ATTACHMENT 29
Unconsolidated Material Description
Special Waste Landfill Permit
Big Sandy Plant – Ash Pond Closure
Lawrence County, Kentucky

The details of the geological subsurface may be found in the geological subsurface report. Geologic conditions have been characterized through investigations conducted by FMSM in 2004-2005, by GeoSyntec in 2010, and Kentucky Power in 2010.

A total of twelve borings were known to have been advanced to the top-of-rock within the proposed ash pond. The borings conducted in 2004 varied in thickness from approximately three to thirty feet. The general description of the soils was that of light brown to brown moist clayey sand with occasional concretions overlying shale bedrock. The materials from the borings were characterized, from top to bottom, as; fly ash, alluvium, and bedrock identified as claystone or sandstone. The following table provides a summary of the materials.

Type	**Texture**	**Thickness**
Fly Ash	Gray to dark gray, Saturated	70 to 130 feet
Alluvium	Light brown to brown moist clayey sand	3 to 30 feet
	Yellowish, grayish brown to brown, stiff to very stiff clay and silty clay	4 to 30 feet

Twenty additional borings were performed in April 2012 by Pennsylvania Drilling Co. of Imperial, Pennsylvania; Frontz Drilling of Wooster, Ohio, and: AEP Civil Laboratory Services. Seven of the borings were converted into monitoring wells and are discussed in detail in the Hydrogeologic Site Investigation (HSI) Report. The remaining 13 borings are discussed in the **Geotechnical Summary Report**, included as a part of this attachment. A typical profile cross section is provided **Figure 3** of Geotechnical Summary Report.

GEOTECHNICAL SUMMARY REPORT

PROPOSED POND CLOSURE
AMERICAN ELECTRIC POWER
BIG SANDY PLANT – LOUISA, KENTUCKY

Prepared for:
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November 2012

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1.1 SCOPE OF WORK PURPOSE AND OBJECTIVES

This report has been prepared to summarize the subsurface exploration conducted between April 2012 and May 2012 on behalf of American Electric Power – Ohio (AEP-Ohio) for the Big Sandy Power Plant located near Louisa, Kentucky. The exploration was performed in and around the facility's ash disposal pond located near the plant and conducted in support of the Ash Pond Closure Project at the site. The data collected was used to define the subsurface profile and to characterize representative values of index and engineering properties. Laboratory testing was initiated subsequent to the drilling activities and was completed between May and August 2012. In addition to the geotechnical subsurface exploration, a geophysical investigation was performed in May 2012 to obtain data that would be useful in performing a seismic site response analysis.

1.2 SITE LOCATION AND BACKGROUND

The Big Sandy Plant operates two units generating coal combustion products (CCPs) and is located in eastern Lawrence County North of the town of Louisa, Kentucky, and just North and West of the Big Sandy River at postal address 23000 Highway 23, Louisa. The ash pond where CCPs are currently disposed is located in a valley northwest of the plant across US23 at north latitude coordinates varying between 38^{o} 10' and 38^{o} 11', and west longitude coordinates ranging between 81^{o} 37' and 81^{o} 38'. A general location map of the Site is provided in **Figure 1**.

AEP is currently filling the upstream end of the reservoir with wet-sluiced fly ash and expects the upstream area will be completely filled prior to closure. The valley slopes above the existing reservoir range from approximately 2H: 1V to 5H: 1V. Ground surface on the slopes and ridges consists of residual or weathered bedrock. Exposed outcrops are typically sandstone but heavily weathered shale is also anticipated.

Based on an aerial survey performed in March 2010, approximately 14 acres of the upstream westernmost area of the reservoir was open water at elevation 684 above mean sea level (msl) as was the downstream easternmost 16 acres of the reservoir, at elevation 658 msl.

1.3 REPORT OUTLINE

Information presented in this geotechnical summary report will be developed in the following order by sections:

1. ***Section 1*** **–** contains a summary of the scope of work associated with the subsurface investigation, the data objectives, and a description of the Site location and background.
2. ***Section 2*** **–** contains general site information including general geologic setting, the results of the review of publicly available information for unstable areas, and a summary of the site walkover.
3. ***Section 3*** **–** contains a description of the preliminary and primary subsurface investigation and conditions encountered during field activities.
4. ***Section 4*** **–** contains a summary of the geotechnical laboratory testing program and the data collected.
5. ***Section 5*** **–** contains general limitations related to the findings presented herein.

2.1 GENERAL GEOLOGIC SETTING

2.1.1 Regional Geology

According to the Kentucky Geological Survey geologic quadrangle map for Fallsburg, Kentucky-West Virginia (GQ-584), the regional geology consists of relatively flat-lying Pennsylvanian-age bedrock underlying the upland areas with a veneer of Quaternary-age alluvium in the deeper stream valleys.

The alluvium in the region typically consists of unconsolidated deposits of silt, sand, and gravel derived from present-day stream processes. The deposits may be up to 50 feet thick, with the greatest thicknesses present in the major stream valleys and less present in the tributary valleys. A relatively thin layer of residual soils generally consisting of clay derived from the weathering of underlying bedrock are generally present at higher elevations. The Pennsylvanian bedrock underlying most of the region consists of siltstones, sandstones, shales, and coal measures of the Monongahela, Conemaugh, and Princess formations. The Monongahela consists of more than 140 feet of sandstones, siltstones and clay shales. The Conemaugh is described as consisting of over 450 feet of sandstone, siltstone, and shale units with some limestone and coal units that are locally used to demarcate upper, middle, and lower portions of the formation. The Princess similarly consists of an assemblage of limestone, siltstone, and shale units, but it also has several mapped coal beds, including the Princess Nos. 5 through 8 within the Fallsburg quadrangle.

2.1.2 Site-Specific Geology

The bedrock beneath the site is mapped as Conemaugh Formation overlying the Princess Formation. The Conemaugh is mapped at elevations greater than approximately 700 feet above mean sea level (msl). The Conemaugh is generally described as siltstone, sandstone and shale separated into an upper and lower section by a limestone member identified as the Brush Creek Limestone at an approximate elevation of 780 feet msl. The Princess is mapped at the site between approximately 580 to 700 feet, msl. The Princess is generally described as a siltstone, sandstone, and shale with coal beds and associated underclays. The Kentucky Geologic Quadrangle (GQ-584) maps two sections of the Princess beneath the Conemaugh separated by a coal bed identified as P-7 located at an approximate elevation of 600 ft, msl. An underclay may be present at the base of this coal bed.

2.1.3 Previous Geotechnical Explorations

Site-specific geologic conditions have been characterized through investigations conducted by FMSM in 2004-2005, by Geosyntec in 2010, and by AEP through installation of the onsite USWAG monitoring wells in 2010. These previous investigations have involved drilling and sampling of soils, rock, and ash deposits, and the installation and testing of wells on site. The site-specific data indicate that the geology of the site consists of relatively flat-lying Pennsylvanian-age bedrock units overlain by residual soils or, in the area currently occupied by the ash pond, by a thick sequence of ash (primarily fly ash) over clay-rich alluvium in the valley bottom.

Five borings in the Horseford valley ash pond were described by Geosyntec as encountering between 60 and 100 feet of loose to very loose (with Standard Penetration Test N-values generally ranging from 0 to 5 blows per foot) gray to dark gray, saturated fly ash. Under the ash, borings encountered alluvium consisting of between approximately 4 and 30 feet of yellowish, grayish brown to brown, stiff to very stiff clay and silty clay.

Residual soils at the site were described at seven (7) locations at the site by FMSM in 2004. The borings indicated the residual soil thicknesses vary from approximately three (3) to thirty (30) feet. The general description of the soils was that of light brown to brown moist clayey sand with occasional concretions overlying shale bedrock.

Twelve borings are known to have been advanced to top-of-rock within the Horseford Creek site footprint. These borings were advanced by FMSM in 2004 and Geosyntec in 2010. Seven borings advanced by FMSM were located at elevations between approximately 750 and 850 feet, msl in the area mapped as the Conemaugh. The top of bedrock reported by FMSM at these locations was identified as shale. The five remaining borings were advanced through the ash pond and valley bottom by Geosyntec, and encountered roughly 70 to 130 feet of fly ash and alluvium before encountering top-of-bedrock identified as either claystone or sandstone.

Six borings were advanced for the installation of USWAG wells in the vicinity of Horseford Creek by AEP in 2010. One of these wells, identified as MW-1010, is located at an approximate elevation of 710 feet, msl. The borehole for this well was advanced by air rotary methods to a depth of 200 feet. Top of rock, consisting of red sandstone, was reportedly encountered at or near ground surface underlain by gray shale encountered at approximately 12 feet below ground surface. Coal beds were reported within the shale at roughly 35 and 80 feet below ground surface measuring approximately 2-foot thick each.

An additional field exploration at the site of Horseford Creek (current ash pond) was performed by URS Corporation (URS) in May 2012 as part of a soil borrow study in support of the fly ash pond closure activities. The purpose of the exploration was to generally characterize the soil comprising the valley walls surrounding the ash pond to determine if there is sufficient material to be used as borrow fill for earthwork activities required for pond closure. The borrow fill material would be placed on top of the existing ash pond and raise the existing grades to receive the soil barrier cap/liner system. The exploration consisted of advancing 21 test pits (TP-1 through TP-10 and TP-12 through TP-22). A “Soil Borrow Study Report” dated July 2012 was issued, under separate cover, to document the results of the field exploration. Some samples collected in the borrow study were utilized for laboratory testing herein.

2.2 SITE WALKOVER

2.2.1 Site Walkover(s)

During both the Preliminary and Primary Investigations, URS conducted walking and driving inspections of the proposed Site in March 2012. The reconnaissance focused on the identification of bedrock outcrops, seeps in the stream valleys adjacent to the proposed landfill, and locations of historic slope failures via classic visual indicators. The walkover information was also utilized to assist in the layout of the soil borings and to demarcate difficult areas to access for drilling equipment. The boring locations were initially staked in the field by URS personnel using a consumer grade 12-channel Global Positioning System (GPS) and located later by URS survey personnel. Borings were spaced to facilitate efficient coverage of the Site and provide both geotechnical and seismic information.

The slopes along the southern and western edges of the site were carefully inspected for signs of existing slope failures and/or instabilities during the site walkover. The following general observations were made:

- Sandstone and shale outcroppings were observed at various elevations along the valley slopes, including in the beds of the intermittent streams located at the slope toe. This indicates that the slopes consist of bedrock with a thin veneer of overburden soils at the surface.

- One existing slope failure was observed near the saddle dam, south of the access road on a very steep cut slope above a previous soil borrow area. No other areas of obvious failures, slides, or rock falls were observed in naturally formed slopes, and no specific area was observed to feature substantial signs of historic slope failure or instability. However, after the drilling activities were completed, another area of slope failure occurred east of the main dam in a man-made slope adjacent to the dam.

- Other telltale signs of possible slope movements included tilted or toppled trees noted intermittently along the slopes. Generally, these observations were of single trees or of small groups (5-10) of trees spread across relatively large lengths of slope. Most often, bent or uprooted trees were observed close to the toe of the slopes, within 15-20 ft of the elevation of the intermittent streams located at the slope toe.

The observations do not indicate that the existing slopes are unstable or are distressed. Signs of instability are not widespread and are most often encountered near the stream beds at the slope toe, where they are likely the result of erosion processes. The intermittent tilted and toppled trees may indicate that creep of the overburden soils is occurring in some areas (because the trees are likely rooted in the soil veneer), but widespread instability was not indicated.

3.1 SUBSURFACE EXPLORATIONS

This section of the report presents a description of the subsurface exploration program performed by URS in April, 2012. The main purpose of this subsurface exploration program was to collect geotechnical, hydrogeological and geophysical information sufficient for design and analysis of the proposed pond closure. A total of twenty (20) borings were drilled, with all borings extending through the overburden soils and terminating within the underlying bedrock at depths between 30 and 166 ft below ground surface (bgs). Boring locations are shown on **Figure 2**. Prior to the commencement of drilling operations, URS worked with AEP to verify the location of each boring relative to subsurface and aboveground utilities.

Eight (8) geotechnical borings (PB-1 through PB-8) within the footprint of the fly ash pond were drilled between April 2nd and April 25th, 2012 by Pennsylvania Drilling Co. of Imperial, Pennsylvania. PB-1 and PB-2 were drilled in open water outside the limits of the current area of ash placement by using a barge-mounted Acker drill rig. Borings PB-1 and PB-2 were advanced to depths of 57 and 77 ft bgs. A steel casing was first sunk through the open water and very soft pond sediments. Drilling through soils was performed using a combination of 3 ¼ and 4 ¼ –inch diameter continuous-flight hollow stem augers (HSAs), and mud rotary techniques using a 4" tricone bit. Drilling through rock was accomplished using 2 or 3-inch NQ core barrels and tooling.

Borings PB-3 through PB-8 were drilled within areas of the ash pond that have currently been filled. To provide access to these locations, earthen embankments were constructed by AEP's contractor Utter Construction, by end-dumping bottom ash over the fly ash materials in the pond. Pennsylvania Drilling then utilized these areas as access roads to drill the borings using a track-mounted CME 55 drill rig. The borings were advanced to between 57.1 and 153 ft bgs and extended through the bottom ash embankment, the pond ash deposits and underlying alluvial soils, and terminating at the top of bedrock. The borings were advanced using a combination of 3 ¼ and 4 ¼-inch inner diameter continuous-flight HSAs and mud rotary techniques using a 4" tricone bit.

Five (5) geotechnical borings (SB-3, SB-4, SB-6, SB-7, and SB-8) were drilled outside of the ash pond and within the existing valley slopes above the pond. These borings were drilled between April 10th and April 12th, 2012 by AEP using a D-120 drill rig. These borings were advanced between 29.7 and 54 ft bgs using 3¼-inch continuous flight HSAs through soil and 2 or 3-inch NX core barrels through rock.

A total of seven (7) hydrogeological borings (HB-1 through HB-7) were drilled and converted to monitoring wells (MW-1201 through 1207). These borings were drilled between April 10 and April 24, 2012 by Frontz Drilling using a CME 55 ATV-mounted drill rig as well as Versa-sonic and Vibra-sonic drill rigs. These borings were advanced between 35 and 166 ft bgs using 6¼-inch continuous flight HSAs through the soil, and TriCore air rotary, HQ Wireline, and Core Barrel drilling in the rock. The bedrock was cored using a combination of 6”outer diameter HQ cores and 4-inch inner diameter core barrels.

Representative soil samples were collected from each of the borings for classification and/or testing. The soil samples were obtained by Standard Penetration Testing (SPT) with a split-spoon sampler, in general accordance with ASTM D 1586.

Undisturbed samples of fly ash and/or fine-grained soils were obtained using 3-inch outside diameter steel (Shelby) tubes, either conventionally pushed in accordance with ASTM D 1587 (in soils), or by utilizing a piston sampler in accordance with ASTM D 6519 (in ash). Table 1, presented below, shows a summarized listing of successful undisturbed samples collected at the site. The Shelby tube samples collected were designated as “ST” while the Piston tube samples were designated as “P” in Table 1 as well as the soil boring logs and laboratory test results shown in Appendix A and B. During collection of the undisturbed samples, the in-situ density of undisturbed samples was estimated in the field using the procedure detailed below:

The length and diameter of an empty Shelby tube were measured using a tape measure and the cross-sectional area was computed. The empty tube along with two expandable tube caps was weighed on an Ohaus Catapult bench scale. After the undisturbed sample was successfully retrieved, the bottom and top of the sample were planed to create a flat surface and remove excess material to allow placement of the expandable tube cap. The recovery was measured with a folding rule following planing, free water was poured out of the tube and expandable caps were placed on top and bottom. The tube was cleaned with towels and water to remove excess soil clinging to the outside surface. The filled tube was then weighed. The weight of the sample was obtained by subtracting the empty weight of the tube and expandable tube caps from the full weight of the tube, caps and sample. The sample volume was computed based on the recovery length and cross-sectional area of the tube. The in-situ density was obtained by dividing the volume into the weight.

Table 1: Summary of Undisturbed Sampling

Boring Number	Sample Number	Sample Depth bgs (ft)	Sample Description
HB-5	ST-1	5.0-7.0	RESIDUUM
PB-1	P-1	30.0-32.0	FLY ASH
	P-2	35.0-37.0	FLY ASH
PB-2	P-1	30.0-32.0	FLY ASH
	P-2	37.5-39.5	FLY ASH
	P-3	49.0-51.0	FLY ASH
	P-4	55.0-57.0	ALLUVIUM
	ST-1	60.0-62.0	ALLUVIUM
PB-3	P-1	20.5-22.5	FLY ASH
	P-2	32.5-34.5	BOTTOM ASH
	P-3	37.5-39.5	BOTTOM ASH
	P-4	57.5-59.5	FLY ASH
	P-5	67.5-69.5	FLY ASH
	ST-1	77.0-79.0	ALLUVIUM
PB-4	P-1	18.0-20.0	FLY ASH
	P-2	27.0-29.0	FLY ASH
	P-3	32.0-34.0	FLY ASH
	P-4	47.0-49.0	FLY ASH
	P-5	62.0-64.0	FLY ASH
	ST-1	89.5-91.5	ALLUVIUM
	ST-2	99.5-101.5	ALLUVIUM
PB-5 OFFSET	P-1A	18.0-20.0	FLY ASH
PB-5	P-1	27.0-29.0	FLY ASH
	P-2	37.0-39.0	ALLUVIUM
PB-6	P-1	16.0-18.0	FLY ASH
	P-2	25.5-27.3	FLY ASH
	P-3	35.5-37.5	FLY ASH
	P-4	43.0-45.0	FLY ASH
	P-5	45.0-47.0	GRAVEL/ FLY ASH
	P-6	53.0-55.0	FLY ASH
	P-7	63.0-65.0	FLY ASH
	P-8	73.0-73.8	ALLUVIUM
	ST-1	80.5-82.0	ALLUVIUM
PB-7	P-1	22.0-24.0	FLY ASH
	P-2	37.0-39.0	FLY ASH
	P-3	47.0-48.2	FLY ASH
	P-4	52.0-54.0	FLY ASH
	P-5	57.0-59.0	FLY ASH
	P-6	62.0-64.0	FLY ASH
	P-7	72.0-74.0	FLY ASH
	P-8	77.0-79.0	FLY ASH
	P-9	82.0-84.0	FLY ASH

Boring Number	Sample Number	Sample Depth bgs (ft)	Sample Description
PB-7	P-10	87.0-89.0	FLY ASH
PB-8	P-1	32.0-34.0	FLY ASH
	P-2	62.0-64.0	FLY ASH
	P-3	77.0-79.0	FLY ASH
	P-4	87.0-89.0	FLY ASH
	P-5	97.0-99.0	FLY ASH
	P-6	117.0-119.0	FLY ASH

A URS field geologist was present to oversee all drilling and sampling operations and to visually classify and log soil and rock samples in general accordance with ASTM D 2487, D 2488 and D 6032. Where applicable, a pocket penetrometer was used in the field to estimate unconfined compressive strength of cohesive soils.

Upon completion, borings not converted to monitoring wells were backfilled with a cement-bentonite grout. After completion of all field drilling activities, the location (northing and easting) and elevation (ft msl) of all borings, with the exception of PB-1 and PB-2 located in the pond, were surveyed by URS. Latitude/ Longitude coordinates of the locations of PB-1 and PB-2 were recorded using a consumer-grade GPS device. The northing/easting and elevations for all the borings are provided below in Table 2.

A complete set of boring logs including soil descriptions, types of sampling, and laboratory test results are provided in **Appendices A** and **B,** respectively.

Table 2: Boring Locations and Elevations

Boring Number	Northing	Easting	Elevation (ft above msl)
HB-1 (MW-1201)	252798	2099724	799.38
HB-2/ SB-1 (MW-1202)	254651.6	2101180	849.59
HB-3 (MW-1206)	251617.9	2104243	695.41
HB-4/ SB-5 (MW-1204)	252025.3	2102075	721.28
HB-5 (MW-1205)	251131	2104397	714.29
HB-6 (MW-1207)	251598.3	2104256	695.02
HB-7/ SB-2 (MW-1203)	252205.1	2101406	728.67
PB-1	Lat = 38°10’57.4” N Long = 83°38’41.3” W		Top of water = 695.1
PB-2	Lat = 38°10’52.5” N Long = 83°33’35.2” W		Top of water = 695.1
PB-3	251582.4	2102704	698.29
PB-4	251302.5	2103601	699.96
PB-5	251174.1	2103663	700.90
PB-6	251301	2103083	698.6
PB-7	251635	2104228	695.3
PB-8	253100.3	2105679	674.03
SB-3	253542.1	2102379	845.75
SB-4	251829.7	2101718	794.03
SB-6	251202.5	2102399	768.75
SB-7	252280.4	2103342	850.41
SB-8	251071	2103738	711.30

3.2 SUBSURFACE CONDITIONS

Based on the results of the soil borings and laboratory test results from the data collected within the limits of the Site, the following discussion characterizes the site-specific subsurface conditions.

3.2.1 Surficial fill materials

Road fill was encountered in borings HB-2/SB-1 (MW-1202), HB-4/SB-5 (MW-1204), SB-3, and SB-8, which were located along or near the haul roads. The road fill consisted of sandy clay (SC), sand (SP), weathered sandstone, and bottom ash. Blow counts in the road fill ranged from 120 to 150 bpf, with an average of 140 bpf, indicating a generally very dense material. The thickness of this layer ranged from 0.5 to 6 ft and averaged 4.6 ft thick.

Other fill was encountered in borings HB-1 (MW-1201), HB-7 (MW-1203), and SB-6. The fill consisted of lean clay (CL), clayey sand (SC), and topsoil. Pocket penetrometers readings in the cohesive soil ranged from 0.75 to 4.5 tsf, with an average of 2.8 tsf, indicating a generally very stiff material. Blow counts in the fill ranged from 4 to 11 bpf, with an average of 7 bpf, indicating a generally loose material. The thickness of the fill ranged from 0.08 to 6 ft and averaged 2.36 ft thick.

3.2.2 Ash Materials

Ash materials were encountered in borings HB-5 (MW-1205), PB-1, PB-2, PB-3, PB-4, PB-5, PB-6, PB-7, and PB-8 (9 out of 20 borings). With the exception of PB-1 and PB-2, ash was encountered at the ground surface.

As depicted in Figure 2, PB-1 and PB-2 were located within the open water approximately 23 ft deep before encountering the underlying soft sediment layer that was 4.5 ft and 2 ft at each boring respectively. This material likely consisted of ash but could not be sampled due to the soft nature of the material and the sampler dropping through the sediments. The ash encountered consisted of both bottom ash and fly ash and ranged in thickness between 16 and 27.5 ft in borings PB-1 and PB-2 respectively. Blow counts for the ash in these borings ranged from 0 to 14 bpf and averaged 2.7 bpf, generally indicating a very loose material.

In the remaining borings in which ash material was encountered, the ash ranged in thickness between 3.5 to 133 ft and averaged 72.6 ft, and consisted of both bottom ash and fly ash. Blow counts for the ash in these borings ranged from 0 to 26 bpf, with an average of 2.2 bpf, indicating a generally very loose material. Intermittent layers of coal gravel (GM) were encountered in the ash material.

Some differentiation in the particle size of the ash materials was visually noted in the fly ash samples encountered during drilling and sampling. Specifically, zones of apparent finer ash materials were often observed interbedded with materials that were visually noted to be coarser. The “finer” samples were described as silt (ML) while the “coarser” samples were described as silty sand (SM) on the boring logs presented in Appendix A.

3.2.3 Alluvium Deposit

Natural alluvium was found in borings HB-3 (MW-1206), HB-7/SB-2 (MW-1203), PB-1, PB-2, PB-3, PB-4, PB-6, PB-7, and PB-8 (9 out of 20 borings). The alluvium was typically found beneath the ash material, with the exception of HB-7/SB-2 (MW-1203) where fill was encountered above the alluvium instead. The natural alluvium consisted of layers containing varying amounts of fat clay (CH), clayey sand/sandy clay (SC), lean clay (CL), organic clay (OH), peat (PT), organic lean clay (OL), sand (SP-SM), silty gravel (GM), clayey gravel (GC), silty clayey sand (SC-SM), and silty sand (SM). Pocket penetrometer readings taken in the cohesive soils of the alluvium ranged between 0.50 and 4.50 tsf and averaged 2.0 tsf, indicating a generally stiff material. Blow counts of the alluvium layer ranged from 3 to 44 blows per foot (bpf) with an average of 17.1 bpf, indicating a generally medium dense material. The thickness of the layer ranged from 9.5 to 26 ft and averaged 16.5 ft.

3.2.4 Residuum Deposit

The natural residuum was found to overlay bedrock in borings HB-1 (MW-1201), HB-2/SB-1 (MW-1202), HB-4/SB-5 (MW-1204), HB-5 (MW-1205), HB-7/SB-2 (MW-1203), PB-2, PB-3, PB-4, PB-5, PB-7, SB-4, SB-6, SB-7, and SB-8 (14 out of 20 borings). The residuum typically consisted of layers containing varying amounts of fat clay (CH), clayey sand/sandy clay (SC), lean clay (CL), clayey gravel (GC), and sand (SP-SM). Pocket penetrometer readings taken in the cohesive soils of the residuum ranged between 1.0 and 4.5 tons per square foot and averaged 3.4 tsf, indicating a generally very stiff material. Blow counts of the residuum layer ranged from 6 to 84 blows per foot (bpf) with an average of 23 bpf, indicating a generally medium dense material. The thickness of the layer ranged from 0.75 to 14 ft and averaged 6.2 ft.

3.2.5 Bedrock

Bedrock was encountered in all borings completed at the Site, with the exception of HB-3 (MW-1206). Bedrock was encountered between 1 and 152.3 ft bgs (526.7– 843.15 ft above msl). Bedrock was found closer to the ground surface outside of the pond and at a greater depth within the pond, below the ash and native materials. The specific bedrock elevations are shown in the table below.

Table 3: Bedrock Elevation Summary

Boring ID	Surface Elevation ft above msl	Bedrock ft bgs	Bedrock ft above msl
HB-1 (MW-1201)	799.4	12.5	786.9
HB-2/SB-1 (MW-1202)	849.6	14.5	835.1
HB-3 (MW-1206)	695.4	NA	NA
HB-4/SB-5 (MW-1204)	721.3	1.75	719.55
HB-5 (MW-1205)	714.3	8	706.3
HB-6 (MW-1207)	695.0	136	559
HB-7/SB-2 (MW-1203)	728.7	26	702.7
PB-1	695.1	53.5	641.6
PB-2	695.1	73.5	621.6
PB-3	698.3	91	607.3
PB-4	700.0	111	589
PB-5	700.9	55	645.9
PB-6	698.6	99	599.6
Boring ID	**Surface Elevation ft above msl**	**Bedrock ft bgs**	**Bedrock ft above msl**
PB-7	695.3	123.5	571.8
PB-8	679.0	152.3	526.7
SB-3	845.7	11.2	834.5
SB-4	794.0	6.3	787.7
SB-6	768.8	14	754.8
SB-7	850.4	7.25	843.15
SB-8	711.3	1	710.3
Average	**736.81**	**52.49**	**686.5**
Min	**679**	**1**	**526.7**
Max	**850.4**	**152.3**	**843.15**

NA indicates bedrock was not encountered in boring.

The bedrock generally consisted of gray/greenish gray or tan moderately to heavily weathered, quartz sandstone or micaceous sandstone with iron staining interbedded with gray/ greenish gray or tan moderately to highly weathered shale/ sandy to silty shale with intermittent coal seams and black-dark gray mudstone. The bedrock encountered appeared to be consistent with the description for the Princess formation encountered at the site and described in further detail in previous sections of the report detailing the site-specific geology.

Rock Quality Designation (RQD) was variable throughout depth and rock type, ranging from 0% to 100% (an average of 50.6%). The table below summarizes the range of RQD values and provides a correlation to typical rock mass quality characteristics. The majority of core samples had a RQD of 50% or less, with only 11.5% of samples having greater than 90% RQD.

Table 4: RQD Summary

RQD	Rock Mass Quality	% of Core Samples
<25%	very poor	25.0
25-50%	poor	25.0
50-75%	fair	21.2
75-90%	good	17.3
90-100%	excellent	11.5

3.2.6 Groundwater

The pond water level was 695.1 ft above mean sea level (msl) in the upper pond area and approximately 660 ft at the lower pond area behind the dam at the time of the exploration. Some borings close to or in the pond encountered similar groundwater elevations (PB-1 through PB-8). However, many borings drilled along the valley slopes around the pond did not encounter water during drilling. Additional information regarding the groundwater conditions for the site, including (but not limited to) water levels from recently installed monitoring wells, written description of groundwater flow, and figures illustrating the phreatic and potentiometric surfaces are presented in the Hydrogeologic Site Investigation Report.

Table 5: Groundwater Elevations

BORING ID	WATER ENCOUNTERED (BGS)	ELEVATION ENCOUNTERED (FT MSL)
HB-1 (MW-1201)	Not encountered	NA
HB-2/SB-1 (MW-1202)	28.85	820.75
HB-3 (MW-1206)	Not encountered	NA
HB-4/SB-5 (MW-1204)	Not encountered	NA
HB-5 (MW-1205)	Not encountered	NA
HB-6 (MW-1207)	Not encountered	NA
HB-7/SB-2 (MW-1203)	Not encountered	NA
PB-1	0	695.1
PB-2	0	695.1
PB-3	4	694.3
PB-4	7.6	692.4
PB-5	10.5	690.4
PB-6	Not encountered	NA
PB-7	8	687.3
PB-8	3.1	675.9
SB-3	Not encountered	NA
SB-4	Not encountered	NA
SB-6	Not encountered	NA
SB-7	Not encountered	NA
SB-8	Not encountered	NA

3.2.7 Typical Subsurface Profile

A typical subsurface profile based on the boring logs is depicted in **Figure 3**. This section is through the pond and shows the general subsurface profile on either side of the pond as well as beneath via borings PB-4, PB-5 and SB-8.

3.2.8 Borrow Material

Potential borrow material was evaluated for placement on top of the existing ash to achieve desired grades and to ascertain suitability of this material to act as subgrade material of earthen cap/ liner for the pond closure. The material was obtained from the test pits and borings conducted during the Borrow Study at the site of Horseford Creek (current ash pond) in May 2012. Details regarding the type of soil encountered, material properties evaluated, and suitability of these soils as potential borrow material are presented in the Soil Borrow Study Report issued under a separate cover in July 2012.

3.3 GEOPHYSICAL TESTING

Geophysical Testing was performed by the URS Maryland Geophysics Team in May 2012 to obtain data utilized for seismic site response analyses. The investigation consisted of vertical seismic profiling (VSP) and multichannel analysis of surface wave (MASW) surveys at the site. The combination of the two methods provided compressional wave (P-wave) and shear wave (S-wave) velocities of the site's subsurface materials. Detailed discussion regarding the geophysical testing and results obtained are provided in the "Geophysical Investigation Report" dated May 31, 2012 and presented in Appendix D.

4.1 LABORATORY TESTING RATIONALE

A laboratory testing program was conducted on selected samples to aid in classification of the soils and to evaluate relevant geotechnical parameters such as soil strength and compressibility. The laboratory testing program included the following type and number of tests:

Table 6: Summary of Laboratory Tests

TEST	STANDARD	NUMBER OF TESTS
Natural moisture content	ASTM D 2216	44
Atterberg Limits	ASTM D 4318	16
Percent Passing #200 Sieve	ASTM D 1140	8
Particle Size Analysis by Sieving	ASTM D 422	10
Particle Size Analysis by Sieving/Hydrometer	ASTM D 422	19
Specific Gravity	ASTM D 854	4
Consolidated Isotropic Undrained Test (CIU)	ASTM D 4767	9 Points
One-Dimensional Consolidation Test	ASTM D 2435	2
Cyclic Triaxial	ASTM D 5311	5
Resonant Column	ASTM D 4015	2

Soil samples obtained from SPT sampling were placed in water-tight labeled jars, sealed at the Site, and transported to the URS office in Cleveland, Ohio. The undisturbed samples were sealed in wax, covered with water-tight tape, and also transported to the URS Cleveland office. Care was taken to keep tube samples upright and to minimize vibrations during transport. The samples were reviewed by a geotechnical engineer, and selected samples were sent to subcontracted laboratory facilities for testing. Laboratory testing on soil (non-ash) samples was performed by Geotechnics in Pittsburgh, Pennsylvania. Laboratory testing on ash and some soil samples was performed by TerraSense, LLC in Totowa, New Jersey. Undisturbed samples of ash were hand-delivered to TerraSense, to minimize sample disturbance during transport and handling.

In addition to the tests performed on subsurface soils encountered during the subsurface exploration, two (2) one-dimensional consolidation tests were also performed by Geotechnics in Pittsburgh, Pennsylvania on select potential borrow materials obtained as part of the Borrow Study. It is anticipated that, during construction, significant compaction of the bottom 2-3 feet of potential borrow material on the top of the pond ash may be difficult to accomplish. The one-dimensional consolidation tests were performed to support analyses of settlement of potentially low-compacted borrow materials.

A summary and interpretation of all lab results is presented in Section 4.2 below. Complete laboratory data, including a tabulation of the lab results performed by sample location and depth for the native soils is presented in Table 12 while results of index testing for the ash samples is presented in Table 13 of **Appendix B**.

4.2 LABORATORY TEST RESULTS

Results of laboratory testing on the fill, ash materials, alluvium, and residuum deposits are summarized in this section. The data is presented in tabular format, and where appropriate, URS has performed engineering interpretation of the lab test data, and the results presented below reflect this interpretation.

4.2.1 Fill

Laboratory testing on samples from the fill was limited to index testing. Results are given in the table below.

Table 7: Summary of Lab Test Results - Fill

LAB TEST	RANGE	AVG.	NUMBER OF TESTS
Moisture Content (%)	16.4-16.7	16.6	2
Atterberg Limits (%)			
Liquid Limit	17-18	17.5	2
Plastic Limit	31	31	2
Plasticity Index	13-15	14	2
Particle Size Analysis (%)			
Gravel	8.3	8.3	1
Sand	44.5	44.5	1
Fines (Silt + Clay)	47.2	47.2	1

4.2.2 Ash Materials

Index tests, strength, consolidation, and dynamic properties were determined using ash materials generated from piston tube samples. Most testing (including static and cyclic triaxial tests, consolidation tests, and resonant column tests) was performed on reconstituted samples prepared in the laboratory using a water pluviation procedure requested by AEP. URS, AEP, and TerraSense, LLC collectively established the pluviation procedure, and an AEP representative visited The TerraSense laboratory on May 10, 2012 to work with TerraSense personnel and view initial application of the procedure in in the lab.

The pluviation procedure involved building up test samples by incrementally releasing ash material into a clear plastic column filled with free water and allowing the solids to settle through the water to the bottom of the column. This process was intended to simulate the actual deposition of ash materials in the pond, and was intended to create a sample that reflected a "loosest" density for the ash. The completely deposited sample was then extruded from the column and directly into the test membrane.

In addition to static testing of shear strength and consolidation properties, ash testing placed special focus on determining dynamic properties of the ash materials, including resonant column testing for establishing shear modulus and damping reduction curves and cyclic triaxial testing to establish liquefaction resistance. Furthermore, as described in Section 3.2.2, the fly ash materials encountered during the subsurface exploration visually exhibited differentiation in particle size, namely zones of finer fly ash materials (sometimes several feet thick) were observed interbedded with coarser materials. To explore differences in material behavior with respect to particle size, both "coarse" and "fine specimens were prepared using the pluviation procedure above, and were tested separately. This was performed by visually segregating "fine" and "coarse" zones from the extruded piston tube samples, and then building the pluviated samples using these segregated materials.

<u>Static and Index Property Testing on Ash</u>

Table 8 and the discussion below includes a summary of index property and static lab testing performed on ash.

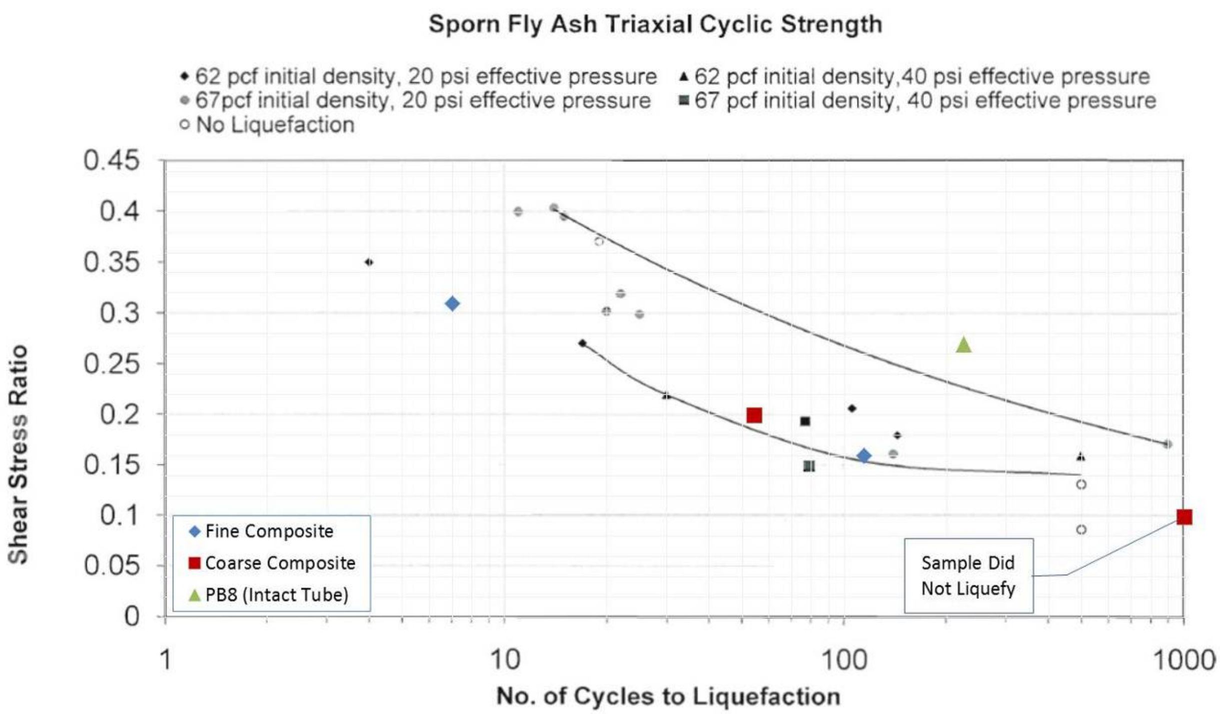
Table 8: Summary of Lab Test Results – Ash

LAB TEST	RANGE	AVG.	NUMBER OF TESTS
Specific Gravity (fine and coarse)	2.277–2.397	2.345	4
Fine Reconstituted Samples			
Dry Unit Weight (pcf)	71.8-99.9	88.3	5
Moisture Content (%)	17.6-40.6	26.3	9
Atterberg Limits (%)	Non-Plastic		
Particle Size Analysis (%)			
Coarse (Gravel + Sand)	4.2-18.4	9.2	10
Fines (Silt + Clay)	81.6-95.8	90.8	10
Percent Finer than 2µm	1-5	3.8	8
Consolidation			
Initial Void ratio	0.836	0.836	1
Compression Index	0.094	0.094	1
Recompression Index	0.017	0.017	1
Swelling Index	0.013	0.013	1
Coarse Composite Sample			
Dry Unit Weight (pcf)	70.4-82.6	77.0	4
Moisture Content (%)	26.1-49.9	37.4	10
Particle Size Analysis (%)			
Coarse (Gravel + Sand)	9.0-29.2	22.0	9
Fines (Silt + Clay)	70.8-91.0	78.0	9
Percent Finer than 2µm	1-7	2.8	9
Consolidation			
Initial Void ratio	1.009	1.009	1
Compression Index	0.096	0.096	1
Recompression Index	0.012	0.012	1
Swelling Index	0.008	0.008	1
Static CIU Triaxial			
Total Strength Friction Angle (deg)	Values based on envelope of 4 test specimens	15.5	4
Total Strength Cohesion Intercept (psi)		1.14	4
Effective Strength Friction Angle (deg)		30.2	4
Effective Strength Cohesion Intercept (psi)		0	4
Static CIU Triaxial (sheared following completion of cyclic triaxial test)			
Undrained Shear Strength (psi)	2.15-149.45	43.6	5

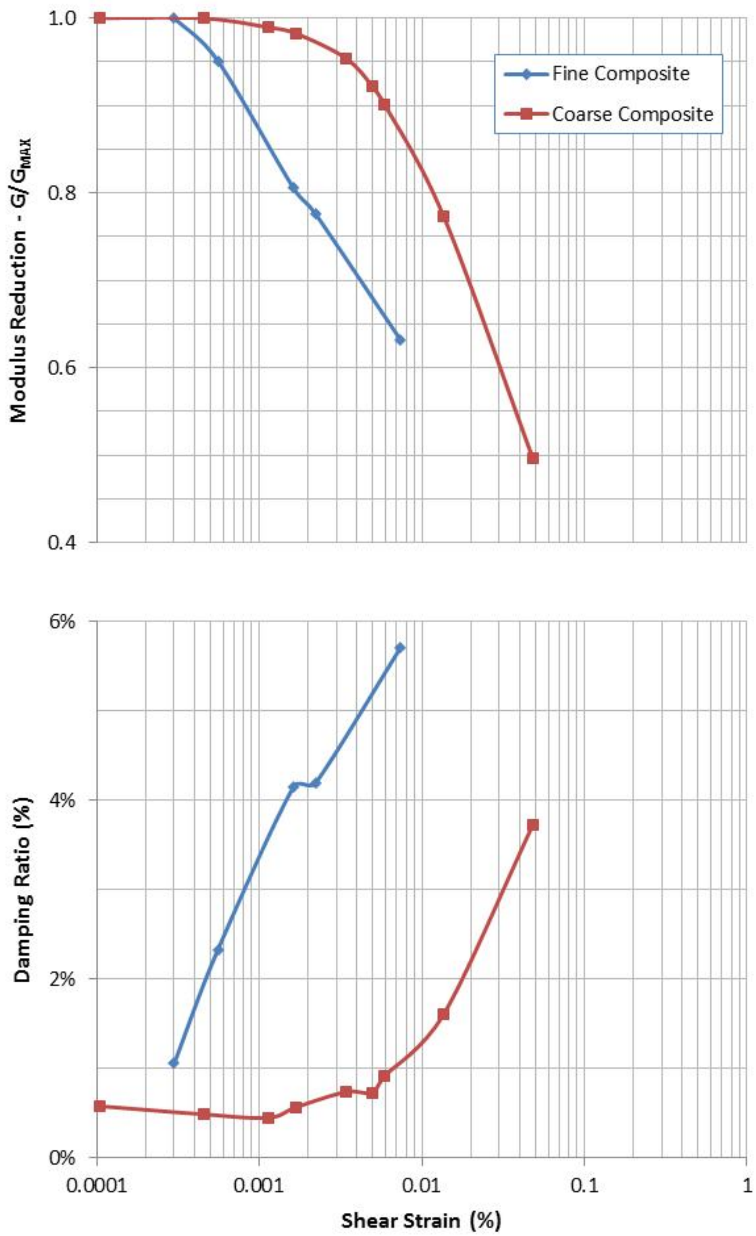
Dynamic Testing on Ash

A total of five (5) ash samples were tested in cyclic triaxial shear. Four of five samples were reconstituted using the pluviation procedure previously described. The fifth was an undisturbed piston tube sample obtained from boring PB-8. During application and demonstration of the pluviation procedure and prior to the start of production testing, the effect of the isotropic confining stress on the density of test specimens was explored by incrementally increasing the confining stress and measuring the resulting specimen density. It was found that specimen densities varied by only 5-6% over a range of confining stresses between 0 and 50 psi. A confining stress of 20 psi was thus selected for all cyclic triaxial tests, to ensure proper function of the test apparatus and to be consistent among test samples. The undisturbed specimen from PB-8 was tested at a confining stress of 30 psi, which was close to the estimated in-situ stress corresponding to the depth at which the sample was collected.

The results of cyclic triaxial testing are depicted in the figure below. The figure is a plot of test cyclic stress ratio (CSR) as a function of the observed number of load cycles to liquefaction (generally defined herein as the number of cycles at which the peak porewater pressure ratio reached 0.95). The test results are superimposed on a curve of the same data that AEP has generated for tests performed on reconstituted samples (using the pluviation procedure implemented herein) from the Sporn Plant.



It is observed that the results for reconstituted samples generally fall within but toward the lower end of the band for the Sporn data. The undisturbed specimen plots well above the band from the Sporn data. Resonant column testing was performed on two reconstituted samples – one fine and one coarse. The results of the resonant column testing are depicted in the figure below:



The results of the resonant column testing for the fine composite sample do not plot well or agree with the coarse composite specimen results. This may represent an issue with the fine specimen or the testing itself, and it is recommended that the fine results not be relied upon for performing detailed analyses.

4.2.3 Alluvium Deposits

Laboratory testing on samples from the alluvium was limited to index testing. Results are given in the table below.

Table 9: Summary of Lab Test Results - Alluvium

LAB TEST	RANGE	AVG.	NUMBER OF TESTS
Moisture Content (%)	10.4-23.7	17	10
Atterberg Limits (%)			
Liquid Limit	20-31	25.3	4
Plastic Limit	15-17	16	4
Plasticity Index	5-14	9.5	4
Particle Size Analysis (%)			
Gravel	0-31.4	10.3	9
Sand	38.5-72.5	51.2	9
Fines (Silt + Clay)	19.3-61.4	38.4	9
UU Shear Strength (psi)	3.31	3.31	1
Consolidation			
Initial Void ratio	0.522-0.995	0.753	3
Compression Index	0.122-0.172	0.152	3
Recompression Index	0.017-0.030	0.022	3
Swelling Index	0.012-0.030	0.018	3

4.2.4 Residuum

Laboratory testing on samples from the residuum was limited to index testing. Results are given in the table below.

Table 10: Summary of Lab Test Results - Residuum

LAB TEST	RANGE	AVG.	NUMBER OF TESTS
Moisture Content (%)	10.4-29.5	17.9	13
Atterberg Limits (%)			
Liquid Limit	24 -62	39.9	10
Plastic Limit	15-30	19.8	10
Plasticity Index	7-37	19.9	10
Particle Size Analysis (%)			
Gravel	4-24.8	13.3	3
Sand	35.3-67.8	53.2	3
Fines (Silt + Clay)	21.1-96.5	61.4	10

4.2.5 Borrow Material

As part of the present study, one-dimensional consolidation testing on selected samples collected during the Borrow Study were performed. Based on the results of the Borrow Study, certain residual soil materials, specifically lean clay with varying amounts of sand, were identified as a potential candidate for use as borrow. In order to mimic potential construction conditions, two select samples of this material from test pits TP-7 and TP-19 were remolded and compacted to 90% of maximum dry density and within +/- 1% of optimum moisture content and then subjected to one-dimensional consolidation testing. Summary Results of this testing are given in the table below with the detailed results of the consolidation test presented in Appendix B.

Table 11: Summary of Consolidation Test Results – Borrow Material

LAB TEST	RANGE	AVG.	NUMBER OF TESTS
Consolidation			
Initial void ratio	0.483 -0.558	0.521	2
Compression Index	0.1346-0.1844	0.1595	2
Recompression Index	0.0177-0.0499	0.0338	2

Additional laboratory testing on borrow materials, including various index tests, proctor tests, remolded permeability tests are included in the "Soil Borrow Study Report", submitted under separate cover.

The conclusions and recommendations presented in this report are based on the assumptions that our understanding of the existing Site conditions and the scope of the project do not change substantially from what has been described herein, and that soil and rock conditions do not deviate substantially from those represented by the borings taken during the subsurface exploration. It is recommended that communication be maintained with URS in order to ensure that the recommendations made herein are properly interpreted, and incorporated into the design and construction.

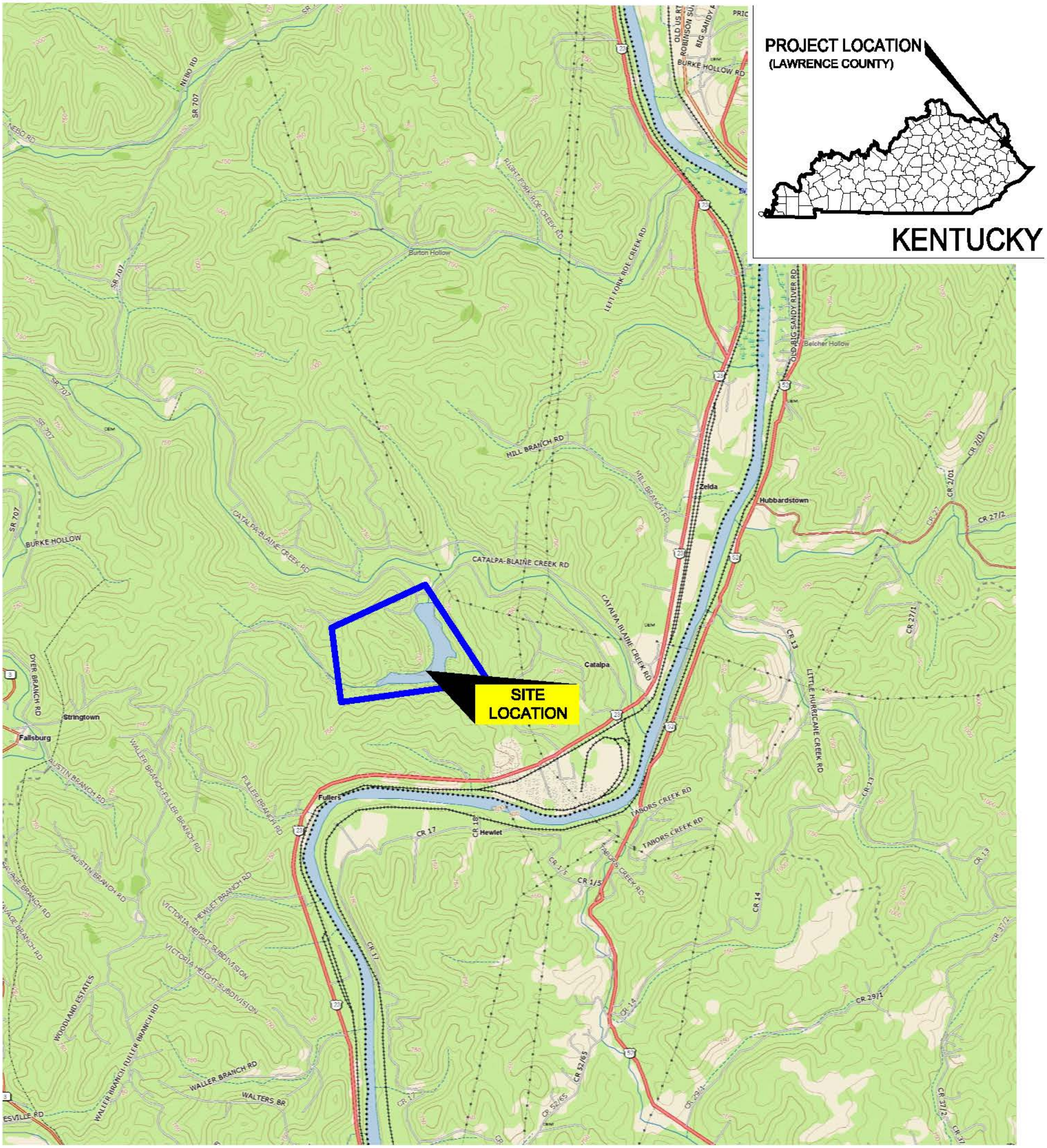
Borings have been spaced as closely as economically feasible, but variations in soil and rock properties between borings, that may become evident during construction, are possible. URS should note any variations and, if necessary, issue changes to the conclusions and recommendations made, where applicable.

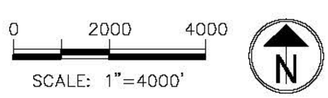
In the event that changes are made to the nature, design, or location of the proposed improvements, the conclusions and recommendations presented herein should not be considered valid, unless the changes are reviewed, and incorporated appropriately in the recommendations provided.

The conclusions and recommendations presented in this report are based on our analysis of the data collected for this project. Conclusions or recommendations made from these data by others are not the responsibility of URS.

URS's services were provided in a manner consistent with the level of care and skill ordinarily exercised by other professional consultants under similar circumstances. No other representation is intended.

FIGURES





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AEP BIG SANDY POND CLOSURE

LOUISA, KENTUCKY

GENERAL LOCATION MAP

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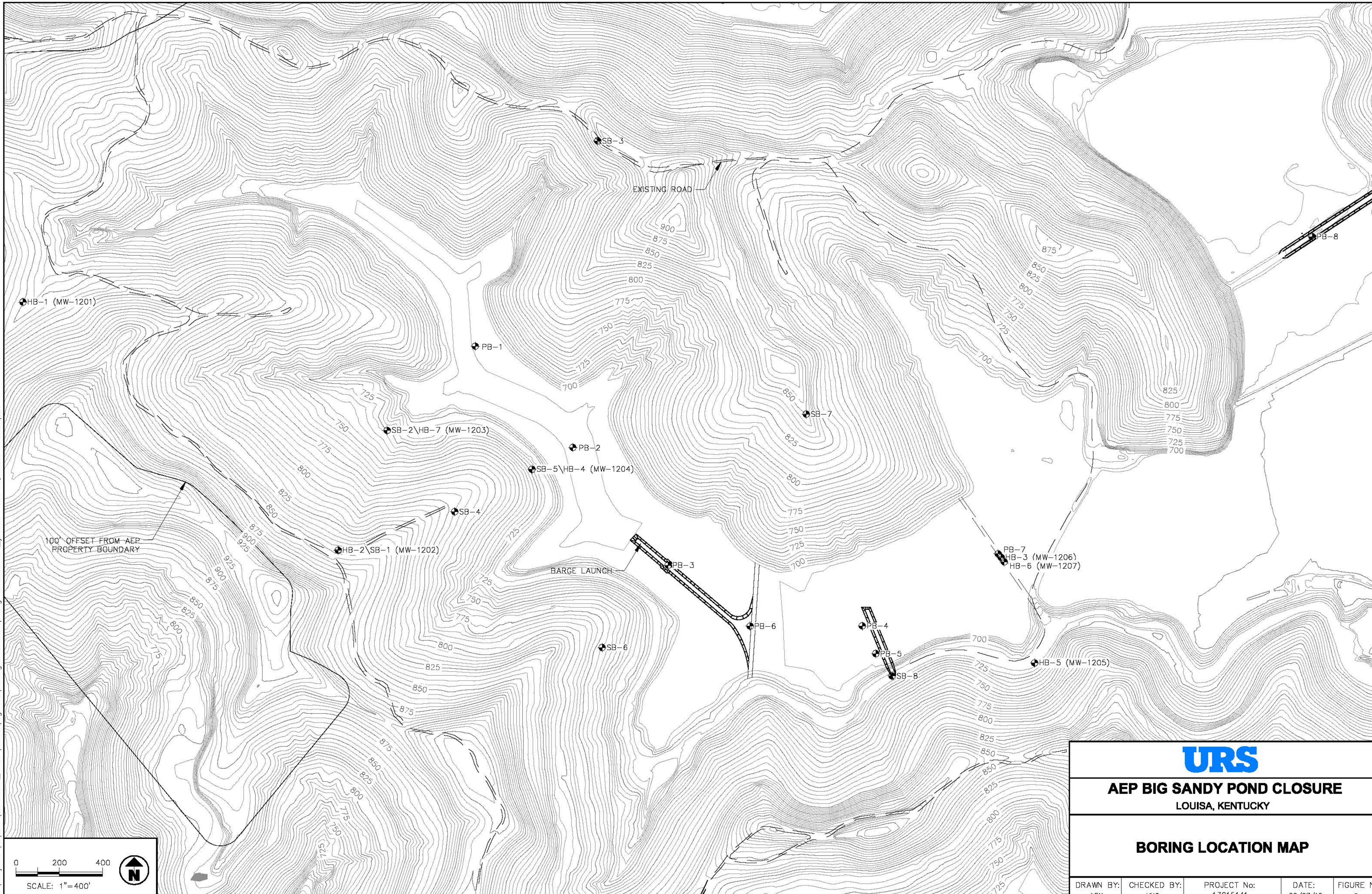

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AEP BIG SANDY POND CLOSURE

LOUISA, KENTUCKY

BORING LOCATION MAP

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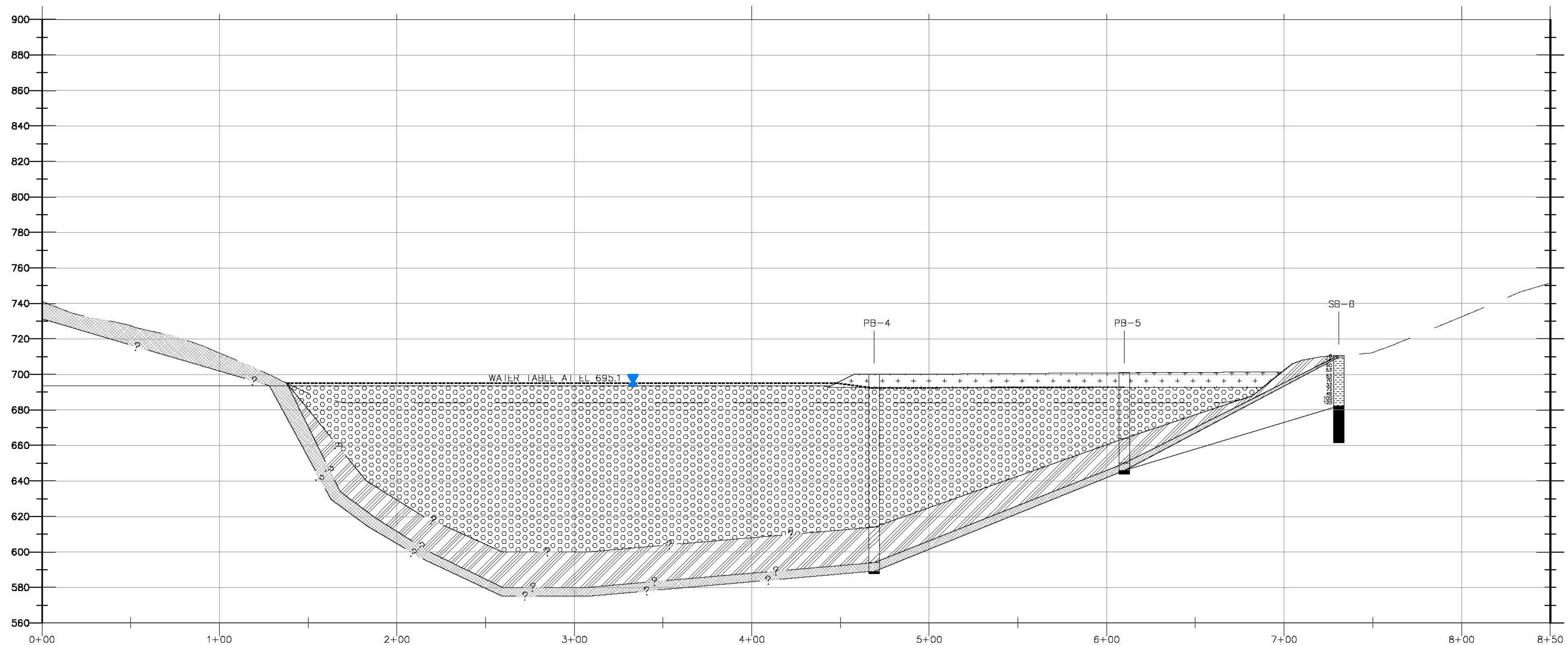

LEGEND:

ASH
ALLUVIUM
SHALE
RESIDUUM
SANDSTONE
FLOATING ASH ROAD
BORING LOCATION
SPT N VALUE
WATER TABLE
? UNKNOWN/ESTIMATED LITHOLOGY

0 30 60
SCALE: 1"=60'

URS

AEP BIG SANDY POND CLOSURE
LOUISA, KENTUCKY

TYPICAL SUBSURFACE PROFILE AT POND

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