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Coal Combustion Waste Impoundment

Task 3- Dam Assessment Report

E. W. Brown Plant

Auxiliary Ash Dam Complex
E.ON U.S. LLC
Harrodsburg, Kentucky

Project # 0-381

Assessment of Dam Safety
Coal Combustion Surface Impoundments
For the REAC Program

Prepared for:

Lockheed Martin Services, Inc.
Edison, New Jersey
For
United States Environmental Protection Agency

Prepared by:

Dewberry
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INTRODUCTION, SUMMARY CONCLUSIONS AND RECOMMENDATIONS

The release of over five million cubic yards of coal ash from the Tennessee Valley Authority's Kingston, Tennessee, facility in December 2008, which flooded more than 300 acres of land, damaging homes and property, is a wake-up call for diligence on coal combustion waste disposal units. We must marshal our best efforts to prevent such catastrophic failure and damage. A first step toward this goal is to assess the stability and functionality of the ash impoundments and other units, then quickly take any needed corrective measures.

This assessment of the stability and functionality of the E. W. Brown Auxiliary Ash Dam management unit is based on a review of available documents and on the site assessment conducted by Dewberry personnel on Tuesday, October 20, 2009. Dewberry found the supporting technical documentation adequate (Section 1.1.3). As detailed in Section 1.2.6, there are recommendations that may help to maintain a safe and trouble-free operation; Dewberry recommends an updated dam break analysis (currently in progress).

In summary, the **E. W. Brown Auxiliary Ash Dam is SATISFACTORY for continued safe and reliable operation, with no recognized existing or potential management unit safety deficiencies.**

PURPOSE AND SCOPE

The U.S. Environmental Protection Agency (EPA) is embarking on an initiative to investigate the potential for catastrophic failure of Coal Combustion Surface Impoundments (i.e., management unit) from occurring at electric utilities in an effort to protect lives and property from the consequences of a dam failure or the improper release of impounded slurry. The EPA initiative is intended to identify conditions that may adversely affect the structural stability and functionality of a management unit and its appurtenant structures (if present); to note the extent of deterioration (if present), status of maintenance and/or a need for immediate repair; to evaluate conformity with current design and construction practices; and to determine the hazard potential classification for units not currently classified by the management unit owner or by a state or federal agency. The initiative will address management units that are classified as having a Less-than-Low, Low, Significant or High Hazard Potential ranking. (For Classification, see pp. 3-8 of the 2004 Federal Guidelines for Dam Safety)

In February 2009, the EPA sent letters to coal-fired electric utilities seeking information on the safety of surface impoundments and similar facilities that receive liquid-borne material that store or dispose of coal combustion waste. This letter was issued under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 104(e), to assist the Agency in assessing the structural stability and functionality of such management units, including which facilities should be visited to perform a safety assessment of the berms, dikes, and dams used in the construction of these impoundments.

EPA asked utility companies to identify all management units: surface impoundments or similar diked or bermed structures; and landfills receiving liquid-borne material that store or dispose of coal-combustion residuals or by-products, including, but not limited to, fly ash, bottom ash, boiler slag, and flue gas emission control residuals. Utility companies responded with information on the size, design, age, and the amount of material placed in the units so that EPA could gauge which management units had or potentially could rank as having High Hazard Potential. The USEPA and its contractors used the following definitions for this study:

"Surface Impoundment or impoundment means a facility or part of a facility which is a natural topographic depression, man-made excavation, or diked area formed primarily of earthen materials (although it may be lined with man-made materials), which is designed to hold an accumulation of liquid wastes or wastes containing free liquids, and which is not an injection well. Examples of surface impoundments are holding, storage, settling, and aeration pits, ponds, and lagoons." For this study, the earthen materials could include coal combustion residuals.

EPA is addressing any land-based units that receive fly ash, bottom ash, boiler slag, or flue gas emission control wastes along with free liquids. If the landfill is receiving coal combustion wastes with liquids limited to that for proper compaction, then there should not be free liquids present and EPA did not seek information on such units which are appropriately designated a landfill. EPA did not provide an exclusion for small units or temporary impoundments. The study covers waste units designated as surface impoundments, and units designated as landfills which receive free liquids. In some cases coal combustion wastes are separated from the water, and the water containing de minimus levels of fly ash, bottom ash, slag, or flue gas emission control wastes, are sent to an impoundment. EPA is including such impoundments in this study, because chemicals of concern may have leached from the solid coal combustion wastes into the waste waters, and suspended solids from the coal combustion wastes remain.

The purpose of this report is to evaluate the condition and potential of waste release from the selected High Hazard Potential management units. This evaluation included a site visit. Prior to conducting the site visit, a two-person team reviewed the information submitted to EPA, reviewed any relevant publicly available information from state or federal agencies regarding the unit hazard potential classification (if any) and accepted information provided via telephone communication with a management unit supervisor.

EPA sent two professional engineers, one licensed in the State of Kentucky, for a one-day site visit. The two-person team met with the owner of the management unit as well as several technical representatives and management unit supervisors to discuss the engineering characteristics of the unit as part of the site visit. During the site visit the team collected additional information about the management unit to be used in determining the hazard potential classification of the unit. Subsequent to the site visit the management unit owner provided additional engineering data pertaining to the management unit.

Factors considered in determining the hazard potential classification of the management units(s) included the age and size of the impoundment, the quantity of coal combustion residuals or by-products that were stored or disposed of in these impoundments, its past operating history, and its geographic location relative to down gradient population centers and/or sensitive environmental systems.

This report presents the opinion of the assessment team as to the potential of catastrophic failure and reports on the condition of the management unit(s). The team considered criteria in evaluating dams under the National Inventory of Dams, in making these determinations.

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LIMITATIONS

The assessment of dam safety reported herein is based on field observations and review of readily available information provided by the owner/operator of the subject coal combustion waste management unit(s). Qualified Dewberry engineering personnel performed the field observations and review and made the assessment in conformance with the required scope of work and in accordance with reasonable and acceptable engineering practices. No other warranty, either written or implied, is made with regard to our assessment of dam safety.

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APPENDIX A – REFERENCE DOCUMENTS

Doc 1	E.W. Brown Ash Pond Facility – Aerial Photo, September 2009
Doc 2	E.W. Brown Auxiliary Ash Pond Dam Construction Permit Application, July 7, 2006
Doc 3 – 127	Auxiliary Ash Pond Design Drawings, November 2007, by FMSM Engineers
Doc 128	ATC Associates Visual Site Inspections Report, 2009

APPENDIX B – PHOTOGRAPHS

Photographs 1 - 132

APPENDIX C – FIELD OBSERVATION CHECKLIST

Dam Inspection Checklist Form

1.0 CONCLUSIONS AND RECOMMENDATIONS

1.1 CONCLUSIONS

Conclusions are based on visual observations from a one-day site visit and review of technical documentation provided by E.ON U. S. LLC.

1.1.1 Conclusions Regarding the Structural Soundness of the Management Unit(s)

The embankment and spillway appear to be structurally sound based on a review of the engineering data provided by the owner's technical staff and Dewberry engineers' observations during the site visit,

1.1.2 Conclusions Regarding the Hydrologic/Hydraulic Safety of the Management Unit(s)

Adequate freeboard and capacity exist to safely pass the Probable Maximum Flood (PMF) based on the engineering analyses provided for Dewberry's review,

1.1.3 Conclusions Regarding the Adequacy of Supporting Technical Documentation

The supporting technical documentation is adequate. Engineering documentation reviewed is referenced in Appendix A.

1.1.4 Conclusions Regarding the Description of the Management Unit(s)

The description of the management unit provided by E.ON U.S. LLC (E.ON) was an accurate representation of what Dewberry observed in the field.

1.1.5 Conclusions Regarding the Field Observations

Dewberry engineers were provided access to all areas in the vicinity of the management units required to conduct a thorough field observation. The visible parts of the embankment dam and outlet structure were observed to have no signs of overstress, significant settlement, shear failure, or other signs of instability. Embankments visually appear structurally sound. There are no apparent indications of unsafe conditions or conditions needing remedial action.

1.1.6 Conclusions Regarding the Adequacy of Maintenance and Methods of Operation

The current maintenance and methods of operation appear to be adequate for the fly ash management unit. There was no evidence of repaired embankments or prior releases observed during the field inspection.

1.1.7 Conclusions Regarding the Adequacy of the Surveillance and Monitoring Program

The surveillance and monitoring program appears to be adequate. Plant personnel monitor the instrumentation on a weekly basis.

1.1.8 Classification Regarding Suitability for Continued Safe and Reliable Operation

Facility is SATISFACTORY for continued safe and reliable operation. 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.

1.2 RECOMMENDATIONS

1.2.1 Recommendations Regarding the Structural Stability

None appear warranted at this time.

1.2.2 Recommendations Regarding the Hydrologic/Hydraulic Safety

None appear warranted at this time.

Although a dam break analysis was not conducted in conjunction with the July 2006 Dam Construction Permit Application, E.ON indicated that such an analysis is currently in progress. The dam break analysis is being conducted as part of the development of an Emergency Operating Plan.

1.2.3 Recommendations Regarding the Supporting Technical Documentation

No recommendations appear warranted at this time.

1.2.4 Recommendations Regarding the Description of the Management Unit(s)

No Recommendations appear warranted at this time.

1.2.5 Recommendations Regarding the Field Observations

No recommendations appear warranted at this time.

1.2.6 Recommendations Regarding the Maintenance and Methods of Operation

The maintenance and operation of the dam seem to be adequate. However, the following recommendations may help maintain safe and trouble-free operation:

- Monitor, address or otherwise repair minor erosion areas and erosion gullies, and isolated seepage spots.

1.2.7 Recommendations Regarding the Surveillance and Monitoring Program

Continue monitoring seepage locations

1.2.8 Recommendations Regarding Continued Safe and Reliable Operation

No recommendations pertaining to the continued safe and reliable operation of the management unit appear warranted at this time.

1.3 PARTICIPANTS AND ACKNOWLEDGEMENT

1.3.1 List of Participants

W. Michael Winkler – E.ON U.S. LLC
Jeffrey B. Heun, P.E. – E.ON U.S. LLC
David J. Millay, P.E. – E.ON U.S. LLC
Jeffrey Fraley – E.ON U.S. LLC
Tamara Lay – E.ON U.S. LLC
Hugh A. Ward, P.E. - Dewberry
Joseph P. Klein, III, P.E. – Dewberry

1.3.2 Acknowledgement and Signature

We acknowledge that the management unit referenced herein has been assessed on October 20, 2009.

Hugh A. Ward, PE (KY # 7164)	Joseph P. Klein, III, P.E. Geotechnical Engineer

2.0 DESCRIPTION OF THE COAL COMBUSTION WASTE MANAGEMENT UNIT(S)

2.1 LOCATION AND GENERAL DESCRIPTION

The E. W Brown Plant is located near the west bank of the Dix River, just upstream of Dix Dam at Herrington Lake in Mercer County, Kentucky approximately 5 miles northeast of Burgin, Kentucky. The plant is operated by Kentucky Utilities Company, a subdivision of E.ON U.S. LLC (E.ON). The Auxiliary Ash Dam is at the south side of the plant site, adjacent to the Main Ash pond. A project location aerial photograph is provided in Appendix A – Doc 01.

The E. W. Brown Auxiliary Ash Dam is a rock and earth fill dam constructed adjacent to the existing Main Ash Pond. The embankment consists of blasted materials excavated from the pond area and nearby on-site areas. The pond bottom and the embankment are lined with a 4 foot thick layer of compacted clay covered with a 60-mil layer Linear Low Density Polyethylene (LLDP) flexible membrane liner. The crest and upper of the upstream slope are protected with a 3 foot thick layer of Size 57 crushed stone aggregate (ASTM D 448 *Standard Classification for Sizes of Aggregate for Road and Bridge Construction*). The No. 57 stone extends down the upstream slope to elevation 866 feet. The stone is held in place by a cellular geosynthetic reinforcement grid. The crest of the dam is at elevation 880 feet. The downstream toe of the dam is at elevation 788 feet, making the dam height 92 feet. At the crest elevation of 880 feet, the impoundment area is approximately 26.0 acres with a total storage capacity of approximately 747 acre-feet. The normal pool elevation is 873 feet, impounding a surface area of approximately 25.7 acres.

The dam was completed in 2008 ft to the current crest elevation of 880 feet. The Auxiliary Ash Pond is scheduled to receive both fly ash and bottom ash during the current phase of construction to expand the adjacent, temporarily out of service Main Ash Pond. The current construction phase at the Main Ash Pond is scheduled for completion in December 2010 at which time the Auxiliary Pond will be expanded and the embankment raised to a crest elevation of 900 feet.

Material for embankment construction was quarried from within the impoundment area and from borrow areas surrounding the Main Ash Pond adjacent to the north side of the Auxiliary Ash Pond, and one borrow area adjacent to the south side of the Auxiliary Ash Pond.

2.2 SIZE AND HAZARD CLASSIFICATION

The classification for size, based on the height of the dam is "Intermediate" and based on the storage capacity is "Intermediate" in accordance with the USACE Recommended Guidelines for Safety Inspection of Dams ER 1110-2-106 criteria summarized in Table 2.2a. However, based on the planned expansion of the Auxiliary Ash Pond, the dam will eventually be classified as "Large".

Table 2.2a USACE ER 1110-2-106 Size Classification

Category	Impoundment	
	Storage (Ac-ft)	Height (ft)
Small	50 and < 1,000	25 and < 40
Intermediate	1,000 and < 50,000	40 and < 100
Large	> 50,000	> 100

The E. W. Brown Auxiliary Ash Dam has been classified by the Kentucky Department for Environmental Control Division of Water (KYDW) as a " Class C - High Hazard" structure. The KYDW rules define High Hazard structures as: "…..structures located such that failure may cause loss of life, or serious damage to houses, industrial or commercial buildings, important public utilities, main highways or major railroads. This classification must be used if failure would cause probable loss of human life." This classification definition is similar to "High Hazard" classification per the Federal Guidelines for Dam Safety dated April 2004. As shown in Table 2.2b, dams assigned the "high hazard potential" classification are those dams where failure or error of operation results in the probable loss of one or more human life is expected, probable economic loss, environmental damages and disruption of lifeline facilities.

Table 2.2b FEMA Federal Guidelines for Dam Safety Hazard Classification

Hazard Potential Classification	Loss of Human Life	Economic, Environmental, Lifeline Losses
Low	None Expected	Low and generally limited to owner
Significant	None Expected	Yes
High	Probable. One or more expected	Yes (but not necessary for this classification)

2.3 AMOUNT AND TYPE OF RESIDUALS CURRENTLY CONTAINED IN THE UNIT(S) AND MAXIMUM CAPACITY

The data reviewed by Dewberry included the Dam Construction Permit Application engineering report dated July 6, 2007 prepared by Fuller, Mossbarger, Scott & May Engineers, Inc. (see Appendix A, Document 2). Data on the volume of residuals stored in the Auxiliary Ash Pond at the time of inspection were not indicated. The surface area for the pond at normal pool elevation is approximately 25.7 acres having a storage capacity of 747 acre-feet, see Table 2.3.

Table 2.3: Amount of Residuals and Maximum Capacity of Unit

	E. W. Brown Auxiliary Ash Pond Dam
Surface Area (acre) Phase 1	25.7
Current Storage Capacity (acre-feet)	Data not provided
Total Storage Capacity (acre-feet) Phase 1	747
Crest Elevation (feet) Phase 1	880
Normal Pond Level (feet) Phase 1	873

2.4 PRINCIPAL PROJECT STRUCTURES

2.4.1 Earth Embankment Dam

The E. W. Brown Auxiliary Ash Dam is a rock and earth fill dam constructed adjacent to the existing Main Ash Pond. The embankment consists of blasted materials excavated from the pond area and nearby on-site areas. The pond bottom and the embankment are lined with a 4 foot thick layer of compacted clay covered with a 60-mil layer Linear Low Density Polyethylene (LLDP) flexible membrane liner. The crest and upper of the upstream slope are protected with a 3 foot thick layer of Size 57 crushed stone aggregate (ASTM D 448 *Standard Classification for Sizes of Aggregate for Road and Bridge Construction*). The No. 57 stone extends down the upstream slope to elevation 866 feet. The stone is held in place by a cellular geosynthetic reinforcement grid. The crest of the dam design elevation 880 feet.

The Auxiliary Ash Pond dam was constructed as the first of two phases. The alignment of the dam forms a "U" with the abutments at an existing low-rise rock face along the west side of the impoundment. Both upstream and downstream slopes are approximately 3 horizontal to 1 vertical. (See Appendix A, Document 37, and Document 38). Data on the "As Constructed" drawings indicates the dam crest elevation actually varies from approximately 880.1 feet to 881.4 feet. Table 2.4.1 displays a summary of the dimensions and size specifications of E. W. Brown Auxiliary Ash Dam. Photo Numbers 1, 2, and 6 - 25 in Appendix B show the embankment of the dam.

Table 2.4.1: Summary of Dam Dimensions and Size	
	E. W. Brown Auxiliary Ash Pond Dam
Dam Height	92 ft.
Crest Width	25 ft.
Length	3,350 ft
Side Slopes (upstream)	3(H):1(V)
Side Slopes (downstream)	3(H):1(V)
Hazard Classification	High

2.4.2 Outlet Structures

The dam primary spillway consists of a 10-foot square concrete decant riser with invert elevation at 870.12 and a 30-inch diameter HDPE pipe running approximately 240 feet through the embankment, connecting to a network of HDPE pipes that run along the toe of the embankment approximately 3,200 feet to the existing Main Ash Pond discharge channel. The discharge channel empties into an unnamed tributary of Herrington Lake. The main spillway is protected by a permanent skimmer and a temporary floating boom. Stop logs are in place from the invert to the normal pool elevation of 873 feet. Data included in Appendix A- Doc 02 state the full flow capacity of the spillway tunnel for Phase 1 is approximately 71 cfs. Photo Numbers 3, 4, 106, and 107 in Appendix B show the main spillway and Photos Number 115-120 and 123 - 129 show the main spillway outlet and outfall conditions.

The dam also has an emergency spillway in the form of an open channel excavated through overburden soil and partially weathered rock beginning at the southwest corner of the impoundment. The emergency spillway is trapezoidal in cross section and acts as a broad crested weir. According to the available documents (see Appendix A- Doc 80) the spillway has a bottom width of 8 ft and side slopes of 2(H):1(V). According to the hydrologic and hydraulic data (Appendix A- Doc 84), the emergency spillway discharge at the dam crest elevation of 880 ft is 231 cfs. When this value is combined with 71 cfs discharge from the principal spillway, the result is a total discharge value of approximately 309 cfs. Photo Numbers 108 - 113 in Appendix B show the emergency spillway.

2.5 CRITICAL INFRASTRUCTURE WITHIN FIVE MILES DOWN GRADIENT

A dam break analysis, including the identification of critical infrastructure located within 5 miles downstream of the dam, is currently underway.

Based on observations at the site and surrounding area, the critical infrastructure includes the railroad line serving the E. W. Brown generating station, the Dix River Dam and local roadways, Also at risk are residences along the bank of the Dix River/Lake Herrington in the vicinity of the plant.

3.0 SUMMARY OF RELEVANT REPORTS, PERMITS AND INCIDENTS

3.1 SUMMARY OF REPORTS ON THE SAFETY OF THE MANAGEMENT UNIT

In response to a Freedom of Information request, the facility owner, E. ON U.S., LLC provided an extensive package of design and construction information for the E. W. Brown Auxiliary Ash Pond dam. The data were provided in electronic files listed in Appendix A.

E. ON U.S., LLC retained ATC Associates Inc. to conduct an inspection of the Auxiliary Ash Pond Dam. The ATC inspection was conducted January 11, 2009, and reported the dam to be in good condition. The ATC report (see Appendix A: Document 128) recommended two high-priority concerns:

- Repair reported leaks and principal spillway manholes below toe of dam
- Monitor seep at south property line.

The leaks at manholes have been repaired and the seep is being monitored.

3.2 SUMMARY OF LOCAL, STATE AND FEDERAL ENVIRONMENTAL PERMITS

The facility is under regulation by the Kentucky Department for Environmental Protection, Division of Water, KY Permit 1213. Kentucky inspects the dam on a biannual basis. As the dam was completed in 2008 the initial State inspection is not scheduled to occur until 2010.

The E. W. Brown Auxiliary Ash Pond spillway discharge is permitted under NODES Permit No. 0002020 which expired January 31, 2007. A renewal application was submitted in mid 2006 and is currently in the public comment phase. A permit renewal is expected late in 2009 or early 2010.

3.3 SUMMARY OF SPILL/RELEASE INCIDENTS

Data reviewed by Dewberry did not indicate any spills, unpermitted release, or other performance related problems with the dam since it became operational in the fall of 2008.

4.0 SUMMARY OF HISTORY OF CONSTRUCTION AND OPERATION

4.1 SUMMARY OF CONSTRUCTION HISTORY

4.1.1 Original Construction

The E. W. Brown Auxiliary Ash Pond dam was completed in 2008 and put into service upon receiving the June 27, 2008 KYDW approval to impound water. Phase 1 constructed the dam to a crest elevation of 880 feet. The planned Phase 2 will raise the dam crest to elevation 900 Feet. The design data, calculations and construction drawings were provided and reviewed.

4.1.2 Significant Changes/Modifications in Design since Original Construction

No significant changes or modification have been made to the embankment since the original construction.

4.1.3 Significant Repairs/Rehabilitation since Original Construction

No significant repairs or modifications have been made to the embankment since the original construction.

4.2 SUMMARY OF OPERATIONAL HISTORY

4.2.1 Original Operational Procedures

The Phase 1 dam was designed to store fly ash and bottom ash from the E. W. Brown coal fired generating plant for a period of about three years during which time the Main Ash pond will be expanded. The Main Ash pond is currently out of service, and all fly ash and bottom ash from the plant is being sluiced to the auxiliary pond.

When the current phase of the Main Ash pond expansion is completed, fly ash will be rerouted to the main pond and bottom ash will continue to be placed in the Auxiliary Ash pond. Also after the completion of the main pond expansion, the auxiliary pond is scheduled for expansion to provide additional bottom ash storage capacity.

4.2.2 Significant Changes in Operational Procedures since Original Startup

No documents are provided to indicate any operational procedures have changed.

4.2.3 Current Operational Procedures

Currently there are no written operational procedures in effect.

4.2.4 Other Notable Events since Original Startup

No notable events were reported to have occurred during the first year of operation.

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5.0 FIELD OBSERVATIONS

5.1 PROJECT OVERVIEW AND SIGNIFICANT FINDINGS

Dewberry personnel Hugh A. Ward, P.E. and Joseph P. Klein, III, P.E. performed a site visit on Tuesday, October 20, 2009, in company with representatives of E.ON U.S. LLC.

The site visit began at 09:00 AM. The weather was clear and warm. Photographs were taken of conditions observed. Please refer to photographs in Appendix B and the Dam Inspection Checklist in Appendix C. Selected photographs are included here for ease of visual reference. All pictures were taken by Dewberry personnel during the site visit.

The overall assessment of the dam was that it was in satisfactory condition and no significant findings were noted.

5.2 EARTH EMBANKMENT DAM

5.2.1 Crest

The dam crest had no signs of any depressions, tension cracks or other indications of settlement or shear failure, and appeared to be in satisfactory condition. The data did not indicate cracking along the crest or downstream face of the dam. Figure 5.2.1-1 shows the conditions of the dam crest.

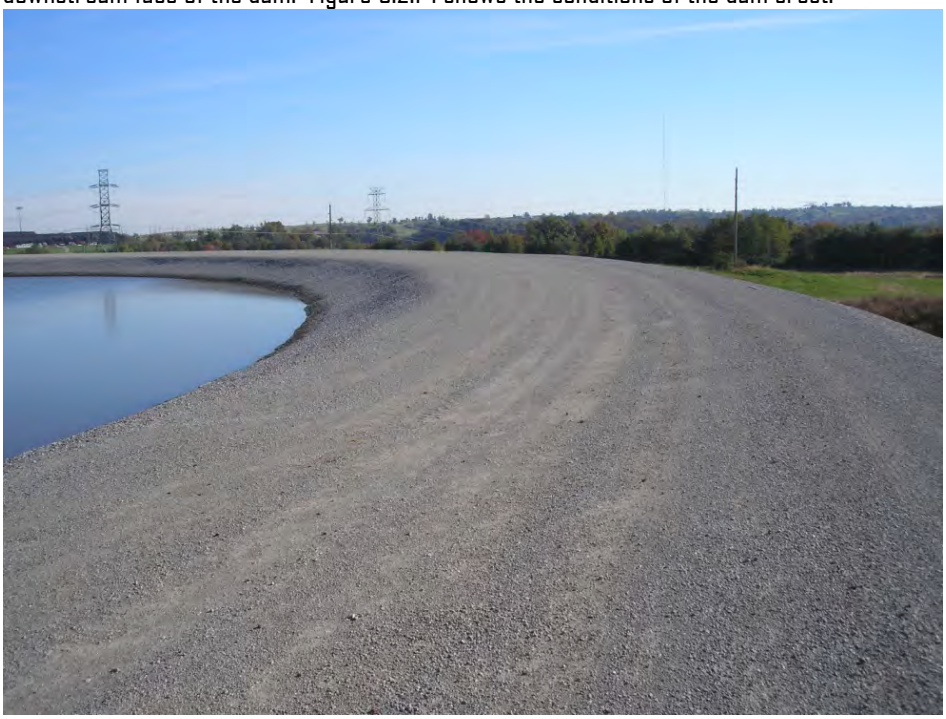

Figure 5.2.1-1. Photo Showing the Dam Crest.

5.2.2 Upstream Slope

The upstream slope is protected ASTM D 448 Size 57 crushed processed stone aggregate. The cellular geosynthetic slope reinforcement is visible at the edge of the water. There were no observed scarps, sloughs, bulging, cracks or scraps or depressions or other indications of slope instability or signs of erosion. Photos 2, 44 – 45, 57, 59 – 69, 73 – 74, 78, 81, 84, 87 – 88, 93 – 94, 97, and 102 - 105 in Appendix B show the upstream slope. Figure 5.2.2-1 depicts part of the upstream slope of the dam embankment.

Figure 5.2.2-1. Photo Showing the Upstream Slope.

5.2.3 Downstream Slope and Toe

The upper portion of the downstream slope is crushed stone aggregate similar to the upstream slope. The remainder of the downstream slope is an exposed earth and rock fill face. There were no observed scarps, sloughs, depressions or other indications of slope instability or signs of significant erosion or uncontrolled seepage. A few isolated erosion gullies were observed and a single wet area of potential seepage was also observed. No seepage was observed over a widespread area or the downstream foundation area and there was no water against the downstream toe. Photos 1, 5 -41, 46, 48 – 50, 52, 54, 55, 77, 82, 83, 85, 86, 89, 90, 96, 98 – 100, and 104 in Appendix B depict various views of the downstream slope. Figure 5.2.3-1 shows the downstream slope from the North Abutment of the dam. Figure 5.2.3-2 shows the only wet area observed on the downstream slope.

No other significant deterioration was indicated in the data reviewed.

Figure 5.2.3-1. Downstream Slope from South Abutment.

Figure 5.2.3-2. Small Seepage Area Southern Segment, Downstream Embankment.

5.2.4 Abutments and Groin Areas

Erosion or uncontrolled seepage was not observed along either groin. The abutments and groin areas appeared to be in excellent condition. As an example, Figure 5.2.4-1 shows the eastern abutment and the southeast corner of the impoundment.

Figure 5.2.4-1. Southwest Segment Abutment

5.3 OUTLET STRUCTURES

5.3.1 Overflow Structure

The dam has a concrete decant riser 10 ft. square with invert elevation at 870 feet and a 30-inch diameter HDPE pipe running approximately 240 feet through the embankment, connecting to a network of HDPE pipes that run along the toe of the embankment approximately 3,200 feet to the existing Main Ash Pond discharge channel. Photo Numbers 3, 4, 106, and 107 in Appendix B show the main spillway and Photos Number 20-22 show the main spillway outlet and outfall conditions. According to data included in Appendix A-Doc 02 the full flow capacity of the spillway tunnel is approximately 71 cfs.

The primary overflow structure was observed to be working properly, discharging flow from the pond, and visually appeared to be in satisfactory condition. There was no sign of clogging of the spillway and the water exiting the outlet was flowing clear. Figure 5.3.1-1 shows the main outlet structure.

The January 22, 2009, ATC Associates, Inc, inspection reported leaks at the principal spillway manholes below the toe of the dam. The inspection report recommended that leak repairs be given a high priority. The leaks have been repaired (see Appendix A: doc 128).

Figure 5.3.1-1. Outlet Structure (Principal Spillway) and the Floating Pier Around it on the Northwest End of Dam.

5.3.2 Outlet Conduit

The outlet conduit appeared to be in good shape and operating normally with no sign of clogging and the water exiting the outlet was flowing clear. Figure 5.3.2-1 shows the water discharging from the main spillway tunnel outfall.

Figure 5.3.2-1. Main Spillway Tunnel Outfall.

5.3.3 Emergency Spillway

The dam has an emergency spillway in the form of an open channel that is excavated through the overburden and blasted rock at the southwest end of the dam. The emergency spillway is trapezoidal in cross section and acts as a broad crested weir. According to the available drawings (see Appendix A- Doc 79) the bottom width of the spillway is 8 ft. and side slopes are 2(H):1(V). The invert of the spillway is at 876 ft. Per the hydrologic and hydraulic review (Appendix A - Doc 02) data the emergency spillway discharge at the dam crest elevation of 880 ft is 238 cfs which when combined with 71 cfs discharge from the principal spillway results in a total discharge value of approximately 309 cfs. Photo Numbers 108 - 113 in Appendix B show the emergency spillway. Figure 5.3.3-1 shows the trapezoidal emergency spillway excavated at the southwest end of the dam.

The emergency spillway appeared to be in good condition with no sign of clogging.

Figure 5.3.3-1. Emergency Spillway at the Southwest end of Dam.

5.3.4 Low Level Outlet

No low level outlet is present.

6.0 HYDROLOGIC/HYDRAULIC SAFETY

6.1 SUPPORTING TECHNICAL DOCUMENTATION

6.1.1 Floods of Record

No documentation has been provided about the floods of record.

6.1.2 Inflow Design Flood

The E. W Brown Auxiliary Ash Dam is classified by the Kentucky Division of Water as a Class C. which is a structure which has "High Hazard" potential. According to regulation 40KAR;030 and Division of Water "Engineering Memorandum No. 5" The Probable Maximum Precipitation (PMP) is defined by the American Meteorological Society as the theoretically greatest depth of precipitation for a given duration that is physically possible over a particular drainage area at a certain time of year. The National Weather Service (NWS) further states that in consideration of the limited knowledge of the complicated processes and interrelationships in storms, PMP values are identified as estimates. The NWS has published application procedures that can be used with PMP estimates to develop spatial and temporal characteristics of a Probable Maximum Storm (PMS). A PMS thus developed can be used with a precipitation-runoff simulation model to calculate a probable maximum flood (PMF) hydrograph.

The E. W. Brown Auxiliary Ash Dam Construction Permit Application document includes Hydrologic and Hydraulic calculations by Fuller, Mossbarger, Scott & May Engineers, Inc and is included as Appendix A-Doc 02. Hydrologic routing was analyzed using the U.S. Army Corps of Engineers Hydrologic Engineering Center Hydrologic Modeling System (HED-HMS V3.0.1) software. The principal spillway riser structure was designed using overflow weir equations and pipe culvert discharge curves. The Emergency Spillway was designed using a hydraulic model USACOE HEC-RAS V3.1.3. The 2006 permit application includes sample calculations for the Principal Spillway, Emergency Spillway and Freeboard Hydrographs (including the 6-hr PMP and PMP generated runoff) and pipe sizes analyzed. The report indicates the dam was designed to safely handle the full probable maximum precipitation design storm without overtopping, assuming the reservoir pool is at the design normal pool elevation at the time of the storm. The report indicates that the Phase 1 normal pool elevation provides 7 feet of freeboard. The report estimates that a probable maximum precipitation event would raise the reservoir approximately 5.6 feet with no outflow, leaving a freeboard of approximately 1.4 feet.

6.1.3 Spillway Rating

The Hydrologic and Hydraulic calculations in the Dam Construction Permit Application (Appendix A- Doc 02) include spillway rating curve values listed in the inflow files for various hydrological simulations. These values were manually calculated following the procedures outlined in the Kentucky Division of Water "Engineering Memorandum NO. 5". As presented above, the hydrologic and hydraulic review (Appendix A-Doc 02) calculation sheets indicate a principal spillway capacity of 71 cfs and an emergency spillway capacity of 238 cfs for a total discharge capacity of approximately 309 cfs at a pond elevation of 876.6 feet.

6.1.4 Downstream Flood Analysis

A downstream flood analysis was not performed as part of the E. W. Brown Auxiliary Ash Pond dam design. A dam break analysis is currently being conducted, but results were not available for the Dewberry evaluation.

6.2 ADEQUACY OF SUPPORTING TECHNICAL DOCUMENTATION

Supporting technical documentation reviewed by Dewberry is adequate.

6.3 ASSESSMENT OF HYDROLOGIC/HYDRAULIC SAFETY

Based on the calculations provided in the 2006 hydrologic and hydraulic design calculations (Appendix A- Doc 02 and Doc 84), the E. W. Brown Auxiliary Ash Pond Phase 1 Dam can safely pass the PMP with a freeboard of 1.4 feet. Hence, the dam failure by overtopping seems to be improbable.

The 2006 Dam Construction Permit Application calculations (Appendix A- Doc 02) also indicate that the E. W. Brown Auxiliary Ash Pond Phase 2 Dam can pass the PMP with a free board of 1.9 feet.

7.0 STRUCTURAL STABILITY

7.1 SUPPORTING TECHNICAL DOCUMENTATION

7.1.1 Stability Analyses and Load Cases Analyzed

The 2006 Dam Construction Permit Application summarizes the stability analysis procedures used in the dam design, The procedures follow the general guidelines of the US Army Corps of Engineers in slope stability engineering manual (see Appendix A- Doc 02, "Dam Construction Permit Application Auxiliary Ash Pond – E. W. Brown Generating Station"). The analyses were based on the results of geotechnical borings and laboratory testing conducted for the Auxiliary Dam design.

The stability analyses evaluated rotational stability using the UTEXAS4 software. The analyses were conducted to verify long-term stability for normal pool and no pool conditions. The result of the analyses and the soil parameters used are provided in Appendix A – Doc 2 "Stability Analyses – Auxiliary Pond Embankment". Based on the results from this analyses it was concluded that the Auxiliary Ash Dam has stability safety factors at or above minimum recommended values.

The stability analyses (Appendix A – Doc 02), for dynamic conditions were conducted using a pseudo-static loading condition based on a peak ground acceleration of 0.100g for a two percent probability of exceedance in 50 years.

7.1.2 Design Properties and Parameters of Materials

The documentation identified in the review data that identifies the design parameters used for the original dam design shown in drawings of the Auxiliary Ash Pond Stability Analysis (see Appendix A-Doc 115 and 116). The drawings provided the results of stability analyses for the Phase 1 dam that currently exists as well as the proposed future Phase 2 dam. The density values listed in the parameter tables for the downstream slope range from 110 to 118 pounds per cubic foot (PCF). Angle of shearing resistance under effective stress analysis range is 28° to 38° for various zones and, where applicable, the effective cohesive strength is 100 pound per square foot.

7.1.3 Uplift and/or Phreatic Surface Assumptions

No uplift or phreatic surface considerations are included in the stability analyses. The Auxiliary Ash Pond and upstream slope of the embankment and the pond bottom are lined with a 4-foot thick compacted clay zone capped by a 60-mil Liner Low-Density Polyethylene (LLDP) flexible membrane liner. (See Appendix A – Doc. 68).

7.1.4 Factors of Safety and Base Stresses

The Auxiliary Ash Pond Dam – Stability Analysis (Appendix A – Doc 02) Safety Factors computed in conjunction with the stability analyses of the proposed reconfiguration and expansion program currently under construction are as listed in Table 7.1.4

Based on the results summarized in the table, the Auxiliary Ash Dam was found to have stability safety factors at or above the minimum required values (Appendix A: Doc 115 and 116).

Table 7.1.4: Factors of Safety E. W. Brown Auxiliary Ash Dam

Location/Loading Condition	Required Safety Factor (Army Corps)	Computed Safety Factor
Downstream Static (Drained)	1.5	1.8
Downstream Seismic (Drained)	1.2	1.3
Upstream Static (Drained)No Pool	1.5	Not Provided
Upstream Seismic	1.2	Not Provided

7.1.5 Liquefaction Potential

The documentation reviewed by Dewberry did not include an evaluation of liquefaction potential. Based on the geologic conditions and foundation preparation procedures outlined in the Permit Application Report (Appendix A Doc. 02), and as summarized in Section 7.1.6., foundation soil conditions do not appear susceptible to liquefaction.

7.1.6 Critical Geological Conditions and Seismicity

Data in the Dam Construction Permit Application (See Appendix A – Doc 02) indicate the E. W. Brown Auxiliary Ash Pond is underlain by rock of the Lexington, and Tyrone Limestone formations. Members of the Lexington formation at the site include: Greer Limestone, Logana Limestone, and Curdsville Limestone. The Tyrone Limestone formation underlies the Curdsville Limestone.

The foundation for the Auxiliary Ash Pond embankment and liner consists of a 25-foot thick zone of treated soil and rock. The treated zone was formed by blasting to rubblize the top 25 feet of soil and bedrock. At the northeast corner of the Auxiliary Ash Pond, near the existing Main Ash Pond embankment, overburden was removed to bedrock and irregular bedrock material treated in accordance with pre-engineered solutions on the design drawings (Appendix A: Doc. 67).

The documents provided indicate that seismicity was considered in the design. The slope stability analyses included a dynamic load condition based on a peak ground acceleration of 0.100 g.

As part of this assessment, the current Seismic Risk Map of the United States was also reviewed using the U. S. Geologic Survey web site. The 2%/50 year return period peak ground acceleration mapped for the sire is 0.100 g. The seismic design criteria are appropriate for this dam.

7.2 ADEQUACY OF SUPPORTING TECHNICAL DOCUMENTATION

Structural stability documentation is adequate.

7.3 ASSESSMENT OF STRUCTURAL STABILITY

Overall, the structural stability of the embankment appears to be satisfactory based on the observations during the October 20, 2009 field visit and dam evaluation by Dewberry, the 2006 Dam Construction Application Report, and the post-construction drawings.

- There were no indications of scarps, sloughs, depressions or bulging anywhere along the dam;
- Boils, sinks or uncontrolled seepage was not observed along the slopes, groins or toe;
- The crest appeared free of depressions and no significant vertical or horizontal alignment variations were observed; and
- The computed factors of safety comply with accepted criteria.

8.0 ADEQUACY OF MAINTENANCE AND METHODS OF OPERATION

8.1 OPERATIONAL PROCEDURES

The facility is operated currently for storage of fly ash and bottom ash coal combustion products. Coal combustion process waste water and stormwater falling directly into the reservoir are contained in the reservoir. Inflow water is treated through gravity settling and deposition, and discharged through a vertical riser overflow outlet structure. A separate written Operations Plan for the Auxiliary Ash Pond has not been completed. The Auxiliary Ash Pond is being operated under the operating procedures established for the Main Fly Ash Pond.

Discharge from the outflow structure is to an unnamed tributary to Herrington Lake. The facility NPDES permit (KY 0002020) has expired. A renewal application was submitted prior to the expiration date. The renewal process is currently in the public comment phase, is expected to be completed soon, and a new permit issued by late 2009 or early 2010.

8.2 MAINTENANCE OF THE DAM AND PROJECT FACILITIES

The dam was completed and placed into operation in June 2008. A written Maintenance Plan for the Auxiliary Ash Pond is being prepared. The dam is being maintained using the procedures prescribed in the 1991 Main Fly Ash Pond. The owner was unable to provide the plan for this assessment.

8.3 ASSESSMENT OF MAINTENANCE AND METHODS OF OPERATION

8.3.1 Adequacy of Operational Procedures

Based on the assessments of this report operation procedures seem to be adequate.

8.3.2 Adequacy of Maintenance

Based on the assessments of this report maintenance procedures seem to be adequate. The only maintenance issue identified was to continue monitoring the damp area of possible seepage near the downstream toe near the southeast corner of the reservoir.

9.0 ADEQUACY OF SURVEILLANCE AND MONITORING PROGRAM

9.1 SURVEILLANCE PROCEDURES

9.1.1 Surveillance Inspections

Surveillance inspections of the Auxiliary Ash Pond are conducted in accordance with the requirements established for the Main Fly Ash Pond. Those requirements stipulate weekly inspections by E. W. Brown Plant personnel and a written report of observations.

9.1.2 Annual Inspections

The Auxiliary Ash Pond is scheduled for inspection by the Kentucky Division of Water on a biannual basis. Since the dam was completed in 2008, the first State inspection is scheduled for 2010.

A third party inspection was conducted in January 22, 2009 by ATC Associates. The inspection report identified two high priority issues:

- Reported leaks at the principal spillway manholes below the toe of the dam
- Minor seep at the south property line below the gabion wall.

The repairs of leaks at the principal spillway manholes have been made. The ATC-reported seep, as well as the seep identified in this evaluation, are being monitored. No changes have been reported.

9.2 INSTRUMENTATION MONITORING

The E. W. Brown Auxiliary Ash Dam has no instrumented monitoring system in place as part of the Phase 1 construction.

9.3 ASSESSMENT OF SURVEILLANCE AND MONITORING PROGRAM

9.3.1 Adequacy of Inspection Program

Based on the data reviewed by Dewberry, including observations during the site visit, the inspection program is adequate.

9.3.2 Adequacy Instrumentation Monitoring Program

Based on the pond and upstream slope of the embankment being lined, the planned time of about three years between Phase 1 and Phase 2 construction, the current lack of an instrumented monitoring system for the Auxiliary Ash Pond is considered appropriate.