	0.001 ft³/s
Flow Tolerance (Maximum)	10.000 ft³/s

Subsection: Composite Rating Curve
Label: Composite Outlet Structure - 3

Return Event: 0 years
Storm Event: Half PMP

Composite Outflow Summary

Water Surface Elevation (ft)	Flow (ft³/s)	Tailwater Elevation (ft)	Convergence Error (ft)
688.00	0.00	(N/A)	0.00
688.50	5.30	(N/A)	0.00
689.00	15.01	(N/A)	0.00
689.50	27.55	(N/A)	0.00
690.00	42.43	(N/A)	0.00

Contributing Structures
(no Q: Riser - 1,Culvert - 1)
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1
Riser - 1,Culvert - 1

Peak Discharge	9.41 ft³/s
Time to Peak	4.000 hours
Hydrograph Volume	0.460 ac-ft

HYDROGRAPH ORDINATES (ft³/s)
Output Time Increment = 0.250 hours
Time on left represents time for first value in each row.

Time (hours)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)	Flow (ft³/s)
0.000	0.00	0.14	0.52	0.94	1.30
1.250	1.67	2.13	2.69	3.42	4.36
2.500	5.34	6.82	7.94	8.67	9.10
3.750	9.34	9.41	9.38	9.35	9.22
5.000	9.03	8.84	8.59	8.27	7.96
6.250	7.58	7.14	6.72	6.32	5.96
7.500	5.61	5.29	5.12	4.95	4.78
8.750	4.63	4.47	4.33	4.18	4.04
10.000	3.91	3.78	3.66	3.54	3.42
11.250	3.31	3.20	3.09	2.99	2.89
12.500	2.80	2.70	2.62	2.53	2.45
13.750	2.36	2.29	2.21	2.14	2.07
15.000	2.00	1.93	1.87	1.81	1.75
16.250	1.69	1.63	1.58	1.54	1.48
17.500	1.43	1.38	1.34	1.29	1.25
18.750	1.21	1.17	1.13	1.09	1.06
20.000	1.02	(N/A)	(N/A)	(N/A)	(N/A)

Index