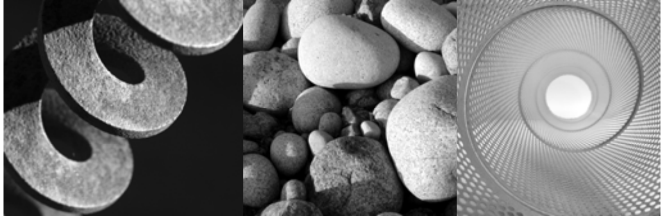

GEI Consultants

Geotechnical
Environmental and
Water Resources
Engineering

Coal Ash Impoundment – Specific Site Assessment Report

Westar Energy, Jeffrey Energy Center
Bottom Ash Lake Dam
Bottom Ash Pond Dam

Submitted to:
Lockheed-Martin Corporation
2890 Wood Bridge Avenue
Building 209 BAYF
Edison, NJ 08837

Submitted by:
GEI Consultants, Inc.
6950 South Potomac Street, Suite 300
Centennial, CO 80112

June 2009
Project 091330

Steven R. Townsley, P.E.
Senior Project Engineer

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1.0 Introduction

1.1 Purpose

This report presents the results of a specific site assessment of the dam safety of Bottom Ash Lake Dam and Bottom Ash Pond Dam coal combustion waste impoundments at Westar Energy, Jeffrey Energy Center. This report presents information for Bottom Ash Pond Dam coal combustion waste impoundment because failure of this dam could potentially jeopardize the dam safety of Bottom Ash Lake Dam or cause an uncontrolled release of coal combustion waste through the spillway and into downstream waters.

1.2 Scope of Work

The scope of work between GEI and Lockheed-Martin Corporation for the site assessment is summarized in the following tasks:

1. Acquire and review existing reports and drawings relating to the safety of the project provided by the U.S. Environmental Protection Agency (EPA) and Owners.

2. Conduct detailed physical inspections of the project facilities. While on-site, fill out Field Assessment Check Lists provided by EPA for each management unit being assessed.

3. Review and evaluate stability analyses of the project's coal combustion waste impoundment structures.

4. Review the appropriateness of the inflow design flood (IDF), and adequacy of spillways or ability to store IDF, including considering the hazard potential in light of conditions observed during the inspections or to the downstream channel.

5. Review existing performance monitoring programs and recommend any additional monitoring required.

6. Review existing geologic assessments for the projects.

7. Submit draft and final reports.

1.3 Authorization

GEI Consultants, Inc., performed the coal combustion waste impoundment assessment for the EPA as a subcontractor to Lockheed Martin who is a contractor to the EPA. This work was authorized by the Lockheed-Martin under the P.O. No.: 7100052068; EAC #0-381 between Lockheed-Martin and GEI Consultants, Inc. (GEI), dated June 5, 2009.

1.4 Project Personnel

The scope of work for this task order was completed by the following personnel from GEI:

Steven R. Townsley, P.E.,	Senior Project Engineer/Task Leader
Nick Miller, P.E.	Staff Engineer
Stephen G. Brown, P.E.	Project Manager

Program Manager for the EPA was Stephen Hoffman. Program Manager for Lockheed-Martin Corporation was Dennis Miller.

1.5 Limitation of Liability

This report summarizes the assessment of dam safety of the coal combustion waste impoundments at Jeffrey Energy Center. The purpose of each assessment is to determine the structural integrity of the impoundments and provide summaries and recommendations based on engineering judgment. GEI used a professional standard of practice to review, analyze, and apply pertinent data. No warrantees, express or implied, are provided by GEI. Reuse of this report for any other purpose, in part or in whole, is at the sole risk of the user.

1.6 Project Datum

Elevations in this report refer to National Geodetic Vertical Datum (NGVD) 1929 mean sea level.

1.7 Prior Inspections

Westar Energy contracts the engineering firm Black & Veatch (B&V) to perform on-site safety inspections of the coal combustion waste impoundments facilities annually. The most recent B&V safety inspection was performed on September 29, 2008. Based on Bottom Ash Lake Dam's current class "B" or significant hazard classification, the Kansas Department of Agriculture, Water Resource Division requires dam safety inspections of the surface impoundment facilities to be conducted once every five years. The most recent Kansas Department of Agriculture safety inspection was performed in conjunction with the specific site assessment presented herein. References for these reports are provided in Section 13 of this report.

2.0 Description of Project Facilities

2.1 General

Jeffrey Energy Center (JEC) is a coal-fired power plant located in Eastern Kansas, approximately 7 miles northwest of the city of St. Mary's in Pottawatomie County (Figure 1). JEC is jointly owned by Westar Energy, Kansas Gas and Electric Company, and KCP&L – Greater Missouri Operations Company. JEC is composed of three separate 720-MW units providing a total energy center capacity of 2.16 GW. JEC has several supporting facilities on-site including an industrial landfill and three water impoundments. These facilities are located approximately one mile west of the main plant. The three coal combustion waste impoundments on-site include Bottom Ash Settling Pond, Bottom Ash Pond, and Bottom Ash Lake. Bottom Ash Pond and Bottom Ash Lake are described in detail in the following sections. Bottom Ash Settling Pond is a small, non-engineered structure that is not classified with the state, therefore Bottom Ash Settling Pond was not included in the specific site assessment or description of the project facilities.

2.2 Dams and Reservoirs

The Jeffrey Energy Center includes two coal combustion waste dams and their associated appurtenant facilities:

- Bottom Ash Pond Dam
- Bottom Ash Lake Dam

Bottom Ash Pond Dam is located at the upstream end of the Bottom Ash Lake, as shown on the aerial photograph (Figure 2). Bottom Ash Pond Dam is an embankment constructed of Type "C" fly ash produced from plant operations. Bottom Ash Pond Dam is approximately 25-feet high, 1050-feet long, with a 30-foot wide crest and approximately 3H:1V side slopes. The dam crest is at elevation 1170.0. Bottom Ash Pond has a total capacity of 550 acre-feet, and a surface area of 72.1 acres at the normal operating pool El. 1164.0. The elevation-area-capacity curve for Bottom Ash Pond is shown on Figure 3. The majority of inflows to Bottom Ash Pond are from the upstream Bottom Ash Settling Pond where primary settling of the bottom ash and boiler slag occurs. The majority of the remaining coal combustion waste settles out in the Bottom Ash Pond before discharging to Bottom Ash Lake.

Bottom Ash Lake Dam is the main dam located on the Lost Creek tributary. Bottom Ash Lake Dam is a zoned earthen embankment including a clay core, random fill shell, a cutoff trench, a grout curtain, a vertical chimney drain and horizontal drainage blanket. The embankment is approximately 90-feet high, 2040-feet long, with a 70-foot wide crest and varying side slopes. The dam crest is at elevation 1165.0, and has a 150-foot long stabilizing berm on the upstream and downstream slopes between elevations 1115.0 and 1107.5 as shown on Figure 8. Bottom Ash Lake has a total capacity of about 3,000 acre-feet, and a surface area of about 120 acres at the normal operating pool El. 1144.0. The elevation-area-capacity curve for Bottom Ash Lake is shown on Figure 3. Inflows to Bottom Ash Lake are primarily decant water discharged from Bottom Ash Pond. Bottom Ash Lake is a source of recycle water that is pumped to the bottom ash handling system and bottom ash storage for the power generating facility at the Jeffrey Energy Center. Information concerning the dams is presented in Table 1.

Table 1: Jeffrey Energy Center - Dam Parameters Summary

Parameter	Value	
Dam	Bottom Ash Pond Dam	Bottom Ash Lake Dam
Height (ft)	25	90
Length (ft)	1,050	2,040
Crest Width (ft)	30	70
Crest Elevation (ft)	1,170	1,165
Side Slopes	3H:1V	Varies
Normal Pool El. (ft)	1,164	1,144
Normal Storage Volume (ac-ft)	550	3,000
Normal Surface Area (acres)	72.1	120

2.3 Spillways

Bottom Ash Pond Dam and Bottom Ash Lake Dam each have a spillway for passing excess flood flows. Bottom Ash Pond Dam Spillway is an uncontrolled open channel spillway that is excavated into rock in the left abutment (looking downstream) of the embankment. The spillway is approximately 450-feet long, 40-feet wide, with 3H:1V side slopes, and has a rock control crest at El. 1165.0. The spillway is lined with a minimum of 1.5-foot thick layer of limestone riprap. The spillway channel discharges into Bottom Ash Lake. The Bottom Ash Pond spillway capacity curve is shown on Figure 4.

Bottom Ash Lake Dam Spillway is an uncontrolled open channel spillway that is excavated into rock near the left abutment at the southeast corner of the reservoir. The spillway is approximately 1100-feet long, 200-feet wide, with 3H:1V side slopes, and a 10-foot-wide concrete control crest at El. 1148.0. The spillway is lined with a minimum of 1.5-foot thick layer of limestone riprap. The spillway channel terminates at an elevation of about 1142.0, where the channel transitions back to the natural grass lined Lost Creek tributary channel. All discharges through the spillway are routed to the Lost Creek tributary, which eventually flows into the Kansas River. The Bottom Ash Lake spillway capacity curve is shown on Figure 4. A summary of the spillway parameters is presented in Table 2.

Table 2: Jeffrey Energy Center - Spillway Parameters Summary

Parameter	Value	
Reservoir	Bottom Ash Pond	Bottom Ash Lake
Spillway Length (ft)	450	1,100
Crest Elevation (ft)	1065	1048
Crest Width (ft)	40	200
Side Slopes	3H:1V	3H:1V

2.4 Intakes and Outlet Works

Bottom Ash Pond includes a single outlet located near the left abutment approximately 130-feet north of the right side slope of the spillway. The outlet works consists of a 4-foot diameter drop inlet (vertical riser pipe) with trash rack and anti-vortex plate connected to approximately 155-feet of horizontal 3-foot diameter corrugated metal pipe. The normal pool elevation of the reservoir is maintained by the uncontrolled sill of the vertical riser pipe that is set at El. 1163.0. All flow through the Bottom Ash Pond outlet works discharges into Bottom Ash Lake.

Bottom Ash Lake includes a single outlet located on the south bank of the reservoir rim, about 250-feet east of the emergency spillway. The outlet works consists of a large concrete intake structure which is connected to a pump and pipeline system that recycles water back to the power plant for the bottom ash handling system. The water recycling system is operated to maintain the reservoir water surface below the spillway crest at El. 1148.0, typically at El. 1144.0. The only potential discharge from the reservoir to the downstream channel would occur through the reservoir spillway after the all appropriate regulatory allowances are met.

2.5 Toe Drain

Bottom Ash Lake Dam includes a riprap lined toe drain channel that runs the length of the downstream slope. The toe drain collects seepage conveyed by the internal chimney and blanket drains. At the center of the dam, the right and left toe drain channels are combined in a small riprap lined basin where flow is channeled through a V-notch weir and to the downstream channel. The toe drain channel has a bottom width of 3-feet, 2H:1V side slopes, and has a minimum depth of 3-feet. The V-notch weir is constructed of a thin steel plate embedded in a 1-foot thick concrete wall.

Bottom Ash Pond Dam does not have a toe drain or internal drains. The water surface of Bottom Ash Lake is against the downstream slope of the Bottom Ash Pond Dam.

2.6 Vicinity Map

The Jeffrey Energy Center is located within Pottawatomie County, Kansas, approximately 6 miles north and 2.5 miles west of the city of St. Mary's, as shown on Figure 1. The Jeffrey Energy Center is located in the North ½ of Section 7, Township 9 South, Range 12 East. The supporting project facilities including Bottom Ash Pond and Bottom Ash Lake are approximately 1 mile west of the main plant. Bottom Ash Pond Dam is located in the SE ¼ of the NW ¼ of Section 12, Township 9 South, Range 11 West. Bottom Ash Lake Dam is located in the NW ¼ of the SE ¼ of Section 11, Township 9 South, Range 11 East. Both dams are located on a small tributary to Lost Creek, which eventually flows into the Kansas River.

2.7 Plan and Sectional Drawings

Engineering drawings and reports for various project features are available in the Owner's files. For reference purposes, project plan and sectional drawings from the Owner's files are reproduced in this report as follows:

Bottom Ash Pond Dam Plan	Figure 5 (Dwg 28480-DS-S3001)
Bottom Ash Pond Dam Section	Figure 6 (Dwg 28480-DS-S3002)
Bottom Ash Lake Dam Plan	Figure 7 (Dwg S1601)
Bottom Ash Lake Dam Sections	Figure 8 (Dwg S1606)
Bottom Ash Lake Spillway Profile	Figure 9 (Dwg S1604)
Bottom Ash Lake Spillway Sections	Figure 10 (Dwg S1605)

2.8 Standard Operational Procedures

The Jeffrey Energy Center is a coal fired power plant composed of three 720 MW units that provides electric power to millions of customers. Jeffrey Energy Center has the capacity to generate 1,857 MW of electrical power. Coal is delivered to the power plant by train, where it is then combusted to power the steam turbines. The burning of coal produces several gases which are vented from the boiler, and bottom ash, which is made of coarse fragments, falls to the bottom of the boiler, and is removed along with boiler slag. The bottom ash and boiler slag is mixed with water into slurry and is sluiced from the plant to the Bottom Ash Settling Pond, where the primary settling occurs and a large majority of bottom ash and boiler slag settles from solution. The water is then decanted and discharged from the settling pond to Bottom Ash Pond, where the majority of the remaining finer coal combustion waste, such as fly ash, settles out and remains for permanent disposal. Bottom Ash Pond is maintained at

El. 1164.0 by the ponds drop inlet outlet pipe structure. The decanted water is discharged through the outlet pipe to Bottom Ash Lake. The water in Bottom Ash Lake is recycled back to the plant's bottom ash handling system via the intake structure and pump system. The recycled water is pumped at a rate to maintain the lake water surface elevation below the spillway crest at El. 1148.0, typically El. 1144.0. If necessary, after achieving the appropriate regulatory allowances, water can be safely discharge from the lake through the spillway.

3.0 Summary of Construction History and Operation

Bottom Ash Lake Dam was designed by Black & Veatch Consulting Engineers prior to 1977 for the primary purpose of water and bottom ash storage at Jeffrey Energy Center. Bottom Ash Lake Dam was commissioned in 1978 in conjunction with the original start-up of Jeffrey Energy Center, Unit 1. Construction of Bottom Ash Lake Dam was substantially completed by 1979. There has been no expansion of the original dam.

Bottom Ash Lake historically has been operated as described in the normal operating procedures in Section 2.8. However during a period of operation from 1978 to 1981, the facility intermittently placed flue gas emissions control residue in the lake while installing and starting up a scrubber system. The material placed during these operations remains permanently disposed in Bottom Ash Lake.

Bottom Ash Pond Dam was originally constructed by plant staff in the early 1980s by subdividing Bottom Ash Lake with a new dike. The embankment was primarily constructed of Type "C" fly ash generated from plant operations. The fly ash was placed in lifts between 9 and 15 inches, at suitable moisture content and compacted (B&V, 1999). In 2000, the dam was expanded by raising the embankment and adding instrumentation and the emergency spillway. The expansion was designed by Black & Veatch Consulting Engineers. However, currently the final design in Westar's possession does not include a Professional Engineers signature or license number and is not approved by the Kansas DWR (Westar Energy, 2009).

Bottom Ash Pond historically has been operated as described in the normal operating procedures in Section 2.8. However during a period of operation from 1981 to 1992, the facility placed flue gas emissions control residue in the pond while periodically operating the scrubber system at the site. In 2008, the facility installed new scrubbers and began to again route flue gas emission control residues to the pond. This current operation is temporary until construction of a residue filtration system and gypsum dry landfill site can be completed. The material placed during these operations remains permanently disposed in Bottom Ash Pond.

4.0 Geologic and Seismic Considerations

The Jeffrey Energy Center is located 7 miles northwest of the city of St. Mary's in Pottawatomie County, Kansas. This area of Kansas is within the Dissected Till Plains Physiographic Province. The Dissected Till Plains is further broken down into the Kansas Drift plains and the attenuated drift border within Pottawatomie County. The Jeffrey Energy Center is located in the Kansas Drift Plains sub-province. The Kansas Drift Plains deposit includes thick deposits of till and Loess away from the ice margin. Loess deposits are windblown silt. Till deposits are made up of heterogeneous unstratified, unsorted, mixes of clay, silt, sand, gravel, and boulders deposited by glacial ice. Below the Kansas Drift Plains deposit is Permian aged bedrock. The bedrock, which is part of the Council Grove group, consists of interbedded limestone and shale. Bedrock units in the area gently dip to the east on a regional basis.

Seismic acceleration based on the on the Uniform Building Code Seismic Zone Map maximum ground motion for Pottawatomie County is 0.05g, which corresponds to an earthquake return period of about 2,500 years. This value is consistent with the United States Geological Survey regional probabilistic ground motion. The acceleration associated with the maximum credible earthquake.

The Jeffrey Energy Center contains two coal combustion waste impoundment structures: (1) Bottom Ash Lake Dam and (2) Bottom Ash Pond Dam (also called Fines Containment Dam).

Documentation presenting geologic information for the facilities at Jeffrey Energy Center included:

- Black & Veatch 1999 "DRAFT-Fines Containment Dam-Stability Report." This report provided the results of a field investigation of the Bottom Ash Pond dam and a structural stability analysis of the existing Bottom Ash Pond Dam structure.
- Black & Veatch 1987 "Bottom Ash Lake Dam Inspection Report".

As part of the 1999 Bottom Ash Pond Dam study, five borings were drilled along the crest of the Bottom Ash Pond Dam. The borings show the dam was founded on weathered bedrock at the abutments and soil under the main embankment. The soil consists of soft alluvial clay to very stiff clay and silty clay till. The weathered bedrock at the abutments is Neva Limestone. The embankment itself is constructed of fly ash

As part of the 1987 Bottom Ash Lake Dam study, design documents related to structural stability were reviewed, including laboratory tests of all pertinent soil types, and shales, residual clays, limestones, colluviums, and alluviums. The report indicates the dam is founded on the various geologic formations including the Bennett, Hamlin, Hughes Creek and Roca Shales, and the Long Creek Limestone. Other bedrock exposed along the drainage in the area includes the Cottonwood Limestone Member, Beattie Limestone Formation, Eskridge Shale Formation, and Grenola Limestone Formation. At several locations along the dam alignment considerable excavations of unsuitable, weak, compressible alluvium and weathered materials was required to reach the suitable rock foundation materials.

5.0 Instrumentation

5.1 Location and Type

The location of existing instrumentation at Bottom Ash Pond Dam and Bottom Ash Lake Dam is shown on Figure 5 and 7, respectively, and consists of the following:

5.1.1 Bottom Ash Lake Dam

- Standpipe Piezometers for monitoring water levels in various parts of the dam
- Vibrating Wire Piezometers for monitoring water levels in various parts of the dam
- Vertical Movement Devices for monitoring settlement of the surface of the dam
- Survey Monuments (benchmarks) for surveying control of vertical and horizontal movement of the dam
- One V-notch weir for monitoring seepage flow from the toe drain

5.1.2 Bottom Ash Pond Dam

- Standpipe Piezometers for monitoring water levels in various parts of the dam

5.1.3 Summary of Monitoring Well Locations

Monitoring wells are located on Bottom Ash Lake Dam and Bottom Ash Pond Dam to measure piezometric levels within the dams. The well numbers and locations of each well are summarized in Table 3 below.

Table 3: Monitoring Well Locations

Well Number	Location		Stratum Monitored
	Station	Offset (ft)	
Bottom Ash Lake Dam			
PB-1	3+00	200 DS	Left Abutment
PB-2	6+00	80 DS	Embankment Fill
PB-3	8+00	0.0	Embankment Core
PB-4	8+00	210 DS	Embankment Fill
PB-7	11+00	280 DS	Foundation
PB-8	12+00	600 DS	DS In-Situ Materials
PB-9	14+00	0.0	Embankment Core
PB-10	14+50	210 DS	Embankment Fill
PB-12	17+00	500 DS	DS In-Situ Materials
PB-13	19+00	80 DS	Foundation
PB-14	22+50	200 DS	Right Abutment

Well Number	Location		Stratum Monitored
	Station	Offset (ft)	
PB-15	7+99	85 US	US Embankment Fill
Bottom Ash Pond Dam			
WR-2	3+71.9	0.0	Foundation
WR-3	6+07.7	0.0	Embankment
WR-4	8+46.0	0.0	Foundation

5.2 Time Versus Reading Graphs of Data

5.2.1 Bottom Ash Lake Dam

Bottom Ash Lake Dam piezometers have been monitored since 1979 when the dam was constructed. During the first five years of operation the piezometer data was typically recorded quarterly. Subsequently, the readings were reduced to bi-annually, and after 1997 readings were recorded annually. The piezometric level data versus time (1982 through 2008) are plotted on Figures A-1 and A-2 in Appendix A. Similarly, the vertical movement devices (VMD) at Bottom Ash Lake Dam have been monitored since the construction of the dam, beginning in 1979. VMD readings were typically recorded on a bi-annual basis up until 1997, when readings were recorded annually. The vertical measurement device elevation data versus time (1979 to 2008) are plotted on Figures A-3 through A-6 in Appendix A.

5.2.2 Bottom Ash Pond Dam

Bottom Ash Pond Dam piezometers have been monitored since February of 1999. Piezometer readings typically occur on an annual basis. The piezometric level data versus time (1999 through 2006) are plotted on Figure A-7 in Appendix A.

5.3 Evaluation

5.3.1 Bottom Ash Lake Dam

The piezometer readings tend to fluctuate in response to changes in reservoir elevation. Review of the available data indicates most of the readings are generally consistent with past history. Piezometers PB-3, PB-9, and PB-15 show noticeably higher water levels than the other piezometers because piezometers PB-3 and PB-9 measure the water level in the embankment clay core and PB-15 is in the upstream embankment fill. Water levels in clay core piezometer PB-3 are generally 20 feet higher than the upstream shell piezometer PB-15, which is anomalous. Very high readings were obtained in 2001 and 2002 in PB-3 that indicate the stand pipe was full of water. Readings have not been made since 2003 in PB-3 and the instrument should be evaluated and rehabilitated or replaced. Similarly, PB-15 is no longer read and should be evaluated, rehabilitated or replaced. Additionally, PB-13 was damaged and the standpipe was broken off due to mowing operations. Piezometer PB-13 should be rehabilitated or replaced. The water levels downstream of the clay core are typically about 30 feet lower than those upstream of the clay core, indicating the clay core and chimney drain are serving to reduce pressure head of seepage through the dam. However the horizontal drain under the downstream shell does not appear to be highly effective in lowering the phreatic surface.

Bottom Ash Lake Dam vertical movement device data obtained since construction indicate that about 0.2 to 0.7 feet of settlement occurred at the dam crest in the first 20 years following construction, and relatively little settlement since that time. The amount and rate of crest settlement is considered minor for a dam of this size that has a clay core. Data from Vertical Movement Devices have fluctuated slightly with time, which could be a result of temperature variations or other man-caused disturbances. Little, or no, settlement is evident from instruments near the downstream toe, which is consistent with the reduced fill thickness at that location. The dam crest was constructed with camber above the normal crest El. 1165.0. Several crest Vertical Movement Devices indicate the existing crest is 0.5 to 1.0 foot lower than the design crest.

5.3.2 Bottom Ash Pond Dam

The piezometer readings tend to fluctuate in response to changes in reservoir elevation. Our review indicates most of the readings are generally consistent with past history.

6.0 Field Assessment

6.1 General

A site visit to assess the condition of Bottom Ash Lake Dam and Bottom Ash Pond Dam at Jeffrey Energy Center was performed on May 19, 2009, by Messrs. Steven R. Townsley, P.E., and Nicholas D. Miller, P.E., of GEI. Nicole Cruise of Environmental Protection Agency and Messrs. Bill Eastman, Craig Swartzendruber, Jared Morrison, Troy Mussetter, Tom Brown, David Walter, and Andy Evans of Westar Energy assisted in the assessment. Also present was Gary Christensen of the Kansas Department of Health & Environment, and. Conducting a separate safety inspection of the dam for the State of Kansas was Ambrose J. Ketter, P.E. of the Kansas Division of Water Resources.

The weather during the site visit (May 19, 2009) was generally clear and sunny, with the temperatures around 80 degrees Fahrenheit. The week preceding the inspection, a considerable amount of rainfall occurred at the site; however the ground was dry at the time of the site visit.

Field observations are organized as follows:

- Bottom Ash Lake Dam
- Bottom Ash Pond Dam

A checklist is provided in Appendix B and photographs are provided in Appendix C. Sections 6.2 and 6.3 describe observations made during the assessment relative to key project features. Section 6.4 presents specific observations.

6.2 Bottom Ash Lake Dam

Field assessment of the Bottom Ash Lake Dam included walking the dam crest, upstream slope, downstream slope, emergency spillway, and toe drain channels. We saw no obvious signs of settlement or displacement or adverse seepage that would adversely affect the dam safety of Bottom Ash Lake Dam.

6.2.1 Dam Crest

The dam crest appeared to be in good condition. No signs of cracking or settlement were observed during the assessment. However, review of settlement VMDs indicate the crest is 0.5 to 1.0 foot lower than the time of construction. The dam crest has three vehicle trails that traverse the length of the dam (Photos 26 – 29). The dam crest also has some low lying grassy vegetation that should be cleared or maintained to an acceptable level to make visual inspection of the dam easier.

6.2.2 Upstream Slope

The upstream slope of the dam is protected by riprap and appeared to be in excellent condition. No vegetation or signs of instability were observed along the upstream slope (Photos 30 – 33). However, some minor weathering and deterioration of the riprap was observed near the normal operating pool elevation, this is likely due to wave and freeze/thaw action (Photo 31).

6.2.3 Downstream Slope

The downstream slope of the dam has a well-established stand of grass, which provides some erosion protection. No obvious signs of slumping, instability or significant erosion were observed on the downstream slope (Photos 13, 16, and 18). A broken monitoring well (PB-13) was observed on the right side of the downstream slope, some minor erosion was observed beneath the concrete pad of the well (Photo 24). Additionally, a few small trees were observed on the downstream slope of the stability berm near the toe drain (Photo 21).

6.2.4 Emergency Spillway and Control Section

The limestone riprap both upstream and downstream of the concrete control crest showed extensive deterioration along the entire length of the control crest (Photos 1 – 4). Minor concrete spalling was also observed at a few locations on the top of the concrete control crest. The approach channel to the emergency spillway was also observed to have extensive riprap deterioration showing significant variability in riprap size (Photos 5-8). The riprap lining on the channel downstream of the control crest showed less deterioration and more consistent riprap sizes (Photo 9). Several small trees were observed at the exit of the riprap lined spillway channel which should be removed (Photo 10).

6.2.5 Toe Drain and V-Notch Weir

The toe drain was dry at the time of the assessment and appeared to be in good condition (Photos 11, 12, 14). Significant amounts of sediment were observed throughout the majority of the left toe drain channel (Photos 15, 17). The sediment deposits in the left toe drain channel appear to be from surface erosion observed near the left abutment and areas downstream of the dam. Only minor amounts of sediment were observed in the right toe drain channel (Photos 23 and 25). Additionally, a significant amount of silt and sediment has accumulated behind the V-notch weir (Photo 19 – 21).

In general, the toe drain is reported to not have collected seepage at any time in its history. The piezometer data indicates seepage is moving through the dam and downstream blanket drain. These conditions are not consistent and raise questions about where the seepage is draining to and whether there is a potential dam safety concern.

6.2.6 Water Surface Elevations and Reservoir Discharge

The reservoir water surface elevation was estimated to be approximately 3-feet below the crest of the emergency spillway. This water surface level correlates to an elevation of approximately 1145.0. No discharge was observed through the emergency spillway (Invert El. 1148.0) or the downstream toe drain from Bottom Ash Lake Dam during the field assessment.

6.3 Bottom Ash Pond Dam

Field assessment of the Bottom Ash Pond Dam included walking the dam crest, upstream slope, downstream slope, and emergency spillway. We saw no obvious signs of settlement or displacement or adverse seepage that would adversely affect the dam safety of Bottom Ash Pond Dam.

6.3.1 Dam Crest

The dam crest appeared to be in good condition. No signs of cracking of settlement were observed during the assessment. No vegetation was observed on the dam crest (Photos BAP 11, BAP 13).

6.3.2 Upstream Slope

The upstream slope of the dam is protected by riprap and appeared to be in excellent condition. No vegetation or signs of instability were observed along the upstream slope (Photos BAP 14, BAP 15).

6.3.3 Downstream Slope

The downstream slope of the dam appeared to be in good condition. No obvious signs of slumping or instability were observed on the downstream slope (Photo BAP 10, BAP 12, and BAP 16). The downstream slope has no erosion protection. Several locations along the downstream slope showed signs of minor erosion and the formation of small erosion rills (Photos BAP 6, BAP 17).

6.3.4 Emergency Spillway

The emergency spillway appeared to be in good condition (Photos BAP 1 – 4). The riprap protection was fairly consistent for the entire length of the spillway and only showed minor signs of deterioration (Photo BAP 9).

6.3.5 Outlet Works

The outlet works appeared to be in fair to good condition. The inlet trash rack and anti-vortex plate showed no signs of damage or deterioration (Photo BAP 5). The corrugated metal outlet pipe showed noticeable signs of corrosion and rusting at the outlet (Photo BAP 7). The remaining portions of the outlet works were not inspected due to the outlet works operating during the assessment. The riprap slope protection downstream of the outlet works appeared to be in good condition and showed no signs of deterioration (Photo BAP 8).

6.3.6 Water Surface Elevations and Reservoir Discharge

The reservoir water surface elevation was estimated to be approximately 0.3-feet above the outlet works inlet sill. This water surface level correlates to an elevation of approximately 1163.30. The discharge through the outlet works was estimated to be approximately 5 to 10 cubic feet per second (cfs) at the time of the inspection.

6.4 Field Inspection Observations

6.4.1 Settlement

There was no evidence of significant settlement of project structures.

6.4.2 Movement

There was no evidence observed during the inspection to indicate differential movement of project structures.

6.4.3 Erosion

There was no significant erosion of the dams or abutments noted during the assessment. Some erosion of left abutment at Bottom Ash Lake Dam was observed that contributes to sediment in the toe drain. Minor erosion of the downstream slope was observed at Bottom Ash Pond Dam.

6.4.4 Seepage

There was no evidence of uncontrolled seepage through the dams during the assessment. When Bottom Ash Lake Dam was inspected on April 6, 1987, seepage of approximately 1 gpm near the toe drain at Sta 20+25 was observed. Seepage at this location was not observed during this assessment. However, the seepage may have been obscured beneath the vegetation or riprap protection.

Piezometric water levels in the project structures appear to be inconsistent with those assumed in the stability analyses. This raises questions about where the seepage is draining to and whether there is a potential dam safety concern.

6.4.5 Leakage

We did not observe water leaking from any of the project structures.

6.4.6 Cracking

There were no new cracks observed in the upstream or downstream slopes or the crests of the dams.

6.4.7 Deterioration

No significant deterioration of project structures was observed.

6.4.8 Geologic Conditions

The geology of the project features is as described in the prior reports. There have been no studies or events (landslide, earthquake, etc.) that would result in changes to the description of local geologic conditions.

6.4.9 Foundation Deterioration

No signs of foundation deterioration were observed.

6.4.10 Condition of Spillway and Outlet Works

In general, the project spillways were in good condition. Bottom Ash Lake spillway showed significant signs of riprap deterioration surrounding the concrete control crest and on the approach channel. Additionally, several small trees were observed within the channel of the

Bottom Ash Lake spillway. Bottom Ash Pond outlet works showed noticeable signs of corrosion and rusting of the corrugated metal pipe near the outlet.

6.4.11 Reservoir Rim Stability

The reservoir rims visible from the dam crests did not show any evidence of landslides or shoreline instability that would threaten the safety of the dams.

6.4.12 Uplift Pressures on Structures, Foundations, and Abutments

No evidence of uplift pressure issues was observed.

6.4.13 Other Significant Conditions

No other conditions were observed that would affect the safety of the project structures.

7.0 Spillway Adequacy

7.1 Floods of Record

Floods of record have not been evaluated for Bottom Ash Lake and Bottom Ash Pond Dams. The discharge capacity (19,500 cfs) of Bottom Ash Lake Dam spillway, at the maximum elevation of the riprap lining (El. 1162.0), appears to be adequate to pass the design flood (10,374 cfs) estimated by Black & Veatch. The discharge capacity (1,311 cfs) of Bottom Ash Pond Dam at the maximum spillway elevation (El. 1170.0) appears to be adequate to pass the 100-year design flood (290 cfs) estimated by Black & Veatch.

7.2 Inflow Design Floods

Currently, Bottom Ash Lake Dam is classified as a class “B” or significant hazard potential structure. However, the DWR has recently recommended that the dam be upgraded to a class “C” or high hazard structure based on their most recent dam safety inspection (conducted concurrently with this specific site assessment). Based on the current class “B” hazard rating, the DWR requires the dam to be able to pass a flood event generated by the equivalent of a 30 percent probable maximum precipitation (PMP) with three feet of freeboard. A class “C” High hazard classification requires the dam to pass 40 percent PMP with three feet of freeboard. Federal guidelines suggest that significant hazard dams be able to pass a flood equivalent to 50 percent PMP with a minimum of three feet of freeboard. GEI was provided with limited information on the inflow design floods Bottom Ash Lake. Based on the provided “as-built” drawings developed by Black & Veatch in 1980, the dam is capable of passing a precipitation event of 33.8 inches, which is assumed to be 100 percent of the PMP developed using Hydrometeorological Report No. 51. This precipitation event produced a reservoir peak inflow rate of 15,633 cfs, an inflow volume of 8,235 ac-ft, and a maximum reservoir water surface elevation of 1157.3, which provides 7.7-feet of freeboard. The maximum discharge through the emergency spillway during this event was estimated to be 10,374 cfs, which is less than the capacity of the spillway (19,500 cfs). This flood developed by Black & Veatch considerably exceeds the regulatory requirements applicable to Bottom Ash Lake Dam.

Currently, Bottom Ash Pond Dam does not have a hazard classification registered with the DWR. However, the existing dam structure, which was raised in 2000 (see Sec. 3), was designed and constructed as a class “A” or low hazard structure according to the DWR classification criteria. Under a class “A” or low hazard rating, the DWR requires the dam to be able to pass a flood event generated by the equivalent of a 100-year, 6-hour precipitation event with three feet of freeboard. GEI was provided with limited information on the inflow design floods for Bottom Ash Pond. Based on the provided "as-built" drawings developed by Black & Veatch in 2000, the spillway is capable of passing a precipitation that produces a reservoir peak inflow rate of 2,100 cfs. This inflow rate generates a maximum reservoir water surface elevation of 1166.3, which provides 3.7-feet of freeboard. The maximum discharge through the outlet works and emergency spillway during this event was estimated to be 290 cfs, which is less than the spillway capacity (1,311 cfs) at the dam crest. This flood developed by Black & Veatch conforms to the state regulatory requirements applicable to Bottom Ash Pond Dam.

7.2.1 Determination of the PMF

Not applicable.

7.2.2 Freeboard Adequacy

Freeboard is adequate at all facilities.

7.2.3 Dam Break Analysis

A dam break analysis and inundation mapping has not been performed for Bottom Ash Lake Dam. Currently, Bottom Ash Lake Dam is included in an EAP developed for Makeup Lake Dam, Auxiliary Makeup Lake Dam and Bottom Ash Lake Dam. According to the state records, the developed EAP does not include a breach inundation map for the reservoirs. Currently, the state is recommending that Westar Energy develop a dam breach analysis for Bottom Ash Lake to determine the potential limits of downstream flood inundation.

Currently Bottom Ash Pond is not required to have a dam break analysis because it is not a registered dam structure with the DWR and only class "B" and "C" hazard classifications structures are required to have an EAP and dam break analysis. However, the hazard classification of the Bottom Ash Pond Dam could potentially be increased to a significant hazard structure under federal guidelines depending on results of a dam break analysis and inundation mapping. A dam break analysis for Bottom Ash Pond Dam would have to assume the water level in Bottom Ash Lake is at the spillway crest because a dam break analysis cannot rely on the mechanical systems to regulate the lake level. With this assumption, any coal combustion waste flowing through the breach of Bottom Ash Pond Dam would enter Bottom Ash Lake and discharge through the spillway. This discharge of waste materials could potentially have significant environmental impacts on the receiving tributaries and surrounding areas, as well as significant economic impacts related to the environmental cleanup of the waste materials. Based on the potential for significant environmental and economic impacts we believe Bottom Ash Pond Dam should be included in a dam breach analysis for Bottom Ash Lake Dam.

7.3 Spillway Rating Curves

Spillway rating curves for both dams were provided by Westar Energy. The spillway rating curves were developed by Black & Veatch. The spillway rating curves are shown on Figure 4.

7.4 Evaluation

Upon review of the spillway rating curves and design floods developed by Black & Veatch, the emergency spillway discharge capacity at Bottom Ash Lake and Bottom Ash Pond Dams appears to be adequate for passing the regulatory design floods based on the current or designed hazard classifications for the dams. However, Bottom Ash Pond spillway may not be adequate if Bottom Ash Pond Dam is determined to be a significant hazard structure under federal guidelines based on the results of dam breach analysis and inundation mapping for the structure.

8.0 Structural Stability

8.1 Visual Observations

8.1.1 Bottom Ash Pond Dam

No visible signs of instability were evident associated with the dam and the appurtenant structures during the May 19, 2009 specific site assessment.

8.1.2 Bottom Ash Lake Dam

No visible signs of instability were evident associated with the dam and the appurtenant structures during the May 19, 2009 specific site assessment. Additionally, previous inspections have not raised issues associated with visible signs of instability.

8.2 Discussion of Stability Analysis

8.2.1 Bottom Ash Pond Dam

The results of slope stability analyses are reported in the Black & Veatch 1999 "DRAFT-Fines Containment Dam-Stability Report." This study was completed to evaluate the structure in its existing condition, and to assess the ability of the structure to accommodate an additional 5 feet of ash storage.

The structural stability analyses completed as part of the 1999 study were used to determine if the structure was capable of containing water and coal combustion waste. Using SLOPE/W Version 3, by GEO-SLOPE International, steady state seepage was evaluated using the Bishop Method. End of construction analyses were not performed because the structure had been in place for several years and no additional height is planned. The rapid drawdown condition was not modeled on the upstream face because Black & Veatch concluded the condition is highly unlikely due to the fixed sill elevation of the decanting outlet pipe. Seismic acceleration of 0.05g was applied to the structure based on the United States Geological Survey ground motion applicable to low hazard dams in Pottawattamie County.

The material properties used in the stability modeling were based on laboratory testing of site-specific materials with conservative adjustments. The geometry of the modeled section was slightly more conservative than actual conditions. Slopes were steepened in the model where the theoretical embankment height was less than five feet.

The phreatic surface in the dam is monitored by piezometers. A linear phreatic surface assigned for modeling was based on a reservoir water elevation with 5 additional feet of storage (El. 1163.0) and the water level at the spillway crest in Bottom Ash Lake (El. 1148). The analysis for the maximum flood stage pool assumed an upstream water surface at El. 1167.5.

The stability analyses included in the 1999 report were reviewed. The loading conditions used in the previous analyses have not changed except that rapid drawdown should be evaluated. We believe the previous analyses did not adequately address sensitivity of the failure surfaces to varied tailwater elevations at Bottom Ash Lake, the phreatic surface within the embankment, or the variability of the fly ash embankment material properties.

Fly ash embankment material varied in strength from generally strong in the upper 75 percent of the dam to weak in the lower 25 percent of the dam height. All the fly ash is modeled using undrained strength parameters. We understand from our interview of Westar Energy engineers that the initial several feet of the Bottom Ash Pond Dam were not placed as compacted engineered fill. This zone of weaker fly ash is confirmed in the boring information. We suggest an evaluation of the dam be performed modeling the dam as two zones of material. The lower zone should reflect the weaker materials encountered in the geotechnical investigation and drained strength parameters should be established for this material.

Tailwater effects from Bottom Ash Lake should be neglected from the stability analysis because the water surface elevation of Bottom Ash Lake can vary. The load from water does have a minor stabilizing effect on the downstream stability of the Pond Dam and it would be reasonable to ignore the downstream reservoir. Also, the position of the phreatic surface should be re-evaluated if no tailwater is considered.

The phreatic surface used in the stability model is assumed linear from upstream reservoir levels to the downstream tailwater. The surface does correspond with the water level recorded in an observation well in the dam embankment. However, future conditions in an aging embankment may contribute to higher water level than is currently seen. It would be conservative to assign a higher phreatic surface to reflect future hydraulic conductivity properties of the fly ash embankment.

It is our opinion that the previous analyses should be supplemented with analyses containing rapid drawdown conditions, re-evaluated fly ash material properties (particularly drained properties for the lower 25 percent of embankment height), a more conservative phreatic surface, and neglecting the tailwater from Bottom Ash Lake on the downstream toe.

8.2.2 Bottom Ash Lake Dam

The design report was not provided for review. A discussion of the slope stability analyses completed for the design of the dam is included in the Black & Veatch 1987 "Bottom Ash Lake Dam Inspection Report." This investigation was completed to assess the general safety of the dam. The stability modeling was completed in ICES-SLOPE using the Bishop Method, and the Morgenstern-Price Method. Four cross sections were analyzed for End of Construction, Rapid Drawdown, Full Reservoir- steady state seepage, and Full Reservoir with seismic loading.

The phreatic surface assigned upstream of the core of Bottom Ash Lake Dam for modeling full reservoir conditions was set at the spillway crest (El. 1148.0). The phreatic surface assigned to the downstream side of the dam was set at the elevation of the horizontal drainage blanket. Information on the phreatic surface in the dam can be obtained from the piezometers. The assumed phreatic surfaces for the full reservoir analyses conflicts with the available piezometers data. The piezometer data indicates that the phreatic surface downstream of the core is significantly above the horizontal drainage blanket. The elevated phreatic surface will adversely affect the modeled stability of the dam. Additional analyses should be performed using the piezometer data to evaluate the sensitivity of the dam stability and seepage stability to varied phreatic surface conditions.

The discussion of the design stability analyses included in the 1987 report was reviewed. The material properties used in the stability modeling were based on laboratory testing of site-specific materials with strengths selected from the lower end of the range. Drained and undrained shear strength envelopes were developed for the various soils and foundation materials for use in the design. The end of construction case and rapid drawdown case were appropriately analyzed using the undrained shear strength of the soils, which reflects the reduced strength of the soil due to internal pore pressures that build up in the soil. The steady seepage and earthquake loading cases were appropriately analyzed using the drained soil strength parameters.

8.3 Factors of Safety

8.3.1 Bottom Ash Pond Dam

We reviewed the computed factors of safety for the embankment contained in the Black and Veatch 1999 draft report. This report show factors of safety ranging from 1.17 to 2.45, all of which exceed the stability criteria using assumptions and methods of analysis accepted by the Kansas State Board of Agriculture, Division of Water Resources, Engineering Guide 1, dated May 1986.

The sliding block with seismic case at the maximum flood stage pool was the most critical stability scenario producing a factor of safety of 1.17, which is acceptable based on the state regulatory factor of safety of 1.10 for sliding block earthquake stability. This combination of maximum flood with earthquake still exceeded the accepted industry standards for earthquake loading conditions.

8.3.2 Bottom Ash Lake Dam

We reviewed the computed factors of safety for the embankment contained in the Black & Veatch Bottom Ash Lake Dam Inspection Report, dated April 1987. The report discussed the minimum factor of safety calculated for each loading condition. We compare the reported calculated factors of safety to minimum required factors of safety in accordance with Kansas Dam Safety and FERC guidelines in Table 4.

Table 4: Stability Factors of Safety for Bottom Ash Lake Dam and Guidance Values

Loading Condition	Min. Calculated FOS	Min. Required FOS (Kansas)	Min. Required FOS (FERC)
End of Construction	1.30	**	1.30
Rapid Drawdown	1.07	**	1.20
Full Reservoir – Steady Seepage	1.50	1.50	1.50
Full Reservoir – SS with Earthquake (0.15g)	1.00	**	1.00

Notes: **Values not specified in Kansas Dam Safety Regulations (2007), but guidance given to use industry accepted values.

As indicated in Table 4, the calculated factor of safety for rapid drawdown is significantly below the federal guidance. An additional consideration for rapid drawdown is the 1987 analysis only considered a partial drawdown, not a full drawdown to the dead pool. Also indicated in Table 4 is the calculated factor of safety for full reservoir – steady seepage just meets the Kansas and federal guidance value. If the observed higher phreatic surface conditions based on piezometer data are included in the analysis the resulting factor of safety would not meet the required 1.50 for this loading condition.

8.4 Seismic Stability - Liquefaction Potential

The liquefaction potential at the various project features was not evaluated in the design studies because saturated granular soils that are potentially liquefiable are not present in the dam embankment and foundation.

8.5 Summary of Results

8.5.1 Bottom Ash Pond Dam

We expect the stability analysis will be very sensitive to the strength assigned to the lower, non-engineered fill in the dam embankment, somewhat sensitive to the position of the phreatic surface, and slightly sensitive to the inclusion of tailwater at the downstream toe. The 1999 stability analyses should be supplemented with analyses addressing modified fly ash material properties to represent drained strengths of the lower non-engineered embankment fill, a more conservative piezometric surface to reflect future aging of the dam, and neglecting tailwater effects from Bottom Ash Lake at the downstream toe. A rapid drawdown stability case should also be evaluated. Addressing these issues may result in the stability of Bottom Ash Pond Dam potentially not meeting all of the federal minimum required dam stability factors of safety, and potentially not meeting all seepage stability requirements.

8.5.2 Bottom Ash Lake Dam

The calculated factor of safety for rapid drawdown is significantly below the federal guidance. In addition, the rapid drawdown analysis should evaluate a full drawdown to the dead pool, or reasoning why it does not need to be considered. Also, the analysis of full reservoir – steady seepage should address the observed higher phreatic surface, which would likely cause the resulting factor of safety to not meet the minimum required value of 1.50 for this loading condition. The phreatic surface conditions should also be documented relative to the lack of seepage collected by the toe ditch and evaluated in a seepage analysis so that a consistent model of the seepage performance of the dam can be developed.

9.0 Adequacy of Maintenance and Methods of Operation

9.1 Procedures

There are no Standard Operating Procedures for the Bottom Ash Lake or Bottom Ash Pond. The operations of the lakes are determined by the water recycle needs of the main plant's bottom ash handling system. The current plant operations include mixing bottom ash and boiler slag with water into slurry and sluicing the slurry to the Bottom Ash Settling Pond, where the primary settling occurs and a large majority of bottom ash and boiler slag settles from solution. The water is then discharged from the settling pond to Bottom Ash Pond, where the majority of the remaining waste settles out and remains for permanent disposal. Bottom Ash Pond is maintained at El. 1164.0 by the ponds service spillway outlet works structure. The water is routed through the outlet works to Bottom Ash Lake. The water in Bottom Ash Lake is pumped back to the plant's bottom ash handling system via an intake structure and pump system. The recycled water is pumped at a rate to maintain the lake water surface elevation below the spillway crest, which is at El. 1148.0. If necessary, after achieving the appropriate regulatory allowances, water can be safely discharge from the lake through the spillway.

9.2 Maintenance of Dams

Maintenance of Bottom Ash Lake and Bottom Ash Pond dams at Jeffrey Energy Center is performed or subcontracted by Westar Energy staff. Inspections are made annually by consulting engineers contracted by Westar Energy. The Kansas DWR also performs safety inspections of the dams every five years. The vegetation on the downstream slope of Bottom Ash Lake Dam is maintained by annual mowing. Mowing is not required at Bottom Ash Pond Dam.

9.3 Surveillance

Westar Energy staff is responsible for the surveillance of the dams and appurtenant facilities. Monitoring of the dams instrumentation currently occurs annually, typically during the annual inspection. The main power plant is manned 24 hours a day and operators can respond to potential emergency situation at the dams. There are no automatic warning systems for either Bottom Ash Pond Dam or Bottom Ash Lake Dam.

10.0 Emergency Action Plan

The Kansas Department of agriculture, Division of Water Resources requires that all class "B" significant hazard and class "C" high hazard dams to have an emergency action plan. Bottom Ash Lake Dam is included in an Emergency Action Plan (EAP) developed for Makeup Lake Dam, Auxiliary Makeup Lake Dam and Bottom Ash Lake Dam. According to the state records, the developed EAP does not include a breach inundation map for the reservoirs. Currently, the state is recommending that Westar Energy develop a dam breach analysis for Bottom Ash Lake to determine the potential limits of downstream flood inundation. Currently, Bottom Ash Pond Dam is not required to have an EAP because it is not registered with the state and the dam was designed as a class "A" low hazard structure. The EAP was not reviewed as part of the assessment.

11.0 Conclusions

11.1 Assessment of Dams

11.1.1 Field Assessment

The dams, spillways, and outlet works facilities associated with the Bottom Ash Lake and Bottom Ash Pond were generally found to be in fair condition. Issues of potential concern for the Bottom Ash Lake and Bottom Ash Pond facilities were identified from our field assessment as follows.

1. Significant amounts of sediment were observed throughout the majority of the left toe drain channel at Bottom Ash Lake. Additionally, a significant amount of silt and sediment has accumulated behind the V-notch weir. The sediment deposits in the toe drain appear to be from surface erosion observed near the left abutment and areas downstream of the dam. However, the piezometer data indicates seepage is moving through the dam and downstream blanket drain, but there has been no seepage observed in the toe drain historically. This raises questions about where the seepage is draining to, is it mobilizing material, and if it is causing a dam safety concern.

2. The riprap surrounding the emergency spillway concrete control crest at Bottom Ash Lake is significantly deteriorated. The approach channel to the emergency spillway was also observed to have extensive riprap deterioration showing significant variability in riprap size. Additionally, minor concrete spalling was observed on the top of the concrete control crest. Several small trees were also observed at the exit of the riprap lined spillway channel.

3. The CMP outlet conduit for Bottom Ash Pond shows signs of severe corrosion and may have limited service life.

11.1.2 Stability Analysis (Adequacy of Factors of Safety)

We expect the stability analysis will be very sensitive to the strength assigned to the lower, non-engineered fill in the dam embankment, somewhat sensitive to the position of the phreatic surface, and slightly sensitive to the inclusion of tailwater at the downstream toe. The 1999 stability analyses should be supplemented with analyses addressing modified fly ash material properties to represent drained strengths of the lower non-engineered embankment fill, a more conservative piezometric surface to reflect future aging of the dam, and neglecting tailwater effects from Bottom Ash Lake at the downstream toe. A rapid drawdown stability case should also be evaluated. Addressing these issues may result in the stability of Bottom Ash Pond Dam potentially not meeting all of the federal minimum required dam stability factors of safety, and potentially not meeting all seepage stability requirements.

The calculated factor of safety for rapid drawdown is significantly below the federal guidance. In addition, the rapid drawdown analysis should evaluate a full drawdown to the dead pool, or reasoning why it does not need to be considered. Also, the analysis of full reservoir – steady seepage should address the observed higher phreatic surface, which would likely cause the resulting factor of safety to not meet the minimum required value of 1.50 for this loading condition. The phreatic surface conditions should also be documented relative to the lack of seepage collected by the toe ditch and evaluated in a seepage analysis so that a consistent model of the seepage performance of the dam can be developed.

11.1.3 Stress Evaluation

Stress evaluation is not applicable to the dams at Jeffrey Energy Center because there are no structural elements or buildings that would warrant a stress evaluation.

11.1.4 Spillway Adequacy

The discharge capacity of Bottom Ash Lake spillway appears to be adequate for passing the PMP design flood estimated by Black & Veatch Consulting Engineers, in 1980. Similarly, the discharge capacity of Bottom Ash Pond spillway appears to be adequate for passing the 100-year, 6-hour design flood estimated by Black & Veatch Consulting Engineers, in 2000. However, the spillway of Bottom Ash Pond Dam may not be adequate to pass the regulatory flood if the hazard potential classification of the dam is increased to significant hazard under federal guidelines.

11.2 Adequacy of Instrumentation and Monitoring of Instrumentation

Instrumentation and monitoring programs are fair. Low areas of the dam crest as indicated by vertical movement devices should be addressed. There are some issues with the instrumentation including:

- Piezometers PB-3, PB-13, and PB-15 are damaged or unreadable and need to be evaluated, rehabilitated, or replaced.
- Piezometers PB-7 and PB-9 have shown an anomalous rise in readings in recent years, these piezometers should be evaluated.
- Evaluate the phreatic surface through the embankment and the lack of drainage collection in the toe drain.

The frequency of monitoring also is considered adequate; however additional monitoring may be appropriate to address the issues listed above.

11.3 Adequacy of Maintenance and Surveillance

Bottom Ash Lake Dam and Bottom Ash Pond Dam have satisfactory maintenance and surveillance programs. However, the outlet conduit for Bottom Ash Pond Dam shows signs of severe corrosion and the CMP is expected to have a limited service life and has not been dewatered and thoroughly inspected based on previous inspection reports. In the near future, Westar Energy should dewater the outlet conduit for inspection and maintenance to ensure leakage or seepage through corroded or rusted section of the conduit is not adversely affecting the embankment stability.

12.0 Recommendations

12.1 Corrective Measures for the Structures

12.1.1 Bottom Ash Lake

1. The calculated factor of safety for rapid drawdown is significantly below the federal guidance. In addition, the rapid drawdown analysis should evaluate a full drawdown to the dead pool, or reasoning why it does not need to be considered. Also, the analysis of full reservoir – steady seepage should address the observed higher phreatic surface, which would likely cause the resulting factor of safety to not meet the minimum required value of 1.50 for this loading condition. The phreatic surface conditions should also be documented relative to the lack of seepage collected by the toe ditch and evaluated in a seepage analysis so that a consistent model of the seepage performance of the dam can be developed.

2. Significant amounts of silt and sediment have accumulated in the toe drain and behind the V-notch weir due to surface water run-on from the abutment area. We recommend the accumulated sediment be removed from these locations and the toe drain and basin behind the V-notch weir be returned to the original design condition. This will include replacing any displaced or damage riprap or bedding material. The sediment is not associated with internal erosion of the blanket/toe drain. However; the lack of seepage collection by the toe ditch is not consistent with the piezometer readings and should be further evaluated within the next six months.

3. We recommend a dam breach analysis and inundation mapping be performed for Bottom Ash Lake Dam for inclusion in an emergency action plan for the structure. A dam breach analysis for Bottom Ash Pond Dam should be included in the document and the results should be used to further investigate the hazard classification of the Bottom Ash Pond Dam.

4. The riprap near the control crest and the approach channel to the spillway is significantly deteriorated and continues to degrade annually. In the current condition, it is likely that noticeable erosion of the spillway would occur in these locations during high flow events. We recommend the condition of the riprap be monitored closely, and repair or replacement may be necessary if the condition of the riprap continues to deteriorate.

5. Several small trees were observed at the end of the riprap lined spillway channel. These trees should be removed within the next year to ensure the spillway operates as designed. If the trees are not removed soon, they could have a significant effect on the performance of the spillway and will be more expensive and difficult to remove in the future.

6. A few small trees were observed along the downstream slope of the stability berm, near the V-notch weir. These trees should be removed within the next year. If these trees are not removed, they could potentially initiate seepage paths or affect the stability of the slope. All vegetation in this area and on the downstream slope should be maintained to an acceptable level that will not obstruct visual dam safety inspections.

7. The riprap on the upstream slope of the dam is in excellent condition. However, minor deterioration of riprap was observed near the reservoir's normal pool elevation. The riprap in this location should be monitored for continued deterioration.

12.1.2 Bottom Ash Pond

1. The Bottom Ash Pond Dam likely qualifies as a significant hazard structure under federal guidelines due to the potential for significant economic/environmental damage associated with failure of the dam. A dam breach analysis and inundation mapping should be performed for Bottom Ash Pond Dam.

2. The 1999 stability analyses for Bottom Ash Pond Dam should be supplemented with analyses addressing modified fly ash material properties to represent drained strengths of the lower non-engineered embankment fill, a more conservative piezometric surface to reflect future aging of the dam, and neglecting tailwater effects from Bottom Ash Lake at the downstream toe. A rapid drawdown stability case should also be evaluated. Addressing these issues may result in the stability of Bottom Ash Pond Dam potentially not meeting all of the federal minimum required dam stability factors of safety, and potentially not meeting all seepage stability requirements.

3. The CMP outlet conduit showed noticeable signs of corrosion and rusting through the pipe side wall, near the outlet. The outlet conduit has not been previously dewatered and thoroughly inspected. In the near future, the outlet conduit should be dewatered for inspection and maintenance to ensure leakage or seepage through corroded or rusted section of the conduit is not adversely affecting the embankment stability and to assess measures to extend the service life of the outlet pipe.

4. The downstream slope of Bottom Ash Pond Dam showed minor signs of surface erosion and the formation of small erosion rills. Currently, this is not a dam safety concern. If erosion on the downstream slope continues, the slope should be repaired or riprap slope protection should be installed in the future.

12.2 Corrective Measures Required for Maintenance and Surveillance Procedures

None.

12.3 Corrective Measures Required for the Methods of Operation of the Project Works

None.

12.4 Any New or Additional Monitoring Instruments, Periodic Observations, or Other Methods of Monitoring Project Works or Conditions That May Be Required

There are several issues associated with the instrumentation at Bottom Ash Lake Dam. Piezometers PB-3, PB-13, and PB-15 are damaged or unreadable and need to be evaluated, rehabilitated, or replaced. Piezometers PB-7 and PB-9 have shown an anomalous rise in readings in recent years, these piezometers should be evaluated. An evaluation of the phreatic surface through the embankment and the lack of drainage collection in the toe drain should be performed. Additional instrumentation and monitoring may be needed to address these issues.

12.5 Acknowledgement of Assessment

I acknowledge that the management unit(s) referenced herein was personally inspected by me and was found to be in the following condition **(select one only):**

SATISFACTORY

FAIR

POOR

UNSATISFACTORY

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

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

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

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

I acknowledge that the management unit referenced herein:

Has been assessed on May 19, 2009 (date)

Signature: ______________________

List of Participants:

Steven R. Townsley, P.E.	GEI Consultants, Inc.
Nicholas D. Miller, P.E.	GEI Consultants, Inc.
Nicole Cruise	Environmental Protection Agency
Bill Eastman	Westar Energy
Craig Swartzendruber	Westar Energy
Jared Morrison	Westar Energy
Troy Mussetter	Westar Energy
Tom Brown	Westar Energy
David Walter	Westar Energy
Andy Evans	Westar Energy
Gary Christensen	Kansas Department of Health & Environment
Ambrose J. Ketter, P.E.	Kansas Division of Water Resources

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Appendix A

Instrumentation

Appendix B

Inspection Checklist

May 19, 2009

Appendix C

Inspection Photographs

May 19, 2009

Appendix D

Reply to Request for Information Under Section 104(e)