Report of Geotechnical Exploration

Peabody Ash Pond
Paradise Fossil Plant
Muhlenberg County, Kentucky

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Prepared for:
Tennessee Valley Authority
Chattanooga, Tennessee

February 9, 2010

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Mr. Barry Snider
Tennessee Valley Authority
1101 Market Street, LP 5E-C
Chattanooga, Tennessee 37402

Re: Report of Geotechnical Exploration
Peabody Ash Pond
Paradise Fossil Plant
Muhlenberg County, Kentucky

Dear Mr. Snider:

Stantec Consulting Services Inc. (Stantec) has completed a geotechnical exploration of the Peabody Ash Pond at the Paradise Fossil Plant. Our report, transmitted herewith, includes discussions of general site conditions, scope of work performed, subsurface conditions and results of laboratory testing and engineering analyses. The report also includes a review of historical documentation provided by TVA, and our conclusions and recommendations relative to the conditions encountered at the site. These services were performed under Engineering Service Request ESR/TAO 951 in accordance with the terms and provisions established in our System-Wide Services Agreement dated July 30, 2009.

Stantec appreciates the opportunity to provide engineering services for this project. If you have any questions, or if we may be of further assistance, please contact our office.

Sincerely,

STANTEC CONSULTING SERVICES INC.

Sharath C. Vemuri, PE
Geotechnical Engineer

Hugo R. Aparicio, PE
Principal

/rdr

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Executive Summary

Stantec has completed a geotechnical exploration of the Peabody Ash Pond at Paradise Fossil Plant. Stantec's scope of work consisted of reviewing pertinent historical documentation provided by TVA, field observations, geotechnical exploration, engineering analyses and providing recommendations to perform certain improvements to the facility.

The Peabody Ash Pond consists of a main pond and an adjoining stilling pond. It is approximately 137 acres in area and partially enclosed by a 1.0-mile long dike with a maximum height of approximately 18 feet. The pond was built in 1997 on a previously strip mined and reclaimed area. It is our understanding that the previous strip mining operations left earthen fill dikes along the southern and eastern sides of the pond, next to Jacobs Creek. The approximate crest elevation of the earth dikes is 400 feet. TVA raised these dikes to 408 feet (current elevation) in 1997 for using the site as a fly-ash disposal pond. Reasonably complete design and as-built drawing information was provided by TVA, however, no information documenting engineering analysis, project specific material testing and construction quality assurance records were available for review.

The geotechnical exploration conducted by Stantec consisted of advancing 19 borings, performing field testing, installing piezometers (PZs) to monitor phreatic levels, and laboratory testing of soil samples. The exploration encountered mine-spoil deposits (lean clays) as the dike material in every boring and confirmed that this material was utilized to construct the initial dike during strip mining operations and subsequent containment dike built by TVA in 1997.

Seepage analysis was performed on a typical cross section of the dike using a finite element seepage model developed based on estimated material properties of the predominant soils. Steady-state conditions were assumed to estimate total hydraulic head values at selected nodal points and compared to values measured in the piezometers. Attempt to adjust the hydraulic properties of the subsurface materials to develop a seepage model that matches actual PZ readings was fairly successful. A minimum factor of safety of 9.5 against piping was obtained from the seepage analysis.

Slope stability of the dike was evaluated using two-dimensional limit equilibrium method of analysis, assuming static, long-term and fully drained conditions within the existing dike. Slope stability analysis was performed for a typical cross section of the dike using SLOPE/W and shear strength parameters selected based on laboratory testing. The minimum factor of safety against sliding obtained from the slope stability analysis is 1.7.

It is recommended that certain improvements be performed along the exterior slope of the dike. All the improvements are actually related to the small dike constructed during strip mining operations that preceded the development of the ash pond. After removing dense vegetation, the top of the dike should be reshaped such that positive grade is provided. There are areas where the slope of the small dike toes out along a steep bank of the Jacobs Creek channel. The corrective measures will likely include flattening of the slopes and armoring using sand and crushed limestone filter.

It is our understanding that at some point in future, TVA plans to increase the height of the dike to elevation 420 feet for creating additional storage capacity. Stantec recommends that the height of the dike be increased only after the geotechnical recommendations presented in this report are properly addressed. It is also recommended that a detailed engineering analysis (seepage and slope stability) be performed for this case prior to raising the dike.

Report of Geotechnical Exploration

Peabody Ash Pond
Paradise Fossil Plant
Muhlenberg County, Kentucky

1. Introduction

1.1. General

Tennessee Valley Authority (TVA) retained Stantec Consulting Services Inc. (Stantec) to perform facility assessments at eleven (11) active fossil plants and one closed fossil plant near the Watts Bar Nuclear Power plant. Specifically, Stantec was requested to assess the coal combustion by-product (CCB) disposal facilities at these plants. In general the facilities consisted of ash ponds, scrubber sludge (gypsum) ponds, wet ash dredge cells, dry ash stacks and gypsum stacks. A number of facilities were abandoned (having completed their design life), while majority of them were actively receiving by-products at the time of this project.

1.2. Facilities Assessment Project

Stantec's scope of work for the facilities assessment project was divided into four (4) main phases designated as Phases 1 through 4. Phase 1 was sub-divided into two phases, 1A and 1B. A brief description of Stantec's scope of work for each of the phases is presented in the following paragraphs.

- Phase 1A – Review most recent TVA inspection reports, observe critical disposal features accompanied by TVA personnel, develop a list of primary concerns and recommend immediate action or engineering assessment as considered necessary.

- Phase 1B – Review available historical documentation, visit sites for more detailed observations and measurements, complete dam safety checklists adapted from standard dam safety protocols, recommend immediate action as judged necessary and recommend sites/features that should undergo further evaluation.

- Phase 2 – Evaluate TVA facilities based on current dam safety criteria adopted by the state where the plant is located, conduct geotechnical explorations and engineering analyses at sites recommended in Phase 1B as well as complete conceptual and final repair designs and budget level costs estimates.

- Phase 3 – Design of repairs for sites recommended in Phase 2, plans and specifications for construction as well as permit/planning documents.

- Phase 4 – Dam safety training for TVA Staff and preparation of operation manuals.

At the time of this writing, Phase 1 of the assessment was completed at all fossil plants and Phase 2 was being implemented at several facilities located within the different plants. Phase 1 report recommended that Phase 2 evaluations include geotechnical exploration and hydraulic/hydrologic assessment. This report addresses the results of Phase 2 geotechnical exploration of Peabody Ash Pond facility located within the Paradise Fossil Plant.

2. Paradise Fossil Plant

2.1. General

The Paradise Fossil Plant is located in western Kentucky on the banks of Green River near the town of Drakesboro, Kentucky. The plant can be accessed by taking State Route 176 northeast from Drakesboro. Figure 1 shows the approximate location of the plant.

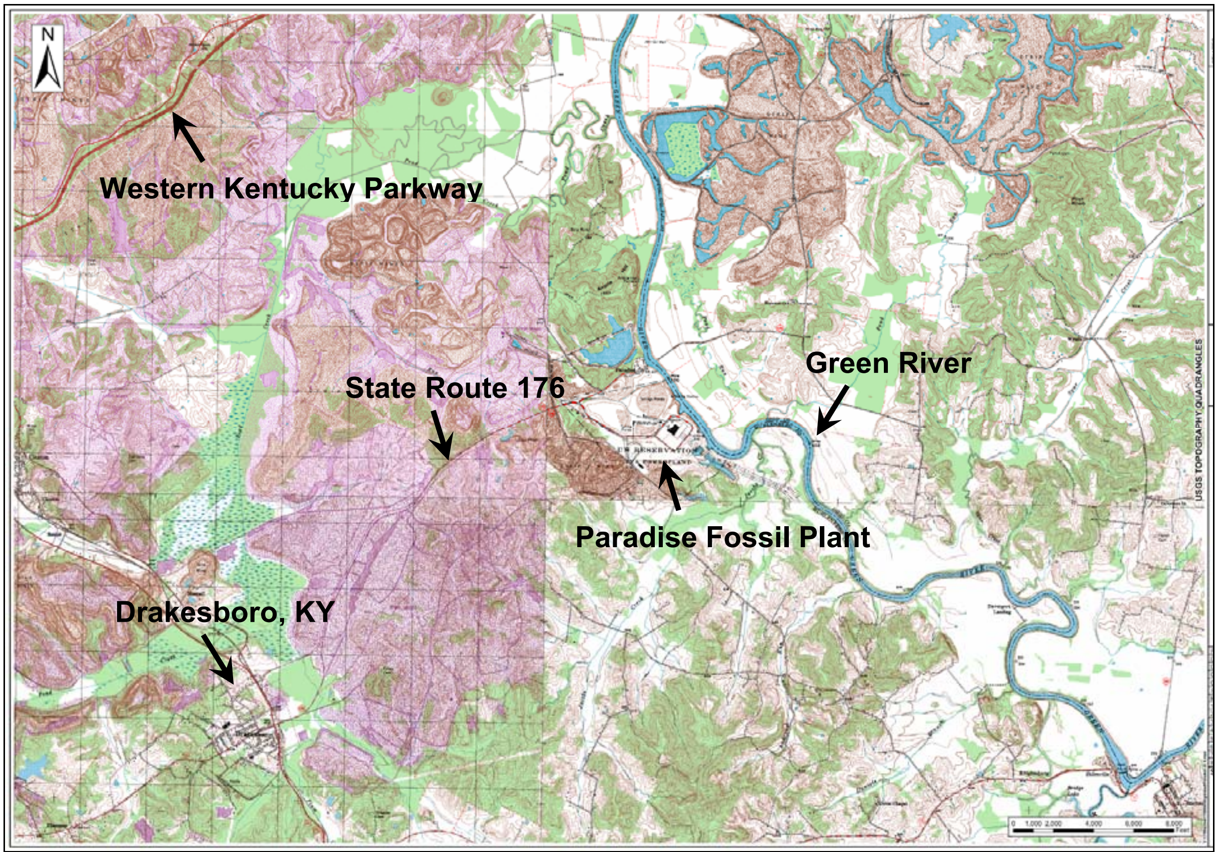

Figure 1. Approximate Site Location

2.2. Power Generation

Paradise Fossil Plant has three generating units completed between 1963 and 1970, and three large natural-draft cooling towers to provide cooling water. The plant generates 14 billion kilowatt-hours of electricity a year, enough to supply more than 930,000 homes. The winter net dependable generating capacity is 2,273 megawatts and the plant consumes approximately 20,000 tons of coal a day.

3. Peabody Ash Pond

The Peabody Ash Pond is located in the southeast corner of the Paradise facility (see Figure 2). The Peabody Ash Pond is bordered by Jacobs Creek along the east side, two lagoons belonging to the Green River watershed on the south, hilly and grassy areas along the west and Jacobs Creek Ash Disposal Pond on the north. Based on the historic documents reviewed (see Table 1), the construction of the dike took place sometime during 1997. The pond was put into operation in September 1997. The facility consists of a main pond and a stilling pond. The layout of the two ponds is presented in Figure 3.

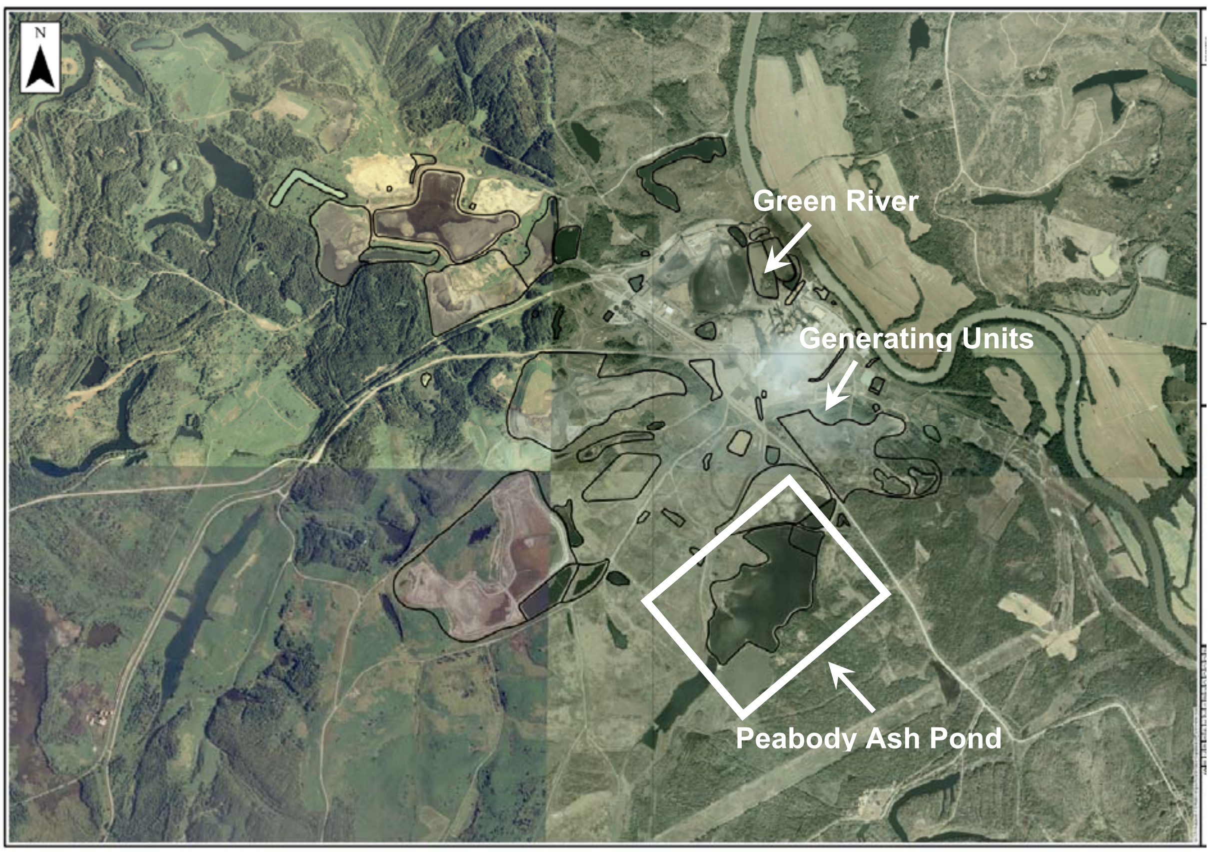

Figure 2. Location of Peabody Ash Pond

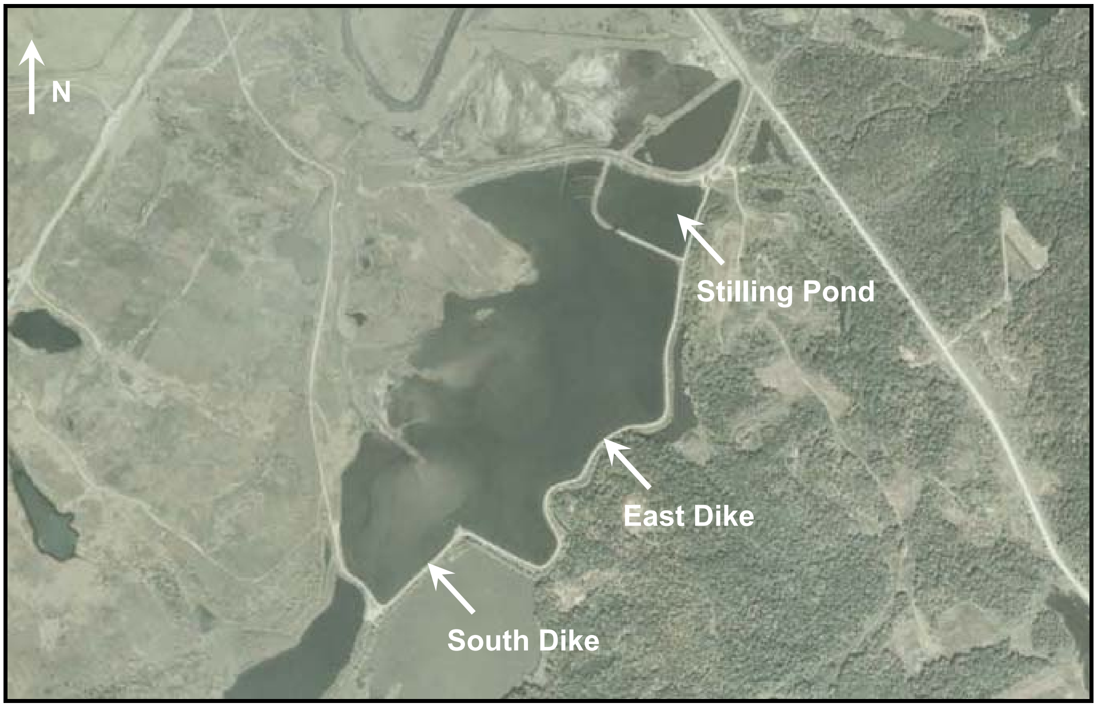

Figure 3. Peabody Ash Pond Complex

Table 1 presents key details relative to the development and dimensions of the facility.

Table 1. Details of Peabody Ash Pond

Item	Value
Construction	1996-97
Surface Area	137 Acres
Current Maximum Height	18 feet
Current Elevation of Dike	408 feet
Planned Final Elevation of Dike	420 feet
Current Overall Dike Length	5,500 feet

4. Scope of Work

The scope of the geotechnical exploration was divided into the following tasks.

a. Review of Available Information

b. Review of General Site Geology and Coal Mining Records

c. Subsurface Exploration

d. Field Instrumentation and Monitoring

e. Surveying

f. Laboratory Testing

g. Review of Existing Conditions and Ongoing repairs

h. Engineering Analyses

The work performed as part of these tasks is described in the following paragraphs

5. Review of Available Information

5.1. General

As part of the Phase 1 of facilities assessment project, Stantec reviewed all the documents provided by TVA pertaining to the Peabody Ash Pond. However, only the documents listed below (in Table 2) were considered relevant to the geotechnical exploration.

Table 2. List of Documents Reviewed for Geotechnical Exploration

Reference No.[1]	Document Name	Type of Document	Dated	Agency	TVA Reference No.
1	Environmental Assessment Report	Report	March, 1989	TVA	NA[2]
2	Jacobs Creek Ash Disposal Area Extension	Design Drawings	January, 1996 & February, 1997	TVA	10W3274 1 through 6
3	PAF Draft Report on Fly Ash Expansion from Jerry Glover to Phil Pfeifer	Report	March 29, 1998	TVA	NA[2]
4	Annual Inspection of Waste Disposal Areas[3]	Reports	FY'96 to FY'08	TVA	NA[2]

(1) Presented as attachments in this order in Appendix A
(2) Not Applicable
(3) Copies of annual reports received from TVA are not included with the report due to space constraints

5.2. Site History

The documents listed in Table 2 were used to gain an understanding of key events related to the planning, construction and operation of the Peabody Ash Pond. These events are listed in Table 3 in chronological order.

Table 3. Summary of Events

Date*	Event
March, 1988	Environmental Site Assessment for new Peabody Ash Pond
January, 1996	Initial Issue of General Plan Drawings
February, 1997	Revisions to General Plan Drawings
Feb, 1997 -Sep, 1997	Construction of Peabody Ash Pond
September, 1997	Peabody Ash Pond put into operation

*-All dates listed are approximate based on Stantec's review of available documents

Based on the historic documentation reviewed, the Peabody Ash Pond site was built on land that was previously strip mined and reclaimed. The land was originally not owned by TVA and was purchased sometime between 1988 and 1996 and later turned into fly ash disposal area. The previous strip mining operations left earthen fill dikes along the southern and eastern sides with approximate crest elevation of 400 feet. It is our understanding that the existing dikes left over from strip mining operations were too low to allow the pond to be operated above the 100-year flood elevation. In order to meet the environmental standards at that time, and for the pond to be totally above the 100-year flood elevation (while allowing enough retention time for suspended solids), TVA raised the dikes to crest elevation 408 feet. A divider dike was constructed in the northeast portion of the area to form a stilling pool. Figure 5 provides a schematic representation of dike construction obtained from the historic drawing number 10W3274-3 (dated January, 1996) provided by TVA. A copy of this drawing is also presented in Appendix A.

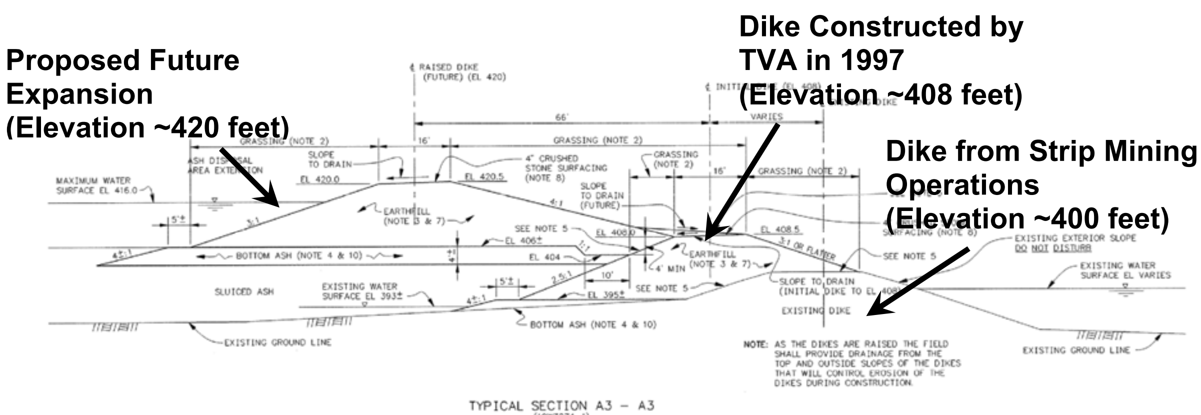

Figure 4. Cross Section of Dike from Historic Drawing No. 10W3274-3

5.3. 2009 Renovations and Existing Conditions

In February, 2009 the east and south dike interior slopes had dense phragmites growth. Despite the vegetative growth, over the years wave action had eroded most of the interior slope above and below the normal pool elevation. Based on work plans issued by Stantec, the interior slopes were repaired by TVA in June, 2009. The repairs included removal of vegetation along the interior slopes followed by armoring using filter fabric and Class II channel lining.

The exterior slopes consist of dense brush, weeds and tall trees with some intermingled grass. Tall trees were mostly noted along the original dike that was left undisturbed when the impounding dike was constructed. Most of the trees are 12 inch diameter or less, but some larger trees were also noted. There are two areas where the small earthen fill dike formed during past strip mining operations has slopes that toe out or transition into a drainage channel with a steep bank. While the historical information (Figure 5) shows the slope of the small earthen dike as 3:1, today there are areas where the channel bank slope is steeper. In one area near the northeast corner of the pond (see Figure 6), the steep slope resulted in some sloughing.

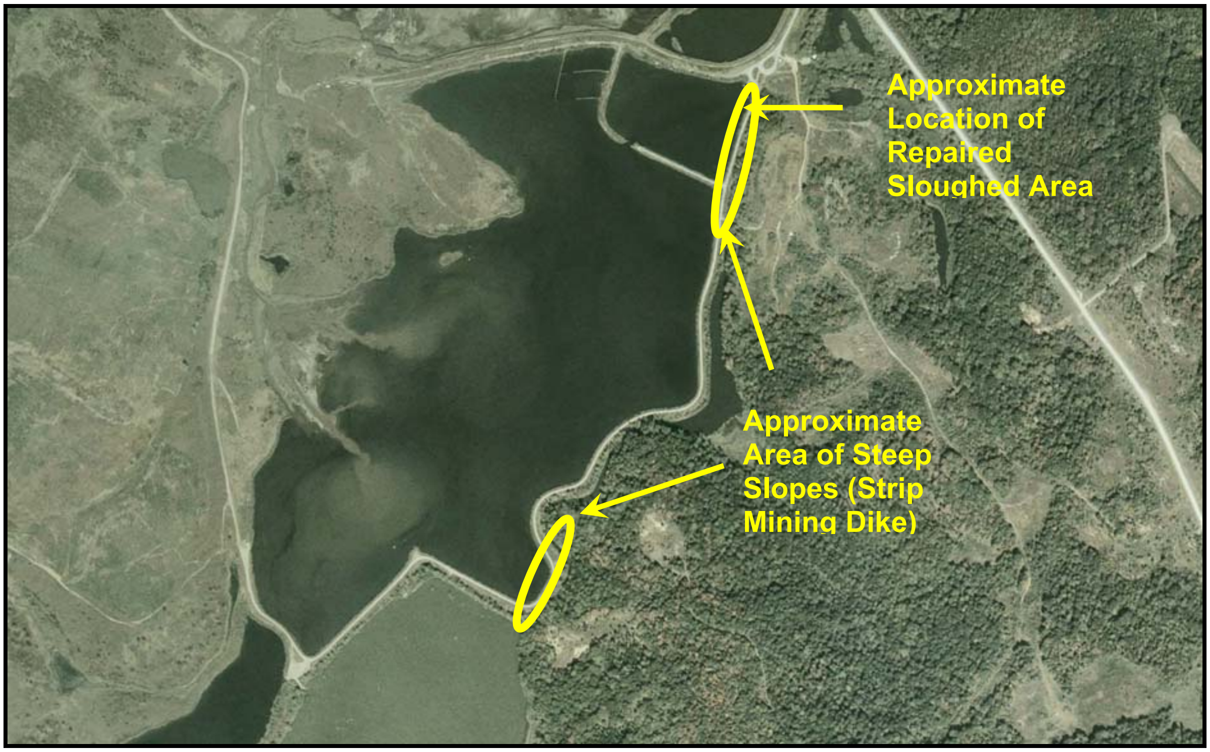

Figure 5. Approximate Location of Repaired Sloughed Area

The sloughed area was approximately 35 feet in width and 10 feet in height extending from the top of original dike (at elevation 400 feet) to the toe of the slope (at elevation 390 feet). Following an issuance of work plan by Stantec, the sloughed area was repaired by TVA. Repair measured consisted of removing vegetation and loose material in the area and slope armoring using filter fabric and Class II channel lining. The work was completed in August, 2009.

Also, there are isolated areas along the top of this earthen dike where standing water occurs due to lack of proper grade. Standing water was observed after certain precipitation events.

6. General Site Geology

6.1. Geology

The Paradise Fossil Plant is underlain by coal rich Pennsylvanian age bedrock formations. Extensive strip mining operations performed prior to the construction of the plant have significantly altered the topography and geology within the vicinity of the plant and, as such, large areas of the plant are underlain by deep mine spoil deposits.

According to the USGS Geologic Map of the Rochester Quadrangle (1974), the Peabody Ash Pond vicinity is underlain by alluvium deposits and bedrock belonging to the Sturgis and Carbondale Formations, in general order of descending geology. The Sturgis Formation is described as consisting of inter layered sandstone, shale, coal, underclay, limestone and siltstone. The coal seams listed within this formation in descending order are known as No. 13 and No. 12. The mapping also shows one unnamed seam above No. 13 seam. The Carbondale Formation generally consists of cyclic sequences of fine-grained sandstone, sandy shale, coal, and silty underclay. This formation contains in descending order the No. 11, No. 10, No. 9, No. 7 and No.6 coal seams. No. 11 seam was mapped as the top of the formation.

The No. 13 seam is shown outcropping within the footprint of the site, while an unnamed seam outcropped southwest of the site (see Figure 4). According to the topographic information shown in the geologic map, the site was developed over what used to be the floodplain of Jacobs Creek and one of its tributaries. The floodplain is shown to have contained alluvial deposits generally consisting of gravel, sand, silt, and clay.

6.2. Coal Mining

Extensive coal mining has occurred in the Peabody Ash Pond vicinity over the years (see Table 4). Coal seams mined in the vicinity include West Kentucky Coal Bed Numbers 9, 10 and 11 associated with the Carbondale Formation and West Kentucky Coal Bed Numbers 12 and 13 associated with the Sturgis Formation. There have also been numerous rider coal seams and unnamed coal seams mined in the vicinity of the power plant. Mine maps obtained from the Kentucky Mine Mapping Information System are presented along with the aerial mapping in Appendix I.

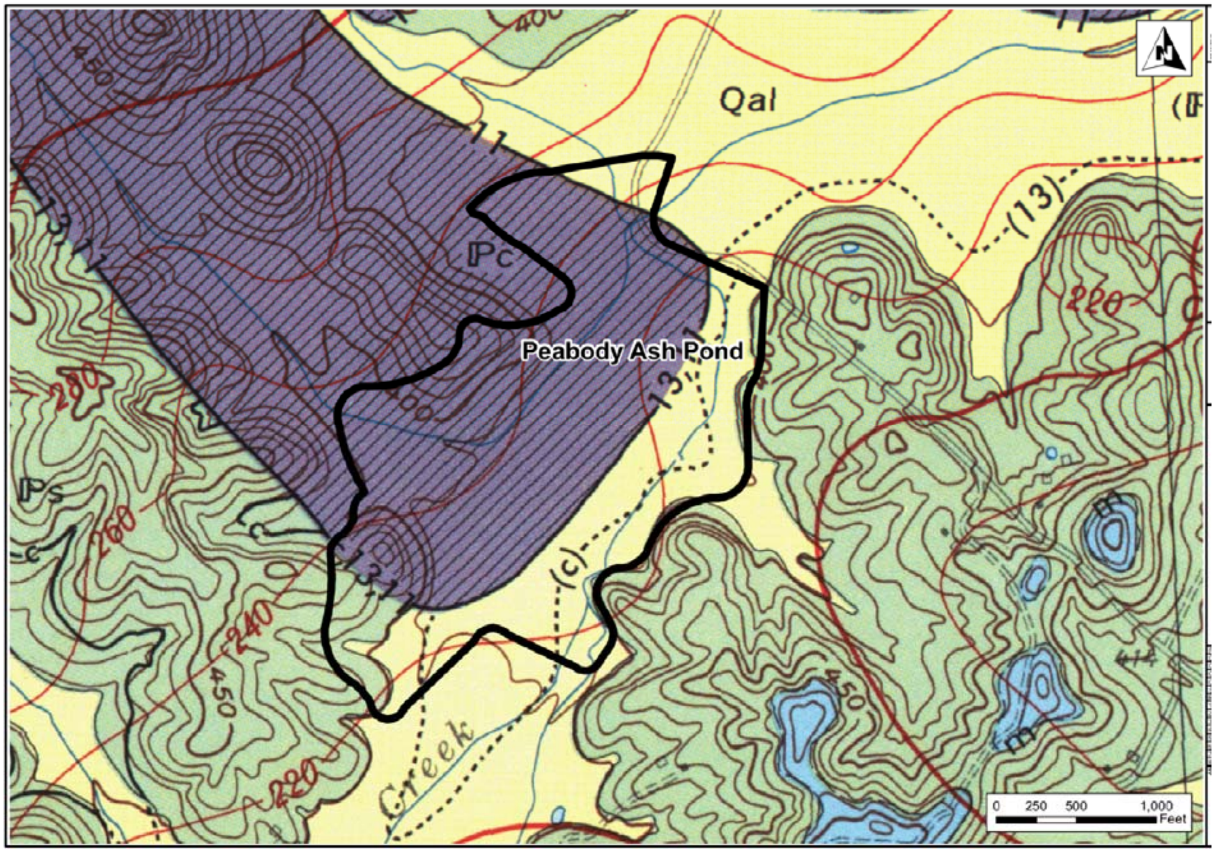

Figure 6. Geologic Map of Peabody Ash Pond (Source: USGS)

Table 4. Mining Activity in the Area of Scrubber Sludge Complex

Seam No.(1)	State File No.(s)	Type(2)	Company	Date(s) Mined	Seam(s) Mined	Type of Mining(3)
580	02106	SRC	Pittsburg & Midway Coal	1960-79	9,10,11,12,13	Surface
585	02106	SRC	Pittsburg & Midway Coal	1960-79	9,10,11,12,13	Surface
590	00825-2	STC	Peabody Coal Co.	1962-81	9,11,12,13	Surface
	00825-2	STC	Peabody Coal Co.	1962-81	9,11,12,13	Surface
600	05877-15	UTC	Peabody Coal Company	1974-91	9	Deep

(1) In descending elevation;

(2) SRC=Surface Rail Coal, STC = Surface Truck Coal, UTC=Underground Truck Coal, NA=Not Available;

(3) Surface = Area Surface Mining, Deep = Room and Pillar (or) Room and Rib Underground Mining

7. Subsurface Exploration

7.1. General

Fieldwork for the geotechnical exploration was performed by Stantec during the months of August and September, 2009. The field work consisted of advancing a total of nineteen (19) borings at the project site. Boring locations were staked and surveyed by Stantec. The locations of the borings and their corresponding elevations are given on the boring layout drawing presented in Appendix B. The subsurface exploration was performed using 4¼ inch (ID) hollow stem augers following a carbide tipped tooth bit. Rock coring was performed using NQ size coring equipment.

Standard Penetration Testing (SPT) was performed in all of the borings at continuous depth intervals. A standard penetration test consists of dropping a 140-pound hammer to drive a split-barrel sampler 18 inches. The consistency or relative density of the soil material is estimated by the number of blows it takes to drive the split spoon sampler the last 12 inches. This method is typically used to obtain soil samples, estimate the consistency or relative density of the soil and also to estimate the vertical limits of the subsurface soil horizons. The results of SPT testing are presented on the boring logs included in Appendix B and D.

Undisturbed Shelby tube samples of soils were also obtained from various borings at selected depth intervals. All Shelby tube samples were sealed with caps in the field and transported to laboratory for testing. A list of recovered samples, including sample depths and percent recovery is presented on the boring logs in Appendix B. In addition, disturbed bag samples of auger cuttings were also obtained during the subsurface exploration for further laboratory testing.

Upon completion of the drilling and sampling procedures, the boreholes were either backfilled with auger cuttings or well backfill materials (if piezometer was installed). A geologist was present on-site throughout the drilling and sampling operations. The geologist directed the drill crew, logged the subsurface materials encountered during the exploration and collected soil and rock samples. Particular attention was given to soil's color, texture, moisture content and consistency or relative density. Samples will be available for review up to thirty (30) days following the submittal of final version of this report, at which time the samples will be discarded unless prior arrangements for storage have been made.

7.2. Summary of Borings

A boring layout drawing is presented on a drawing included in Appendix B. Typed boring logs are presented in Appendix B and D. Summary of boring information is presented in Table 5, where all measurements are expressed in feet.

Table 5. Summary of Borings

Boring No.	Top of Hole (Elevation)	Bottom of Hole (Elevation)	Bottom of Hole (Feet)	Top of Rock* (Elevation)	Begin Core (Elevation)	Length of Core (Feet)
STN-1	411.2	364.7	46.5	No Refusal	- -	- -
STN-2	408.6	367.1	41.5	No Refusal	- -	- -
STN-3	408.5	346.5	62.0	353.5	352.0	5.5
STN-4	407.9	361.4	46.5	No Refusal	- -	- -
STN-5	407.9	361.4	46.5	No Refusal	- -	- -
STN-6	407.8	372.4	35.4	377.0	- -	- -
STN-7	401.4	376.9	24.5	378.4	- -	- -
STN-8	408.4	372.5	35.9	378.4	- -	- -
STN-9	407.8	373.8	34.0	380.8	- -	- -
STN-10	Not Drilled					

Table 5. Summary of Borings

Boring No.	Top of Hole (Elevation)	Bottom of Hole (Elevation)	Bottom of Hole (Feet)	Top of Rock* (Elevation)	Begin Core (Elevation)	Length of Core (Feet)
STN-11	408.4	363.1	45.3	368.4	- -	- -
STN-12	408.5	362.0	46.5	362.6	- -	- -
STN-13	Not Drilled					
STN-14	408.3	370.1	38.2	No Refusal	- -	- -
STN-15	407.9	372.0	35.9	375.9	- -	- -
STN-16	400.1	375.6	24.5	376.1	- -	- -
STN-17	407.8	361.3	46.5	No Refusal	- -	- -
STN-18	408.0	361.5	46.5	No Refusal	- -	- -
STN-19	Not Drilled					
STN-20	408.3	342.6	65.7	348.1	348.1	5.5
STN-21	408.6	362.1	46.5	No Refusal	- -	- -
STN-22	405.7	375.7	30.0	No Refusal	- -	- -

*- Approximate, actual determination cannot be made without rock coring.

7.3. Subsurface Soil Conditions

The subsurface conditions encountered in different borings consisted of mine-spoils (Soil 1 and Soil 2) underlain by alluvial deposits (Soil 4, Soil 5 and Soil 6) belonging to the Jacobs Creek flood plain. Bottom Ash (Soil 3) was also encountered in several borings beneath Soil 1.

Soil 1 encountered in different borings consisted of mine-spoil. Soil 1 can be visually described as lean clay with intermediate sand lenses, brown to gray with some reddish mottling, moist to wet, soft to very stiff and with heterogeneous mixture of coal, shale, and chert fragments. Laboratory tests classified Soil 1 as CL according to Unified Soil Classification System (USCS) and A-6(7) or A-6(8) according to American Association of State Highway and Transportation Officials (AASHTO) soil classification system.

Soil 2 encountered in different borings consisted of mine-spoil. Soil 2 can be visually described as lean clay with sand, olive gray to grayish brown with intermittent orange mottling, moist to wet, stiff to very stiff and with heterogeneous mixture of coal, shale, and chert fragments. Laboratory tests classified Soil 2 as SC or CL according to USCS and A-6(4) or A-6(14) according to AASHTO soil classification system.

Soil 3 encountered in only few of the borings consisted of bottom ash with sand, black to dark brown, wet, loose to very loose and with fine to gravel sized coal fragments.

Soil 4 consisted of clayey sand, brown to grayish brown, moist to wet and loose to medium dense. Laboratory tests classified Soil 4 as SC according to USCS and A-4(0) and A-4(1) according to AASHTO soil classification system.

Soil 5 consisted of lean clay, light to dark brown with orange mottling, moist to wet, soft to stiff and with occasional chert fragments. Laboratory tests classified Soil 5 as SC or CL according to USCS and A-6(4) or A-6(14) according to AASHTO soil classification system.

Soil 6 can be visually described as lean clay, gray to brownish gray with some orange mottling, moist to wet, very soft to stiff, with some silt and traces of sand and occasional traces of coal and chert fragments. Laboratory tests classified Soil 6 as SC or CL according to USCS and A-6(4) or A-6(14) according to AASHTO soil classification system.

7.4. Bedrock Conditions

Rock coring was performed in Borings STN-3 and STN-20. The top of rock was at elevations 353.5 feet in STN-3 and 348.1 feet in STN-20. Bedrock encountered in STN-3 and STN-20 can be described as shale, light gray and moderately hard. The rock core recovery percentage was 95 percent in STN-3 and 100 percent in STN-20. Rock Quality Designation (RQD) values were 62 percent and 66 percent in STN-3 and STN-20, respectively.

7.5. Subsurface Water

Subsurface water was encountered in most of the borings advanced during this exploration. The water level reading was taken after the boring had been drilled and before the installation of instrumentation. The depths to water noted immediately after drilling are shown on the boring logs presented in Appendix B and D. Additional water level readings were obtained from piezometers installed in some of the borings as discussed in the following section of this report.

8. Field Instrumentation and Monitoring

8.1. General

As part of the geotechnical exploration, Stantec installed nine (9) piezometers in the boreholes. The following paragraphs provide additional details regarding the instrumentation and monitoring program.

8.2. Instrumentation

The instrumentations installed as part of the geotechnical exploration were standpipe piezometers (PZ) consisting of a 5-feet long perforated screen attached to riser pipe. The annulus around the perforated screen was filled with sand and a bentonite seal was placed above and below the sand layer to isolate the reading zone. Above the isolated zone, the annular space between the riser pipe and the borehole was backfilled to the surface with bentonite grout to prevent vertical migration of water. The riser pipe was terminated slightly below ground level (approximately 0.2 feet) and protected with a flush mount metal cover. Table 6 provides a summary of the piezometers installed. Appendix C presents the PZ Instrumentation Details.

Table 6. Summary of Instrumentation*

Boring No.	ID
STN-1	PZ-1
STN-6	PZ-6
STN-7	PZ-7
STN-12	PZ-12
STN-15	PZ-15
STN-16	PZ-16
STN-18	PZ-18
STN-21	PZ-21
STN-22	PZ-22

*-All instruments installed are piezometers

8.3. Monitoring

Stantec began a monitoring program upon installation of instruments listed above. The purpose of the monitoring program was to obtain periodic water level readings (from PZs) using a water level indicator. Stantec's schedule for monitoring program is presented in Table 7. Results of monitoring program are presented in Appendix F.

Table 7. Instrumentation Reading Schedule

Month	Reading No.	Tentatively Scheduled	Actual Date	Status
1	1	September 14, 2009	September 21, 2009	Complete
2	2	October 12, 2009	October 20, 2009	Complete
3	3	November 16, 2009	November 16, 2009	Complete
4	4	December 14, 2009	December 13, 2009	Complete
5	5	January 11, 2010	January 18, 2010	Complete
6	6	February 15, 2010		Scheduled

9. Laboratory Testing

The soil samples obtained from the boreholes were subjected to laboratory tests in general accordance with ASTM standard testing procedures. Detailed results of laboratory testing are presented in Appendix F. A summary of laboratory tests performed is presented in Table 8.

Table 8. Summary of Laboratory Tests Performed

Serial No.	Testing for	Standard
1	Natural Moisture Content	ASTM D 2216
2	Atterberg Limits	ASTM D 4318
3	Specific Gravity	ASTM D 422
4	Particle Size Analysis	ASTM D 854
5	Shear Strength	ASTM D 4767, ASTM D 2850
6	Permeability	ASTM D 5084

10. Review of Completed Repairs

As part of a facilities assessment project, Stantec has been assisting TVA with repairs associated with wave erosion along interior slopes and isolated exterior slope sloughing and maintenance for the Peabody Ash Pond. Repairs performed over the past few months included slope stabilization measures and slope armoring. Stantec has issued two work plans associated with the repairs as summarized in Table 9.

Table 9. Dike Repair Work Plans at Peabody Ash Pond

No.(1)	Location	Type of Disturbance	Repair Type	Work plan Issued	Work Completed
1	East and South Dikes	Erosion of Interior Slopes	Slope Armoring	April 30, 2009	June 26, 2009
2	East Dike	Sloughing of Exterior Slope	Slope Armoring	July 15, 2009	August 12, 2009

11. Engineering Analyses

11.1. General

Based on the review of available information, results of geotechnical exploration and results of laboratory testing, Stantec performed engineering analyses of the Peabody Ash Pond. This included seepage and slope stability analysis of typical cross section of the dike. The analysis procedure and results of the analyses are presented in the following paragraphs.

11.2. Seepage Analysis

11.2.1. Background

The objective of seepage analysis was to understand the total head (and pore water pressure) distribution within a given cross section of the dike for slope subsequent stability analysis. Seepage analysis was performed using SEEP/W, a numerical software tool developed by Geo-Slope International Inc. SEEP/W is a finite element software product for analyzing groundwater seepage and pore-water pressure distribution problems within porous materials such as soil and rock.

The first step in the seepage analysis was to develop a cross section of the dike. Stantec utilized boring logs, historic drawings and survey information to estimate the subsurface horizons at each cross section. SEEP/W uses the concept of regions and points to define the geometry of a problem and to facilitate discretization (or meshing) of the problem. Upon estimating the geometry of the model, material properties were assigned for the *Saturated/Unsaturated Model* offered in SEEP/W. The next step in the process was to define boundary conditions. All boundary conditions were applied to region points and region lines. Upon defining the boundary conditions, the model was analyzed using *Steady State* seepage analysis option available in SEEP/W based on the assumption that the boundary conditions are constant over time. Specific details regarding the analysis procedure are presented in the following sections.

11.2.2. Typical Cross-Section

Seepage analysis was performed for a typical cross section (AA') taken through borings STN-21 and STN-22. The typical cross section was generally representative of the remaining portions of the dike. The subsurface soil horizons for the cross section were estimated based on the information gathered from the borings, historic cross section from drawing number 10W3274-3 (Figure 4) and straight interpolation between borings.

11.2.3. Material Properties

The material properties used for seepage analysis are presented in Table 10.

Table 10. Material Properties for Seepage Analysis

Soil Horizon	Saturated k_v (cm/s)	Ratio k_h / k_v	Specific Gravity G_s	Void Ratio e	Volumetric Water Content		Estimated From
					Saturated (ft^3/ft^3)	Residual (ft^3/ft^3)	
Soil 1: Lean Clay with Sand	1.0e-7	10	2.72	0.40	0.29	0.02	Results of Laboratory Testing
Soil 2: Lean Clay with Sand	1.0e-7	10	2.72	0.40	0.29	0.02	Assumed same as Soil 1
Hydraulically Placed Ash	3.0e-5	50	2.31	0.85	0.46	0.04	TVA – Kingston Fossil Plant
Soil 4: Clayey Sand	1.1e-7	20	2.67	0.47	0.32	0.02	Results of Laboratory Testing
Soil 6: Silty Clay	5.8E-8	50	2.7	0.60	0.38	0.03	Results of Laboratory Testing

Note: SEEP/W requires input parameters k_h and ratio of k_v/k_h

11.2.4. Results

Detailed results of seepage analysis are presented in Appendix H. Table 11 presents a comparison of the SEEP/W results (total head) with the measurements taken from the piezometers.

Table 11. Total Head Measurements*

Cross-Section	Piezometer	SEEP/W Value (feet)	Field PZ Value on 11/16/2009	Difference Average Field Measurement
A-A'	PZ-21	400.9	401.2	0.3
	PZ-22	400.3	401.5	1.2

The results from the seepage analysis were also utilized to calculate the factor of safety against piping. Summary of computed exit gradients and factor of safety against piping are presented in Table 12.

Table 12. Summary of Factor of Safety Against Piping

Cross Section	Vertical Gradient (i_v) at Critical Exit Point	Material	Critical Gradient (i_{crit})	F_{piping}
A-A'	0.13	Soil 2: Lean Clay with Sand	1.23	9.5

11.3. Stability Analysis

11.3.1. General

The stability of the existing dike slope2 (for typical cross-section) was evaluated using SLOPE/W Computer Program. Factor of safety against sliding was calculated using Spencer's method.

11.3.2. Material Properties

The material properties used for slope stability analysis are presented in Table 13.

Table 13. Material Properties for SLOPE/W

Soil Horizon	Unit Weight (pcf)		Effective Shear Strength Parameters	
	γ_{moist}	γ_{sat}	c' (psf)	ϕ' (degrees)
Soil 1: Lean Clay with Sand	138	139	0	32
Soil 2: Lean Clay with Sand	138	139	0	32
Hydraulically Placed Ash	100	107	0	25
Soil 4: Clayey Sand	129	133	0	30
Soil 6: Silty Clay	126	129	0	30

11.3.3. Results

The computed factors of safety are presented in Table 14. Results of slope stability analysis are presented in Appendix H.

Table 14. Summary of Factors of Safety Against Sliding

Cross-Section	Down Stream Side	Up Stream Side
A-A'	1.7	2.2

12. Conclusions and Recommendations

12.1. General

The conclusions and recommendations that follow are based on the review of project documentation made available by TVA, site visits, results of the geotechnical exploration and results of engineering analyses reported herein. If additional information becomes available or site conditions change, Stantec should be notified so that appropriate adjustments can be made to the conclusions and recommendations contained herein.

12.2. Subsurface Conditions

The subsurface conditions noted during the exploration are consistent with site history in that mine-spoils belonging to strip mine operations and alluvial deposits belonging to Jacobs Creek were noted in almost all of the borings. Soils 1 and 2 were mine-spoil materials classified as lean clays with sand. Specifically, Soil 1 was used as earthen fill for constructing the Peabody Ash Pond dike sometime during 1997. Soil 2 was used as earthen fill to construct the dike during previous strip mining operations. Soil 3 was bottom ash material placed as foundation material during the 1997 dike construction by TVA (See Figure 4). Soils 4, 5 and 6 were alluvial soils belonging to the Jacobs Creek flood plain. The elevation of top of rock ranged from approximately 354 feet in the northern portion of the site to approximately 348 feet in the southern portion of the site. The cored portion of the bedrock consisted of Shale described as light gray and moderately hard.

12.3. Seepage and Slope Stability of Typical Cross Section

The seepage analysis of typical cross section indicates a factor of safety against piping of 9.5. The factor of safety against sliding obtained from the slope stability analysis of this cross section ranges from 1.7 to 2.2.

12.4. Drain Channel Bank below Strip Mine Earth Dike

As indicated in Section 5 of this report, the Peabody Ash Pond was built on land previously strip mined and reclaimed. The strip mining operations left small earth dikes along the southern and eastern sides of the facility that toe out along a drainage channel. The ash pond dikes were built as an extension of these earth dikes as shown in Figure 4. There are two areas (see Figure 5) where the toe of the strip mine dike transitions into a steep drain channel bank, presumably created as a result of channel flow scouring. It is possible that similar scouring caused sloughing of the same earth dike near the northeast side of the ash pond, which was repaired in 2009.

It is recommended that the drainage channel adjacent to the strip mine dike be armored where the channel bank slope is steeper than 2.5H:1V. If left unattended, these areas may eventually cause sloughing similar to the one observed near the northeast side of the ash pond. The repair work should begin by mowing the dense vegetation covering these areas. After proper inspection of the mowed surfaces, the vegetation in bank areas to be repaired should be stripped. The corrective measures will likely include flattening of the slopes and armoring using sand and crushed limestone filter.

As described in Section 5 of this report, the top of the strip mine earth dike remains wet probably due to poor grade conditions. It is recommended that these areas be regraded to promote positive drainage.

12.6 Closure

The scope of Stantec's services did not include an environmental assessment or investigation for the presence or absence of hazardous or toxic materials in the soil, surface water or groundwater at the project site. Any statements in this report or on the boring logs regarding odors noted or unusual or suspicious items or conditions observed are strictly for the information of the client.

The conclusions and recommendations presented herein are based on information gathered from the boring advanced during this exploration using that degree of care and skill ordinarily exercised under similar circumstances by competent members of the engineering profession. No warranties can be made regarding the continuity of conditions between and beyond borings.

Appendix A

Historic Documents

Appendix B

Boring Layout and Typed Logs of Boring

Appendix C

Instrumentation Layout and Logs

Appendix D

Graphical Logs and Borings

Appendix E

Typical Cross Section

Appendix F

Piezometer Readings

Appendix G

Results of Laboratory Testing

Appendix H

Results of Engineering Analysis

Appendix I

Mine Maps