History of Construction

CFR 257.73(c)(1)

Bottom Ash Pond Complex
Cardinal Plant
Brilliant, Ohio

September, 2016

Prepared for: Cardinal Operating Company - Cardinal Plant

Brilliant, Ohio

Prepared by: Geotechnical Engineering Services

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GERS-16-066

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Attachments

1.0 OBJECTIVE

This report was prepared by AEP- Geotechnical Engineering Services (GES) section to fulfill requirements of CFR 257.73(c)(1) with an evaluation of the facility.

2.0 DESCRIPTION OF CCR THE IMPOUNDMENT

The Cardinal Power Plant in Wells Township, Jefferson County, near the town of Brilliant in eastern Ohio. The Cardinal Power Plant is owned by Buckeye Power and AEP Generation Resources (GENCO) a unit of American Electric Power. is operated by Cardinal Operating Company. The facility operates two surface impoundments for storing CCR; the Bottom Ash Pond (BAP) Complex and Cardinal Fly Ash Reservoir II (FAR II) Dam. The focus of this report is the Bottom Ash Pond Complex.

The BAP complex is comprised of diked embankments on the east and west sides while the north and south sides of the BAP are incised. The complex consists of two separate ponds, the larger bottom ash pond and the smaller recirculation pond. The entire crest length is just over a mile, and the nominal crest width is 20 feet. The north end of the pond has been partially filled in with ash and the exact limits of the pond are poorly defined.

The pond complex was originally developed as part of the construction of Units 1 and 2 in the 1960s. The crest of the dikes forming the original pond was at El. 658.0. However, the pond complex was raised to a crest elevation of 970.0 and extensively modified in 1974 as part of the construction of Unit 3.

3.0 SUMMARY OF OWNERSHIP 257.73(c)(1)(i)

[The name and address of the person(s) owning or operating the CCR unit: the name associated with the CCR unit: and the identification number of the CCR unit if one has been assigned by the state.]

The Cardinal Power Plant is located at 306 County Road 7 East, Brilliant, OH, 43913 County, near the town of Brilliant, Jefferson County, Ohio. It is owned by Buckeye Power and AEP Generation Resources (GENCO) and operated by Cardinal Operating Company. The facility operates the BAP complex dam, ODNR# 0105-004.

4.0 LOCATION OF THE CCR UNIT 257.73 (c)(1)(ii)

[The location of the CCR unit identified on the most recent U.S. Geological Survey (USGS) 7 ½ minute or 15 minute topographic quadrangle map, or a topographic map of equivalent scale if a USGS map is not available.]

A location map is included in Attachment A.

5.0 STATEMENT OF PURPOSE 257.73 (c)(1)(iii)

[A statement of the purpose for which the CCR unit is being used.]

The bottom ash pond complex consists of two components: the bottom ash pond and the recirculation pond (RCP). The bottom ash pond complex is utilized for the storage and collection of bottom ash, Bottom ash-laden water and other storm water is discharged via thirteen (13) pipes into the northwest corner of the bottom ash pond, the coarse bottom ash settles out closer to the discharge lines while the finer bottom ash settles out at farther locations within the pond. The water in the RCP is used to sluice the fly ash from the plant to FAR II via the pump station.

6.0 NAME AND SIZE OF WATERSHED THE CCR UNIT IS LOCATED 257.73 (c)(1)(iv)

[The name and size in acres of the watershed within which the CCR unit is located.]

The Cardinal BAP Complex is located within the Upper Ohio-Wheeling Water Shed (HUC 05030106) which is approximately 1,517.0 square miles (970,876 acres) (USGS).

The Cardinal Bottom Ash Complex is comprised of diked embankments on three sides which directs storm water away from the impoundment and limits runoff to that which falls directly on the pond surface. The area of the pond is approximately 24.3 acres. The pond also receives pumped inflow from plant facilities and stormwater collection areas.

7.0 DESCRIPTION OF THE FOUNDATION AND ABUTMENT MATERIALS 257.73(c)(1)(v)

[A description of the physical and engineering properties of the foundation and abutment materials on which the CCR unit is located.]

The geotechnical reports in Attachment B provide the specific properties of the foundation materials. The original ground surface at the site is generally located between El. 645 and 655. Near surface soils generally consist of a layer of alluvium silt, clay and fine sand (organic in some locations) over glacial outwash deposits of variable thickness overlying the bedrock surface. The alluvium clays and silts were deposited in the backwater of the Ohio River, while the outwash materials typically consist of sand, gravel and silt deposits deposited during the last ice age. Based on geological literature, the glacial outwash extends to the bedrock surface, estimated to be roughly 50 to 60 feet below the natural ground surface at the pond. The upper most bedrock consists of shale and/or sandstone belonging to the Conemaugh Group of Pennsylvanian Age. The soils were screened for liquefaction potential and found to be non-liquefiable. The geotechnical reports in Attachment B include the screening calculations.

Based on the historical cross-sections extending through both the Bottom Ash Pond and the Recirculation Pond from the vertical expansion, the original ash pond embankments along the Ohio River ranged in height from 4 to 6 feet above the bottom of the ash pond.

A subsurface investigation was conducted in 2009 and the strength parameters of the foundation as well as the embankment were defined based on laboratory tests or correlations to known strengths based on blow counts. Table 1 lists the material properties for the foundation material. The geotechnical reports in Attachment B also provide the specific properties of the foundation materials.

Table 1 Strength Parameters for main Natural/constructed zones.

Layer	γ_m	c'	φ'
	pcf	psf	degrees
Newer Embankment Fill	125	0	31
Original Embankment Fill	125	100	30
Alluvium Silt/Clay	125	0	30
Organic Clayey Silt	125	0	30
Loose Glacial Outwash Sand/Gravel	115	0	29
MDe Glacial Outwash Sand/Gravel	120	0	34

<u>8.0</u> DESCRIPTION OF EACH CONSTRUCTED ZONE OR STAGE OF THE CCR UNIT 257.73 (c)(1)(vi)

[A statement of the type, size, range, and physical and engineering properties of the materials used in constructing each zone or stage of the CCR unit; and the approximate dates of construction of each successive stage of construction of the CCR unit.]

The BAP complex embankments have maximum height of approximately 25 feet and are constructed of compacted clay on a slope ranging from 2.5:1 (2.5 feet horizontal, 1 foot vertical). The elevation at the top of the embankment around the perimeter of the BAP is approximately 670 feet msl, and the normal operating level is approximately 665 feet msl. The embankment fill materials dike ranged from hard silty Clay to fine and coarse gravel, overlying native material. The interior bottom elevation of the BAP Complex is approximately 645 feet msl.

The pond complex was originally developed as part of the construction of Units 1 and 2 in the 1960s. The crest of the dikes forming the original pond was at El. 658.0. However, the pond complex was raised to a crest elevation of 970.0 and extensively modified in 1974 as part of the construction of Unit 3.

Figure 1 details original embankment and the vertical expansion of the embankment.

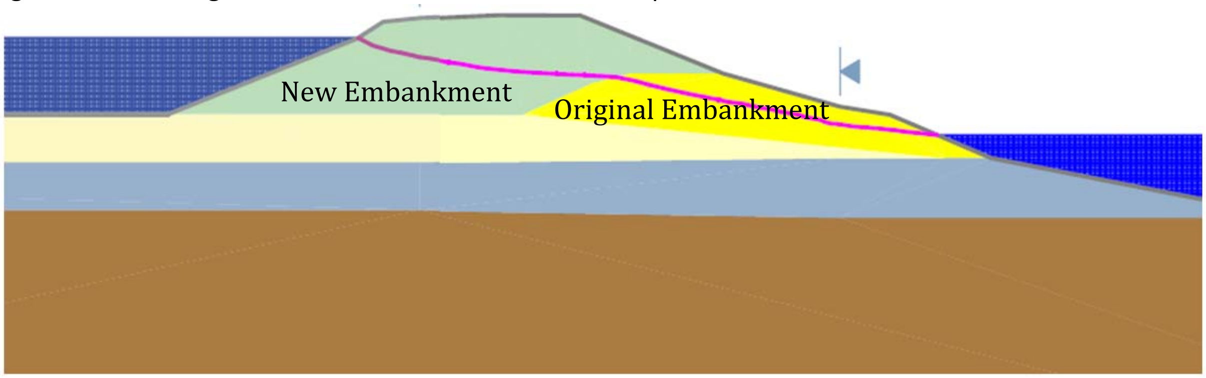


Figure 1. Original grades and subsequent raising.

Table 1 lists the material properties for the material used in the construction of the original and the newer embankment. The geotechnical reports in Attachment B also provide the specific properties of the embankment materials.

<u>9.0</u> ENGINEERING STRUCTURES AND APPURTENANCES, 257.73 (c)(1)(vii)

[At a scale that details engineering structures and appurtenances relevant to the design, construction, operation, and maintenance of the CCR unit, detailed dimensional drawings of the CCR unit, including a plan view and cross sections of the length and width of the CCR unit, showing all zones, foundation improvements, drainage provisions, spillways, diversion ditches, outlets, instrument locations, and slope protection…]

The outlet works for the Bottom Ash Pond is located at southeast side of the bottom ash pond consists of a drop inlet spillway structure with slide gates. The gates are 4 feet in length. A 36-inch outlet pipe conveys the water through the divider dike and into the Recirculation Pond. According to the field survey, the elevation of the top of the current slide gate is 665.20.

Discharge to the Ohio River is through a principal spillway located at the south end of the recirculation pond (a drop outlet and a 36”-pipe). During normal operation, there is no discharge to the river;

rather all flows are re-circulated into the plant via the pump station located on the west side of the re-circulation pond.

The engineering drawings of the engineering structures and appurtenances are included in Attachment C.

10.0 SUMMARY OF POOL SURFACE ELEVATIONS, AND MAXIMUM DEPTH OF CCR, 257.73 (c)(1)(vii)

[…in addition to the normal operating pool surface elevation and the maximum pool elevation following peak discharge from the inflow design flood, the expected maximum depth of CCR within the CCR surface impoundment.]

The Bottom Ash Pond Complex is regulated by ODNR and is identified as a Class II dam, and as such, must safely pass 50% of the Probable Maximum Flood (PMF) in accordance with OAC Rule 1501:21-13-02.

The table below describes the normal pool elevations and maximum pool elevations as well as maximum depth of CCR within the impoundment. The maximum pool elevation have been determined based on the 50% PMP storm analysis based on the Ohio State Requirements. Complete results of the hydrology and hydraulic analysis are included in the Addendum to Bottom Ash Pond Investigation Report by S&ME, December, 2010 in Attachment E.

	Bottom Ash Pond	**Clearwater Pond**
Normal Pool Elevation	665	664.5
Maximum Pool Elevation following peak discharge from inflow design flood	668.1	668.1
Expected Maximum depth of CCR within impoundment	15 ft	0

11.0 FEATURES THAT COULD ADVERSELY AFFECT OPERATION DUE TO MALFUNCTION OR MIS-OPERATION (257.73 (c)(1)(vii))

[…and any identifiable natural or manmade features that could adversely affect operations of the CCR unit due to malfunction or mis-operation]

In the event of malfunction or mis-operation of any of the pond's appurtenances the ponds operations could be adversely affected. These structures include service spillway, weir structures and influent sluicing piping and associated structures. See design drawings in Attachment C for location and details of all appurtenances.

During an extreme flood event, natural debris may collect along the outlet to the service spillway. However, the spillway complete blockage would not be an expected condition. In addition, at the current operating level, the pond capacity is sufficient to contain the entire design storm.

12.0 DESCRIPTION OF THE TYPE, PURPOSE AND LOCATION OF EXISTING INSTRUMENTATION 257.73 (c)(1)(viii)

[A description of the type, purpose, and location of existing instrumentation.]

The instrumentation program for the BAP complex consists of five (5) open stand pipe piezometers. The location of the instruments is shown in plan in Plate 1 drawing (Attachment D). Two out of the five piezometers were originally installed to monitor the phreatic surface in the eastern and the western embankments. Three out of the five piezometers were installed during the 2009 investigation to monitor the phreatic surface in the eastern embankment 2 at the crest and one at the toe of the slope.

The piezometers are read on 30 days basis. This information is used to monitor the buildup of pore pressure during and after construction and to evaluate the embankment stability in terms of effective stresses.

13.0 AREA – CAPACITY CURVES FOR THE CCR UNIT 257.73 (c)(1)(ix)

[Area-capacity curves for the CCR unit.]

Figure 5 shows the area capacity curves for the Cardinal BAP Complex and is included in the Hydrology and Hydraulic Analysis in the Cardinal Generating Plant Addendum to Bottom Ash Pond Investigation Report by SM&E, December, 2010 in Attachment E.

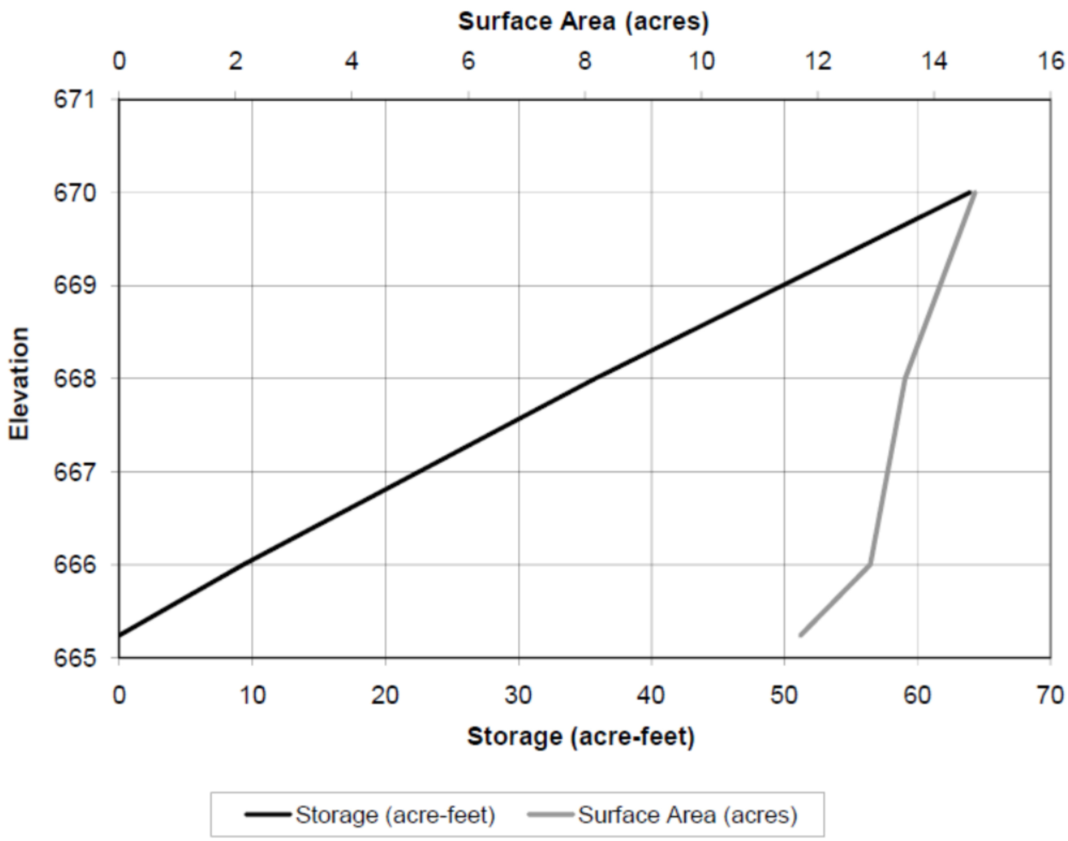


Figure 5. Capacity curves the BAP Complex.

<u>14.0</u> DESCRIPTION OF EACH SPILLWAY AND DIVERSION 257.73 (c)(1)(x)

[A description of each spillway and diversion design features and capacities and calculations used in their determination.]

The outlet works for the Bottom Ash Pond consists of a drop inlet spillway structure with slide gates. The gates are 4 feet in length. A 36-inch outlet pipe conveys the water to the Recirculation Pond. The elevation of the top of the current slide gate is 665.24 according to the field survey. Complete details of each spillway structure are included with the design drawings in Attachment C. Hydrology and Hydraulic Analysis which include calculations for each spillway structure are included in Attachment E.

There are no diversions present for this facility.

<u>15.0</u> SUMMARY CONSTRUCTION SPECIFICATIONS AND PROVISIONS FOR SURVEILLANCE, MAINTENANCE AND REPAIR 257.73 (c)(1)(xi)

[The construction specifications and provisions for surveillance, maintenance, and repair of the CCR unit.]

Original and the raising construction specifications are not existent, however the site investigation report included in Attachment B.

As required by the CCR rules the BAP complex is inspected at least every 7 days by a qualified person. Also as a requirement of the CCR rules the impoundment is also inspected annually by a professional engineer.

An impoundment maintenance plan is provided in Attachment F. If repairs are found to be necessary during any inspection they will be completed as needed.

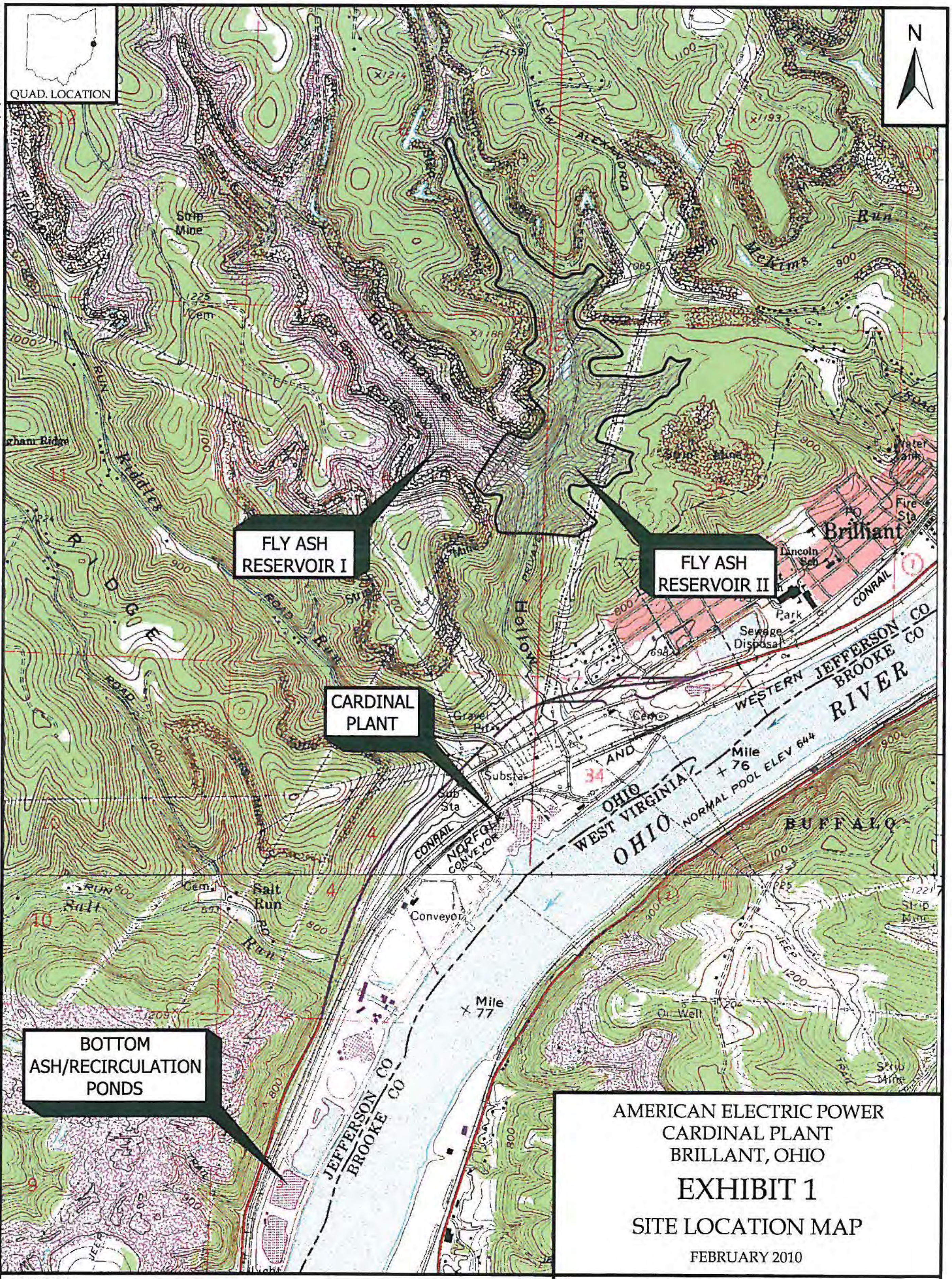
<u>16.0</u> RECORD OR KNOWLEDGE OF STRUCTURAL INSTABILITY 257.73 (c)(1)(xii)

[Any record or knowledge of the structural instability of the CCR unit.]

To date there has been no record or knowledge of any structural instability of the CCR unit.

<u>ATTACHMENT A</u>

LOCATION MAP



AMERICAN ELECTRIC POWER
CARDINAL PLANT
BRILLANT, OHIO

EXHIBIT 1

SITE LOCATION MAP

FEBRUARY 2010

SOURCE:
7.5 MINUTE TILTONSVILLE, OHIO U.S.G.S. QUADRANGLE MAP

PLOTTED: 2/5/2010 10:02:32 AM

P:\PR48249\cadd\Figure 1.dwg 12/10/2009 8:34:37 AM VanZandt, Ryan

<u>ATTACHMENT B</u>

DESIGN REPORTS

Bottom Ash Pond
Initial Safety Factor Assessment
Cardinal Power Plant
Brilliant, Ohio
S&ME Project No. 7217-15-007A

Prepared for:

American Electric Power
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December 30, 2015

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Appendices

1.0 Introduction

1.1 Background

In April of 2015, the US EPA formally published national regulations for disposal of coal combustion residuals (CCR) from electric facilities. As part of the rule, the owner or operator of the CCR unit must obtain a certification from a qualified professional engineer stating that aspects of the CCR impoundments are in accordance with the rules. Based on our understanding of the Request for Fee Estimate received from AEP on April 29, 2015, AEP specifically requested P.E. certification to fulfill the requirements of 40 CFR § 257.73(e), *Periodic Safety Factor Assessments*. In the employment of BBC&M Engineering, Inc., the undersigned engineers conducted site investigations at the bottom ash pond in 2009 and 2010. Due to our familiarity with the site, S&ME was selected to perform the Safety Factor Assessment for this facility. S&ME understands that certification and/or documentation for other structural integrity criteria will be performed by AEP or other consultants.

1.2 Location and Geologic Conditions

The Cardinal Generating Plant is located along the Ohio River between Brilliant, Ohio and Tiltonsville, Ohio. The Bottom Ash Pond Complex is located along the west bank of the river just to the south of the Unit 3 area. The Bottom Ash Complex consists of two components: the Bottom Ash Pond and the Recirculation Pond. The Bottom Ash Pond is located north of the Recirculation Pond and they are separated by an earthen embankment. The crest elevation for all of the embankments has a minimum Elevation of 670 feet. The total length of the exterior embankment along the Ohio River is approximately 2,000 feet. Based on the current topography around the bottom ash complex, there is no discernable embankment on the north and south ends, thus the areas of the pond embankments are typically identified by referencing the eastern or western embankments. The bottom ash pond is operated at a constant Elevation of 664.5 feet. For comparison, the normal pool for this stretch of the Ohio River is EL. 644, as controlled by the Pike Island Dam Both ponds are isolated from exterior surface water inflow and during normal operation, all water that enters the pond is pumped back to the plant via the pump station located within the Recirculation Pond. The exception is during high rainfall events where the principal spillway may activate releasing water into the Ohio River through an NPDES outfall. The discharge is controlled by a 4-foot wide weir surveyed at Elevation 666.2. A review of the historical plans available for the bottom ash pond facility is included in Appendix V.

The original ground surface at the site is generally located between El. 645 and 655. Near surface soils generally consist of a layer of alluvium silt, clay and fine sand (organic in some locations) over glacial outwash deposits of variable thickness overlying the bedrock surface. The alluvium clays and silts were deposited in the backwater of the Ohio River, while the outwash materials typically consist of sand, gravel and silt deposits deposited during the last ice age. Based on geological literature, the glacial outwash extends to the bedrock surface, estimated to be roughly 50 to 60 feet below the natural ground surface at the pond. The upper most bedrock most likely consists of shale and/or sandstone belonging to the Conemaugh Group of Pennsylvanian Age.

Figure 1-1 – Cardinal Plant

1.3 Previous Investigations

In 2009, the undersigned engineers, when in the employment of BBC&M Engineering, Inc., completed a subsurface investigation and geotechnical assessment of the bottom ash pond embankments. The assessment, dated August 4, 2009, concluded that the embankment exhibited adequate factors of safety against slope failure under steady-state seepage and seismic loading conditions relative to typical US Army Corps of Engineers requirements. In 2010, BBC&M Engineering, Inc. performed additional geotechnical analyses and an hydrology and hydraulic evaluation of the pond. As part of this work, additional slope stability failure modes were examined, including the maximum surcharge pool and rapid drawdown load cases. A report documenting the additional geotechnical analysis, dated December 17, 2010, was submitted as an addendum to the 2009 report. The text from the 2009 report and an excerpt from the 2010 follow-up report is Appendices V and VI.

2.0 Scope of Work

In accordance with AEP's request, the following work items were performed by S&ME:

1. S&ME completed a cursory review of previously conducted assessment work performed by the undersigned engineers, as well as a limited number of construction documents made available by AEP.

2. S&ME visited the site along with personnel from AEP. The site visit was not a formal inspection, but rather served to document any significant modifications or changed conditions that may have taken place since the time of the previous investigations.

3. Upon completing Tasks 1 and 2, S&ME determined that there was insufficient information to certify the structural integrity of the surface impoundment in accordance with the requirements of 40 CFR § 257.73(e). To this end, S&ME was authorized to perform a supplemental investigation to support the safety factor assessment. Details regarding the investigation are described in the following sections of this report.

3.0 Information Review and Site Visit

S&ME conducted a cursory review of previous documents relating to the bottom ash pond and conducted a site visit at the facility. AEP provided S&ME with the following documents:

- Site Development Plan 1973 (Dwg. 3-3017-5 and 3-3027-3)
- Assessment of Dam Safety Final Report, Clough Harbour, & Assoc., December, 2009
- Bottom Ash Pond Subsurface Investigation & Analysis, BBC&M Engineering, Inc., August, 2009
- Addendum to Bottom Ash Pond Investigation, BBC&M Engineering, Inc., December, 2010

On August 18, 2015, the undersigned S&ME personnel met with Dr. Mohammad Ajlouni (AEP Civil Engineering) and Mr. Randy Sims (Landfill Operations) at the Cardinal Plant and conducted a site visit at the bottom ash pond. The participants discussed and observed the operations of the bottom ash and recirculation ponds, including the hydraulic structures within the ponds. During our visit, two localized possible seepage areas were observed on the outboard slope of the eastern embankment of the recirculation pond. Based on discussions with the group, it was believed that the seepage areas were relatively new.

One apparent seepage area was located immediately north of the existing riprap and the other was approximately 300 feet north of the riprap. The limits of the possible seepage areas were delineated with a handheld GPS unit. The apparent seepage areas range from 35 to 50 feet wide by 6 to 8 feet high. The seepage areas were observed to be wetter than the surrounding area and were muddy in some areas, which may be a result of mowing operations. While the ground surface has been softened as a result of seepage, there was no indication of flowing water emanating at either of the areas at the time of our visit. Additionally there was no indication of piping of soil. S&ME understands the riprap on the outboard slope of the recirculation pond to the south of the new seepage area was constructed as an inverted filter; similar seepage conditions were observed in this area resulting in construction of the filter. Based on the historical drawings, the embankments do not contain any internal drains to intercept/control the phreatic surface within the embankment. Despite this, S&ME understands the embankments have otherwise performed well, particularly in regard to shallow sloughs along the outboard slope of the 41 years that they have been in service in the current configuration.

While no other visual observations suggested dam safety concerns, S&ME noted the following modifications to the bottom ash pond complex since the 2009 and 2010 assessments:

- The northern section of the western bottom ash pond embankment was widened on the outboard side to create additional space for construction staging.
- Crest improvements were made to raise low areas and establish a consistent top of dam Elevation of 670 feet.
- The 2009 investigation focused only on the river side embankment. Although the river side embankment is significantly taller than the west embankment, investigation of the west embankment was believed to be warranted.

4.0 Field and Laboratory Work

As part of the 2009 investigation, 7 soil borings were performed along the eastern embankment of the bottom ash pond and recirculation pond. For the 2015 supplemental investigation, S&ME performed 4 soil borings along the western embankments, as well as two additional shallow borings through the eastern embankment crest upstream from the identified seepage areas. The borings are designated as CD-BAP-1501 through B-1505 and MW-BAP-4 through MW-BAP-5. Boring CD-BAP-1503, originally planned to be located at the toe of the west embankment could not be accessed and was not performed. Boring numbers with 'MW' indicate a monitoring well was installed at this location, which were performed as part of a separate hydrogeology study. Additionally, S&ME installed three other monitoring wells, designated MW-BAP-1 through MW-BAP-3, and advanced one soil boring designated CD-BAP-1506 as part of the separate hydrogeology study at the bottom ash pond facility. Although not performed as part of this factor of safety assessment, the results from these explorations were considered in developing our understanding of the embankments and foundation soils. Locations of all explorations are shown on the Plan of Borings included as Drawing No. 1 in Appendix I.

Laboratory testing was performed on selected representative soil samples obtained during the field investigations to determine natural moisture content (ASTM D2216), liquid and plastic limits (S&ME adjustment to ASTM D4318), and grain size analyses (ASTM D422). The results of these and other tests permit an evaluation of the strength, compressibility and permeability characteristics of the soils encountered at this site.

The results of the moisture content testing and of the liquid and plastic limits are graphically displayed on the individual boring logs presented in Appendix I. All laboratory test results, including a summary of laboratory test results and grain size analyses are presented in Appendix II.

5.0 Subsurface Conditions

5.1 Stratigraphy

Borings CD-BAP-1501,CD-BAP-1502, and MW-BAP-5 were performed from the crest of the western embankment, while Boring MW-BAP-4 was performed from the toe of the western embankment. Based on the descriptions of the samples recovered in the borings and laboratory testing, the subsurface stratigraphy for each section can generally be described in descending order from the top of the western embankment as follows:

- Borings CD-BAP-1502 and MW-BAP-5 were performed from the crest of the embankment encountered 15 inches of aggregate at the ground surface overlying 10 to 13 feet of embankment fill consisting of medium-dense to dense find to coarse sand and gravel and hard clayey silt. SPT N-values (corrected for 60% energy) ranged from 13 to 60 while hand penetrometer measurements on samples exhibiting cohesion ranged from __ to 4.5+ tons per square foot (tsf).
- Boring CD-BAP-1501 was performed from the widened crest area. The boring encountered 15 inches aggregate underlain by 11.5 feet of embankment fill consisting of a thin stratum of medium-stiff clayey silt over of loose to medium dense fine to coarse sand.
- Underlying the embankments, the borings encountered alluvial soils consisting of

Borings CD-BAP-1504 and CD-BAP-1505 were performed from the crest of the eastern embankment adjacent to the observed seepage areas. The main purpose of these boring was to identify potential anomalies within the embankments that would suggest a unique circumstance which could be contributing to the observed seepage. Both borings were advanced to a depth of 16 feet within the embankment fill. For reference, the seepage areas were observed to begin approximately 6 to 8 feet below the crest. These borings, along with results from the sampling from monitoring wells MW-BAP-1, MW-BAP-2 and MW-BAP-3 did not reveal any appreciable differences from the crest borings performed during the 2009 investigation, such as a layer or zone of clean sand, as the embankment fill was already known to contain soils of a varying degree.

The stratigraphy of the eastern embankments is summarized in the text from the 2009 Investigation included as Appendix V.

5.2 Groundwater Conditions

Groundwater observations were made as each boring was being advanced and measurements were made at the completion of drilling. The groundwater observations are graphically displayed on the boring logs and also noted at the bottom of the log, and are referenced from the ground surface. Groundwater was encountered within the crest borings at a depth of approximately 15 feet. Groundwater in Boring MW-BAP-4 was encountered at a depth of 5.5 feet. The groundwater readings correlate to an approximate Elevation of 655 feet.

Temporary open standpipe piezometers were installed in Borings CD-BAP-1504 and CD-BAP-1505 to obtain groundwater information in relation to the observed seepage area. Unfortunately, owing to the presence of overhead electric along the outboard side of the crest, the borings had to be performed near the inboard side of the crest. Several longer term groundwater readings were taken during the course of the field work. The readings are summarized on the individual well logs, and generally range between Elevation 661 and Elevation 663. The readings indicate a small decrease in water level from the recirculation pond operating pool. It should be noted that all of the wells positioned within the crest are located on the inboard side to avoid blocking the road as well as the overhead power lines.

5.3 Shear Strength and Permeability

The laboratory testing results for the 2015 investigation were compared to laboratory testing completed as part of the 2009 investigation. The comparison of the index testing was performed to determine if there was any justification for developing different shear strength and permeability values for the subsurface materials encountered in the western side of the complex than had been previously been estimated for cross-sections on the eastern side in 2009. As the results of the 2009 laboratory index testing are very similar to the new index testing results, S&ME is of the opinion that the strength parameters used to characterize the eastern embankment and foundation soils in 2009 are applicable to the supplemental investigation of the western embankment and foundation soils.

The shear strength parameters used in the slope stability analysis are shown in Table 5-1.

Table 5-1 – Shear Strength Parameters

Material Description	γ_{wet} *(pcf)*	*Effective*		*Reference*
		ϕ'	c' (psf)	
Newer Embankment Fill	125	31°	0	SPT and Index Testing Correlations
Original Embankment Fill	125	30°	100	Index Testing Correlations
Alluvium Silt and Clay	125	30°	0	Index Testing Correlations
Organic Clayey Silt	125	30°	0	Index Testing Correlations and CU Triaxial Test (BBCM 2009)
Very Loose to Loose Glacial Outwash Sand and Gravel	115	29°	0	SPT and Grain Size Correlations
Medium Dense Glacial Outwash Sand and Gravel	120	34°	0	SPT and Grain Size Correlations
Granular Embankment Fill(1)	115	30°	0	SPT and Grain Size Correlations

(1)Applies only to widened crest area on the northwestern side of bottom ash pond

6.0 Safety Factor Assessment

As part of the safety factor assessment, S&ME completed Parts 1 and 2 of Section 257.73(e) of the Final Rules for the Disposal of Coal Combustion Residuals from Electric Utilities published on April 17, 2015 in the Federal Register. In accordance with the Rule, the analysis was performed for the critical cross-sections(s) that are anticipated to be most susceptible of all cross-sections to structural failure based on appropriate engineering considerations. The Rule specified the following loading conditions for analysis:

i. Static Factor of Safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.
ii. Calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.50.
iii. The calculated seismic factor of safety must equal or exceed 1.00.
iv. For dikes constructed of soils susceptible to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

6.1 Limit Equilibrium Analyses

The 2009 Investigation Report and the 2010 Addendum discuss in detail the subsurface investigation, laboratory testing, parameter justification, seepage analyses and limit equilibrium slope stability analyses that were performed to develop safety factors for the bottom ash pond embankments. As mentioned previously, engineering parameters developed as part of the 2009 and 2010 investigations were utilized for the new analyses associated with the western embankment as the laboratory testing and subsurface investigation did not encounter soil properties that differed greatly from the soils encountered in the previous investigations.

In summary, four sections along the eastern (river-side) embankment and two sections along the western embankment were studied. Both cross-sections through the western embankment are located within the bottom ash pond as the embankment adjacent to the recirculation pond is only 4 to 6 feet high and access to the toe was not readily available. Subsurface information for each section was obtained by performing borings through the crest and toe of the embankment. Based on a review of all six sections explored, three were selected for detailed limit equilibrium stability analysis (two on the eastern embankment and one on the western embankment).

Prior to performing the limit equilibrium stability analyses as part of the 2009 assessment, seepage analyses were performed to develop a better understanding of the likely phreatic surface within the embankment and foundation. The models were calibrated by adding additional total head boundary conditions within the subsurface to best model the groundwater table as observed in the observation wells. Although a classically shaped phreatic surface extending from the ash pond level to the Ohio River was generated by the seepage analyses, much of the seepage emanating from the ponds appears to be moving downward through the newer embankment fill and thin stratum of alluvium soils and into the glacial outwash sand and gravel stratum which essentially serves as a drain.

Results of the slope stability analysis indicate that the critical cross-section occurs through the eastern embankment of the bottom ash pond (referred to as Section D in the 2009 and 2010 assessments). The design cross-section does not vary along the eastern embankment, but Section D yielded the lowest factors of safety due to slight variations in the outboard slope. All load cases performed for the Safety Factor Assessment as well as additional load cases evaluated for typical US Army Corps of Engineer's requirements met the minimum factor of safety for global stability.

One observed seepage area is located just north of Section B and the other is located approximately 200 feet south. Comparison of boring logs for CD-BAP-1504 and CD-BAP-1505 with the log for boring CD-PZ-BAP-0902 located at Section B do not reveal any key differences in the embankment fill. In fact, Boring CD-PZ-BAP-0902 exhibited a larger zone of granular embankment fill located within the observed elevation of seepage on the outboard slope, but no seepage was observed adjacent to this boring. The fill soils are believed to vary laterally through the embankment as much as it was observed to vary vertically at the boring locations, suggesting that the granular layers observed in the borings are unlikely to extend all the way through the embankment. Considering this, it is the opinion of S&ME that at this time, the seepage areas are representative of localized pockets of more permeable soils within the overall embankment matrix. As such, it is not believed that the phreatic surface intercepts the outboard face, but rather that there are narrow zones of seepage with unsaturated soils beneath. Nonetheless, these areas should be addressed, as further discussed below.

As noted, the seepage observed during our August, 2015 site visit appeared to occur in two isolated areas. With time, the outboard slope at these locations may weaken due to the presence of groundwater within close proximity to the ground surface resulting in reduced shear strength and shallow slope failures. Though such a failure would typically be minor in extent, S&ME recommends these areas be addressed in the near future before they lead to more significant issues over time. Construction of an inverted filter may be suitable given the performance of the existing inverted filter on the south end. S&ME also recommends continued monitoring of these areas to ensure soils particles are not being carried from inside the embankment.

6.2 Liquefaction Potential of Embankment Soils

S&ME evaluated the potential of the embankment soils to liquefy during a seismic event. The embankment material is classified as a fined grained material and the recovered samples with gradation testing were evaluated following guidelines presented in the 2003 NEHRP (National Earthquake Hazards Reduction Program) Recommended Provisions for Seismic Regulations for New Buildings and Other Structures. The provisions in Chapter 7 indicate that liquefaction potential in fine grained soils should be assessed provided the following criteria are met (Seed and Idriss 1982; Seed et al., 1983): the weight of the soil particles finer than 0.005 mm is less than 15 percent of the dry unit weight of a specimen of the soil; the liquid limit of soil is less than 35 percent; and the moisture content of the in-place soil is greater than 0.9 times the liquid limit. If all of these criteria are not met, the soils may be considered non-liquefiable.

Laboratory testing results from 16 fine grained samples that were available from the 2009 and 2015 investigations for evaluation of the screening criteria. Of the 16 samples, 8 samples contained data to check all three screening criteria, and 7 samples contained data to check two screening criterion. Based on the results of the screening, no sample met all 3 criteria; therefore, these fine grained embankment fill can be considered non-liquefiable. A table depicting this evaluation is included in Appendix IV.

The potential for the coarse grained embankment soils to resist liquefaction was evaluated. The fine grained (cohesive) and coarse grained (granular) embankment soils appear to be from the same borrow source as there are no well-defined layers and often only minor variations in the percent by weight of the recovered sample change the main description from fine grained to coarse grained. Although construction records were not available, the density of the coarse grained samples and consistency of the fine grained samples within the embankment fill suggest they were well compacted. Based on the controlled manner in which the fill was placed, the coarse grained embankment soils can be considered non-liquefiable.

6.3 Summary of Results

A summary of the computed safety factors for the critical cross-section is provided in Table 5-2. Also included in the table are the minimum values defined in 40 CFR § 257.73(e)(1) subparts (i) through (iv). Graphical output corresponding to the analysis cases are presented in Appendix IV along with additional slope stability load cases evaluated during the course of the bottom ash pond assessments.

Table 6-1 – Safety Factor Summary

Analysis Case	Minimum Safety Factor	Computed Safety Factor
Long-term, maximum storage pool	1.50	1.52
Maximum surcharge pool	1.40	1.52
Pseudo-static seismic loading	1.00	1.09
Embankment Liquefaction	1.20	Non-liquefiable

7.0 Certification

Based on our previous investigations and current assessment of the Bottom Ash Pond facility, S&ME certifies that this assessment meets the requirements of paragraphs (e)(1) and (e)(2) of Part 257.73 for the critical cross-section of the embankment.

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

Sincerely,

S&ME, Inc.

STATE OF OHIO
MICHAEL T. ROMANELLO
E-74384
REGISTERED
PROFESSIONAL ENGINEER

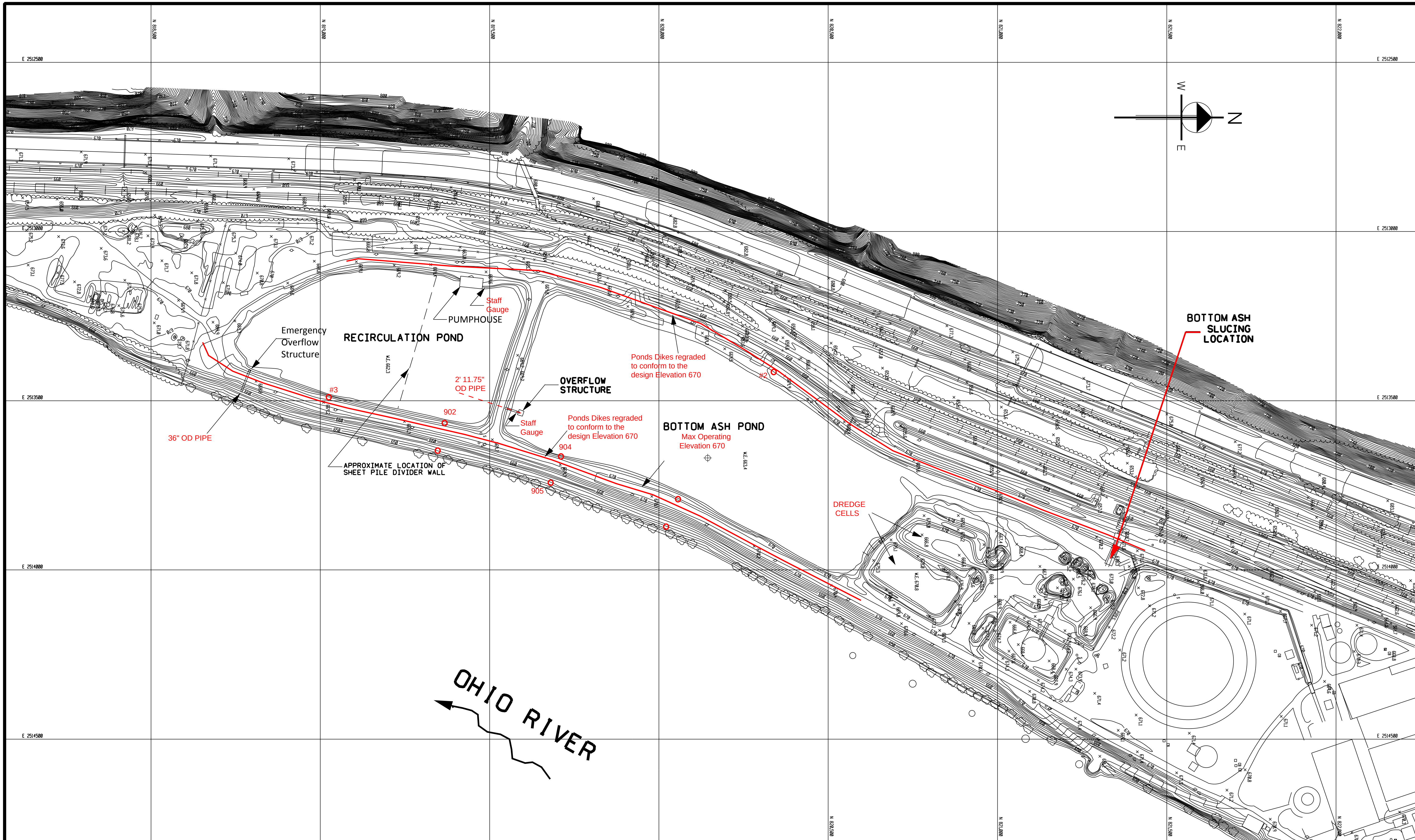
12-30-15

Michael T. Romanello, P.E.
Project Engineer
Registration No. 74384

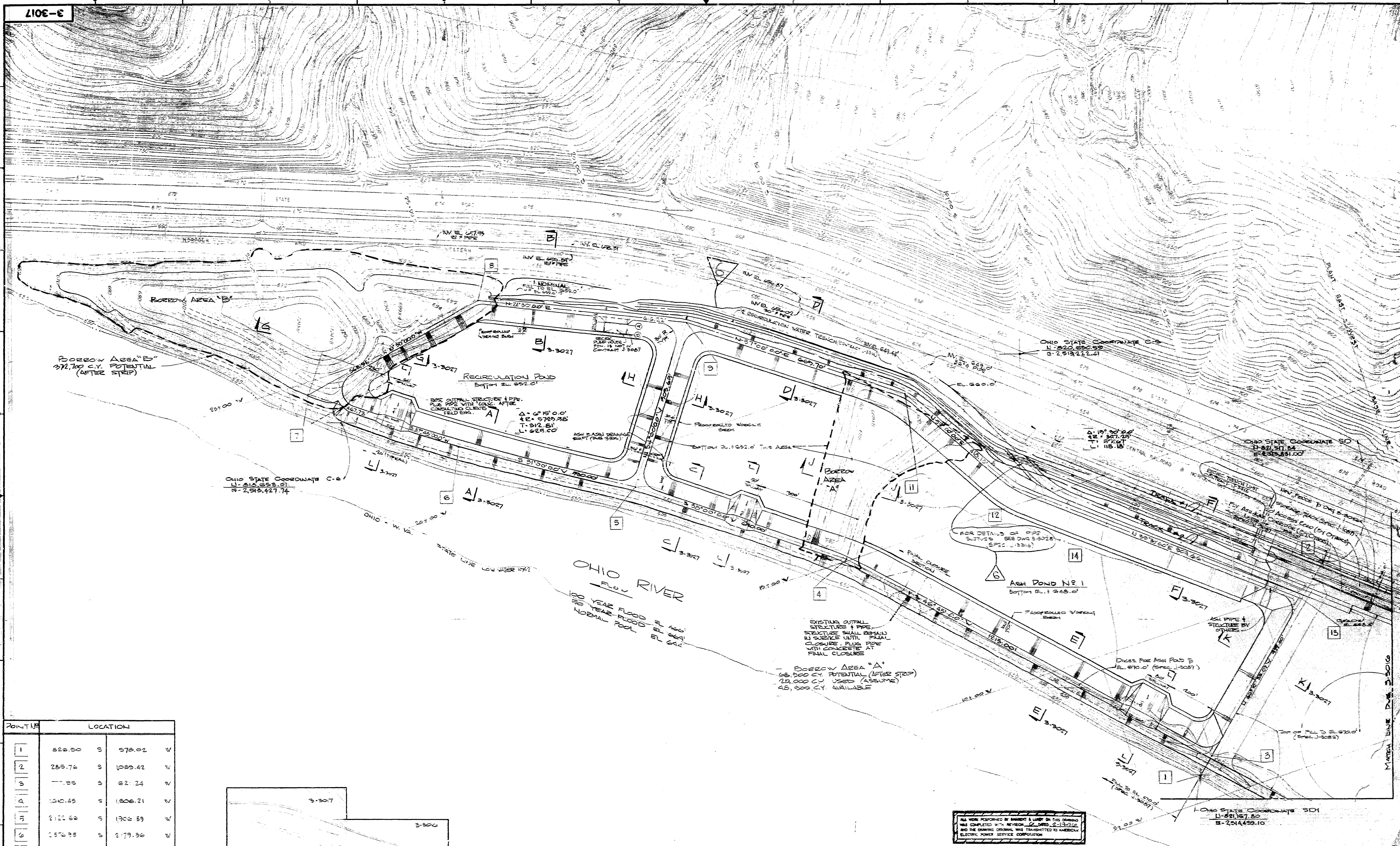
Michael G. Rowland, P.E.
Senior Engineer
Registration No. 65559

ATTACHMENT C

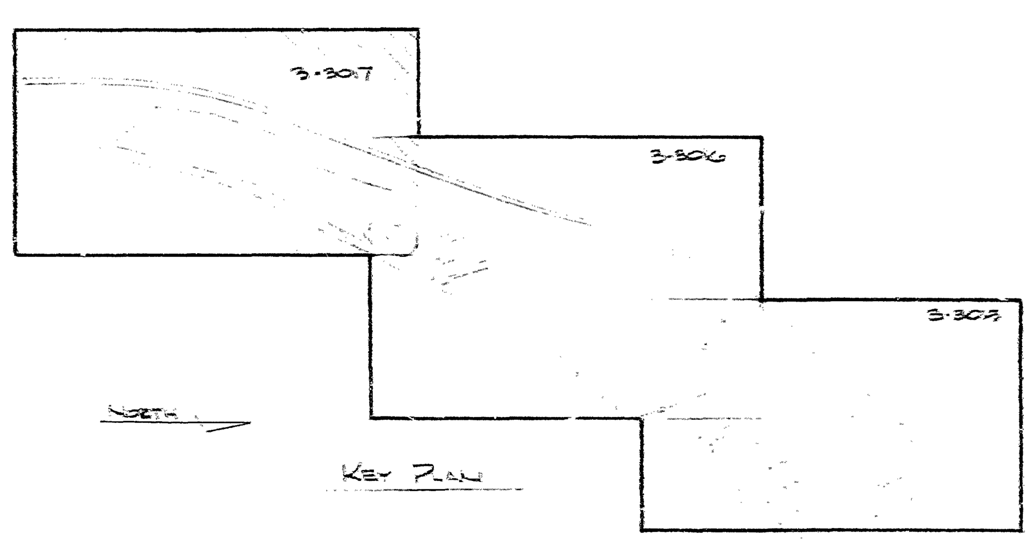
DESIGN DRAWINGS



DRN BY: Amanda Graphics	AMERICAN ELECTRIC POWER	AMERICAN ELECTRIC POWER	AEP SERVICE CORP. 1 RIVERSIDE PLAZA COLUMBUS, OH 43215
DATE: 1-29-2014	CARDINAL PLANT BRILLANT OHIO		
SCALE: N.T.S	BOTTOM ASH AND RECIRCLATION PONDS	EXHIBIT 5	



POINT NO.	LOCATION			
1	826.50	S	576.02	W
2	285.76	S	1059.42	W
3	777.85	S	621.24	W
4	1610.45	S	1,506.21	W
5	2121.66	S	1,906.59	W
6	2,576.95	S	2,179.36	W
7	[illegible]	S	2,465.71	W
8	2,387.35	S	2,569.40	W
9	516.61	S	2,515.86	W
10				
11	[illegible]	S	1,910.32	W
12	[illegible]	S	1,552.41	W
13	578.86	S	976.98	W
14	772.47	S	1,514.57	W



NOTES

1. FOR GENERAL NOTES SEE DWG. 3-3015, SPEC. J-3056
2. STOCKPILED TOPSOIL MATERIAL SHALL BE DEPOSITED IN A 4" LAYER ON THE EXTERIOR SLOPES OF SECTIONS A-A, B-B, C-C, D-D, E-E, & F-F.
3. CLARIFY LIMIT LINE OF NEW WORK FOR SPEC. J-3087 SOUTH OF SPLITTER DIKE.
4. ALL WORK FOR RECIRCULATION WATER TRENCH SHALL BE PERFORMED UNDER CONTRACT J-3316 AS DIRECTED BY PURCHASERS REPRESENTATIVES, UNLESS OTHERWISE NOTED.

REFERENCE DRAWINGS

3-3015	SITE DEVELOPMENT PLAN - PLANT AREA - SHEET 1
3-3016	SITE DEVELOPMENT PLAN - PLANT AREA - SHEET 2
3-3027	SITE DEVELOPMENT - ASH POND AREA - SECTIONS
3-3061	ASH BASIN DRAINAGE SHAFT - PLAN & SECTIONS
3-3028	SITE DEVELOPMENT - ASH POND RECIRC. TRENCH - PLAN & SEC.
3-3029	SITE DEVELOPMENT - ASH POND RECIRC. TRENCH & ROAD PLAN

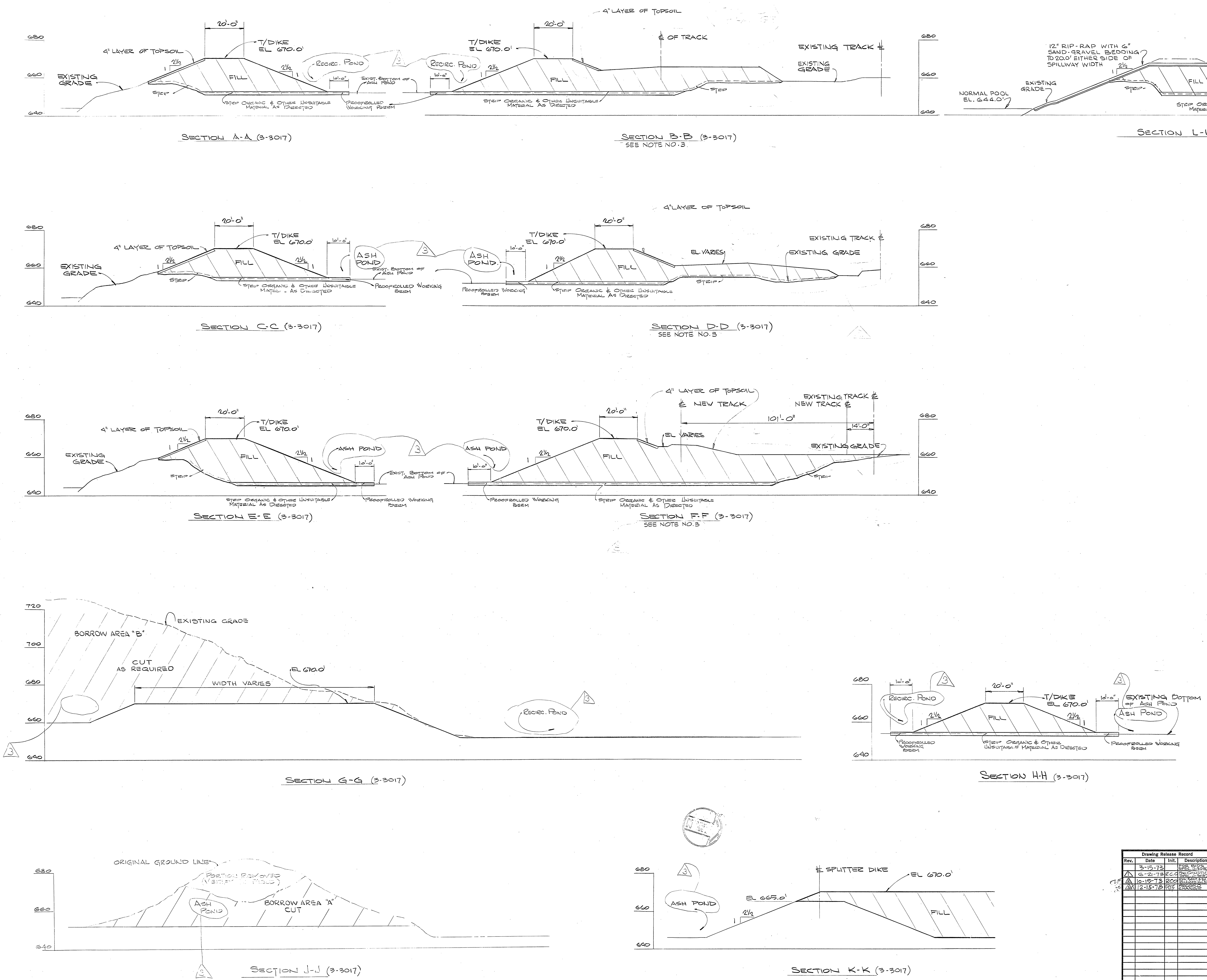
Drawing Release Record			
Rev.	Date	Init.	Description
	11-22-72		
1	5-14-72	RCO	
2	3-15-73		
3	4-3-73		
4	6-21-73	RCO	
5	10-19-73	RCO	
6	2-13-76		

SITE DEVELOPMENT PLAN
ASH STORAGE AREAS SHEET 3
CARDINAL NO. 3
BUCKEYE POWER INC.
BRILLIANT, OHIO

SCALE 1" = 100'-0"
DRAWN A.P. ODISHOO JR. 11-21-72
CHECKED R.C. ODEGARD 3-13-73
ENGINEER R. [illegible] 3-13-73
APPROVED [illegible] 3-13-73
JOB NO. 4442-03

SARGENT & LUNDY ENGINEERS CHICAGO

DRAWING NO. 3-3017-6



NOTES

1. FILL FOR DIKES SHALL CONSIST OF A CONTROLLED COMPACTED FILL CCF2.
2. FOR GENERAL NOTES SEE DWG. 3-3015.
3. EARTHFILL SHOWN ON SECTION B-B, D-D & F-F ARE 'RECORD CHANGE' BASED ON ACTUAL FIELD CONDITIONS AS SURVEYED ON NOV. 9, 1974.

REFERENCE DRAWINGS

3-3017	SITE DEVELOPMENT ASH STORAGE AREA SHEET 3
3-3029	SITE DEVELOPMENT - ASH POND RECIRCULATION TRENCH & ROAD PLAN.
3-3042	SITE DEVELOPMENT - ASH POND RECIRCULATION TRENCH SECTIONS - SHEET 1
3-3043	SITE DEVELOPMENT - ASH POND RECIRCULATION TRENCH SECTIONS - SHEET 2

ALL WORK PERFORMED BY SARGENT & LUNDY ON THIS DRAWING WAS COMPLETED WITH REVISION 3 DATED 12-15-78 AND THE DRAWING ORIGINAL WAS TRANSMITTED TO AMERICAN ELECTRIC POWER SERVICE CORPORATION

STATE OF OHIO R. N. BERGSTROM E-18613 REGISTERED PROFESSIONAL ENGINEER

Drawing Release Record

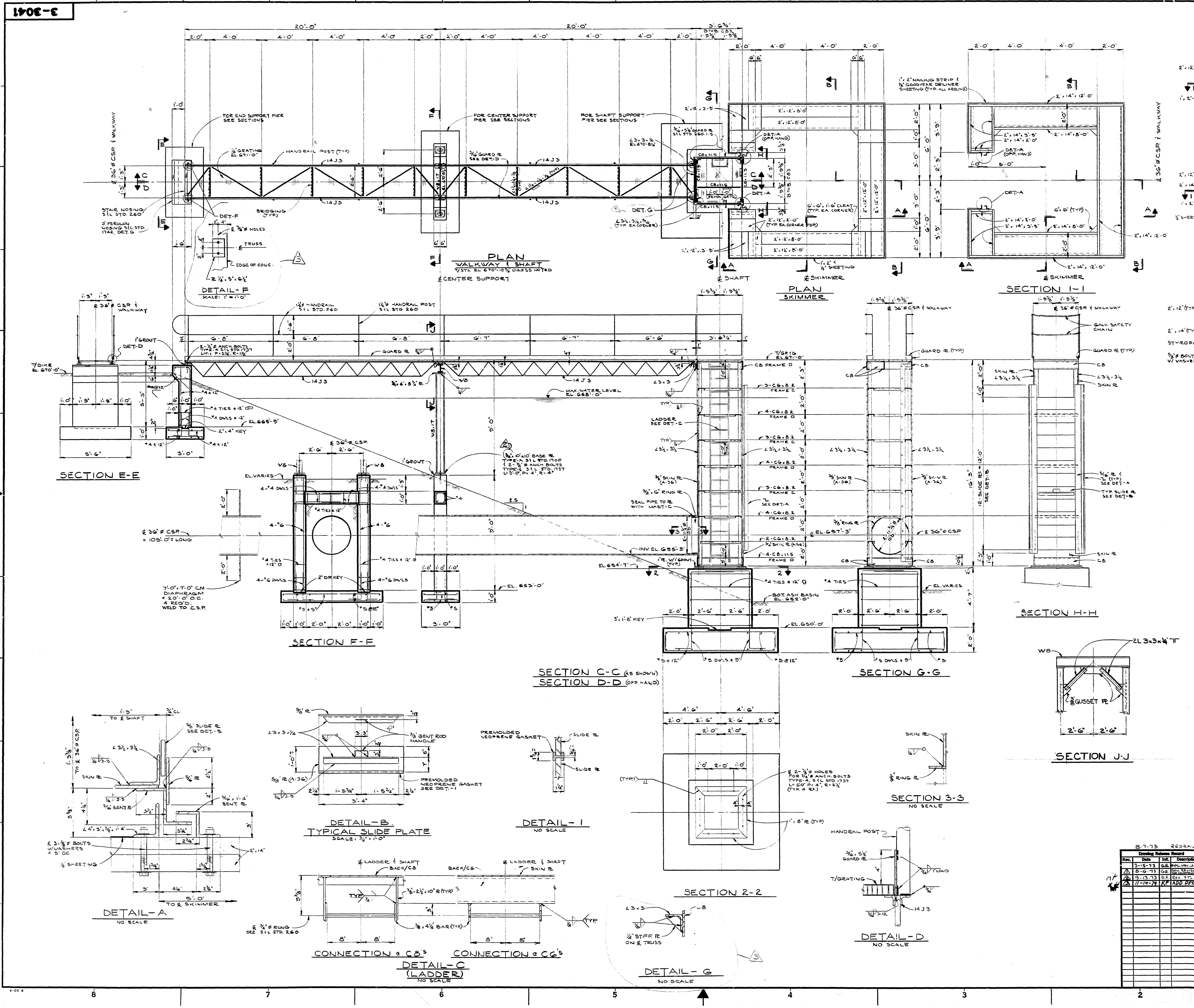
Rev.	Date	Init.	Description
	3-15-73		FOR BIDS SPEC. J-3087
1	6-21-73	R.C.O	FOR CONSTR. SPEC. J-3087
2	10-19-73	RCO	REV. SECT. B-B & J-J RELEASED HOLDS
3	12-15-78	RTS	RECORD CHANGE

SITE DEVELOPMENT
ASH STORAGE AREA SECTIONS
CARDINAL PLANT UNIT 3
BUCKEYE POWER, INC.
BRILLIANT, OHIO

SCALE 1" = 20'-0"
DRAWN G. BOLE 11-21-72
CHECKED R.C. ODEGARD 6-19-73
ENGINEER R. Torp-Smith 6-19-73
APPROVED R N Bergstrom
JOB NO. 4642-03

SARGENT & LUNDY ENGINEERS CHICAGO

DRAWING NO. 3-3027-3



NOTES

1. SEE DWG. 3-3017 FOR THE LOCATION OF THIS STRUCTURE.
2. ALL STEEL SHALL BE GALVANIZED UNLESS OTHERWISE NOTED.

REFERENCE DRAWINGS

3-3017	SITE DEVELOPMENT PLAN ASH STORAGE AREAS - SH. 3

ALL WORK PERFORMED BY SARGENT & LUNDY ON THIS DRAWING WAS COMPLETED WITH REVISION 3 DATED 11-14-74 AND THE DRAWING ORIGINAL WAS TRANSMITTED TO AMERICAN ELECTRIC POWER SERVICE CORPORATION

STATE OF OHIO
R. N. BERGSTROM
E-10613
REGISTERED PROFESSIONAL ENGINEER

8-7-73 REDRAWN

Drawing Release Record

Rev.	Date	Init.	Description
	3-15-73	G.E.	BIDS. SPEC. J-3417
1	8-16-73	GE	GEN. REVISION - FOR CONSTRUCTION
2	9-13-73	G.E.	REV. STL.
3	11-14-74	KF	ADD DETAIL

MK

ASH BASIN DRAINAGE SHAFT PLAN & SECTIONS

CARDINAL PLANT UNIT 3
BUCKEYE POWER, INC.
BRILLIANT, OHIO

SCALE 3/8" = 1'-0" U.N.

DRAWN J. HUFFMAN 8-7-73

CHECKED [signature] 8-16-73

ENGINEER R. Tony Smith 8-17-73

APPROVED R.N. Bergstrom 8-17-73

JOB NO. 4642

SARGENT & LUNDY ENGINEERS CHICAGO

DRAWING NO. 3-3041-3

ATTACHMENT D

INSTRUMENTATION LOCATION MAP

ATTACHMENT E

HYDROLOGY AND HYDROLOGIC REPORT

Cardinal Generating Plant
Addendum to Bottom Ash Pond Investigation

Brilliant, Ohio

Report to

American Electric Power Service Corp.
Columbus, Ohio

Prepared by

BBC&M Engineering, Inc.
Dublin, Ohio

December, 2010
Addendum to August, 2009 Report

TABLE OF CONTENTS

LIST OF APPENDICES

H&H ANALYSIS

Introduction

The Bottom Ash Pond is located to the north of the Recirculation Pond and they are separated by an earthen embankment. The crest of the embankment surrounding the Bottom Ash Pond is protected with a gravel wearing surface. Water is pumped into the pond from the plant facilities for treatment. Water flows from the Bottom Ash Pond to the Recirculation Pond via a spillway structure. Water is pumped from the Recirculation Pond back into the plant system as necessary. Any overflow would exit the pond to the Ohio River via an NPDES outfall incorporating a weir control structure.

The Bottom Ash Pond is identified as a Class II dam by ODNR, and as such must safely pass 50% of the Probable Maximum Flood (PMF) in accordance with OAC Rule 1501:21-13-02. Regarding minimum required freeboard, OAC Rule 1501:21-13-07(A) states "...*the minimum elevation of the top of the dam shall be at least five feet higher than the elevation of the designed maximum operating pool level unless otherwise approved by the chief*".

Existing Conditions

The crest elevation for the Bottom Ash Pond is listed on the ODNR fact sheet as nominal Elevation 670.0 (msl). A field survey performed by AEP in November 2010, showed that the crest varies in Elevation from 668.3' to 669.4' (see Plate 1 of Appendix C). It is understood that AEP plans to perform maintenance to restore the crest to the original Elevation of 670.0.

The ODNR fact sheet, as well as a stormwater report by FMSM dated December 2005 and provided by AEP, lists the pond drainage area as 24.3 acres, which is slightly larger than the pond footprint. The maximum pumped inflow from plant facilities and stormwater collection areas to the Bottom Ash Pond is 23.32 MGD (36 cfs) according to an AEP water balance diagram dated 7/12/2006. The pond is isolated from substantial exterior surface water runoff.

The outlet works for the Bottom Ash Pond consists of a drop inlet spillway structure with slide gates. The gates are 4 feet in length. A 36-inch oulet pipe conveys the water to the Recirculation Pond. The elevation of the top of the current slide gate is 665.24 according to the field survey. A site visit on October 7, 2010 noted the pool level in the Bottom Ash Pond at Elevation 665.5. The pool level in the Recirculation Pond was at 663.8 during the site visit and is controlled by a 4-foot wide weir surveyed at Elevation 666.20. As the Recirculation Pond level was below the outlet weir, active discharging was not occurring during our site visit.

Analysis

This design storm was analyzed, along with the maximum pumped inflow, to develop maximum pool operating levels. A storage-area-elevation table was developed for the pond's live storage (from normal pool to top of dam) based on 1994 aerial mapping provided by AEP. This table is presented on Plate 6 of Appendix C. Since negligible drainage area runoff is occurring, 50% of the Probable Maximum Precipitation (PMP) was taken as being equivalent to 50% of the PMF. The PMP value used for this site was 33.0 inches for a 24-hour storm event, based on charts contained in HMR-51. A curve number (CN) of 99 was used for the pond area.

Using accepted engineering equations, rating curves for the outlet system were estimated, as shown on Plates 2 through 5 of Appendix C. The total inflow was routed through the pond system using the HEC-HMS computer program, which was developed by the U.S. Army Corps of Engineers. The analysis was performed assuming tailwater in the Recirculation Pond at Elevation 663.0. Rating curves and other input values are contained in Appendix C. Several cases and iterations were performed with different beginning water elevations to determine the maximum safe operating levels, described as follows:

Case 1: The pond was analyzed with the normal operating level being located at the top of the slide gate weir (Elevation 665.24).

Case 2: Iterations were performed to find the maximum safe operating pool level that would not overtop the dam crest (Elevation 670.0) during the design storm.

Case 3: The pond was analyzed with the normal operating level being located at Elevation 665.0 (5 feet of freeboard).

Case 4: The pond was analyzed with the normal operating level being located at Elevation 666.0 (4 feet of freeboard). It is understood a variance from 5 feet to 4 feet may be requested for the freeboard requirement.

Results

The results of the analysis routing the design storm and pumped inflow through the pond for the various cases are summarized in Table 2.

Table 2: Summary of Pond Routing Results

Case	Normal Operating Water Level El.	Freeboard with nominal Crest El. 670	Max. Resultant Water Level El.
1	665.24	4.76 feet	668.3
2	667.1	2.9 feet	670.0
3	665.0	5.0 feet	668.1
4	666.0	4.0 feet	669.0

Detailed computed results, including flow rates and pond hydrographs, are included on Plates 7 through 15 of Appendix C.

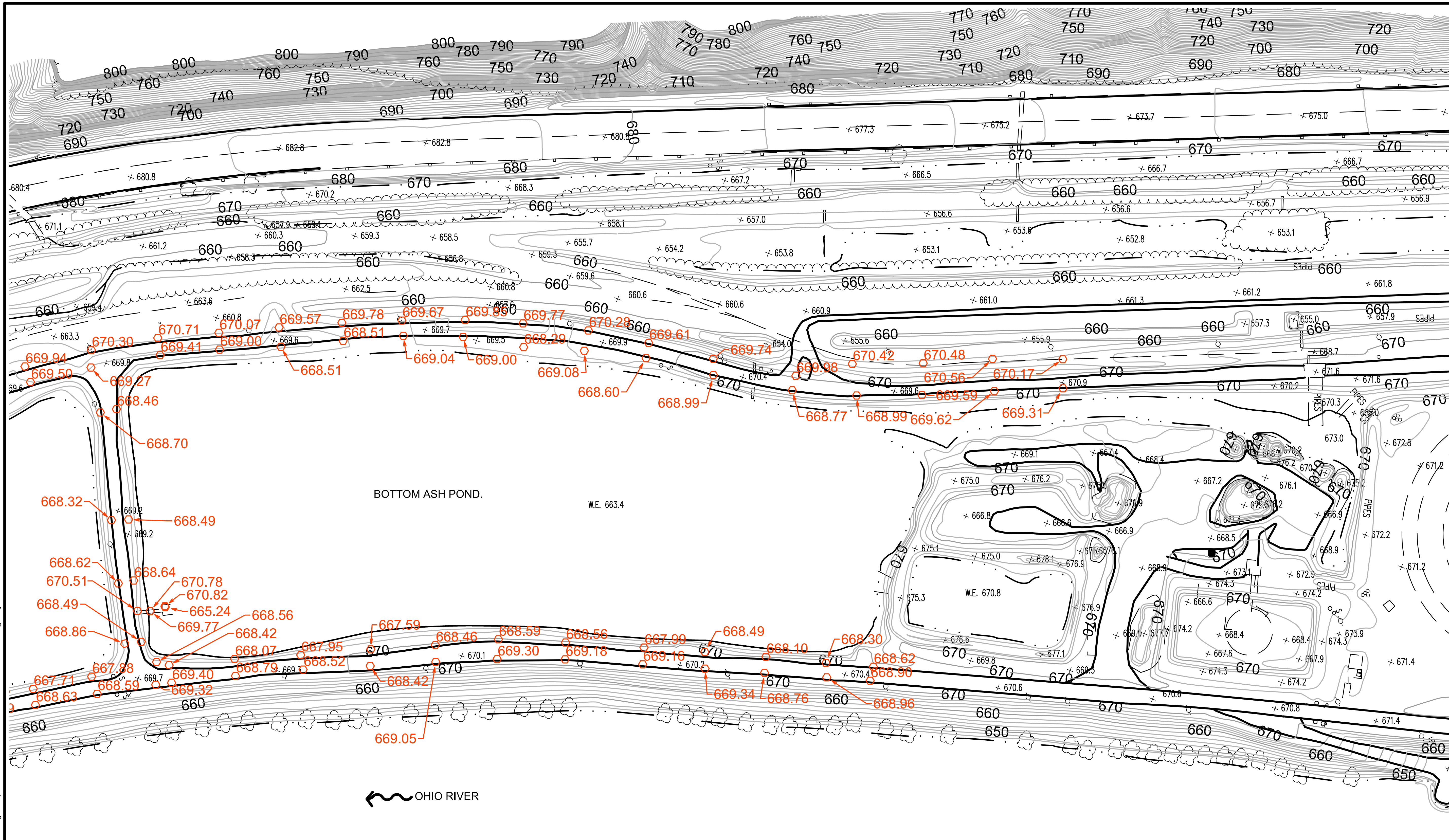
Conclusions

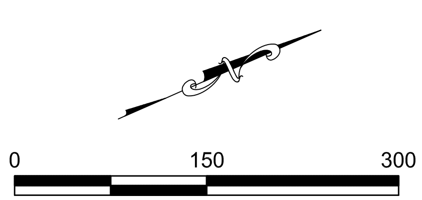
The pond storage is sufficient to contain the design storm. However, the current normal pool level is not sufficient to meet the 5-foot freeboard requirement. It is understood that material will be added to the road surrounding the pond to restore the crest to a consistent elevation of 670.0. If this work is completed, a slide gate will still have to be removed to lower the normal pool level in the Bottom Ash Pond. Based on construction drawings by Sargent & Lundy, dated August 1973, the slide gates each have a height of 1 foot. A reduced weir elevation of 664.24 would allow for a maximum operating pool level of Elevation 665.0 and 5 feet of freeboard. This pool level creates 0.76 feet of head over the spillway weir and allows for a normal pumping inflow rate of 5.5 MGD, given that the pool level (tailwater) for the Recirculation Pond is lower than Elevation 665.0.

One option would be to obtain a variance to change the minimum freeboard requirement to 4 feet. If this is obtained, the maximum operating pool level in the Bottom Ash Pond may be maintained at Elevation 666.0. The maximum operating pool level of the Recirculation Pond should be maintained below the maximum operating pool level of the Bottom Ash Pond.

APPENDIX C

H & H Analysis





SCALE IN FEET

NOTE: TOPOGRAPHY AND FEATURES SHOWN ARE FROM 1994 AERIAL MAPPING PROVIDED BY AEP.

LEGEND

700.0 SURVEY DATA,PERFORMED BY AEP DURING NOVEMBER 2010

FIELD SURVEY DATA	
BOTTOM ASH POND CARDINAL GENERATING STATION	BBCM Solutions To Build On Columbus (614) 793-2226 Cleveland (216) 901-1000 Cincinnati (513) 771-8471 Dayton (937) 424-1011
Project: 011-11497-013	Drawn By: ARW
Drawing Date: 12-16-2010	Approved By: AJS
Last Updated: 12-16-2010	Scale: 1"=150' 1:1

PLATE 1

Images:
Xrefs:
File Last Updated: Dec 16, 2010
Plot Info: 12-16-2010 @ 4:39pm By: AWeinandy
BBC&M Filename: I:\DEPTS\CADD\Drawings\Projects\011-11497-013\Civil3D\Base 11-16-10.dwg Layout: 11x17

Bottom Ash Pond Spillway Capacity - Case 1 - Existing Conditions						
Lake Elevation feet	Stop Log Weir Flow cfs	Pipe Inlet Flow cfs	Pressure Pipe Flow cfs	**Control Flow cfs**	***Total Outflow MGD***	Control Type
663.00	0.0	83.3	0.0	**0.0**	***0.0***	Stop Log Weir Flow
664.00	0.0	90.0	31.6	**0.0**	***0.0***	Stop Log Weir Flow
665.00	0.0	96.2	44.7	**0.0**	***0.0***	Stop Log Weir Flow
666.00	8.5	102.1	54.7	**8.5**	***5.5***	Stop Log Weir Flow
667.00	29.8	107.6	63.2	**29.8**	***19.3***	Stop Log Weir Flow
668.00	58.5	112.8	70.7	**58.5**	***37.8***	Stop Log Weir Flow
669.00	93.1	117.8	77.4	**77.4**	***50.0***	Pressure Pipe Flow
670.00	132.6	122.7	83.6	**83.6**	***54.0***	Pressure Pipe Flow

Bottom Ash Pond Spillway Capacity - Case 2 - Max Water at Elev 670						
Lake Elevation feet	Stop Log Weir Flow cfs	Pipe Inlet Flow cfs	Pressure Pipe Flow cfs	**Control Flow cfs**	***Total Outflow MGD***	Control Type
665.00	0.0	96.2	44.7	**0.0**	***0.0***	Stop Log Weir Flow
666.00	0.0	102.1	54.7	**0.0**	***0.0***	Stop Log Weir Flow
667.00	0.0	107.6	63.2	**0.0**	***0.0***	Stop Log Weir Flow
668.00	12.8	112.8	70.7	**12.8**	***8.2***	Stop Log Weir Flow
669.00	36.1	117.8	77.4	**36.1**	***23.3***	Stop Log Weir Flow
670.00	66.3	122.7	83.6	**66.3**	***42.9***	Stop Log Weir Flow
671.00	102.1	127.3	89.4	**89.4**	***57.8***	Pressure Pipe Flow

Bottom Ash Pond Spillway Capacity - Case 3 - NP Elev 665						
Lake Elevation feet	Stop Log Weir Flow cfs	Pipe Inlet Flow cfs	Pressure Pipe Flow cfs	**Control Flow cfs**	***Total Outflow MGD***	Control Type
664.00	0.0	90.0	31.6	**0.0**	***0.0***	Stop Log Weir Flow
665.00	0.0	96.2	44.7	**0.0**	***0.0***	Stop Log Weir Flow
666.00	12.8	102.1	54.7	**12.8**	***8.2***	Stop Log Weir Flow
667.00	36.1	107.6	63.2	**36.1**	***23.3***	Stop Log Weir Flow
668.00	66.3	112.8	70.7	**66.3**	***42.9***	Stop Log Weir Flow
669.00	102.1	117.8	77.4	**77.4**	***50.0***	Pressure Pipe Flow
670.00	142.7	122.7	83.6	**83.6**	***54.0***	Pressure Pipe Flow

Bottom Ash Pond Spillway Capacity - Case 4 - NP Elev 666						
Lake Elevation feet	Stop Log Weir Flow cfs	Pipe Inlet Flow cfs	Pressure Pipe Flow cfs	**Control Flow cfs**	***Total Outflow MGD***	Control Type
665.00	0.0	96.2	44.7	**0.0**	***0.0***	Stop Log Weir Flow
666.00	0.0	102.1	54.7	**0.0**	***0.0***	Stop Log Weir Flow
667.00	12.8	107.6	63.2	**12.8**	***8.2***	Stop Log Weir Flow
668.00	36.1	112.8	70.7	**36.1**	***23.3***	Stop Log Weir Flow
669.00	66.3	117.8	77.4	**66.3**	***42.9***	Stop Log Weir Flow
670.00	102.1	122.7	83.6	**83.6**	***54.0***	Pressure Pipe Flow

Bottom Ash Pond Weir Rating - Case 1
Weir Flow

$$Q = C_{SCW} L H^{\frac{3}{2}}$$

$$C_{SCW} = 3.27 + 0.4\left(\frac{H}{H_c}\right)$$

for $H/H_c < 0.3$, C_{SCW} becomes 3.33

***L*=**	**3.83**
***g*=**	**32.2**
***Crest Elevation*=**	**665.24**

Elevation	H	Q
665.24	0.00	0.0
666.00	0.76	8.5
667.00	1.76	29.8
668.00	2.76	58.5
669.00	3.76	93.1
670.00	4.76	132.6

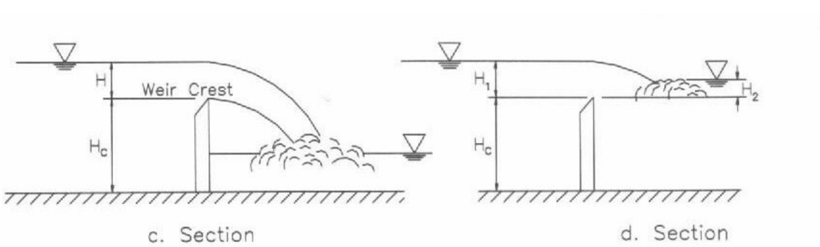


Figure 8-13. Sharp crested weirs.

Reference:
FHWA-SA-96-078
Urban Drainage Design Manual
Hydraulic Engineering Circular 22
November, 1996

Bottom Ash Pond 36" Pipe Rating
Pipe Inlet Control

$$Q = CA\sqrt{2gh_1}$$

for C=0.6 orifice equation becomes:

$$Q = 3.78D^2\sqrt{h_1}$$

d= **36.0** **INCHES**
Orifice Elevation = **657.00**

Headwater Elevation (ft.)	**Orifice**	
	Discharge (cfs)	**Velocity (ft/s)**
657.00	*0.0*	0.0
658.00	*34.0*	4.8
659.00	*48.1*	6.8
660.00	*58.9*	8.3
661.00	*68.0*	9.6
662.00	*76.1*	10.8
663.00	*83.3*	11.8
664.00	*90.0*	12.7
665.00	*96.2*	13.6
666.00	*102.1*	14.4
667.00	*107.6*	15.2
668.00	*112.8*	16.0
669.00	*117.8*	16.7
670.00	*122.7*	17.4
671.00	*127.3*	18.0

Reference:
FHWA-SA-96-078
Urban Drainage Design Manual
Hydraulic Engineering Circular 22
November, 1996

Pressure Pipe Flow Computed with the Energy Equation

(from inlet to Recirc. Pond)

Manning's n= 0.013
Inlet Invert: 657
Outlet Invert (z_2): 656
Entrance Coefficent K_e= 0.5
Outlet Coefficent K_o= 1
Bend Coefficent K_b= 0
Pipe Diameter in inches= 36
Pipe Diameter in feet (D)= *3.00*
Pipe Length in feet (L)= 100
Darcy-Weisbach *f* = *0.022*

(Assuming tailwater at El. 663.0):

Headwater Elevation (z_1) (ft)	Outlet Velocity (ft/s)	Outlet Flow Rate (ft^3/s)
657.00	0.00	0.00
658.00	0.00	0.00
659.00	0.00	0.00
660.00	0.00	0.00
661.00	0.00	0.00
662.00	0.00	0.00
663.00	0.00	0.00
664.00	4.47	31.60
665.00	6.32	44.69
666.00	7.74	54.73
667.00	8.94	63.20
668.00	10.00	70.66
669.00	10.95	77.40
670.00	11.83	83.60
671.00	12.64	89.38

The Darcy-Weisbach friction factor is related to Manning's n through the following equation:

$$f = \frac{185 \quad n^2}{D^{\frac{1}{3}}}$$

The Energy Equation is:

$$\frac{p_1}{\gamma} + \frac{v_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{v_2^2}{2g} + z_2 + \sum h_L$$

Where:

$$\sum h_L = \frac{v^2}{2g}\left(f\frac{L}{D} + K_e + K_o + K_b \right)$$

Because p_1, v_1 and p_2 all are equal to 0 the energy equation becomes:

$$z_1 - z_2 = \frac{v^2}{2g} + \frac{v^2}{2g}\left(f\frac{L}{D} + K_e + K_o + K_b \right)$$

Solving for v gives:

$$v = \sqrt{\frac{2g(z_1 - z_2)}{\left(1 + \left(f\frac{L}{D} + K_e + K_o + K_b \right)\right)}}$$

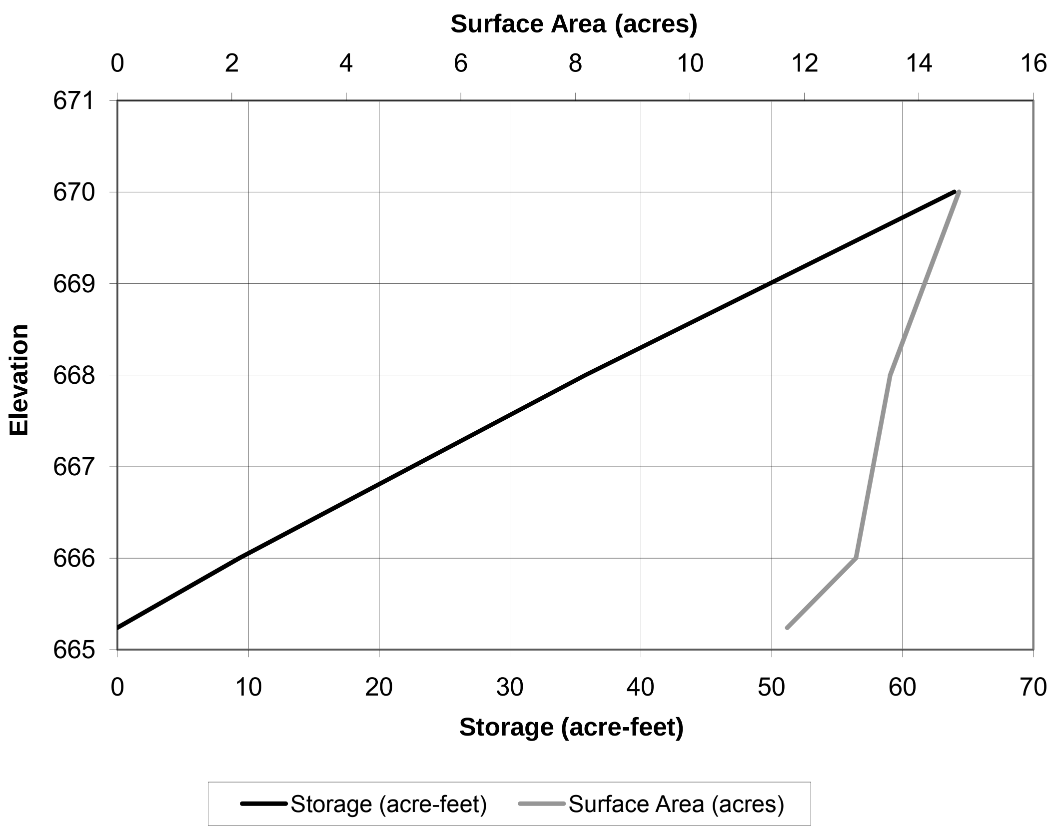
Determine flow rate Q by:

$$Q = VA$$

	Bottom Ash Pond - Live Storage Volume Computations					
	Elevation	Area	Avg Area	Distance	Volume	Cum Vol
		acres	acres	feet	ac-ft	ac-ft
Normal Pool	665.24	11.70				0
			12.30	0.76	9.35	
	666	12.90				9.3
			13.20	2	26.40	
	668	13.50				35.7
			14.10	2	28.20	
	670	14.70				63.9

Bottom Ash Pond- Surface Area/Storage/Elevation

Note: From topography provided by AEP



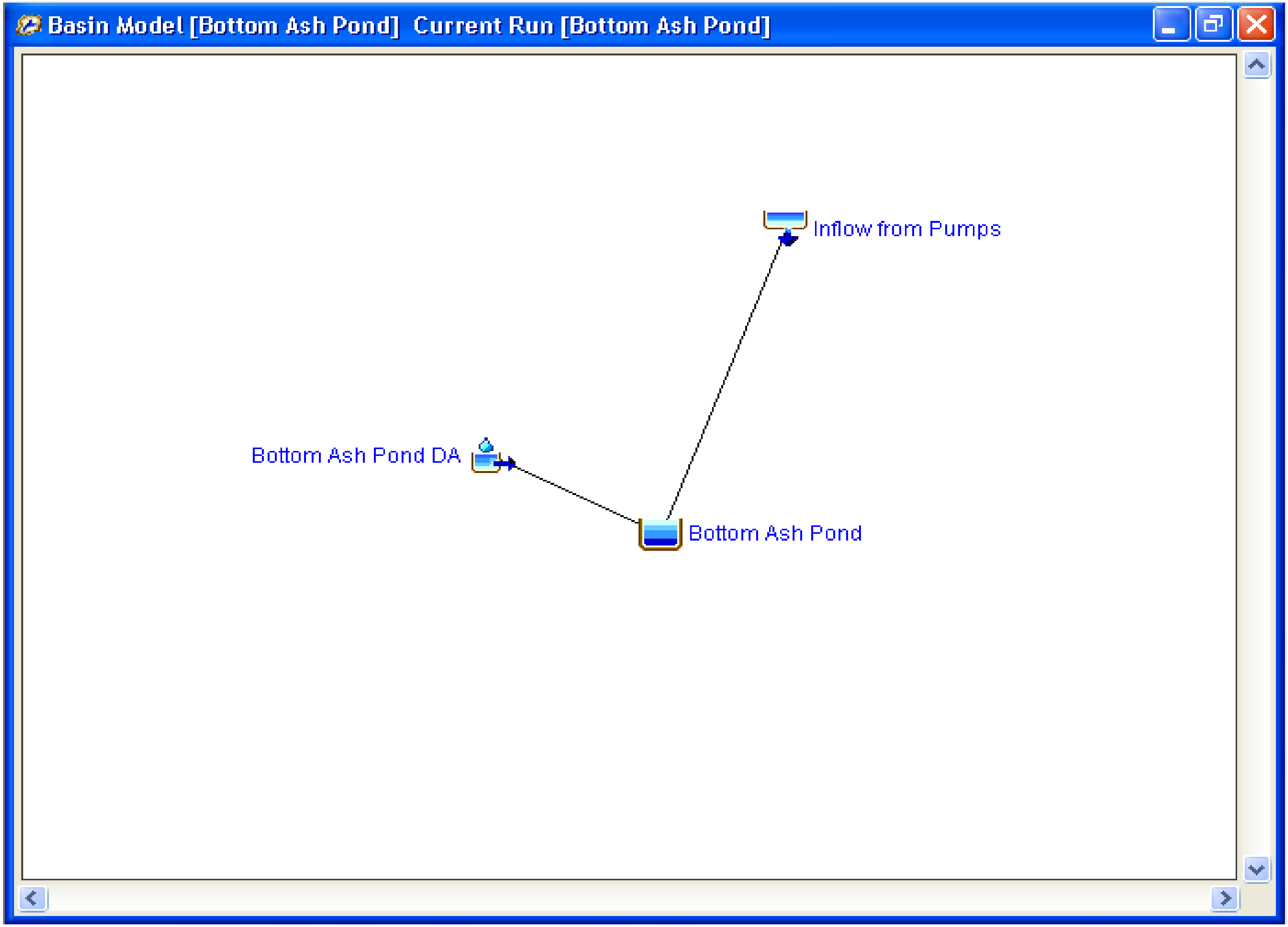
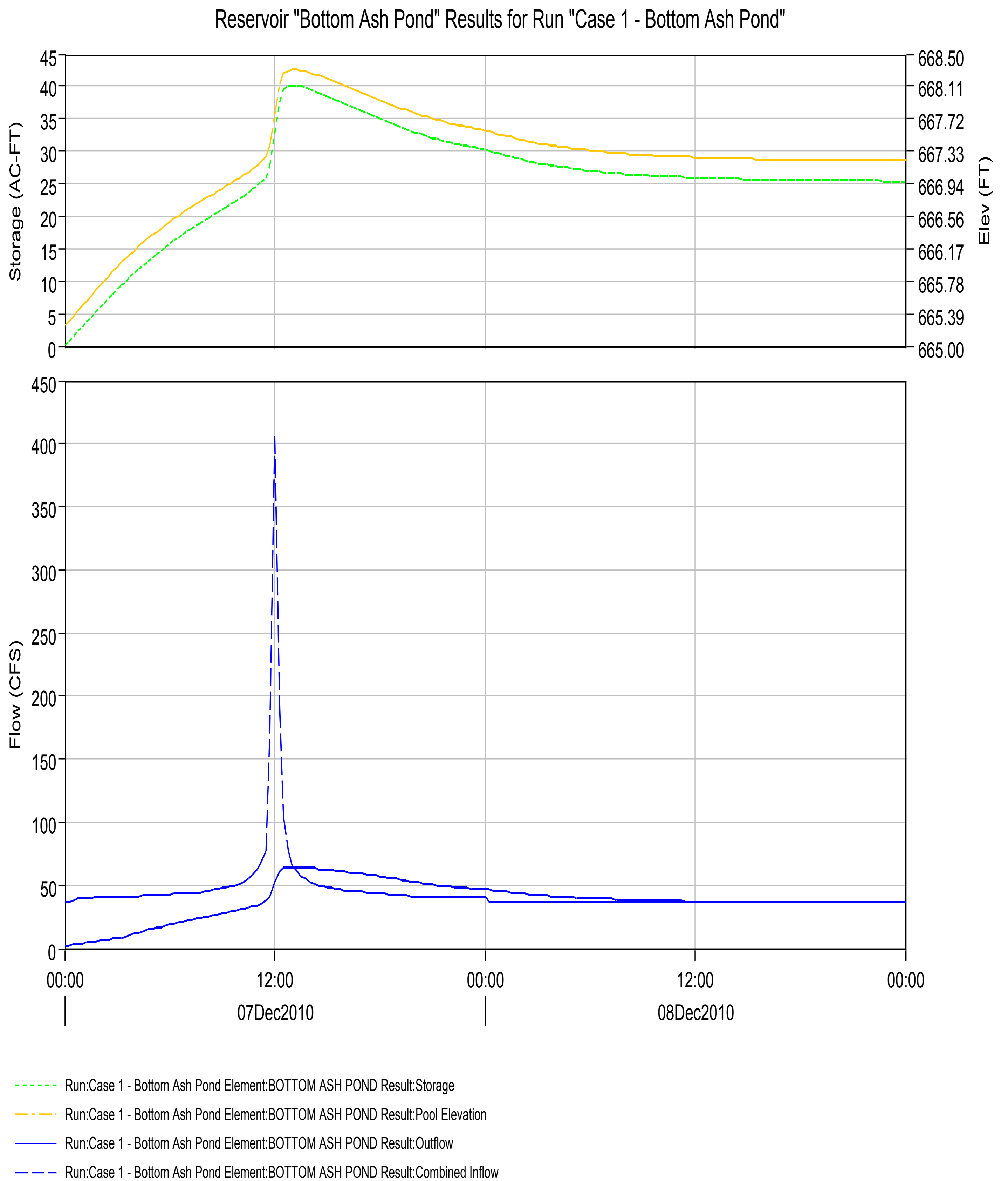

Basin Model [Bottom Ash Pond] Current Run [Bottom Ash Pond]
Inflow from Pumps
Bottom Ash Pond DA
Bottom Ash Pond

PLATE 7

Project:	Bottom Ash Pond		
Simulation Run:	Case 1 - Bottom Ash Pond	Reservoir:	Bottom Ash Pond
Start of Run:	07Dec2010, 00:00	Basin Model:	Case 1 - Bottom Ash Pond
End of Run:	09Dec2010, 00:00	Meteorologic Model:	50 Percent PMP - 24 Hour
Compute Time:	08Dec2010, 12:23:27	Control Specifications:	Bottom Ash Pond
Volume Units:	AC-FT		

Computed Results

Peak Inflow :	406.2 (CFS)	Date/Time of Peak Inflow :	07Dec2010, 12:00
Peak Outflow :	64.4 (CFS)	Date/Time of Peak Outflow :	07Dec2010, 13:00
Total Inflow :	176.0 (AC-FT)	Peak Storage :	40.1 (AC-FT)
Total Outflow :	150.7 (AC-FT)	Peak Elevation :	668.3 (FT)



Reservoir "Bottom Ash Pond" Results for Run "Case 1 - Bottom Ash Pond"
Storage (AC-FT)
Elev (FT)
Flow (CFS)
0
5
10
15
20
25
30
35
40
45
665.00
665.39
665.78
666.17
666.56
666.94
667.33
667.72
668.11
668.50
0
50
100
150
200
250
300
350
400
450
00:00
12:00
00:00
12:00
00:00
07Dec2010
08Dec2010
Run:Case 1 - Bottom Ash Pond Element:BOTTOM ASH POND Result:Storage
Run:Case 1 - Bottom Ash Pond Element:BOTTOM ASH POND Result:Pool Elevation
Run:Case 1 - Bottom Ash Pond Element:BOTTOM ASH POND Result:Outflow
Run:Case 1 - Bottom Ash Pond Element:BOTTOM ASH POND Result:Combined Inflow

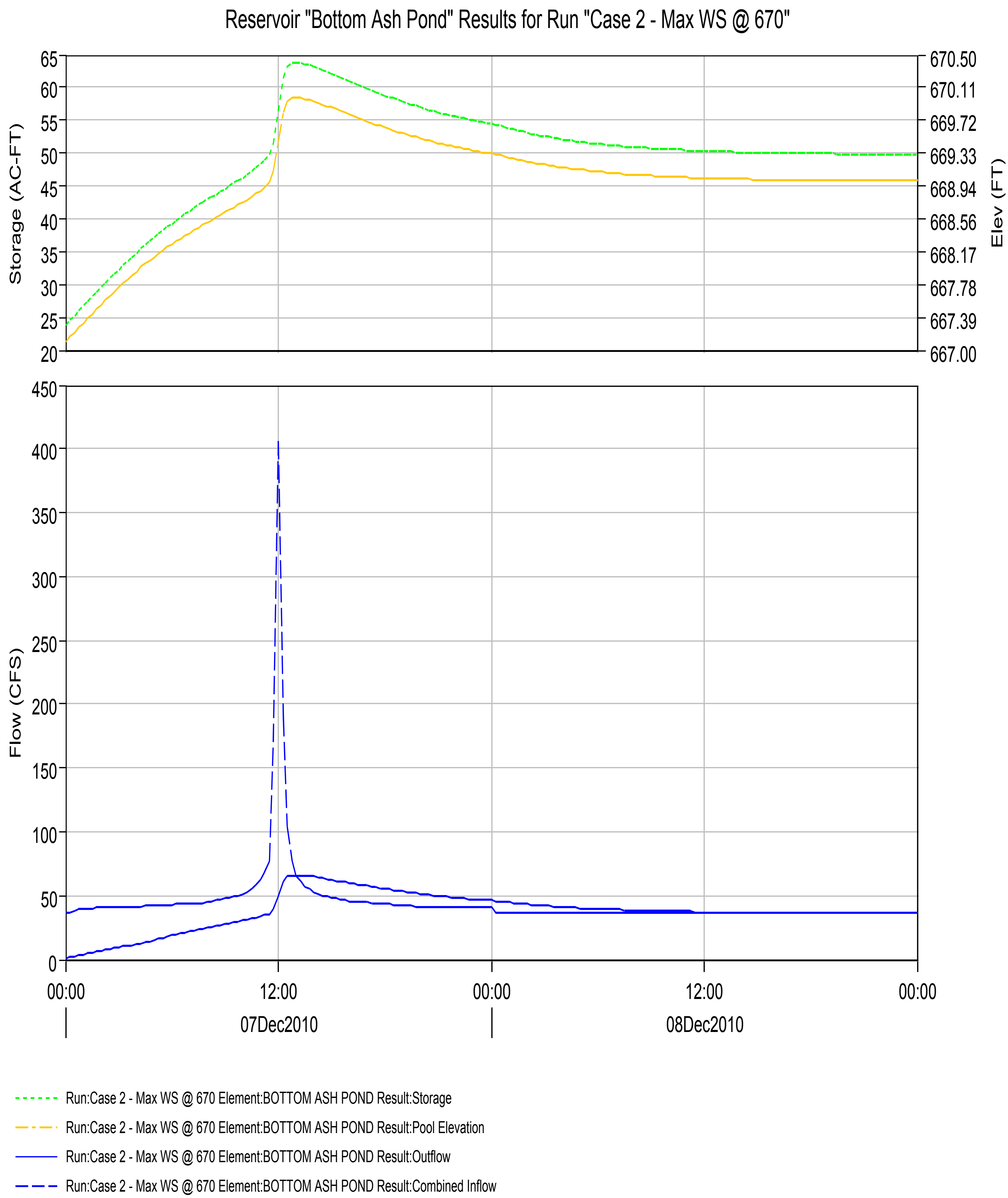
	Project:	Bottom Ash Pond	
Simulation Run:	Case 2 - Max WS @ 670	Reservoir:	Bottom Ash Pond

Start of Run:	07Dec2010, 00:00	Basin Model:	Case 2 - Bottom Ash Pond
End of Run:	09Dec2010, 00:00	Meteorologic Model:	50 Percent PMP - 24 Hour
Compute Time:	08Dec2010, 12:34:32	Control Specifications:	Bottom Ash Pond

Volume Units: AC-FT

Computed Results

Peak Inflow :	406.2 (CFS)	Date/Time of Peak Inflow :	07Dec2010, 12:00
Peak Outflow :	66.1 (CFS)	Date/Time of Peak Outflow :	07Dec2010, 13:00
Total Inflow :	176.0 (AC-FT)	Peak Storage :	63.8 (AC-FT)
Total Outflow :	150.0 (AC-FT)	Peak Elevation :	670.0 (FT)



Reservoir "Bottom Ash Pond" Results for Run "Case 2 - Max WS @ 670"
Storage (AC-FT)
Elev (FT)
65
60
55
50
45
40
35
30
25
20
670.50
670.11
669.72
669.33
668.94
668.56
668.17
667.78
667.39
667.00
Flow (CFS)
450
400
350
300
250
200
150
100
50
0
00:00
12:00
00:00
12:00
00:00
07Dec2010
08Dec2010
Run:Case 2 - Max WS @ 670 Element:BOTTOM ASH POND Result:Storage
Run:Case 2 - Max WS @ 670 Element:BOTTOM ASH POND Result:Pool Elevation
Run:Case 2 - Max WS @ 670 Element:BOTTOM ASH POND Result:Outflow
Run:Case 2 - Max WS @ 670 Element:BOTTOM ASH POND Result:Combined Inflow

PLATE 11

	Project:	Bottom Ash Pond	
Simulation Run:	Case 3 - NP @ 665.0	Reservoir:	Bottom Ash Pond

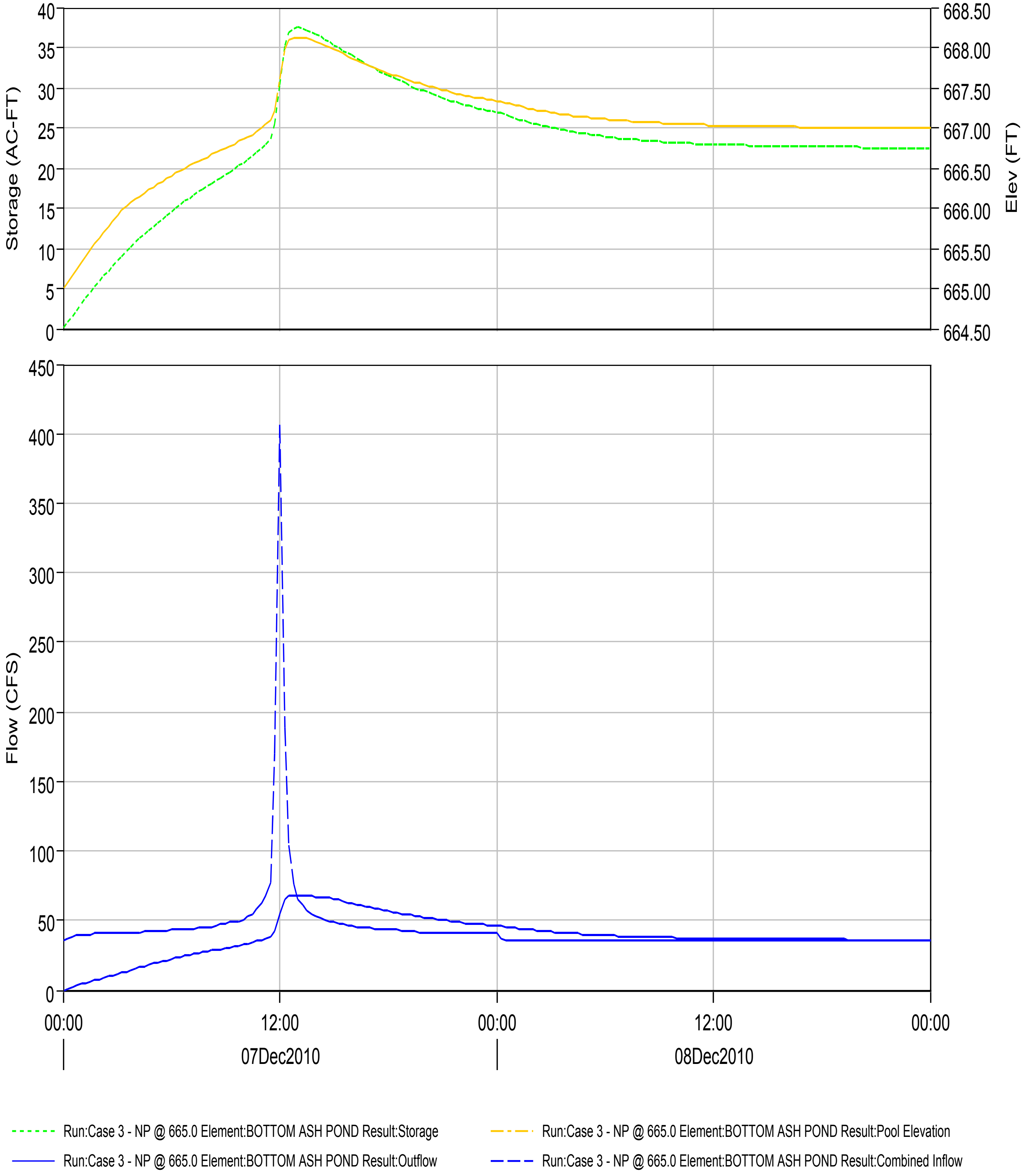
Start of Run:	07Dec2010, 00:00	Basin Model:	Case 3 - Bottom Ash Pond
End of Run:	09Dec2010, 00:00	Meteorologic Model:	50 Percent PMP - 24 Hour
Compute Time:	08Dec2010, 12:17:34	Control Specifications:	Bottom Ash Pond

Volume Units: AC-FT

Computed Results

Peak Inflow :	406.2 (CFS)	Date/Time of Peak Inflow :	07Dec2010, 12:00
Peak Outflow :	67.7 (CFS)	Date/Time of Peak Outflow :	07Dec2010, 13:00
Total Inflow :	176.0 (AC-FT)	Peak Storage :	37.5 (AC-FT)
Total Outflow :	153.6 (AC-FT)	Peak Elevation :	668.1 (FT)

Reservoir "Bottom Ash Pond" Results for Run "Case 3 - NP @ 665.0"



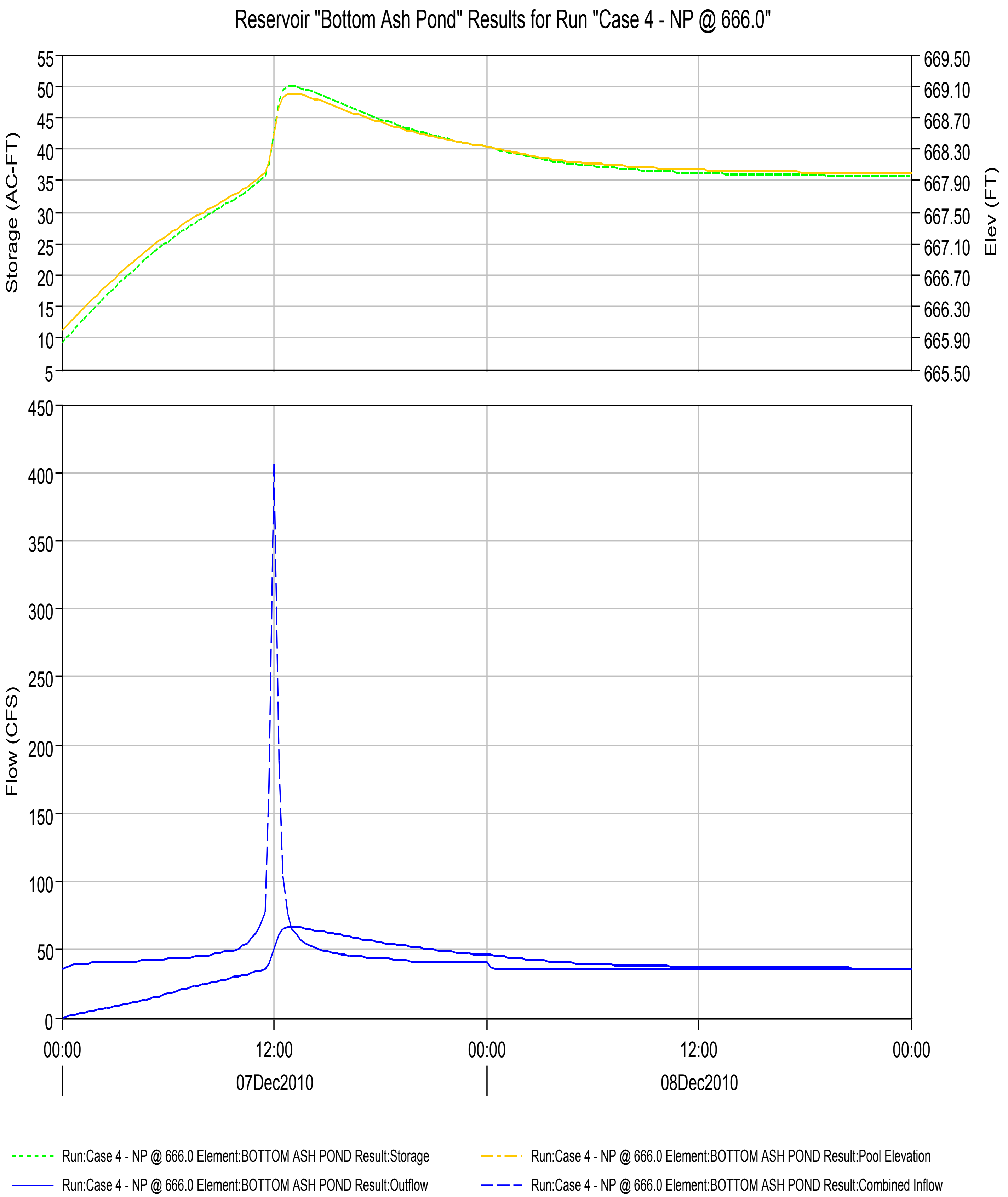
Project:	Bottom Ash Pond		
Simulation Run:	Case 4 - NP @ 666.0	Reservoir:	Bottom Ash Pond

Start of Run:	07Dec2010, 00:00	Basin Model:	Case 4 - Bottom Ash Pond
End of Run:	09Dec2010, 00:00	Meteorologic Model:	50 Percent PMP - 24 Hour
Compute Time:	08Dec2010, 12:21:45	Control Specifications:	Bottom Ash Pond

Volume Units: AC-FT

Computed Results

Peak Inflow :	406.2 (CFS)	Date/Time of Peak Inflow :	07Dec2010, 12:00
Peak Outflow :	66.4 (CFS)	Date/Time of Peak Outflow :	07Dec2010, 13:00
Total Inflow :	176.0 (AC-FT)	Peak Storage :	49.9 (AC-FT)
Total Outflow :	149.6 (AC-FT)	Peak Elevation :	669.0 (FT)



Reservoir "Bottom Ash Pond" Results for Run "Case 4 - NP @ 666.0"
Storage (AC-FT)
55
50
45
40
35
30
25
20
15
10
5
Elev (FT)
669.50
669.10
668.70
668.30
667.90
667.50
667.10
666.70
666.30
665.90
665.50
Flow (CFS)
450
400
350
300
250
200
150
100
50
0
00:00
12:00
00:00
12:00
00:00
07Dec2010
08Dec2010
Run:Case 4 - NP @ 666.0 Element:BOTTOM ASH POND Result:Storage
Run:Case 4 - NP @ 666.0 Element:BOTTOM ASH POND Result:Pool Elevation
Run:Case 4 - NP @ 666.0 Element:BOTTOM ASH POND Result:Outflow
Run:Case 4 - NP @ 666.0 Element:BOTTOM ASH POND Result:Combined Inflow

PLATE 15

<u>ATTACHMENT F</u>

MAINTENANCE PLAN

Operation, Maintenance, and Inspection Manual for Fly Ash Dam II & Bottom Ash Ponds Complex Dikes

American Electric Power

Cardinal Operating Company
306 County Road 7E Brilliant,
Ohio 43913

Plant Ash Dam: 0105-004
Fly Ash No. 1 Dam: 0205-009
Fly Ash No. 2 Dam: 0205-010

MAR 19 2015

March 2015

STATE OF OHIO
Soil and Water Resources
DAM SAFETY REPAIR PROGRAM
APR 06 2015
APPROVED

TABLE OF CONTENTS

LIST OF EXHIBITS

APPENDICES

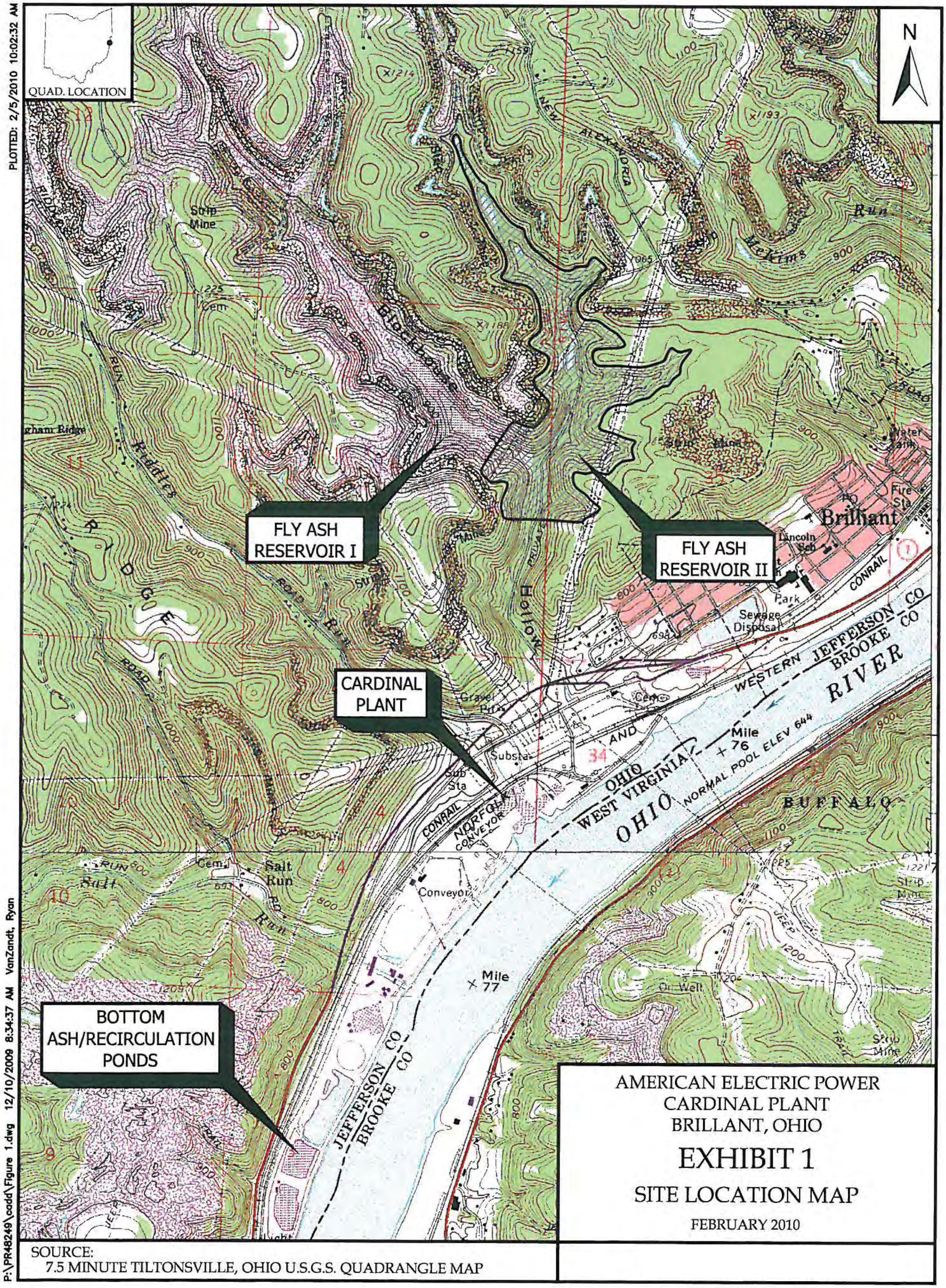
1.0 INTRODUCTION

This Operation, Maintenance, and Inspection (OM&I) Manual was prepared in accordance with Section 1501:21-15-06 of the Ohio Laws and Administrative Rules for Issuing Construction Permits for and Making Periodic Inspections of Dams, Dikes, and Levees. It is intended to assist the owner in regular operation, maintenance, and inspection activities. This manual was prepared for Cardinal Plant's Fly Ash Dam II (FAD II) and the Bottom Ash Ponds (BAP) complex conveying coal ash slurry. Exhibit 1 shows the location of the dams.

The Cardinal FAD II coal ash dam and the BAP complex dikes have been conservatively designed and carefully constructed; however, small problems can develop over time. Experience has shown that some of these small problems can become major problems if corrective measures are not promptly taken. The main intent of this manual, therefore, is to provide the guidelines for a regular operation, maintenance, and inspection program that will detect problems at an early stage so that they can then be corrected. This manual presents the procedures for the operation, maintenance and inspection of the FAD II and the BAP complex dikes.

Much of the information in this manual has been based on the requirements of publications issued by the Ohio Department of Natural Resources (ODNR), Division of Water, Dam Inspection Section. The publications are a series of Fact Sheets; copies of pertinent Fact Sheets are contained in Appendix D. In addition to providing basic recommendations for operation, maintenance, and inspection procedures, the Fact Sheets give a great deal of background information, including causes of dam failures, common problems and solutions, and reference to organizations and bureaus which can provide information and advice. The Fact Sheets are valuable publications to have as an adjunct to this manual.

This OM&I Manual supersedes any and all previous OM&I Manuals that have been used at the facility.


QUAD. LOCATION
N
FLY ASH RESERVOIR I
FLY ASH RESERVOIR II
CARDINAL PLANT
BOTTOM ASH/RECIRCULATION PONDS
Brilliant
OHIO
WEST VIRGINIA
OHIO RIVER
JEFFERSON CO
BROOKE CO
NORMAL POOL ELEV 644
Mile 76
Mile 77
AMERICAN ELECTRIC POWER
CARDINAL PLANT
BRILLANT, OHIO
EXHIBIT 1
SITE LOCATION MAP
FEBRUARY 2010
SOURCE:
7.5 MINUTE TILTONSVILLE, OHIO U.S.G.S. QUADRANGLE MAP
PLOTTED: 2/5/2010 10:02:32 AM
P:\PR48249\cadd\Figure 1.dwg 12/10/2009 8:34:37 AM VanZandt, Ryan

2.0 PROJECT DESCRIPTION

2.1 General

FAD I, FAD II, and the BAP complex are owned by AEP and Buckeye Power and operated by Cardinal Operating Company. They are located near the Cardinal Power Plant in Wells Township, Jefferson County, near Brilliant, Ohio. The Cardinal FAD I and FAD II are located approximately 1 mile northwest of the Cardinal Power Plant. The BAP complex is located at the southern part of the Cardinal power plant. The ponds were constructed for the settling/sedimentation and collection/storage of coal combustion byproducts. Exhibit 1 shows the FAD II and BAP complex in relation to the Cardinal Plant.

2.2 Fly Ash Dam I

Cardinal Fly Ash Dam I (FAD I) is the plant's original fly ash retention dam constructed in the early 1970s. The dam is an earth and rockfill dam having a final design crest elevation of 1001.5 feet. The dam has upstream (u/s) and downstream (d/s) slopes of approximately 2.5 Horizontal to 1 Vertical (2.5H:1V). As ash placement behind FAD I reached its maximum allowed level, Cardinal FAD II was constructed and began operation in the late 1980s. Fly Ash Dam I reservoir is closed, no longer receives fly ash slurry, and has no permanent pool. This area has been remitted by the Ohio Environmental Protection Agency (EPA) as a solid waste landfill (Permit to Install [PTI] Permit No. 06-07993, dated May 11, 2007) for the disposal of synthetic gypsum generated by the air pollution control equipment constructed at the Cardinal plant that captures sulfur dioxide emissions. Flow through FAR I is conveyed to FAR II via the FAD I emergency spillway.

2.3 Fly Ash Dam II

FAD II is located on Blockhouse Run, which flows directly into the Ohio River. Blockhouse Run splits into two branches, designated as the East Branch and the West Branch. The split in Blockhouse Run is approximately one mile upstream of the Ohio River. Runoff from both the east and west branch watersheds drains into the reservoir.

Fly Ash Reservoir II (FAR II), created by FAD II, is utilized for the storage of fly ash, which is discharged as slurry from six (6) 10” discharge pipes located at the upstream (north) end of the reservoir as shown on Exhibit 2. The fly ash settles out within the reservoir as the water flows toward the dam where the effluent overflows through the service spillway (overflow structure). Stop logs are placed in the discharge shaft of the overflow structure as necessary to maintain settling action or to limit discharge. The reservoir will cover approximately 168 acres at Elevation 974, the maximum operating pool elevation.

The FAD II dam consists of a 250-foot high arched embankment with a 13 ft high MSE Wall on top of the roller compacted concrete (RCC) cap on the upper 50 feet of the upstream face and an emergency spillway on the left abutment that is an open channel cut through rock. The dam has a crest elevation of 983 feet. The dam crest has a width of 22 feet and a length of 1,645 feet. The dam is designed for a storage capacity of 11,868 acre-feet with stop logs at elevation 972.5 feet and with a corresponding maximum operating pond elevation of 974 feet. Table 1 summarizes pertinent information for FAD II.

Table 1 FAD II and BAP Complex Data

Parameter	FAD II	BAP Complex
Embankment Crest Elevation (feet)	983	670
Emergency Spillway Crest Elevation (feet)	975.5	665.5
Maximum Operating Pool Level (feet)	974.0	665
Operating Pool Freeboard (feet)	9	665
Maximum Stop Log Elevation (feet)	972.5	665.5
Surface Area (acres) at Pool Level	161	29

Table 2 includes a list of inlet and outlet structures in addition to an inventory of the works and other significant components existing at the FAD II and their location and characteristics. In addition, Appendix C includes reference information in form of water cycle Diagram, Drawings, and photos of the components.

Table 2

Features and appurtenances	Description
Embankments	Approximately 1645 ft at crest elevation of 983.
Inflow pipes	Six 10” diameter fly ash sluicing steel pipes, 12.87 MGD (EL. 962)
Spillways	Sizes 48” wide, Max elevation: 972.5, adjusted with 6” high stop logs (concrete).
Emergency spillway/overflow	Size: 110.5'x 7.5' elevation: 975.5 (Concrete)
Embankment drainage systems	Exhibit 2 and Appendix C
Monitoring weirs, flumes	Exhibit 2 and Appendix C
Piezometers and monitoring wells	Appendix C
Inclinometers	Annual monitoring, See Appendix C for location
Staff gauge & signage	Exhibit 2 and Appendix C
Settlement monuments	Annual monitoring, See Appendix C for location
Abandoned structures	Grouted in place, Exhibit 2

2.3.1 Fly Ash Dam II Service Spillway (Over Flow Structure)

The service spillway is extended with a new vertical concrete shaft structure with one side opening on top of a sloping concrete shaft structure with one side opening, four feet wide, connecting into a 54 inch diameter pre-stressed concrete cylinder pipe (PCCP).

The bottom of the sloping concrete shaft and the entire 54-inch concrete pipe were constructed within bedrock as part of the 1997 FAD II rising. Stop logs are utilized to promote settling action and control the operating pool level.

Stop logs will be incorporated into the new vertical section to continue to allow for the incremental raising of the operating pool.

2.3.2 Fly Ash Dam II Emergency Spillway

The principle spillway (or overflow structure) is located on the left abutment and is an open channel cut through rock. The flow capacity of the emergency spillway is designed to pass the Probable Maximum Flood when the reservoir reaches its maximum pond elevation, without overtopping the dam. At intermediate pool levels, floods of lesser magnitude will be discharged through the service spillway.

The fly ash dam is normally unattended and the service spillway structure has no remote controlled system to regulate the flow. Because of the nature of the pond and the design of the dam and service spillway structure, there exists sufficient freeboard to mitigate concerns of overtopping during a rainfall event.

2.3.3 Downstream Effects

There are no dams or residences located above the dam or in the east or west watershed boundaries. There are no dams located downstream that could be operated during an emergency to store flood flows. The Ohio River, Cardinal Plant, State Route 7 and the Tidd-dale subdivision of Brilliant, Ohio, all lie directly downstream of the proposed dam. Therefore, a sudden failure of the dam will likely result in loss of human life and damage to homes, high value utility installation and both a railroad and a public road.

2.4 Bottom Ash Pond Complex

The BAP Complex at the Cardinal Plant consists of a BAP (approximately 20 acres) and a Recirculation Pond (RCP) (approximately 9 acres). Flow from the BAP is discharged to the RCP. The exterior dike crest elevation varies and an overflow conduit with an inlet elevation of approximately 665.5 feet controls the maximum Recirculation Pond water level. In 2008, plastic sheet piling was driven across the recirculation pond to modify its flow pattern in preparation of allowing the present overflow structure to discharge from the basin. The arrangement of the BAP Complex is shown in Exhibit 3 and Table 1 summarizes pertinent information for BAP Complex.

The bottom ash pond complex is located along the west bank of the river just to the south of the main plant area. The bottom ash pond complex consists of two components: the bottom ash pond and the recirculation pond (RCP). The bottom ash pond complex is utilized for the storage and collection of bottom ash, Bottom ash-laden water and other storm water is discharged via thirteen (13) pipes into the northwest corner of the bottom ash pond, the coarse bottom ash settles out closer to the discharge lines while the finer bottom ash settles out at farther locations within the pond. Near the southeast side of the bottom ash pond, Overflow Discharge structure (a drop outlet and a 36”-pipe) controls flow from the bottom ash pond into the recirculation pond. The water in the RCP is used to sluice the fly ash form the plant to FAD II via the pump station

Table 3 includes a list of inlet and outlet structures in addition to an inventory of the works existing at the BAP complex and other significant components and their location and characteristics. In addition, Appendix C includes such information in form of water cycle Diagrams, Drawings, and photos of the referenced components.

Table 3

Features and appurtenances	Description
Embankments	Approximately 4700 ft at crest elevation of 670.
Inflow pipes	13 10” diameter fly ash sluicing pipes
Outflow pipes	36” diameter steel pipe into to 36” diameter PVC pipe Exhibit 3 and Appendix C Pumphouse intake pipes: Two 21” diameter for ash sluicing (El 660).
Spillways	Drop inlet with stoplogs and 36” pipe;
Monitoring weirs, flumes	Exhibit 3 and Appendix C
Piezometers and monitoring wells	Annual monitoring, See Exhibit 3 for location
Staff gauge & signage	Exhibit 3
Emergency spillway/overflow	Sharp –crested 3 ft wide 10” weir at EL 665.5
Pump house	Intakes elevation 660, capacity:16.9 MGD

The BAP is located north of the RCP and they are separated by an earthen embankment. Perimeter dikes surround the bottom ash pond complex and are referred to as the BAP complex dike. The crest elevation of the embankments varies with a minimum elevation of 670 feet MSL. An overflow conduit with a variable inlet elevation and a pipe between the

BAP and the RCP controls the maximum BAP water level. The total length of the Interior embankment is approximately 2,500 feet and the total length of the exterior embankment along the Ohio River is approximately 2,000 feet. For comparison, the normal pool for this stretch of the Ohio River is El. 644. Both ponds are isolated from exterior surface water inflow. An overflow conduit with an inlet elevation of approximately 665.5 feet controls the maximum recirculation pond water level. In 2008, plastic sheet piling was driven across the recirculation pond to modify its flow pattern in preparation of allowing the present overflow structure to discharge from the basin. In 2010, the top of the BAP complex exterior dikes were re-graded to insure that the minimum elevation of 670 is applicable all over the dike. The arrangement of bottom ash complex is shown in Exhibit 3.

2.4.2 Downstream Effects

FAD II located upstream of the BAP complex dikes. The Ohio River located downstream of the BAP complex dikes. Therefore, sudden failures of the dikes will not likely result in loss of human life or damage to homes.

3.0 OPERATION OF THE RESERVOIRS

3.1 Mechanical Equipment

The mechanical equipment associated with the FAD II includes three aerators a pump station. The pump station is use to provide water for Ohio American Energy Inc's (OAEI) coal prep plant and is operated by OAEI. The aerators operated by AEP (Please see table 4 below for contact info). The aerators are necessary to mix the pond waters and maintain oxygenated conditions to promote algae bloom to consume phosphate carryover from the synthetic gypsum pollution control equipment. Therefore, the aerators should be inspected periodically to assure proper operating conditions.

The mechanical equipment associated with the BAP Complex includes the pumps located at the Pumphouse in the RCP area. Plant control room coordinator is responsible for monitoring and adjusting the pumping rates for the recirculation water. Typical and maximum flow rates are included in the Plant water cycle included in appendix C.

Table 4. Contacts List for Operating, Maintenance, and Inspecting the dams.

Name	Address	Phone	Responsibility
Eric (Randy) Sims	306 County Road 7 East Brilliant, OH 43913	(740) 314-9982	Dam safety Officer
Unit 3 Team Leader	306 County Road 7 East Brilliant, OH 43913	(740) 598-6530	Management of flow rates in and from impoundments

3.2 Outflow Measurements

Flow measurements from FAD II are measured utilizing a Parshal flume at the outlet of the impact basin immediately downstream from the dam as shown on Exhibit 2.

3.3 Drawdown Plan

There is no drain for the fly ash reservoir II due to its purpose of sedimentation. The only procedure that exists for lowering the pool elevations is the removal of the grouted stop logs in the drop inlet structures. If necessary, use alternate means to drain the pond, such as siphons or pumps. It may be necessary to excavate a hole in accumulated fly ash to enhance removal of water. All drawdown activities are to be coordinated with AEP Civil Engineering.

3.4 Safe Rate of Reservoir Drawdown

Deliberate drawdown beyond normal operational requirements shall typically not exceed 1 foot per week, except for emergency situations. Faster drawdown rates may be required under emergency conditions with the approval of the AEP Geotechnical Engineering.

3.5 Safe Dredging and temporary Stockpiling

BAP is the only pond among Cardinal Plant ponds that currently involves dredging and temporary stockpiling material above the top of dike elevation. Dredging and temporary stockpiling activities take place on regular bases to allow for the use of the bottom ash pond for settling of bottom ash. The dredged material is being beneficially used in the construction activities at the plant. Coarse bottom ash excavated closer to the sluicing point and stockpiled temporarily to allow for water draining. The finer bottom ash is usually dredged into dredging cell that exists within the BAP complex. The dredging unit is not allowed to operate next to the toe of the dam due not only to water depth requirements but also for dam safety. Once dewatered, the stockpiles are excavated and materials transported off-site for beneficial use in landfill construction.

3.6 Vandalism

"No Trespassing" signs shall be posted where appropriate. Railings or fences and warning signs shall be erected around dangerous areas.

3.7 Emergency Conditions

If any of the following conditions occur or appear imminent, the Emergency Action Plan (EAP) (separate document) shall be implemented immediately:

1. Overtopping or nearly overtopping of the embankment.
2. Piping through the embankment, spillway, or foundation.
3. A large slide in the embankment.

3.8 Records

Accurate records shall be kept of the following items:

1. Maintenance and major repairs. Appendix A contains a sample maintenance/repair log; an alternate log system may be used following plant record keeping procedures.

2. Specific observations and changes recorded and photographs taken during normal inspection periods (see Appendix B).
3. Date, hour, and maximum elevation of extreme high-water occurrences and the associated rainfall.
4. Amount, rate, and reasons for drawdown.
5. Readings made of water levels in piezometers in and near the embankment.
6. Complete and up-to-date set of as-built plans and specifications which show all changes made since the completion of the dam.
7. Visual observation of the horizontal and vertical alignment on an annual basis. If needed, the alignments should be surveyed to verify any changes.
8. Seepage location, quantity and content of flow, and size of wet area for later comparison. V-notch weirs can be used to collect and measure flow rates.
9. Erosion location and extent of erosion for later comparison.

4.0 MAINTENANCE PLAN

This section describes general maintenance procedures to be implemented at Cardinal FAD II and the BAP complex. In addition to the information provided in the following paragraphs, the ODNR has prepared a series of Fact Sheets for guidance on operation and maintenance at dams; several pertinent fact sheets are included in Appendix D for quick reference by AEP. Maintenance work to control seepage; repair cracks, slides, sloughing, damaged or deteriorated riprap; fill settled or low areas in the embankment; and repair concrete appurtenances should be performed based on the recommendations of AEP Civil Engineering.

4.1 Vegetation

1. Grassed areas shall be mown at least twice per year.
2. Paths created by pedestrian, vehicular, or animal traffic shall be minimized, and any barren areas which develop should be seeded.
3. Any cracks and/or erosion gullies which develop shall be completely filled with thoroughly compacted soil. The area shall be resodded if less than 100 square feet (sf), and reseeded if larger than 100 sf.
4. Trees and brush shall not be permitted to grow on the embankment. Tree and brush growth in the creek channel downstream of the FAD II impact basin shall be minimized. Remove any trees or brushes from the embankment and within 25 ft of the groins before they become established. The roots of any tree that is cut down should be pulled out. The resulting hole should be backfilled with tamped topsoil and reseeded. Replace areas of sparse or displaced riprap on the upstream slopes. This should be budgeted and performed annually to assure no growth of trees and brush on the embankment. ODNR Fact Sheet 94-28, Trees and Brush, in Appendix D, outlines the importance of properly maintained embankment vegetation.

4.2 Erosion

1. Promptly repair any eroded areas on the embankment to prevent more serious damage to the embankment (see Section 4.1 Vegetation). Repair erosion gullies to provide an even slope surface. Minor rills and gullies shall be filled with compacted cohesive soil, and then top soiled and seeded.
2. Erosion in large gullies can be slowed by stacking and securing bales of hay across the gully until permanent repairs can be made.
3. Causes of erosion shall be eliminated. Surface drainage should be spread out in thin layers as sheet flow.

4.3 Seepage

1. Any areas of seepage shall be noted and observed for evidence of piping erosion. Seepage containing soil is a sign of potential serious damage to the dam which may lead to failure of the dam and should be promptly addressed. Professional engineering assistance for control of any seepage problems shall be obtained.
2. Maintain written records of seepage (see Section 3.7 Records).

4.4 Cracks, Slides, Sloughing, and Settlement

1. Cracks, slides, sloughing, and settlement are signs of embankment distress and indicate that maintenance or remedial work is necessary.
2. A Professional Engineer shall determine the cause of stress before any repairs are made. Maintain written records of problems found and repairs completed (see Section 3.7 Records).

4.5 Rodent Control

1. Activities of rodents, such as groundhogs, muskrats, and beavers can endanger the structural integrity and proper performance of an embankment. Groundhogs and muskrats burrow into an embankment, thereby weakening it and creating seepage paths. Rodent control is therefore essential for a well-maintained dam. Refer to ODNR Fact Sheet 94-27, Rodent Control, in Appendix D, for further information.
2. Repair rodent burrows and implement rodent control procedures as follows:

i. Rodents may be controlled by fumigants. More detailed information on rodent control is contained in ODNR Fact Sheet 94-27, Rodent Control, in Appendix D. Fumigate rodent burrows with ignitable gas cartridges. To fumigate a burrow, light and drop an ignitable gas cartridge as deep into the burrow as possible. The burrow entrances should then be plugged with compacted soil. The procedure should be repeated at all burrow holes. The gas in the cartridge is non-poisonous. However, one should avoid inhaling the gas. Gas cartridges can be purchased at any local farm supply store.

ii. Backfill burrows by following the mud-packing method. First, place one to two lengths of metal stove or vent pipe in a vertical position over the entrance of the burrow. Mud-packing slurry should be made by adding water to a 90 percent bottom ash and 10 percent cement mixture. The slurry should then be poured into the burrow through the vertical pipe. Fly ash or bentonite may be added, as needed, to increase the flowability of slurry. After the burrow is filled, the pipe should be removed. Dry earth should be tamped into the burrow entrance and reseeded. A method for backfilling by mud packing is described in ODNR Fact Sheet 94-27, Rodent Control, in Appendix D.

4.6 Debris

Debris shall be removed from the outlet structures and their discharge pipes to allow free discharge. Caution should be used during high pond levels.

4.7 Concrete Structures

1. All deteriorated concrete surfaces (i.e., spalling, cracking, pitting, etc.) shall be repaired.
2. If sealant is observed to be missing from construction/expansion joints on the concrete outlet structures, monitor the condition and replace the sealant if necessary.

4.8 Toe Drain

1. The toe drain outlets should be inspected and observations recorded on a semiannual basis. Space to record these observations is provided in the Inspection Record form in Appendix B.

2. Areas of known seepage should be monitored for evidence of piping erosion. Seepage containing soil is a sign of potential serious damage to the dam which may lead to failure of the dam and should be promptly addressed. Professional engineering assistance for control of any seepage problems should be obtained.

3. In addition to quarterly monitoring, the toe drain outlet should be monitored during and after periods of high reservoir levels (greater than 2 foot of water over the principal spillway). If flow significantly increases at any time, contact a Professional Engineer for evaluation of the recorded data.

5.0 INSPECTION PROGRAM

5.1 Purpose

The purpose of this inspection program is to detect and document any changes in condition of the dam. AEP has an established Dam Inspection and Maintenance Program (DIMP) applicable throughout the service life of the facility. When a change in condition is detected, AEP-Civil Engineering staff and/or a Professional Engineer shall be contacted to identify any necessary remedial repair or maintenance work. The DIMP also provides a mechanism by which to activate the EAP which is made part of this Operations, Maintenance and Inspection Manual. The program consists of the following steps:

1. Conduct scheduled and unscheduled field inspections to check for signs of malfunction and to read the geotechnical instrumentation.
2. Graphically plot and interpret field measurements.
3. Investigate problems as they develop.
4. Design and implement preventive and remedial measures as required.
5. Perform regularly scheduled and routine maintenance work on the dam and its appurtenances.
6. Activate the EAP in the event that an unsafe condition is detected.

The description of the field instrumentation and the details of the DIMP are presented in the following sections.

For clear identification, a pictorial representation of potential problems and resolutions has been excerpted from Federal Emergency Management Agency (FEMA) 145, Dam Safety: An Owner's Guidance Manual, August 1987, and is contained in Appendix E for reference.

5.2 Personnel

Inspections shall be performed by a responsible person familiar with this Operation, Maintenance, and Inspection Manual. The same personnel shall perform all regular dam inspections to maintain consistency in reporting as well as familiarity with the structure. A checklist outlining the major inspection items for the dam and appurtenances is provided in Appendix B. Plant personnel should use this checklist to inspect the dam and report the findings. Currently, Mr. Randy Sims is the plant personnel responsible for performing Dam Inspections. Copies of the inspection findings should be sent to AEP Civil Engineering for evaluation.

5.3 Periodic Inspections

a. Periodic inspection of the dams is extremely important. AEP has regularly inspected the dams on a quarterly basis. AEP shall continue quarterly inspections.

   i. Three of the quarterly inspections can be completed by Cardinal Plant personnel.

   ii. The fourth quarterly inspections shall be completed by an engineer knowledgeable in dam safety. This inspector may be either a qualified AEP engineer or an independent consulting engineer. This inspection shall be a comprehensive review of field conditions and instrumentation readings.

b. Inspection instructions and an inspection checklist to be used to record observations are found in Appendix B.

c. The inspection procedures and findings must be documented in writing. The quarterly inspection reports shall be maintained for a minimum of 10 years.

d. If problems are found during an inspection that may affect the integrity of the dam, the EAP for the dam shall be followed for the appropriate emergency condition (A, B, or C) and the identified problems shall be placed under increased surveillance and scheduled for repair as appropriate. See also Appendix E for additional guidance.

e. Problems found during an inspection which do not immediately affect the integrity of the dam shall be noted and scheduled for follow-up monitoring and repair as appropriate.

5.4 Event Inspections

A brief inspection shall be made within 24 hours of unusual event such as seismic activity or significant precipitation event (e.g., greater than 3 inch of rain in 24 hours or 6 inches of rain in seven days) or within 24 to 48 hours after placing three or more stoplogs in the drop-inlet structures to ensure that the outlet structures and their discharge pipes are unobstructed, no earth slide has occurred, no significant erosion gullies have formed, and no seepage is present. Concentrate inspections at known problem areas; pool level; debris at outlet structure; new or increased seepage. These Inspections shall be recorded on the dam inspection checklist. Instrumentation should be recorded if new or increased seepage is detected during this inspection.

5.5 Informal Inspections

Informal inspections include both daily and weekly surveillance by Plant personnel looking for changes in conditions (slips along dam face, erosion gullies, excessive settlement, malfunctioning drains, new seepage areas, etc).

Informal inspections shall be made after every significant precipitation event (e.g., greater than 1/2 inch of rain or 3 inches of snow in 24 hours) to ensure that the outlet structures and their discharge pipes are unobstructed, no earth slide has occurred, no significant erosion gullies have formed, and no seepage is present.

These inspections shall be documented either on the checklist form or on an inspection log by indicating the date and time of the inspection, the inspector name(s), the weather conditions, any observed deficiencies or unusual change in the operating or physical conditions, and the overall physical condition of the dam or dike.

5.6 Instrumentation —Fly Ash Dam II

The following instrumentation has been installed to monitor key aspects of the dam's performance:

5.6.1 Seepage Collection/Measurement

Since the 1997 raising, seepage has been identified at three primary locations, specifically:

1. Along the right abutment of FAD II from a spring.
2. Along the left channel slope of the emergency spillway channel.
3. Above the discharge channel along the left side emerging from the bedrock
4. Additionally, a new seep was identified in June of 2013 along the right downstream abutment/dam groin. In October of 2013, an inverted filter and drain was installed. The pipe exiting the drain has been monitored at regular intervals since this time

and the seepage rate has been found to be approximately 0.25 gallons/minute and seepage itself free of fines. One last reading should be obtained within the week prior to stop log placement.

5. Any additional seeps discovered after the pool level has been raised will be added to the inspection list and monitored. If possible, collect seepage and monitor the flow through the use of a V-notch weir or a pipe.

6. Attention should be given to the area at the right groin downstream of the installed PVC sheet pile #79 to be able to trigger any seepage occurring in that area.

If seepage increases by more than 25% at any location, AEP Civil Engineering will immediately be contacted for evaluation.

AEP maintains a Drain and Seepage Zone Spreadsheet detailing drain number and location. This worksheet is included in Appendix B, Section 6 – Pipe Drains as part of the inspection checklist.

5.6.2 Piezometers/Observation Wells

1. Water levels in the piezometers shall be determined and recorded on a quarterly basis to monitor changes in the pore pressures within the dam. Water levels shall be measured to the nearest tenth of a foot. A form for recording the piezometer readings is provided in Appendix B.

2. In addition to quarterly monitoring, the piezometers shall be monitored during and after periods of high pool levels (pool level rise greater than 2 feet from a precipitation event). If piezometer water levels within the dam rise more than 2 feet during a flood event, contact AEP-Civil Engineering staff and/or a Professional Engineer for evaluation of the recorded data.

3. All piezometer monitoring must be done with regard to the safety of the personnel performing the monitoring. Personnel shall cease monitoring activities if weather conditions become hazardous (i.e., lightning), if failure of the dam is imminent, or if safe exit from the embankment will be cut off by flood flows.

5.6.3 Surface Monuments

More than 60 survey monuments have been installed on FAD II to monitor horizontal and vertical movements (See Appendix C). A monitoring plan illustration can be found in

Appendix B. Annual surveys are performed by AEP Civil Laboratory. Copies of the surveys should be sent to:

1. Cardinal Plant Manager
2. AEP Civil Engineering.

5.6.4 Slope Inclinometers

Five slope inclinometers have been installed on FAD II to monitor horizontal movements with depth along the central section of the dam (See Appendix C). Annual reading of the slope inclinometers are performed by AEP Civil Engineering Laboratory. Copies of the readings should be sent to:

1. Cardinal Plant Manager
2. AEP Civil Engineering.

6.0 EMERGENCY ACTION PLAN

The EAP for FAD II is made part of this O&M Manual but is provided as a separate document. The EAP includes the notification flowcharts of individuals/agencies that will be contacted in the event of unsafe conditions detected at any of the three dams.

6.1 Unsafe — Emergency

Each of the malfunctions listed under the UNSAFE — EMERGENCY performance corresponds to a rapid/instantaneous failure condition. Therefore, in the event that one or more of these malfunctions are detected, there may not be enough time for a thorough evaluation of the situation. Accordingly, the first action to be taken by field personnel is notifying the Team Leader who in turn should activate the EAP.

6.2 Unsafe — Non Emergency

Malfunctions under the category of UNSAFE — NON EMERGENCY corresponds to potentially hazardous conditions. These types of malfunctions should allow sufficient time for an expedient evaluation of the situation and for the implementation of remedial measures. Accordingly, the recommended immediate response in the event that one or more of these malfunctions is detected is to use an ALERT as dictated by the EAP and to upgrade the inspection and monitoring program.

6.3 Marginal Deficiency

The malfunctions in the Marginal Deficiency category do not pose a serious threat to the safety of the dam: Therefore, the appropriate field response is to alert the AEP Civil Engineering of the situation and follow up with the inspection checklist report.

6.4 Minor Deficiency

The remaining malfunctions correspond to maintenance rather than immediate safety related problems. These conditions, if detected, will not require any special immediate response other than the normal reporting required under the Dam Inspection and Maintenance Program. If appropriate, an order for maintenance work should be written and implemented by plant personnel.

INSPECTION RESPONSE TABLE

Performance Level of the Dam	Malfunctions or Undesirable Features	Actions to be Taken By Field Personnel (In Order Indicated)
UNSAFE Emergency	• Overtopping or activation of emergency spillway • Breach or slide below the waterline, which reaches the dam crest and/or seeps water. • Springs on abutment or downstream slope with muddy water and progressively increasing flow rate.	1. Notify Team Leader who in turn should issue a Notification. (See EAP) 2. Continue 24-hr. surveillance program, if possible. 3. Read all field instrumentation daily, if possible.
UNSAFE Non-emergency	• Springs on abutments or downstream face with muddy water but stable flow rate. • Pipes, cavities, or holes, which could be attributed to internal erosion, even without evidence of seepage. • Clogged drains. • Slide with no seepage and that does not reach the dam crest. • Noticeable increase in amount of foundation or abutment seepage or piezometer level.	1. Notify Team Leader who in turn should issue an Alert (see EAP). 2. Initiate a daily surveillance program. 3. Read all field instrumentation daily, if possible. 4. Report on Inspection Checklist.
MARGINAL Deficiency	• Cracks parallel or transverse to the dam. • Soft zones in downstream face or toe. • Previously undetected springs with clear water and stable flow rate on face of dam or abutments. • Excessive settlement of crest.	1. Contact AEP Civil Engineering. 2. Report on Inspection Checklist.
MINOR Deficiency	• Damaged instrumentation. • Sloughing. • Rodent burrows. • Surface or riprap erosion. • Trees and tall vegetation on embankments or spillway channel. • Poor vegetal cover.	1. Report on inspection Checklist. 2. Write repair order, if appropriate.

7.0 OWNER'S REVIEW

This Operation, Maintenance, and Inspection Manual was prepared for AEP's Cardinal facility fly ash dam II and bottom ash pond complex and supersedes all previous versions. I have read the Manual on behalf of AEP and understand the actions that will be required of AEP, and acknowledge that the information contained herein is, to the best of my knowledge, accurate as of the date of my signature.

Charles W George — 2-27-15

(Signature) — Date

Charles W George
Plant Manager

APPENDIX A
DAM MAINTENANCE RECORD

CARDINAL FAD II
DAM MAINTENANCE RECORD

FOR YEAR _____________

Maintenance	**Date**	**Initials**	**Comments [a]**
1. Cut/mow grass and clear brush			
2. Cut/mow grass and clear brush			
3. Cut/mow grass and clear brush			
4. Cut/mow grass and clear brush			
5. Remove debris from outlet structures			
6. Repair eroded areas			
7. Concrete repair (describe)			
8. Repair rodent damage			
9. Piezometers Maintenance (if required)			
10. Other (specify)			
11. Other (specify)			

[a] Use additional sheets if necessary.

____
Signature

APPENDIX B
DAM INSPECTION INSTRUCTIONS
AND
DAM INSPECTION CHECKLIST

A. Dam Inspection Instructions

1. Dike Inspection Checklist

a. Inspectors and others should include names and affiliations.

b. Weather and site conditions should include weather conditions and the condition of the ground surface (i.e., wet, snow covered, dry, etc.), at the time of the inspection. Note, if the inspection is occurring immediately after a heavy precipitation (e.g., greater than 0.5 inch rainfall or 3 inches of snow in the preceding 24 hours)

c. Fill in the information requested. Obvious problems will require maintenance. Monitoring will be recommended if there is potential for a problem to occur in the future.

2. Comments

a. A brief description of any noted irregularities, needed maintenance, or problems for each item checked should be made. Abbreviations and short descriptions are recommended.

3. Sketches and Field Measurements

a. Explanatory sketches, measurements of cracks, settlement, and additional explanation of observations should be placed on these pages. A copy of the Cardinal Plant Dam Inspection Location Plan should be used to indicate the locations of any concerns identified during an inspection.

b. Definitions:

CW	Clear Water
BA	Bottom Ash
GPM	Gallons Per Minute
MGD	Million Gallons per Day

CARDINAL PLANT
FLY ASH DAM II
INSPECTION CHECKLIST

CARDINAL PLANT
FLY ASH DAM II
INSPECTION CHECKLIST

1. GENERAL INFORMATION

Date of Inspection	
Inspected by	
Reason for Inspection	
Weather	
Temperature	
Rainfall During Previous 7 Days	
Reservoir Elevation: Fly Ash Dam II	
Available Spillway Freeboard (974.0 - Reservoir Elevation)	
Available Dam Crest Freeboard (983.0 - Reservoir Elevation)	

2. EMBANKMENT CONDITION

Note the conditions of the overflow structures and, to the extent practicable, the discharge pipes. Signify good conditions with a checkmark, problem areas with an X in the appropriate spaces below. The FAD II Inspection Location Page shall be used to indicate malfunction locations. Place a number or letter (location code) on the plan at each problem area. Place the same letter(s) or number(s) next to appropriate malfunction. Place sketches, notes, and comments.

Malfunction	"✔"or "X"	Location Code	Descriptive Features
Bulges			Areal extent and elevation
Cavities or Holes			General shape, size, and elevation
Cracks			Length, width, depth and elevation
Surficial Erosion, Gullies			Length, width, depth, areal extent
Sloughing/Slides			Areal extent, vertical drop
Soft Soil			Areal extent and vegetation
Springs/Seepage/ Wetness			Flow rate, muddy or clear water, areal extent, and elevation
Rodent Burrows			Size, areal extent if clustered
Poor Vegetal Cover			Areal extent

Malfunction	“ ✔ ”or “X”	Location Code	Descriptive Features
Trees or Tall Vegetation			Areal extent, height, trunk size
Excessive Crest Settlement			Settlement/affected crest length
Defects in Crest Road			Size, areal extent
Clogged Drains			Color and origin of deposit/size of color
Deteriorated Rip Rap Outlet Channel			Areal extent
Other (Please specify and describe)			

Note: All malfunctions which occur within the same general area should be shown in the same descriptive sketch or narrative for that particular problem area.

3. OVERFLOW STRUCTURE

Inspect the below listed structures. Place a "✔" in the space if the condition is good; place an "X" in the space if a problem is found and describe the problem below. If necessary, continue description of problem on Page 12, NOTES AND COMMENTS.

Description	**"✔" or "X"**	**Location Code**	**Descriptive Features**
Does discharge flow appear normal?			
Condition of concrete at spillway shaft			
Are extra stop logs available?			
Have stop logs been added? If yes, note number, date, and new top elevation			
Obstruction: note location(s)			
Have obstructions been removed?			
Are access stairs OK?			
Are the any rusted areas in the skimmer?			
Other (please specify)			

4. OUTLET WORKS

Please note the conditions with regard to the following items. If a problem is observed, please describe it.

Does the discharge flow appear normal at the energy dissipater?	
Is the condition of concrete at energy dissipater and Parshall flume OK?	
Is the condition of the Parshall flume OK?	
Is flow through the Parshall flume without turbulence?	
Is there any erosion or riprap problem at the outlet channel?	
Is rubble from the hillside obstructing or threatening to obstruct the outlet channel?	
Other comments.	

5. EMERGENCY SPILLWAY

Please note the conditions with regard to the following items. If a problem is observed, please describe it.

Are there any trees or obstructions in the channel?	
Is there evidence of instability on the side slopes?	
Are there erosion gullies or problems with the vegetal cover in the channel?	
Other comments.	

6. PIPE DRAINS

- Using a stopwatch, determine the time in seconds it takes each of the drainage blanket pipes to fill a 1- or 5-gallon bucket.
- Calculate the pipes discharge in gallons per minute (gpm).

Discharge = 60/time in seconds or 300/time in seconds.

- Record the measurements and describe the turbidity of the discharge in the table below.
- Note: The 12″ diameter spring flow (north of the large weir) can be calculated from the large weir flow minus the sum of all other incoming flows.

Pipe	Time (Sec)	Discharge (gpm)	Description
12″ Dia. Solid E. Underdrain El. 735 (North of Large Weir)			
12″ Dia. Perf. W. Underdrain El. 734 (North of Large Weir)			
12″ Dia. Solid Spring Outlet El. 738 (North of Large Weir)	See Note Above		
4″ Dia. Solid Spring Outlet El. 867 (East Abutment Ditch)			
12″ Dia. Solid Spring Outlet El. 893 (West Abutment Ditch)			
6″ Dia. Solid E. Sprg. Outlet El. 739 (@ Energy Dissipater)			
4″ Dia. Solid W. Sprg. Outlet El. 739 (@ Energy Dissipater)			
6″ Dia. Solid E. Groin Drain El. 907 (In Emerg. Spillway)			
12″ Dia. Solid RCC Drain El. 908 (In Emerg. Spillway)			
6″ Dia. Solid Right Groin Channel. Outlet El. 943			
Other			

7. V-NOTCH WEIRS

7.1 The large 12-inch weir measures the total surface flows, spring flows, and the underdrain flows from the riprap slide repair area.

- Read the head of water acting on the large weir from the staff gauge which is attached to a lumber post located approximately 5 feet upstream of the weir.

- With this reading and the rating curve for a 90° V-notch weir shown Page 14, determine the discharge over the weir in gpm. Record the water head and discharge as follows:

Head, inches	
Discharge, gpm	
Has a significant snowmelt occurred during the last 2 days?	
Additional comments about condition of the _______	

7.2 The small 6-inch weir (located south of the large weir in a small basin) measures all of the dam internal drainage blanket flows.

- Read the head of water acting on the weir from the floor of the weir and subtract 6 inches to obtain the correct reading.

- With this reading and the rating curve for a 90° V-notch weir shown on Page 14, determine the discharge over the weir in gpm.

- Record the water head and discharge as follows:

Head, inches	
Discharge, gpm	
Has a significant snowmelt occurred during the last 2 days?	
Additional comments about condition of the ___________________________	

8. PNEUMATIC PIEZOMETERS

8.1 Obtain water level readings at the piezometers that follow:

- Use the portable indicator to read the pressure, in psi, at each pneumatic piezometer following the procedure outlined in the Instruction Manual for Pneumatic-Pressure Transducer Model 51421102.

- Determine the pressure head in feet of water by multiplying the pressure by 2.308.

- Determine the water elevation or total head by adding the pressure head, in feet of water, to the corresponding elevation of the transducer tip (elevation head).

- Record the pressure and total head calculations in the table below.

Note: The piezometers with an asterisk (*) in front of their identification number should be read on the same schedule as the field inspections. All other piezometers should be read every three months.

PIEZOMETER RECORD

Piezometer No.	Pressure (psi)	Pressure Head (ft)	Elevation Head (ft)	Total Head (ft)	Comments
EXAMPLE	10.5	24.2	730.4	754.5	
P-1A			752.30		
P-2A			771.00		
P-3A			801.30		
P-3B			772.30		
*P-1BE			728.00		
*P-1BW			735.90		
*P-2BE			730.00		
*P-2BW			731.10		
*P-1C			714.40		
*P-2C			711.00		
*P-3C			712.30		
*P-4A			798.90		
P-5A			774.70		
P-5BR			725.30		
P-8A			802.10		
*P-8B			776.00		
*P-9			771.20		
*P-10			769.10		
*P-11			802.60		
P-11B			789.10		
P-RCC1			923.30		
P-RCC2			913.40		
P-RCC3			913.30		

Additional comments regarding piezometer readings and the condition of the terminal panel and housing structure.

9. HYDRAULIC (STANDPIPE) PIEZOMETERS

- Use a water level indicator to measure the depth to water in each hydraulic piezometer. Determine the water elevation (i.e., total head) by subtracting the depth of water from the elevation of the top of riser for the corresponding piezometers.
- Record the readings and calculations on the table below.
- The schedule for reading the hydraulic piezometers should be the same as for conducting the field inspections.

Piezometer

Piezometer No.	**Elevation of Top of Riser**	**Depth to Water**	**Water Elevation**	**Comments**
MW-1D	968.630			
MW-1S	968.630			
MW-5	980.205			
MW-6	980.555			
MW-7	972.500			
Additional comments regarding condition of the piezometer riser, protection casing, vented cap, etc.				

Open Bore Hole (RCC Zone)

Bore Hole No.	**Elevation of Top of RCC**	**Depth to Water**	**Water Elevation**	**Comments**
OB-1	970.205			
OB-2	970.015			
OB-3	969.950			
OB-4	696.915			
OB-5	969.890			
OB-6	696.885			
OB-7	969.865			
OB-8	969.880			
OB-9	969.935			
OB-10	970.015			
OB-11	970.035			
OB-12	961.965			
OB-13	961.240			

10. NOTES AND COMMENTS

11. REPAIR ORDERS WRITTEN AND REPAIRS DONE SINCE PREVIOUS INSPECTION


N
Bottom Ash Pond
Recirculation Pond
BOTTOM ASH COMPLEX
HORIZONTAL CONTROL:
DATUM: NORTH AMERICAN DATUM OF 1927 (NAD27)
ZONE: OHIO SOUTHERN
UNIT: U.S. SURVEY FEET
IMAGERY DATE: MAY, 2012
DRN BY:
DATE:
SCALE:
CARDINAL POWER STATION
BOTTOM ASH COMPLEX
DWG NO: FIGURE 1
AEP AMERICAN ELECTRIC POWER
AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

CARDINAL PLANT
BOTTOM ASH/RECLAIM DIKE
INSPECTION CHECKLIST

CARDINAL PLANT
BOTTOM ASH/RECLAIM POND AREAS
INSPECTION CHECKLIST

1. GENERAL INFORMATION

Date of Inspection	
Inspected by	
Weather	
Temperature	
Bottom Ash Pond Elevation	
Recirculation Pond Elevation	

2. EMBANKMENT CONDITION

Please refer to the Cardinal Ash Storage Areas Inspection Location Plan. Place a number or letter (Location Code) on the location plan at each problem area and place the same number(s) or letter(s) next to the appropriate malfunction below. For each problem area, provide a sketch or narrative describing the pertinent features of the malfunction(s) under NOTES and COMMENTS section.

Malfunction	**"✔" or "X"**	**Location Code**	**Descriptive Features**
Bulges			Areal extent and elevation
Cavities or Holes			General shape, size, and elevation
Cracks			Length, width, depth and elevation
Excessive Crest Settlement			Settlement/affected crest length
Rodent Burrows			Size, areal extent if clustered
Slides			Length, width, vertical drop & elevation
Sloughing			Areal extent and elevation
Springs/Seepage/ Wetness			Flow rate, muddy or clear water, areal extent, and elevation
Soft Soil			Areal extent and vegetation
Surficial Erosion			Length, width, depth, areal extent

Malfunction	“ ✔ ”or “X”	Location Code	Descriptive Features
Trees or Tall Vegetation			Areal extent, height, trunk size
Deteriorated Rip Rap			Areal extent
Poor Vegetal Cover			Areal extent
Other (Please specify and describe)			

Note: All malfunctions which occur within the same general area should be shown in the same descriptive sketch or narrative for that particular problem area.

3. OVERFLOW STRUCTURE

Please mark the appropriate spaces below with a checkmark if condition is good or briefly note observed problems; if necessary, continue description of problem under NOTES and COMMENTS.

Description	“ ✔ ” or “X”	Location Code	Descriptive Features
Does bottom ash discharge flow appear normal?			
Condition of bottom ash spillway tower.			
Condition of bottom ash skimmer.			
Are they any rusted areas in the skimmer?			
Obstructions: note location.			

Description	"✔" or "X"	Location Code	Descriptive Features
Have obstructions been removed?			
Are access stairs and walkway OK?			
Condition of recirculation structure.			
Does the recirculation overflow pipe have flow coming from it?			
Condition of concrete apron.			
Other (please specify)			

4. OUTLET WORKS

Please note the conditions with regard to the following items. If a problem is observed, please describe it.

Does the discharge flow appear normal at the recirculation pond?	
Other comments.	

5. EMERGENCY SPILLWAY

Both emergency spillways were removed from service in 1988 by backfilling with clay and bottom ash. The elevations are the same as the existing embankment crest. Please note the conditions with regard to the following items. If a problem is observed, please describe it.

Other comments.

6. HYDRAULIC (STANDPIPE) PIEZOMETERS

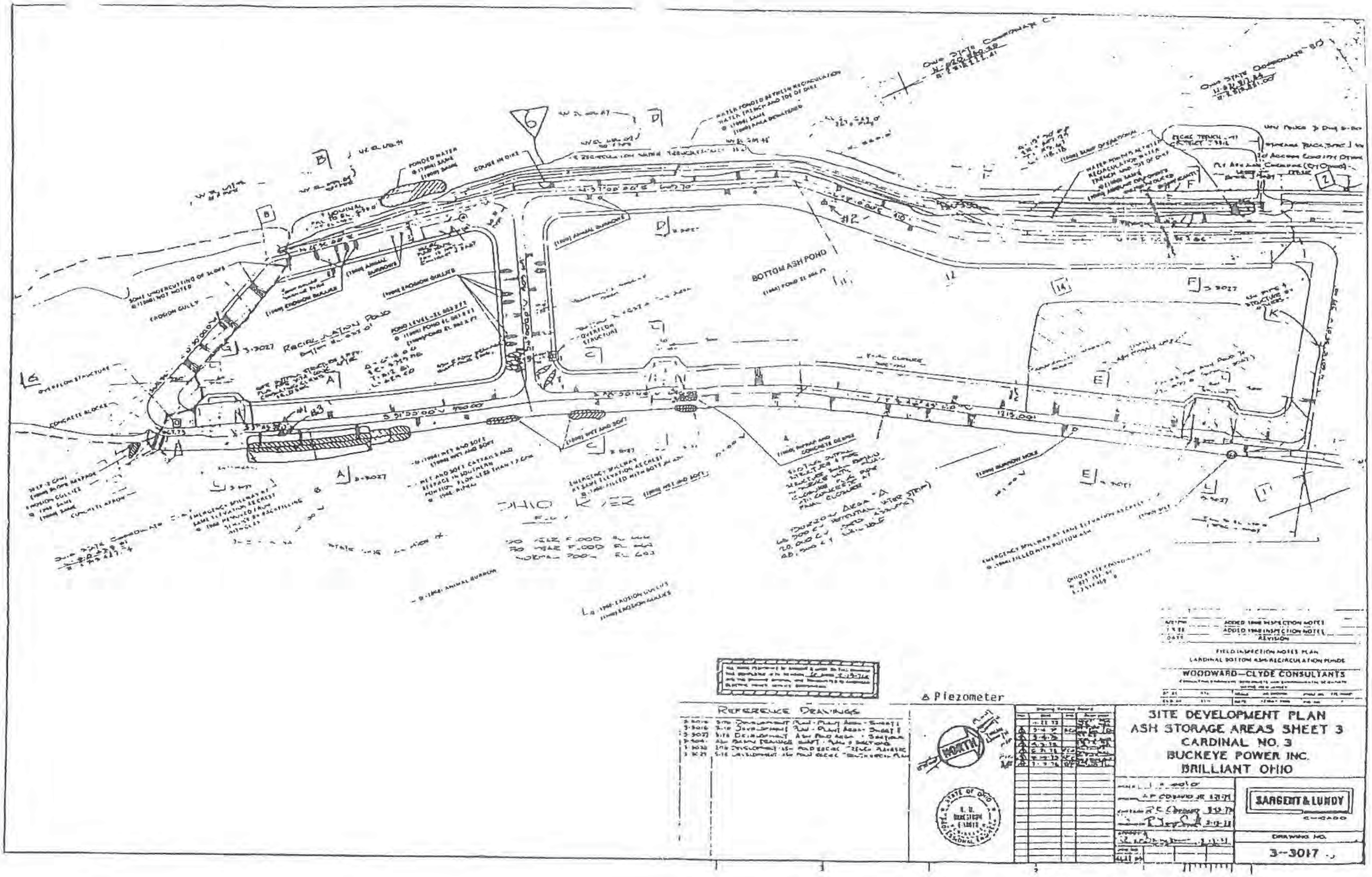
Use a water level indicator to measure the depth to water in each hydraulic piezometer. Determine the water elevation (i.e., total head) by subtracting the depth of water from the elevation of the top of riser for the corresponding piezometer. Record the readings and calculations on the table below. The schedule for reading the hydraulic piezometers should be the same as for conducting the field inspections.

Piezometer No.	Elevation of Top of Riser	Depth to Water	Water Elevation	Comments
1	671.56			Destroyed
2	672.47			
3	671.54			
B-0902	670.60			
B-0904	671.08			
B-0905	652.57			

7. NOTES AND COMMENTS

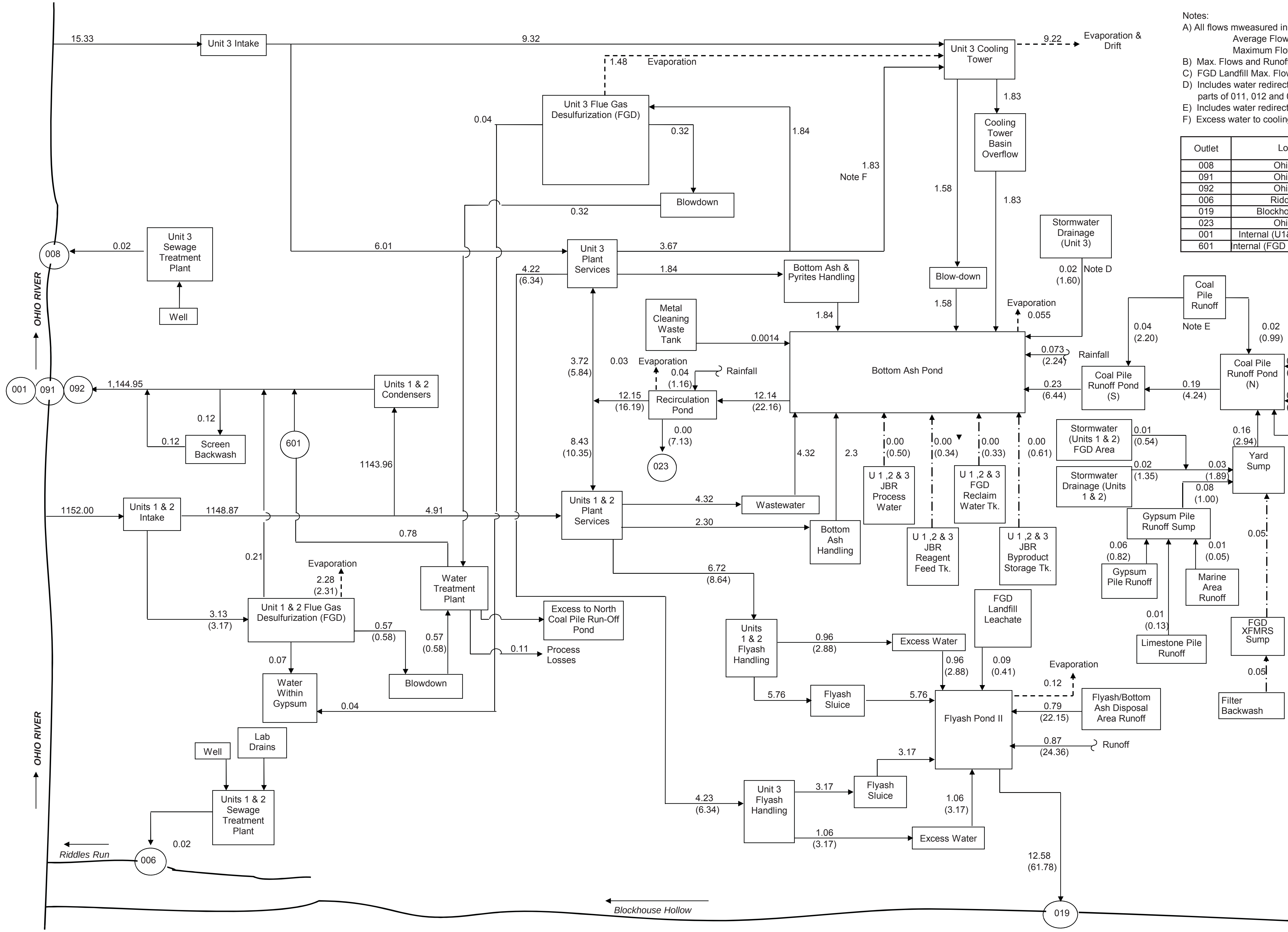
8. <u>REPAIR ORDERS WRITTEN AND REPAIRS DONE SINCE PREVIOUS INSPECTION</u>

Bottom Ash Complex Exhibit



BOTTOM ASH POND
RECIRCULATION POND
OHIO RIVER
Δ Piezometer
REFERENCE DRAWINGS
NORTH
FIELD INSPECTION NOTES PLAN
CARDINAL BOTTOM ASH RECIRCULATION PONDS
WOODWARD-CLYDE CONSULTANTS
SITE DEVELOPMENT PLAN
ASH STORAGE AREAS SHEET 3
CARDINAL NO. 3
BUCKEYE POWER INC.
BRILLIANT OHIO
SARGENT & LUNDY
CHICAGO
DRAWING NO.
3-3017

APPENDIX C
REFERENCE DRAWINGS AND PHOTOS



Notes:

A) All flows mweasured in Million Gallons per Day
Average Flow = MGD
Maximum Flow = (MGD)

B) Max. Flows and Runoff based on 10-yr/24-hr Storm

C) FGD Landfill Max. Flow basedon 25-yr/24-hr Storm

D) Includes water redirected from Outfalls 016, 017, and parts of 011, 012 and 013.

E) Includes water redirected from Outfall 010

F) Excess water to cooling tower.

Outlet	Location	Average Flow (MGD)
008	Ohio River	0.02
091	Ohio River	1,144.95
092	Ohio River	1,144.74
006	Riddles Run	0.02
019	Blockhouse Hollow	12.58
023	Ohio River	0.00
001	Internal (U1&2 Condensers)	1,143.96
601	Internal (FGD Water Treatment	0.78

Process water or Storm Water
Evaporation
Intermittent Flow
XXX - Outlet

12/10/2011

Cardinal Operating Company

Cardinal Plant

Average Flow - MGD
Maximum Flow - (MGD)

Water Balance Diagram

Water & Ecological Resource Services