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Coal Combustion Residue Impoundment

Round 9 - Dam Assessment Report

Northeastern 3 & 4 Station

Bottom Ash Basin
AEP Public Service Company of Oklahoma
Oologah, Oklahoma

Prepared for:

United States Environmental Protection Agency
Office of Resource Conservation and Recovery

Prepared by:

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INTRODUCTION, SUMMARY CONCLUSIONS AND RECOMMENDATIONS

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

This assessment of the stability and functionality of the Northeastern Station Bottom Ash Basin is based on a review of available documents and on the site assessment conducted by Dewberry personnel on Wednesday, February 16, 2011. We found the supporting technical documentation insufficient (Section 1.1.3). As detailed in Section 1.2.3, there are two recommendations based on field observations that may help to maintain a safe and trouble-free operation.

In summary, the Northeastern Station Bottom Ash Basin is rated **POOR** for continued safe and reliable operation. This rating is based on the lack of seismic stability studies to determine structural stability factors of safety for the dam. Upon receipt of data showing adequate structural soundness under seismic conditions (i.e., 2%, 50-year return period), the rating can be changed to satisfactory.

PURPOSE AND SCOPE

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

In early 2009, the EPA sent letters to coal-fired electric utilities seeking information on the safety of surface impoundments and similar facilities that receive liquid-borne material that store or dispose of coal combustion residue. This letter was issued under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

Section 104(e), to assist the Agency in assessing the structural stability and functionality of such management units, including which facilities should be visited to perform a safety assessment of the berms, dikes, and dams used in the construction of these impoundments.

EPA requested that utility companies identify all management units including surface impoundments or similar diked or bermed management units or management units designated as landfills that receive liquid-borne material used for the storage or disposal of residuals or by-products from the combustion of coal, including, but not limited to, fly ash, bottom ash, boiler slag, or flue gas emission control residuals. Utility companies provided information on the size, design, age and the amount of material placed in the units (See Appendix C).

The purpose of this report is **to evaluate the condition and potential of residue release from management units**. This evaluation included a site visit. Prior to conducting the site visit, a two-person team reviewed the information submitted to EPA, reviewed any relevant publicly available information from state or federal agencies regarding the unit hazard potential classification (if any) and accepted information provided in person and via telephone communication with the management unit owner. Also, after the 16 February 2011, field visit additional information was received on 9 March 2011, by Dewberry & Davis LLC about the Northeastern Station Bottom Ash Basin that was reviewed and used in preparation of this report.

This report presents the opinion of the assessment team as to the potential of catastrophic failure and reports on the condition of the management unit(s).

Note: The terms "embankment", "berm", "dike" and "dam" are used interchangeably within this report, as are the terms "pond", "basin", and "impoundment".

LIMITATIONS

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

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1.0 CONCLUSIONS AND RECOMMENDATIONS

1.1 CONCLUSIONS

Conclusions are based on visual observations from a one-day site visit, February 16, 2011, and review of technical documentation provided by AEP Public Service Company of Oklahoma.

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

The structural stability of the dike embankments and spillway cannot be fully determined based on a review of the engineering data and analyses provided by the owner's technical staff. No analyses were performed on structural stability under seismic loadings. Dewberry engineers did not observe any structural issues during the site visit.

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

A hydrologic analysis of the Bottom Ash Pond was provided to Dewberry in June 2011. The analysis demonstrated the pond can retain the 40% Probable Maximum Flood with a freeboard of 1.5 Ft.

1.1.3 Conclusions Regarding the Adequacy of Supporting Technical Documentation

The supporting technical documentation is inadequate for structural stability safety assessments of the Management Unit. Engineering documentation reviewed is referenced in Appendix A.

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

The description of the management unit provided by the owner was an accurate representation of what Dewberry observed in the field.

1.1.5 Conclusions Regarding the Field Observations

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

1.1.6 Conclusions Regarding the Adequacy of Maintenance and Methods of Operation

The current maintenance and methods of operation appear to be adequate for the bottom ash management unit. There was no evidence of significant embankment repairs or prior releases observed during the field inspection. However, there was indication that significant brushy vegetation and trees were cleared in the recent past. The remaining stumps and root balls may become an issue as they decay.

1.1.7 Conclusions Regarding the Adequacy of the Surveillance and Monitoring Program

The surveillance program appears to be adequate. The management unit dikes are not instrumented. Based on the size of the dikes, the portion of the impoundment currently used to store wet bottom ash and stormwater, the history of a current and regular inspection program, installation of a dike monitoring system is not needed at this time.

1.1.8 Classification Regarding Suitability for Continued Safe and Reliable Operation

The Management Unit is rated **POOR** for continued safe and reliable operation until receipt of the deficient documentation concerning seismic stability.

1.2 RECOMMENDATIONS

1.2.1 Recommendations Regarding the Structural Soundness of the Management Unit(s)

It is recommended that AEP perform a seismic analysis of the dikes for the Bottom Ash pond using a 2%, 50-year ground acceleration value to determine the Factor of Safety for the impoundment.

1.2.2 Recommendations Regarding the Hydrologic/Hydraulic Safety

None warranted at this time.

1.2.3 Recommendations Regarding the Maintenance and Methods of Operation

The following recommendations are warranted:

1. Observe remaining tree stumps and root balls for deterioration,
2. Excavate deteriorated organic matter, then fill and compact as needed with select material with high Bentonite content.

1.2.4 Recommendations Regarding the Surveillance and Monitoring Program

It is recommended that a document outlining maintenance and operations procedures be developed.

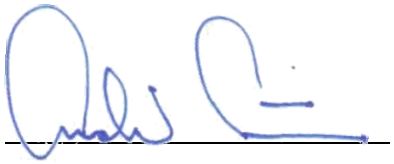
1.3 PARTICIPANTS AND ACKNOWLEDGEMENT

1.3.1 List of Participants

Sam Miller, American Electric Power
William R. Smith, American Electric Power
David Lee, American Electric Power
Gary Merkle, American Electric Power
Mark Barton, American Electric Power
Matt Miller, American Electric Power
Kyle Shepard, P.E., Dewberry
Andrew Cueto, P.E., Dewberry

1.3.2 Acknowledgement and Signature

We acknowledge that the management unit referenced herein has been assessed on February 16, 2011.



Andrew Cueto, P.E., PMP

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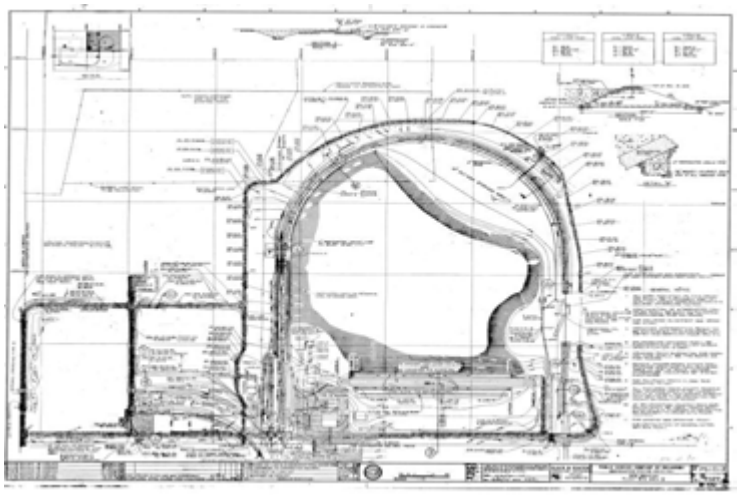
2.0 DESCRIPTION OF THE COAL COMBUSTION RESIDUE MANAGEMENT UNIT(S)

2.1 LOCATION AND GENERAL DESCRIPTION

The Northeastern 3 & 4 Station is located southeast of Oologah Oklahoma. The plant is operated by AEP Public Service Company of Oklahoma. The Bottom Ash Basin is located south of the generating station. A project site map is provided in Appendix A – Doc. 02. An aerial photograph of the impoundment is provided in Appendix A – Doc. 01.



The Northeastern Station Bottom Ash Basin is sandy clay with trace gravel embankment that impounds bottom ash and basin water. It was designed in August 29, 1975 and constructed shortly thereafter in 1979 (Appendix A Doc 2).

The table below provides the dimensions of the embankment:

Table 2.1: Summary of Dam Dimensions and Size	
	Northeastern Station Bottom Ash Basin
Dam Height (ft) (nominal)	26 feet
Crest Width (ft)	29 to 59 feet
Length (ft)	3670 feet
Side Slopes (upstream) H:V	2.5 : 1
Side Slopes (downstream) H:V	2.5 : 1

2.2 COAL COMBUSTION RESIDUE HANDLING

2.2.1 Fly Ash

The Fly Ash disposal process is a dry train procedure. AEP representatives preferred not to tour the Fly Ash disposal train. However, they did describe the process as follows:

1. Fly Ash is electrostatically precipitated and conveyed by gravity to a hopper,
2. The ash is then pneumatically conveyed into a holding silo,
3. The ash is then loaded via gravity feed into trucks (3rd party) to be conveyed to the dry landfill located on the south side of the facility,
4. The ash is stockpiled at the landfill to be either sold to a 3rd party for beneficial reuse or to be permanently disposed of in the landfill.

2.2.2 Bottom Ash

The Bottom Ash disposal process is a wet train procedure. Process was inspected on Wednesday, February 16, 2011 and is described herein.

2.2.3 Boiler Slag

The plant does not produce boiler slag.

2.2.4 Flue Gas Desulfurization Sludge

Flue Gas Desulfurization Sludge is not present at this site.

2.3 SIZE AND HAZARD CLASSIFICATION

The classification for size, based on the height of the dam is "Small", and based on the storage capacity is "Small", in accordance with the USACE Recommended Guidelines for Safety Inspection of dams ER 1110-2-106 criteria summarized in Table 2.2a.

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

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

The State of Oklahoma maintains a Dam Safety program through the Oklahoma Water Resource Board. The AEP – PSC of Oklahoma, Northeastern 3 & 4 Station Bottom Ash Basin embankment is not in the National Inventory of Dams and therefore does not have an established hazard classification. Dewberry conducted a qualitative hazard classification based on the 2004 Federal Guidelines for Dam Safety classification system (shown in Table 2.2b).

Table 2.2b: FEMA Federal Guidelines for Dam Safety Hazard Classification

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

Loss of human life is not probable in the event of a catastrophic failure of the embankment and a failure of the embankment is expected to have a low economic and environmental impact. Therefore, Dewberry evaluated the bottom ash basin as "**low hazard potential**".

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

The data reviewed by Dewberry did not include the volume of residuals stored in the bottom ash basin at the time of inspection. Table 2.3 values are provided in Appendix A – Doc 17.

Table 2.3: Maximum Capacity of Unit	
Northeastern 3 & 4 Station Bottom Ash Basin	
Surface Area (acre)[1]	34.0
Current Storage Capacity (10^3 cubic yards)[1]	237
Current Storage Capacity (acre-feet)[1]	147
Total Storage Capacity (10^3 cubic yards)	757
Total Storage Capacity (acre-feet)	469
Crest Elevation (feet)	630.00
Normal Pond Level (feet)	623.00

[1] Assumes current depth maintained by utility at 623 ft-msl

2.5 PRINCIPAL PROJECT STRUCTURES

2.5.1 Earth Embankment

The Embankment is earthen filled with sandy clay with trace gravel based on original construction boring data (see Appendix A – Doc 06).Approximate minimum crest width is 30 feet. Approximate embankment height is 20 feet at the emergency spillway. The embankment has an inner core anchored into the original ground at a depth of four (4) feet or to the top of rock, whichever was higher. Earthen material used in the inner core was classified in the construction documents as lean clay (CL) according to original specifications. The remainder of embankment uses material classified as CL, clayey sand (SC), clayey gravel (GC), or rock.

2.5.2 Outlet Structures

The discharge water generated by the Bottom Ash Basin is generally re-circulated by the Plant and therefore the Basin does not have a primary outlet structure.

A reinforced concrete overflow structure, which now serves as an emergency discharge, is located at the northwest corner of the Bottom Ash Basin. This structure appears to be in good condition. This structure

outfalls into a detention basin which directs water beneath the perimeter road through a culvert to the west and on into Fourmile Creek. Fourmile Creek then flows into the Verdigris River approximately a mile downstream. The capacity for the concrete overflow is not known.

2.6 CRITICAL INFRASTRUCTURE WITHIN FIVE MILES DOWN GRADIENT

The AEP Public Service Company of Oklahoma Northeastern 3 & 4 Station is located directly west of the dam that impounds Oologah Lake, a U.S. Army Corps of Engineers lake located on the Verdigris River. The Bottom Ash Basin is located on an unnamed tributary of Fourmile Creek which outfalls into the Verdigris River approximately a mile downstream.

No information was provided concerning critical infrastructure immediately downstream along Fourmile Creek and for over five miles downstream on the Verdigris River. Such data should be included in studies concerning a possible breach of the embankments.

3.0 SUMMARY OF RELEVANT REPORTS, PERMITS, AND INCIDENTS

3.1 SUMMARY OF REPORTS ON THE SAFETY OF THE MANAGEMENT UNIT

- Report for the Inspection of the Bottom Ash Pond at Northeastern Station Reservoir, April 2009, Submitted by Golder Associates, Inc.
- Dam & Dike Inspection Report, Bottom Ash Pond at Northeastern 3 & 4 Power Station, Rogers County, Oklahoma, Inspection Date: September 17, 2009. Prepared by AEP Service Corporation, Civil Engineering
- Final Geotechnical Investigation and Stability Evaluation of Bottom Ash Pond, March 11, 2010, Submitted by Standard Testing and Engineering Company.
- Dam & Dike Inspection Report, Bottom Ash Pond at Northeastern 3 & 4 Power Station, Rogers County, Oklahoma, Inspection Date: September 23, 2010. Prepared by AEP Service Corporation, Civil Engineering.

3.2 SUMMARY OF LOCAL, STATE, AND FEDERAL ENVIRONMENTAL PERMITS

While the State of Oklahoma has a Dam Safety Program that is the responsibility of the Oklahoma Water Resources Board (OWRB), this embankment is not currently required to be registered as a dam by the OWRB.

Discharge from the impoundment is regulated by the Oklahoma Department of Environmental Quality and the impoundment has been issued a National Pollutant Discharge Elimination System Permit. Permit No. OK0034380 was originally issued October 1, 1999 and re-issued on December 16, 2006.

3.3 SUMMARY OF SPILL/RELEASE INCIDENTS

Data reviewed by Dewberry did not indicate any spills, unpermitted releases, or other performance related problems with the dam over the last 10 years.

4.0 SUMMARY OF HISTORY OF CONSTRUCTION AND OPERATION

4.1 SUMMARY OF CONSTRUCTION HISTORY

4.1.1 Original Construction

The Northeastern 3 & 4 Station Bottom Ash Basin was constructed in 1979. According to original specifications and documents (see Appendix A – Doc 06) the embankments consist of lean clay, clayey sand, clayey gravel, and rock.

The original overflow structure crest elevation was 625.0. (See Appendix A – Doc 04).

4.1.2 Significant Changes/Modifications in Design since Original Construction

Prior to September 2009, the slope along the eastern portion of the southern embankment was steepened by the plant in order to provide an access road along the embankment crest parallel to the railroad track. The slope angle along the upper 15 feet of the crest in this area (approximately 1,000 feet) is 1:1 instead of the 2.5:1 design slope (H:V).

4.1.3 Significant Repairs/Rehabilitation since Original Construction

Notations have been made in the internal inspection reports over the past two years (2009 and 2010) of the following repairs / rehabilitation:

- Vegetation clearing
- Repair of eroded gullies on embankment slopes

4.2 SUMMARY OF OPERATIONAL PROCEDURES

4.2.1 Original Operational Procedures

The impoundment was designed and operated for bottom ash sedimentation and control. The basin receives plant process coal combustion waste slurry. Treated (via sedimentation) process water is re-circulated into the plant or discharged through the overflow outlet structure.

4.2.2 Significant Changes in Operational Procedures and Original Startup

No documents were provided to indicate any operational procedures have been changed.

4.2.3 Current Operational Procedures

Current operational process and procedures are as follows:

Bottom ash is wet conveyed to the head of the Bottom Ash Pond. A significant portion of the ash is deposited via sedimentation in the front portion of the pond. The Ash is then reclaimed from the pond via front end loaders and stockpiled for reuse and sale to a 3rd party.

Influent proceeds to the remaining portions of the pond where it is polished (i.e., suspended particles settle out). It is then pumped back into the Plant's process water and reused.

4.2.4 Other Notable Events since Original Startup

No additional information was provided to Dewberry of other notable events that have impacted the impoundment's operation.

5.0 FIELD OBSERVATIONS

5.1 PROJECT OVERVIEW AND SIGNIFICANT FINDINGS

Dewberry personnel Andrew Cueto, P.E., and Kyle Shepard, P.E., performed a site visit on Wednesday, February 16, 2011 in company with the participants.

The site visit began at 8:30 AM. The weather was cloudy and cool. Photographs were taken of conditions observed. Please refer to the Dam Inspection Checklist in Appendix B. Selected photographs are included here for ease of visual reference. All pictures were taken by Dewberry personnel during the site visit.

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

5.2 WEST EMBANKMENT

5.2.1 Crest

The crest of the West Embankment showed no signs of depressions, tension cracks, or other indications of settlement or shear failure, and appeared to be in satisfactory condition. A railroad track tops the crest of the embankment for its entire length. Vegetation is present within the track's ballast. Figure 5.2.1-1 shows the conditions of the crest of the West Embankment.

Figure 5.2.1-1. Photo showing railroad on crest and vegetation on the inside slope of West Embankment.

5.2.2 Upstream/Inside Slope

The impoundment's inside slope is generally grass covered, with the exception of the railroad track ballast and embankment slope riprap. Figures 5.2.1-1 and 5.2.2-1 shows these areas.

Figure 5.2.2-1. Inside slope grass and riprap

5.2.3 Downstream/Outside Slope and Toe

There were no observed scarps, sloughs, bulging, cracks, or depressions indicating slope instability or signs of erosion. The outside slope of the West Embankment was uniformly graded and covered with mowed grass. Rock riprap that is part of the toe drain drainage system is visible. The outside slope and toe appears to be in satisfactory condition. Figures 5.2.3-1 and 5.2.3-2 show the general condition of the outside slope and toe of the West Embankment.

Figure 5.2.3-1. West Embankment outside slope condition.

Figure 5.2.3-2. West Embankment toe conditions.

5.2.4 Abutments and Groin Areas

There were no observed abutments or groins for the West Embankment.

5.3 SOUTH EMBANKMENT

5.3.1 Crest

The crest of the South Embankment showed no signs of depressions, tension cracks, or other indications of settlement or shear failure, and appeared to be in satisfactory condition. A railroad track tops the crest of the embankment for its entire length. Vegetation is present within the track's ballast. Figure 5.3.1-1 shows the conditions of the crest of the South Embankment.

Figure 5.3.1-1. Figure showing the South Embankment crest condition.

5.3.2 Upstream/Inside Slope

The South Embankment's inside slope is generally grass covered, with the exception of the access road and embankment slope riprap. Figure 5.3.2-1 shows these areas.

Figure 5.3.2-1. South Embankment inside slope condition.

5.3.3 Downstream/Outside Slope and Toe

There were no observed scarps, sloughs, bulging, cracks, or depressions indicating slope instability or signs of erosion. The outside slope of the South Embankment was uniformly graded and covered with mowed grass. Rock riprap that is part of the toe drain drainage system is visible at the toe of slope. The outside slope and toe appears to be in satisfactory condition. Figure 5.3.3-1 shows the general condition of the outside slope and toe of the South Embankment.

Figure 5.3.3-1. Condition of South Embankment outside slope and toe.

5.3.4 Abutments and Groin Areas

The outside slope of the abutments and groin were uniformly graded and covered with mowed grass. Erosion or uncontrolled seepage was not observed along either groin. Figures 5.3.4-1 shows the representative condition of the abutments and groin.

Figure 5.3.4-1. Southern Groin.

5.4 NORTH EMBANKMENT

5.4.1 Crest

The crest of the North Embankment showed no signs of depressions, tension cracks, or other indications of settlement or shear failure, and appeared to be in satisfactory condition. Two access roads and a railroad track top the crest of this embankment for nearly its entire length. Figure 5.4.1-1 shows the conditions of the crest of the North Embankment.

Figure 5.4.1-1. North embankment crest with two access roads and railroad track at the east end

5.4.2 Upstream/Inside Slope

The North Embankment's inside slope is generally grass covered, with the exception of the embankment slope riprap. Figure 5.4.2-1 shows these conditions.

Figure 5.4.2-1. Conditions of inside slope of North Embankment.

5.4.3 Downstream/Outside Slope and Toe

There were no observed scarps, sloughs, bulging, cracks, or depressions indicating slope instability or signs of erosion. The outside slope of the North Embankment abuts other facilities of the Plant. It is uniformly graded and covered with mowed grass. This slope appears to be in satisfactory condition. Figure 5.4.3-1 shows the general condition of the outside slope of the North Embankment.

Figure 5.4.3-1. Outside slope of North Embankment.

5.4.4 Abutments and Groin Areas

There were no observed scarps, sloughs, bulging, cracks, or depressions indicating slope instability or signs of erosion on the groins of the North Embankment.

Figure 5.4.4-1. Northern Groin.

5.5 OUTLET STRUCTURES

5.5.1 Overflow Structure

The Overflow Structure is detailed in the original design drawings (See Appendix A – Doc 9). The structure has a 24-foot wide opening. The crest elevation is 625.00. The downstream end of the structure has a rock riprap area 10 feet long by 35 feet wide. There was no sign of debris on /in the structure and it is anticipated that the structure will operate as designed when/if the need arises. Doc. 9 and 10 in Appendix A shows the Overflow Structure.

Figure 5.5.1-1. Inlet end of the Overflow Structure.

Figure 5.5.1-2. Downstream view of Overflow Structure.

5.5.2 Outlet Conduit

The treated water from the Bottom Ash Basin is generally circulated back into the plant for reuse. Clear water was observed being re-circulated back to the Plant during the February 16th site visit.

5.5.3 Emergency Spillway

The overflow structure (Section 5.5.1) serves as the emergency spillway.

5.5.4 Low Level Outlet

No Low Level Outlet is present.

6.0 HYDROLOGIC/HYDRAULIC SAFETY

6.1 SUPPORTING TECHNICAL DOCUMENTATION

6.1.1 Flood of Record

No documentation has been provided about the flood of record.

6.1.2 Inflow Design Flood

The hydrologic analysis performed on the Bottom Ash Pond provides inflow design data. The analysis assumes runoff from an area of about 0.31 sq mi (199 acres) flows into the pond plus water pumped from the fly ash landfill retention basin (Basin C). The area encompasses the power plant, coal storage area and the bottom ash pond itself. (See Appendix A Doc 17)

Bottom Ash Pond – Based on Small Size Classification and Low Hazard Potential Classification, the spillway design flood (SDF) criterion is 50- to 100-year frequency. Existing impoundments should be satisfactory for at least the lower end of this range. The precipitation depths at the Northeastern 3 & 4 bottom ash pond, assuming 24-hour duration, are 7.92 inches and 8.85 inches for 50-year frequency and 100-year frequency, respectively, (Appendix A Doc 17). State regulations specify that a small dam with a significant hazard rating must hold a rainfall event equal to 40 percent of the Probable Maximum Flood (40% PMF).

6.1.3 Spillway Rating

Spillway hydraulic data is provided in Table 4 of the hydrologic analysis (Appendix A Doc 17). The maximum discharge rate is 529 cfs. Note the discharge rate is 0 when the pond is maintained at or below 625.0 ft-msl.

6.1.4 Downstream Flood Analysis

No downstream flood analysis data was provided for review.

6.2 ADEQUACY OF SUPPORTING TECHNICAL DOCUMENTATION

The Hydrologic Analysis for Northeastern 3 & 4 Bottom Ash Pond is adequate for determining the hydrologic safety of the pond.

6.3 ASSESSMENT OF HYDROLOGIC/HYDRAULIC SAFETY

Based on the calculations provided in the hydrologic analysis (See Appendix A – Doc 17) the Bottom Ash Pond can retain the 40% PMF design storm event with a freeboard of 1.85 ft, as shown in Table 6.1.

Table 6.1 Peak Flood Elevations for Bottom Ash Pond

Initial Elevation (ft-msl)	Peak Elevation (ft-msl)	Peak Inflow (cfs)	Peak Outflow (cfs)
623.0	627.87	1,490	344
625.0	628.15	1,490	396

Given a crest height of 630.0 ft-msl, a dike failure by overtopping seems improbable.

7.0 STRUCTURAL STABILITY

7.1 SUPPORTING TECHNICAL DOCUMENTATION

7.1.1 Stability Analyses and Load Cases Analyzed

Stability and load design analyses for the original construction design were not provided by the utility. Geotechnical boring data for the original construction were provided (See Appendix A – Doc 6).

A Slope Stability Analysis under steady state conditions was completed by Standard Testing and Engineering Company in March 2010 for by AEP-PSC. There was no rapid drawdown or seismic analysis performed. The pond is situated in an area of 0.1g according to USGS seismicity maps. The steady state stability analysis safety results are provided below. Details of the analysis are provided in Appendix A – Document 16.

7.1.2 Design Parameters and Dam Materials

Documentation provided to Dewberry for review was the March 11, 2010 Final Geotechnical Investigation and Stability Evaluation of Bottom Ash Pond, AEP Northeast Station, Units 3&4 (See Appendix A – Doc. 16).

7.1.3 Uplift and/or Phreatic Surface Assumptions

No documentation of uplift calculations was provided to Dewberry for review. Based on the geotechnical borings (See Appendix A – Doc. 6), the initial phreatic surface was assumed to be at the elevation measured in the borings.

7.1.4 Factors of Safety and Base Stresses

The safety factors computed in the Slope Stability Analysis report (See Appendix A – Doc. 16) are listed in Table 7.1.4. Note that no seismic loading analyses were performed.

Table 7.1.4 Factors of Safety for Northeastern 3 & 4 Bottom Ash Basin

Loading Condition	Soil Property	Required Safety Factor (US Army Corps of Engineers)	Computed Average Safety Factor
Steady State	Sandy Clay	1.5	1.74
Steady State with Seismic Loading		1.0	N/C
High Ground Water Conditions		1.3	N/C
Steady State	Clay	1.5	1.87
Seismic Loading		1.0	N/C
High Ground Water Conditions		1.3	N/C

7.1.5 Liquefaction Potential

The documentation reviewed by Dewberry did not include an evaluation of liquefaction potential. Foundation soil conditions do not appear to be susceptible to liquefaction.

7.1.6 Critical Geological Conditions

There was no documentation provided to Dewberry that included an evaluation of critical geological conditions.

7.2 ADEQUACY OF SUPPORTING TECHNICAL DOCUMENTATION

Structural stability documentation is limited, since no seismic analyses were performed. With no accompanying information concerning hydrology/hydraulics and no assessment of seismicity, we consider the supporting technical documentation to be inadequate.

7.3 ASSESSMENT OF STRUCTURAL STABILITY

Overall, the visual structural stability of the dam appears to be satisfactory based on the following observations made during the February 16, 2010 field visit by Dewberry (See Appendix A – Docs 13, 14, &15 for dam inspection reports):

- The crest appeared free of depressions and no significant vertical or horizontal alignment variations were observed,
- There were no major scarps, sloughs, or bulging along the embankments,
- Boils, sinks, or uncontrolled seepage were not observed along the slopes, groins, or toes of the embankments,
- The computed factors of safety (174 to 187 - Appendix A – Doc. 16) comply with accepted criteria.

However, the lack of non-steady state structural analyses leads to a conclusion of Poor for structural stability for the embankment.

8.0 ADEQUACY OF MAINTENANCE AND METHODS OF OPERATION

8.1 OPERATING PROCEDURES

The facility is operated as a settling basin and storage of bottom ash deposits for low volume wastes, bottom ash transport water (Units 3 & 4), coal pile runoff, and activated sludge-treated sanitary waste. Treated wastewater is evaporated, sent for further treatment at a WWTP prior to discharge through IMP 102, and land application to haul roads around Bottom Ash Basin, coal storage pile, and fly ash disposal basin area.

8.2 MAINTENANCE OF THE DAM AND PROJECT FACILITIES

While no maintenance plan was supplied to Dewberry for review, based upon observations made during the February 16, 2010 site visit and discussions with Plant representatives, dam maintenance appears to be adequate.

8.3 ASSESSMENT OF MAINTENANCE AND METHODS OF OPERATIONS

8.3.1 Adequacy of Operating Procedures

No documented operational procedures were supplied to Dewberry for review. However, a verbal description of maintenance procedures and methods was presented during the site visit.

8.3.2 Adequacy of Maintenance

No record of maintenance was supplied to Dewberry for review. However, a verbal description of maintenance procedures and methods was presented during the site visit. It was observed that the existing operating procedures adequately maintain the Management Unit. It was recommended that these procedures be documented and put into checklists.

9.0 ADEQUACY OF SURVEILLANCE AND MONITORING PROGRAM

9.1 SURVEILLANCE PROCEDURES

Inspections

The Northeastern 3 & 4 Station inspection procedures state, "Quarterly inspections shall be completed by Plant personnel and within 24 hours of unusual events, such as seismic activities or a "significant storm event". A significant storm event is defined as three inches or more of rainfall in 24 hours. Inspections should be documented in accordance to AEP Circular Letter CI-M-CL-010C."

Dewberry was not provided quarterly inspection reports. Annual inspections are performed by American Electric Power Service Corporation, Civil Engineering. Annual reports were provided for 2009 and 2010 (see Appendix A - Docs 14 and 15). A 2009 third party inspection report was also provided (see Appendix A – Doc 13). The inspection reports were comprehensive, with recommendations for improving operations and maintenance.

9.2 INSTRUMENTATION MONITORING

The Northeastern 3 & 4 Station Bottom Ash Basin embankments have three (3) 2-boring water level testing points equally spaced along the embankment. Water level measurements are collected quarterly.

9.3 ASSESSMENT OF SURVEILLANCE AND MONITORING PROGRAM

9.3.1 Adequacy of Inspection Program

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

9.3.2 Adequacy of Instrumentation Monitoring Program

The water level monitoring program appears to be adequate for this facility.

APPENDIX A

Document 1

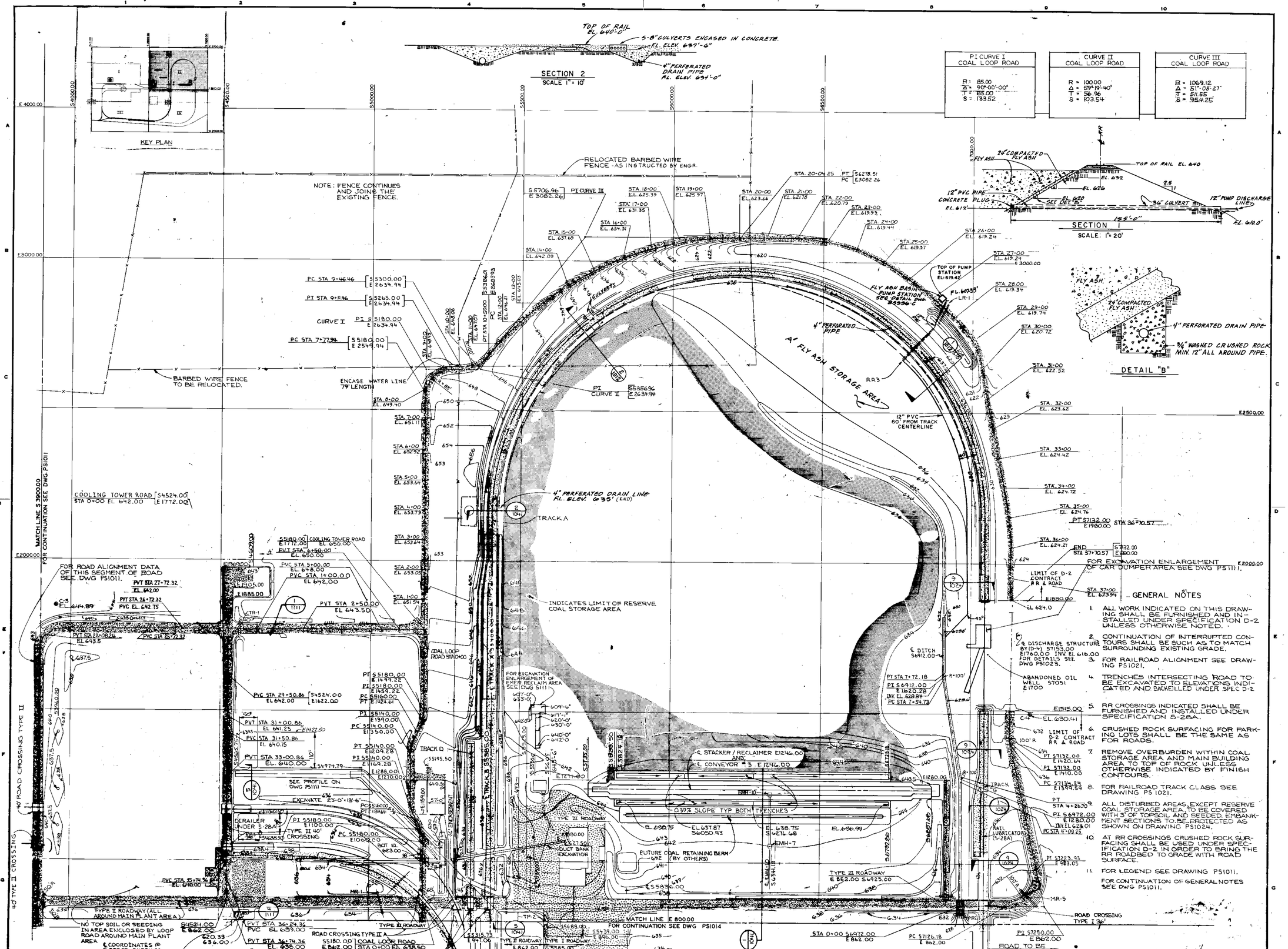
Aerial Map

E 400 Rd
88
169

APPENDIX A

Document 2

Site Grading Plan 1



GENERAL NOTES

1. ALL WORK INDICATED ON THIS DRAWING SHALL BE FURNISHED AND INSTALLED UNDER SPECIFICATION D-2 UNLESS OTHERWISE NOTED.
2. CONTINUATION OF INTERRUPTED CONTOURS SHALL BE SUCH AS TO MATCH SURROUNDING EXISTING GRADE.
3. FOR RAILROAD ALIGNMENT SEE DRAWING PS1021.
4. TRENCHES INTERSECTING ROAD TO BE EXCAVATED TO ELEVATIONS INDICATED AND BACKFILLED UNDER SPEC D-2.
5. RR CROSSINGS INDICATED SHALL BE FURNISHED AND INSTALLED UNDER SPECIFICATION S-28A.
6. CRUSHED ROCK SURFACING FOR PARKING LOTS SHALL BE THE SAME AS FOR ROADS.
7. REMOVE OVERBURDEN WITHIN COAL STORAGE AREA AND MAIN BUILDING AREA TO TOP OF ROCK UNLESS OTHERWISE INDICATED BY FINISH CONTOURS.
8. FOR RAILROAD TRACK CLASS SEE DRAWING PS 1021.
9. ALL DISTURBED AREAS, EXCEPT RESERVE COAL STORAGE AREA, TO BE COVERED WITH 3" OF TOPSOIL AND SEEDED. EMBANKMENT SECTIONS TO BE PROTECTED AS SHOWN ON DRAWING PS1024.
10. AT RR CROSSINGS CRUSHED ROCK SURFACING SHALL BE USED UNDER SPECIFICATION D-2. IN ORDER TO BRING THE RR ROADBED TO GRADE WITH ROAD SURFACE.
11. FOR LEGEND SEE DRAWING PS1011.

FOR CONTINUATION OF GENERAL NOTES SEE DWG PS1011.

10-8-76	REVISED AS CIRCLED	12	JM	TD		
6-15-76	REVISED AS CIRCLED	12	JM	TD		
5-26-76	REVISED AS CIRCLED	11	TS			
5-11-76	REVISED AS CIRCLED	10	JR		6-2-87	REVISED 12" PVC LINE AND UNDERDRAIN #7 @ 19
4-9-76	REVISED AS CIRCLED	9	JC		8-3-86	ADDED 12" PVC FLYASH PUMP DISCHARGE LINE @ 18

4-17-85	ADDED SEC. I, DET. B, RR UNDERDRAIN PIPES, CHANGED CONTOURS	17		
1-15-85	CONFORMED TO CONSTRUCTION RECORDS	16	JR	
1-21-77	REVISED AS CIRCLED	15	JC	
11-12-76	REVISED AS CIRCLED	14	JM	
DATE	REVISIONS AND RECORD OF ISSUE	REV.	BY	CK

SCALE: 1" = 100'

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF OKLAHOMA

DATE 8/29/75 REG. NO. 8892

BLACK & VEATCH CONSULTING ENGINEERS
PROJECT 6571/6572

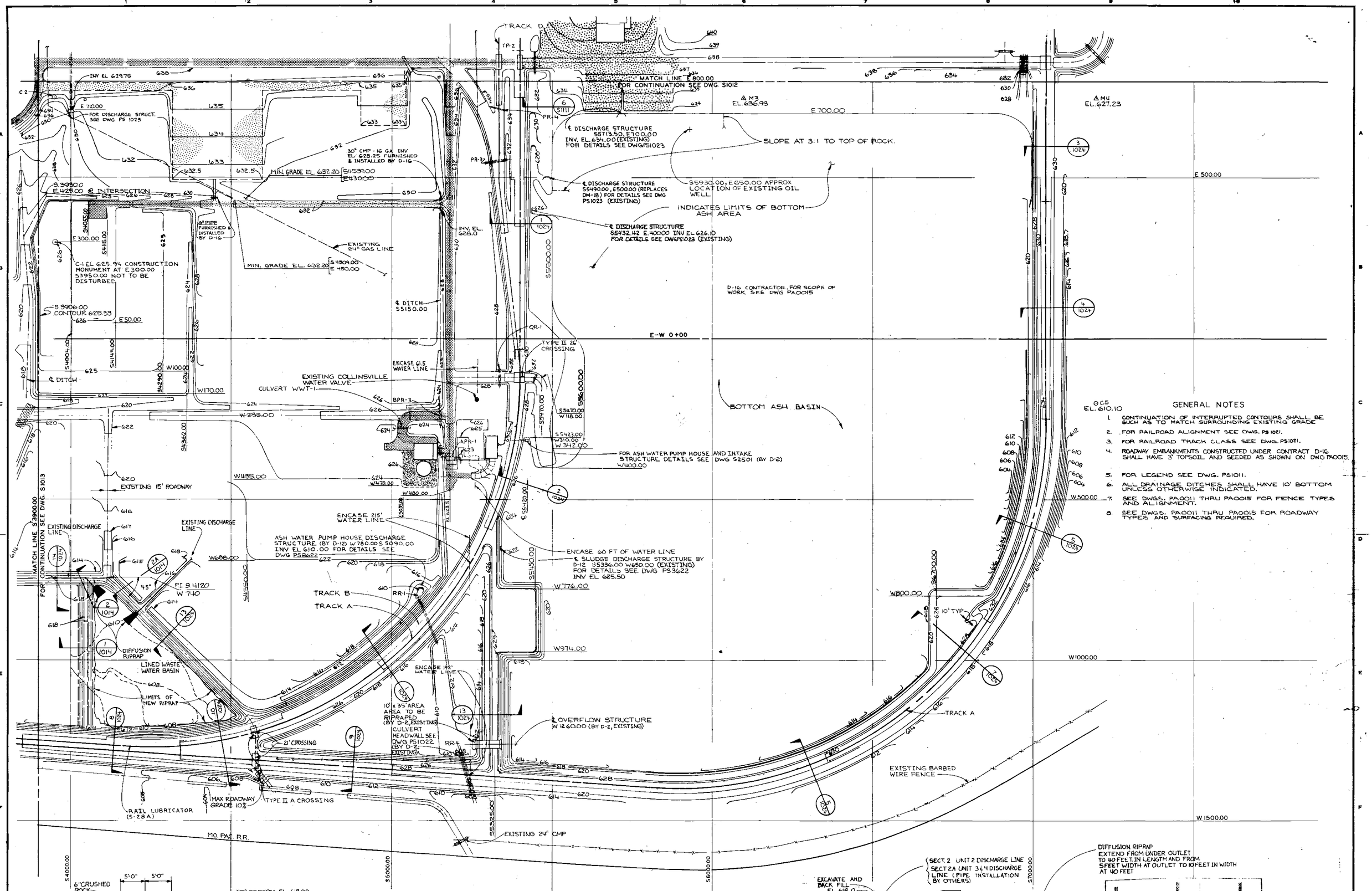
PUBLIC SERVICE COMPANY OF OKLAHOMA
NORTHEASTERN STATION-UNITS 3 & 4
SITE GRADING
PLANT SITE AREA II

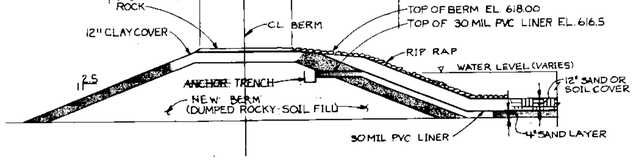
DWG. NO. PS1012
REV. 16
85127-5
PS 1012

APPENDIX A

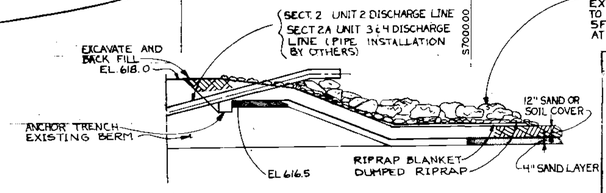
Document 3

Site Grading Plan 2





SECTION 1
NO SCALE



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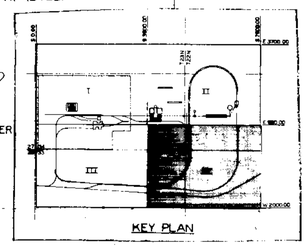


KEY PLAN

REV.	DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP
11-12-76	REVISED AS CIRCLED	13	UM	77	76
10-8-76	REVISED AS CIRCLED	12	UM	77	76
8-11-76	REVISED AS CIRCLED	11	ES	78	78
5-14-76	REVISED AS CIRCLED	10	BM	78	76
3-12-76	REVISED AS CIRCLED	9	CB	77	76
1-13-83	CONFORMED TO CONSTRUCTION RECORDS	21	JR	83	76
6-15-82	ISSUED FOR CONSTRUCTION, SPEC D-16	20	SB	82	76
5-21-82	ISSUED FOR ADDENDUM 1, SPEC D-16	19	SB	DE	76
5-6-82	ISSUED FOR BIDS, SPEC D-16	18	SB	82	76
8-14-80	ISSUED FOR BIDS; 1	17	TW	82	DE
11-3-78	ADDED ROADWAY & CULVERT	16	JR	JG	76
10-5-78	REVISED AS CIRCLED	15	JR	77	76
9-22-78	ISSUED FOR BIDS, SPEC D-12	14	JR	78	76

SCALE: 1" = 100'

DEPT HEAD CLM
DES. ENGR. 77
CHECKED 77
DRAWN KDJ

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF OKLAHOMA
SIGNED
DATE 9/29/75 REG. NO. 8492

BLACK & VEATCH CONSULTING ENGINEERS
PROJECT 6571/6572

PUBLIC SERVICE COMPANY OF OKLAHOMA
NORTHEASTERN STATION—UNITS 3 & 4

SITE GRADING
PLANT SITE AREA IV

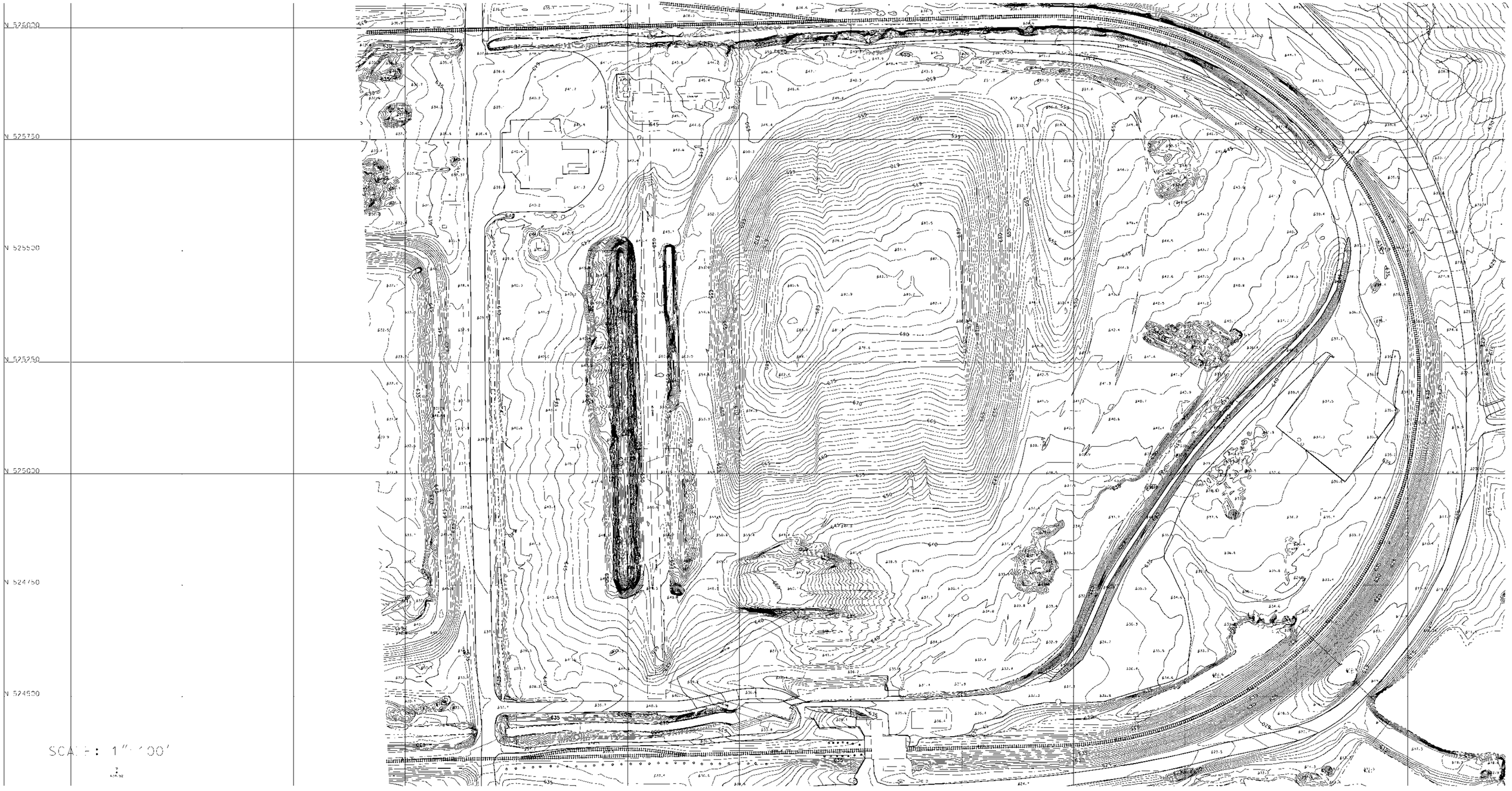
B & V DWG. NO. PS1014
REV. NO. 21
PSO DWG. NO. 85127-E
SHT. 1014

NE34P000006

APPENDIX A

Document 4

Site Topography Map

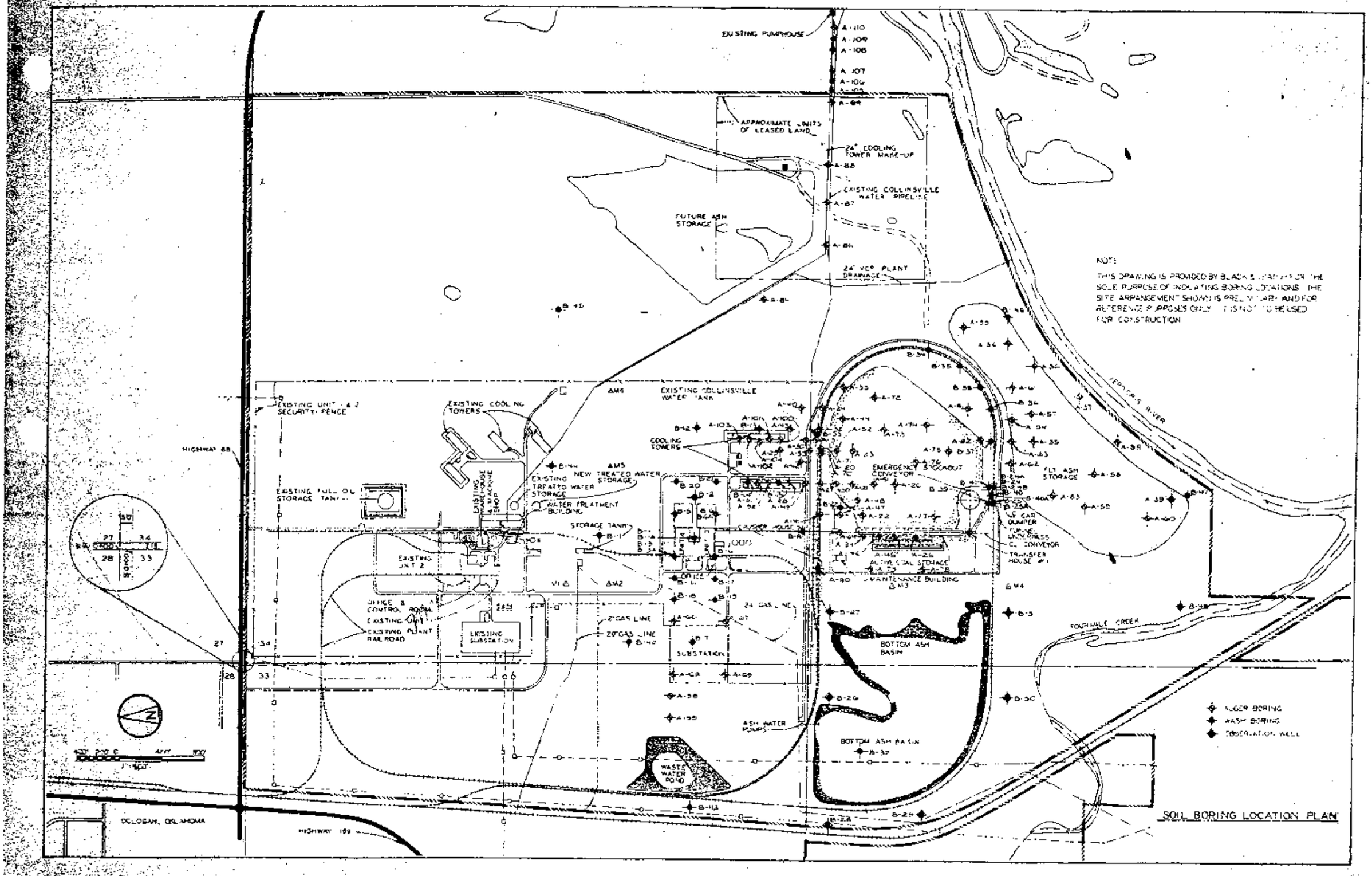


NE34P000094

APPENDIX A

Document 5

Original Soil Boring Location



NE34P000005

APPENDIX A

Document 6

Original Boring Logs

BORING LOG

HOLE NO. A-73

PROJECT Northeast Power Station - Oologah, Oklahoma

SHEET 1 OF 1

HOLE LOCATION 60+00S, 22+00E.

DATE 1-14-75

GR. ELEV. 636.1 WATER TABLE None (After 24 hours) BORED BY Ridcle LOGGED BY Drywater

ELEV.	DEPTH AND SCALE	L.GND.	DESCRIPTION OF MATERIAL (TYPE, COLOR, TEXTURE, CONSISTENCY)
635.1	1.0		CLAY, Silty, Sandy, Dark Brown w/Small Gravel
			LIMESTONE
			NOTE: 1 Bag Sample (Ot) @ 0'-1.0'

CASING INFORMATION

SIZE	FT-RUN	FT-PULLED	FT-LEFT

DRILLING MUD

TYPE	NO SACKS

PENETRATION TEST

FROM	TO	BLOWS/FT

SHELBY TUBE SAMPLES

NO.	FROM	TO

CORING

FROM	TO	RECOVERY

WATER LOSS

CEMENT (NO. SACKS)

REMARKS

CONSULTING ENGINEERING • GEOLOGICAL INVESTIGATION • ENGINEERING INSPECTION

HEMPHILL CORPORATION

4834 SOUTH 83RD EAST AVENUE

OFFICE: (918) 622-5133 TULSA, OKLAHOMA 74145 AFTER HOURS 587-5822

BORING LOG

HOLE NO. A-74

PROJECT Northeast Power Station - Oologah, Oklahoma SHEET 1 OF 1

HOLE LOCATION 64+00S, 9+00E DATE 1-14-75

GR. ELEV. 610.3 WATER TABLE None (After 24 hours) BORED BY Riddle LOGGED BY Drywater

ELEV	DEPTH AND SCALE	LGND.	DESCRIPTION OF MATERIAL (TYPE, COLOR, TEXTURE, CONSISTENCY)
609.3	1.0		CLAY, Silty, Sandy, Dark Brown, Moist Soft
			LIMESTONE
			NOTE: 1 Bag Sample (Qt) @ - 0'-1.0'

CASING INFORMATION

SIZE	FT-RUN	FT-PULLED	FT-LEFT

DRILLING MUD

TYPE	NO. SACKS

PENETRATION TEST

FROM	TO	BLOWS/FT

SHELBY TUBE SAMPLES

NO.	FROM	TO

CORING

FROM	TO	RECOVERY

WATER LOSS

CEMENT (NO. SACKS)

REMARKS

CONSULTING ENGINEERING • GEOLOGICAL INVESTIGATION • ENGINEERING INSPECTION

HEMPHILL CORPORATION

4834 SOUTH 83RD EAST AVENUE

OFFICE (918) 622-5133 TULSA, OKLAHOMA 74145 AFTER HOURS 587-5622

BORING LOG

HOLE NO. [illegible]

PROJECT Northeast Power Station - Oologah, Oklahoma

SHEET 1 OF 1

HOLE LOCATION 54+00S, 94+00E,

DATE 1-14-75

GR. ELEV. 635.4 WATER TABLE None (After 24 hours) BORED BY Riddle LOGGED BY Drywater

ELEV.	DEPTH AND SCALE	LGND.	DESCRIPTION OF MATERIAL (TYPE, COLOR, TEXTURE, CONSISTENCY)
633.7	1.7		CLAY, Silty, Sandy, Dark Brown, Moist Soft
632.4	3.0		CLAY, Sandy, Tan, Moist, Stiff w/Small Gravel
			LIMESTONE
			NOTE: 2 Bag Samples (Qt) @ - 0'-1.7', 1.7'-3.0'

CASING INFORMATION

SIZE	FT-RUN	FT-PULLED	FT-LEFT

DRILLING MUD

TYPE	NO. SACKS

PENETRATION TEST

FROM	TO	BLOWS/FT

SHELBY TUBE SAMPLES

NO.	FROM	TO

CORING

FROM	TO	RECOVERY

WATER LOSS

CEMENT (NO. SACKS)

REMARKS

CONSULTING ENGINEERING • GEOLOGICAL INVESTIGATION • ENGINEERING INSPECTION

HEMPHILL CORPORATION

4834 SOUTH 83RD EAST AVENUE

OFFICE-(918) 622-5133 TULSA OKLAHOMA 74145 AFTER HOURS 587-5822

BORING LOG

HOLE NO. B-26

PROJECT: Northeast Power Station - Oologah, Oklahoma — SHEET 1 OF 1

HOLE LOCATION: 55+00 S, 3+00W — DATE: 12-26-74

GR. ELEV. 627.9 — WATER TABLE: None — BORED BY: Summers — LOGGED BY: Drywater

Drilled with water

ELEV.	DEPTH AND SCALE	LGND	DESCRIPTION OF MATERIAL (TYPE, COLOR, TEXTURE, CONSISTENCY)
625.9	2.0		CLAY, Silty, Sandy, Dark Brown, Moist, Stiff
623.9	4.0		CLAY, Sandy, Reddish, Tan, Moist, Stiff
621.9	6.0		LIMESTONE, Gray
			LIMESTONE, Grayish w/Gray Shale Lenses and partings w/Calcite Crystals
			NOTE: 2.0' casing above surface 6.0' casing below surface Hole Diameter 6 7/8" Point of Change of Hole Diameter 5'0". Reference point elevation 630.4. Boring-casing annulus grouted back to surface. 8.0' of 5" PVC plastic pipe with cap set in hole.
607.9	20.0		Bottom of Hole

CASING INFORMATION

SIZE	FT-RUN	FT-PULLED	FT-LEFT

DRILLING MUD

TYPE	NO. SACKS

PENETRATION TEST

FROM	TO	BLOWS/FT

SHELBY TUBE SAMPLES

NO.	FROM	TO

CORING

FROM	TO	RECOVERY	RQD
6.0	10.0	100%	96%
10.0	15.0	100%	95%
15.0	20.0	100%	100%

WATER LOSS

CEMENT (NO. SACKS)

REMARKS

NOTE: Hole flushed with clear water.

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HEMPHILL CORPORATION

4834 SOUTH 83RD EAST AVENUE

OFFICE-(918) 622-5133 TULSA, OKLAHOMA 74145 AFTER HOURS 587 5822

BORING LOG

HOLE NO. B-27

PROJECT Northeast Power Station - Oologah, Oklahoma SHEET 1 OF 1

HOLE LOCATION 55+00 S, 5+00 E DATE 12/23-27/74

GR. ELEV. 626.0 WATER TABLE None BORED BY Summers LOGGED BY Drywater
(Drilled with water)

ELEV.	DEPTH AND SCALE	LGND	DESCRIPTION OF MATERIAL (TYPE, COLOR, TEXTURE, CONSISTENCY)
626.5	1.5		CLAY, Silty, Sandy, Dark Brown, Moist Stiff
624.5	3.5		LIMESTONE, Grayish
623.5	4.5		LIMESTONE, Grayish w/Tan, Clay Lenses
			LIMESTONE, Grayish w/Gray Shale Lenses and partings and Calcite Cyrstals
			NOTE: 2.0' casing above surface 3.5' casing below surface Hole Diameter 6 7/8" Point of Change of Hole Diameter 3'5". Reference point elevation 630.2. Boring-casing annulus grouted back to surface. 5.5' of 5" PVC plastic pipe with cap set in hole.
613.0	15.0		Bottom of Hole

CASING INFORMATION

SIZE	FT-RUN	FT-PULLED	FT-LEFT

DRILLING MUD

TYPE	NO SACKS

PENETRATION TEST

FROM	TO	BLOWS/FT

SHELBY TUBE SAMPLES

NO.	FROM	TO

CORING

FROM	TO	RECOVERY	RQD
5.0	10.0	96%	96%
10.0	15.0	92%	92%

WATER LOSS

CEMENT (NO. SACKS)

REMARKS

NOTE: Hole flushed with clear water.

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HEMPHILL CORPORATION

4834 SOUTH 83RD EAST AVENUE
TULSA, OKLAHOMA 74145

OFFICE (918) 622-5133 AFTER HOURS 587-5622

BORING LOG

HOLE NO. 9-93

PROJECT Northeast Power Station - Oologah, Oklahoma SHEET 1 OF 2

HOLE LOCATION 55+00 S, 15+00 W DATE 12-23-74

GR. ELEV. 611.8 WATER TABLE None BORED BY Summers LOGGED BY Drywater
(Drilled with water)

ELEV.	DEPTH AND SCALE	LGND.	DESCRIPTION OF MATERIAL (TYPE, COLOR, TEXTURE, CONSISTENCY)
610.8	1.0		CLAY, Silty, Sandy, Dark Brown, Moist, Soft
608.8	3.0		LIMESTONE, Grayish w/Clay Lenses and Gray Shale Partings
605.5	6.3		LIMESTONE, Grayish w/Clay lenses and Gray Shale Partings
			LIMESTONE, Grayish w/Gray Shale Lenses partings and Calcite Crystals
	20.0		

NOTE: 2.0' casing above surface
3.0' casing below surface
Hole Diameter 6 7/8"
Point of change of hole diameter 3'0". Reference point elevation 613.2.

5.0' of PVC plastic pipe with cap set in hole. Boring-casing annulus grouted back to surface.

CASING INFORMATION

SIZE	FT-RUN	FT-PULLED	FT-LEFT

DRILLING MUD

TYPE	NO SACKS

PENETRATION TEST

FROM	TO	BLOWS/FT

SHELBY TUBE SAMPLES

NO.	FROM	TO

CORING

FROM	TO	RECOVERY	RQD
5.0	10.0	86%	86%
10.0	15.0	100%	100%
15.0	20.0	100%	100%
20.0	22.0	90%	90%

WATER LOSS

CEMENT (NO. SACKS)

REMARKS

CONSULTING ENGINEERING • GEOLOGICAL INVESTIGATION • ENGINEERING INSPECTION

HEMPHILL CORPORATION

4834 SOUTH 83RD EAST AVENUE
TULSA, OKLAHOMA 74145

OFFICE-(918) 622-5133 AFTER HOURS 587-5822

BORING LOG

HOLE NO. B-29

PROJECT Northeast Power Station - Oologah, Oklahoma

SHEET 2 OF 2

HOLE LOCATION 55+00 S, 15+00 W

DATE 12-26-74

GR. ELEV. 611.8 WATER TABLE None (Drilled with water) BORED BY Summers LOGGED BY Drywater

ELEV.	DEPTH AND SCALE	LGND.	DESCRIPTION OF MATERIAL (TYPE, COLOR, TEXTURE, CONSISTENCY)
598.8	22.0		LIMESTONE, Grayish w/Gray Shale Lenses Partings and Calcite Cyrstals
			Bottom of Hole

CASING INFORMATION

SIZE	FT-RUN	FT-PULLED	FT-LEFT

DRILLING MUD

TYPE	NO SACKS

PENETRATION TEST

FROM	TO	BLOWS/FT

SHELBY TUBE SAMPLES

NO.	FROM	TO

CORING

FROM	TO	RECOVERY

WATER LOSS

CEMENT (NO. SACKS)

REMARKS

CONSULTING ENGINEERING • GEOLOGICAL INVESTIGATION • ENGINEERING INSPECTION

HEMPHILL CORPORATION

4634 SOUTH 83RD EAST AVENUE

OFFICE (918) 622-5133 TULSA, OKLAHOMA 74145 AFTER HOURS 587-5622

BORING LOG

HOLE NO. B-29

PROJECT Northeast Power Station - Oolocah, Oklahoma **SHEET** 1 **OF** 2

HOLE LOCATION 64+00 S, 14+00 W **DATE** 12-23-74

GR. ELEV. 610.3 **WATER TABLE** None **BORED BY** Summers **LOGGED BY** Drywater
(Drilled with water)

ELEV.	DEPTH AND SCALE	LGND.	DESCRIPTION OF MATERIAL (TYPE, COLOR, TEXTURE, CONSISTENCY)
608.8	1.5		CLAY, Silty, Sandy, Dark Brown, Moist Stiff
606.8	3.5		LIMESTONE, Grayish w/Clay Lenses
598.8	11.5		LIMESTONE, Grayish w/Clay lenses and Gray Shale partings and Calcite Crystals
	20.0		LIMESTONE, Grayish w/Gray Shale Lenses and Partings and Calcite Crystals NOTE: 2.0' casing above surface 3.5' casing below surface Hole Diameter 6 7/8" Point of change of hole diameter 6 7/8". Reference point elevation 612.3. 5'5" of PVC plastic pipe with cap set in hole. Boring-casing annulus grouted back to surface.

CASING INFORMATION

SIZE	FT-RUN	FT-PULLED	FT-LEFT

DRILLING MUD

TYPE	NO SACKS

PENETRATION TEST

FROM	TO	BLOWS/FT

SHELBY TUBE SAMPLES

NO.	FROM	TO

CORING

FROM	TO	RECOVERY	RQD
5.0	10.0	92%	92%
10.0	12.5	96%	96%
12.5	21.0	99%	98%

WATER LOSS

CEMENT (NO. SACKS)

REMARKS

CONSULTING ENGINEERING • GEOLOGICAL INVESTIGATION • ENGINEERING INSPECTION

HEMPHILL CORPORATION

4634 SOUTH 83RD EAST AVENUE
TULSA, OKLAHOMA 74145

OFFICE (918) 622-5133 AFTER HOURS 587-3642

BORING LOG

HOLE NO. B-20

PROJECT Northeast Power Station - Oologah, Oklahoma SHEET 2 OF 2

HOLE LOCATION 64+00 S, 14+00 W DATE 12-27-74

GR. ELEV. 610.3 WATER TABLE None BORED BY Summers LOGGED BY Drywater

(Drilled with water)

ELEV.	DEPTH AND SCALE	LGND.	DESCRIPTION OF MATERIAL (TYPE, COLOR, TEXTURE, CONSISTENCY)
			LIMESTONE, Grayish w/Gray Shale, Lenses and Partings and Calcite Crystals
584.3	26.0		
			Bottom of Hole

CASING INFORMATION

SIZE	FT-RUN	FT-PULLED	FT-LEFT

DRILLING MUD

TYPE	NO. SACKS

PENETRATION TEST

FROM	TO	BLOWS/FT

SHELBY TUBE SAMPLES

NO.	FROM	TO

CORING

FROM	TO	RECOVERY	RQD
21.0	26.0	98%	98%

WATER LOSS

CEMENT (NO. SACKS)

REMARKS

CONSULTING ENGINEERING • GEOLOGICAL INVESTIGATION • ENGINEERING INSPECTION

HEMPHILL CORPORATION
4834 SOUTH 83RD EAST AVENUE
TULSA, OKLAHOMA 74145
OFFICE (918) 622-5133 AFTER HOURS 587-5622

NE34P000168

BORING LOG

HOLE NO. 9-30

PROJECT Northeast Power Station - Oologah, Oklahoma SHEET 1 OF 1

HOLE LOCATION 72+00 S, 3+00 W DATE 12/23&30/74

GR. ELEV. 611.3 WATER TABLE None BORED BY Summers LOGGED BY Drywater
(Drilled with water)

ELEV.	DEPTH AND SCALE	LGND.	DESCRIPTION OF MATERIAL (TYPE, COLOR, TEXTURE, CONSISTENCY)
610.3	1.0		SILT, Clayey, Dark Brown, Very Moist, Soft
608.3	3.0		LIMESTONE, Grayish
			LIMESTONE, Grayish w/Tan, Clay Seams and Shale Partings w/Calcite Crystals and Solution Cavities
			NOTE: Water circulation lost @ 13.5', Hole cut from 13.5' - 20.0' with 3 7/8" roller.
			NOTE: 2.0' casing above surface 3.0' casing **below** surface Hole Diameter 6 7/8" Point of Change of hole diameter 3.0', Reference point elevation 613.4. 5' of 5" PFC w/cap set. Boring-casing annulus grouted back to surface. Hole flushed with clear water
591.3	20.0		Bottom of Hole

CASING INFORMATION

SIZE	FT-RUN	FT-PULLED	FT-LEFT

DRILLING MUD

TYPE	NO. SACKS

PENETRATION TEST

FROM	TO	BLOWS/FT

SHELBY TUBE SAMPLES

NO.	FROM	TO

CORING

FROM	TO	RECOVERY	RQD
5.0	10.0	96%	96%
10.0	13.5	91%	91%

WATER LOSS

CEMENT (NO. SACKS)

REMARKS

CONSULTING ENGINEERING • GEOLOGICAL INVESTIGATION • ENGINEERING INSPECTION

HEMPHILL CORPORATION

4834 SOUTH 83RD EAST AVENUE
TULSA, OKLAHOMA 74145

OFFICE (918) 622-5133 AFTER HOURS 587-5822

BORING LOG

HOLE NO. B-31

PROJECT Northeast Power Station - Oologah, Oklahoma SHEET 1 OF 1

HOLE LOCATION 72+00 S. 5+00 E. DATE 12/23&30/74

GR. ELEV. 624.1 WATER TABLE None BORED BY Summers LOGGED BY Drywater

(Drilled with water)

ELEV.	DEPTH AND SCALE	LGND.	DESCRIPTION OF MATERIAL (TYPE, COLOR, TEXTURE, CONSISTENCY)
623.1	1.0		SILT, Clayey, Sandy, Dark Brown, Very Moist, Soft
622.6	1.5		CLAY, Silty, Sandy, Tan, Moist
620.6	3.5		LIMESTONE, Grayish
618.6	5.5		LIMESTONE, Grayish w/Tan, Clay Lenses
609.1	15.0		LIMESTONE, Grayish, w/Gray Shale Lenses and Partings w/Calcite Crystals
			Bottom of Hole NOTE: 2.0' casing above surface 3.5' casing below surface Hole Diameter 6 7/8". Point of change of hole diameter 3.5'. Reference point elevation 626.2. 5'5" of 5" PVC pipe w/cap set. Boring-casing annulus grouted back to surface. Hole flushed with clear water.

CASING INFORMATION

SIZE	FT-RUN	FT-PULLED	FT-LEFT

DRILLING MUD

TYPE	NO SACKS

PENETRATION TEST

FROM	TO	BLOWS/FT

SHELBY TUBE SAMPLES

NO.	FROM	TO

CORING

FROM	TO	RECOVERY	RQD
5.0	10.0	96%	94%
10.0	15.0	100%	100%

WATER LOSS

CEMENT (NO. SACKS)

REMARKS

CONSULTING ENGINEERING • GEOLOGICAL INVESTIGATION • ENGINEERING INSPECTION

HEMPHILL CORPORATION

4834 SOUTH 83RD EAST AVENUE

OFFICE-(918) 622-5130 TULSA OKLAHOMA 74145 AFTER HOURS 587-5622

BORING LOG

HOLE NO. B-32

PROJECT: Northeast Power Station - Oologah, Oklahoma — SHEET 1 OF 1

HOLE LOCATION: 58+00 S, 8+00 W — DATE: 12-20-74

GR. ELEV. 623.1 — WATER TABLE: None (Drilled with water) — BORED BY: Summers — LOGGED BY: Drywater

ELEV.	DEPTH AND SCALE	LGND.	DESCRIPTION OF MATERIAL (TYPE, COLOR, TEXTURE, CONSISTENCY)
622.1	1.0		SILT, Clayey, Sandy, Dark Brown, Moist Soft
620.1	3.0		CLAY, Sandy, Red Brown, Tan w/Gray, Moist Stiff w/Limestone Fragments
618.6	4.5		LIMESTONE, Grayish w/Tan Clay Lenses
			LIMESTONE, Grayish w/Gray Shale Lenses and Partings and Calcite Crystals
603.1	20.0		Bottom of Hole

CASING INFORMATION

SIZE	FT-RUN	FT-PULLED	FT-LEFT

DRILLING MUD

TYPE	NO. SACKS

PENETRATION TEST

FROM	TO	BLOWS/FT
3.0	3.0	50/C

SHELBY TUBE SAMPLES

NO.	FROM	TO
1	1.0	3.0

(Hand Penetrometer Average-3.75+TSF)

CORING

FROM	TO	RECOVERY	RQD
5.0	10.0	100%	100%
10.0	20.0	98%	92%

WATER LOSS

CEMENT (NO. SACKS)

REMARKS

CONSULTING ENGINEERING • GEOLOGICAL INVESTIGATION • ENGINEERING INSPECTION

HEMPHILL CORPORATION

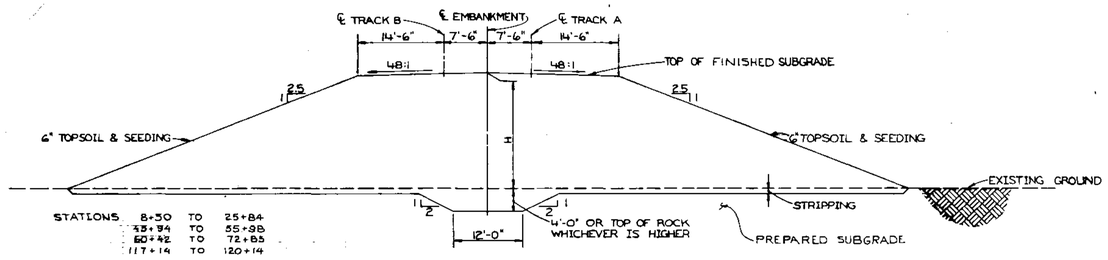
4834 SOUTH 83RD EAST AVENUE
TULSA, OKLAHOMA 74145

OFFICE (918) 622-5133 — AFTER HOURS 587-5622

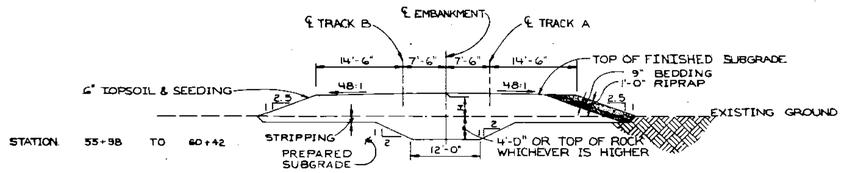
APPENDIX A

Document 7

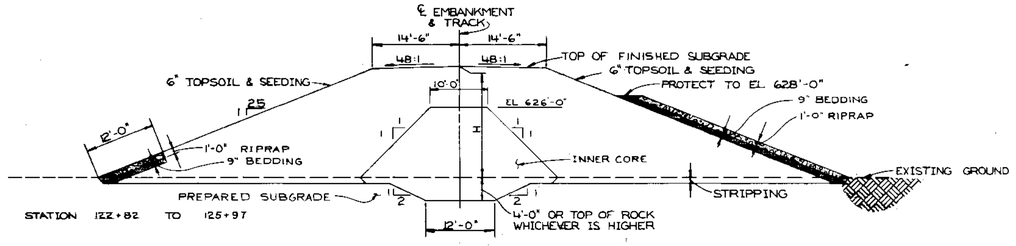
Embankment Sections



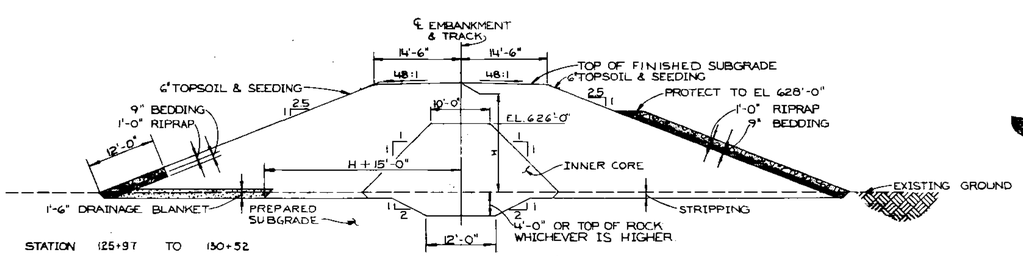
TYPICAL SECTION 1



TYPICAL SECTION 2



IMPERVIOUS ENBANKMENT SECTION 3



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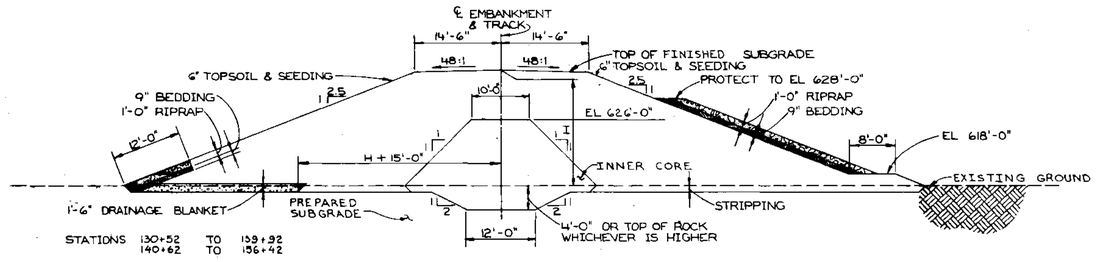

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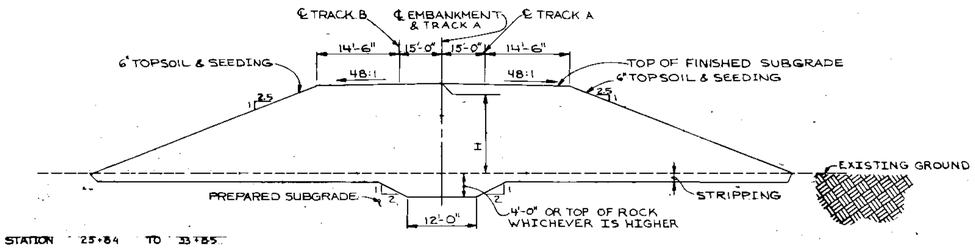
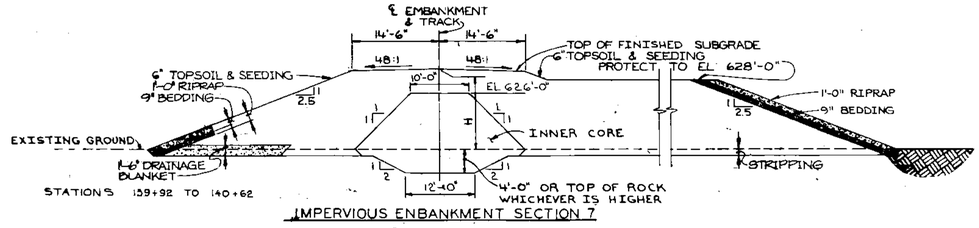
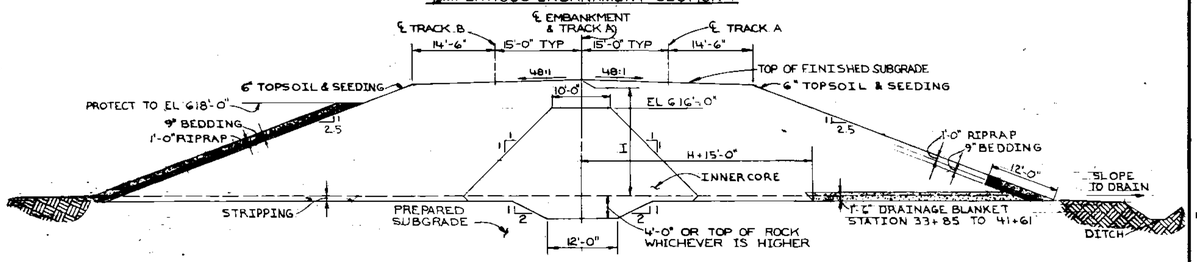


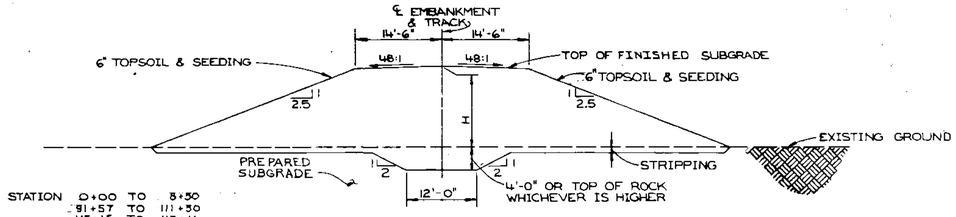
IMPERVIOUS EMBANKMENT SECTION 6



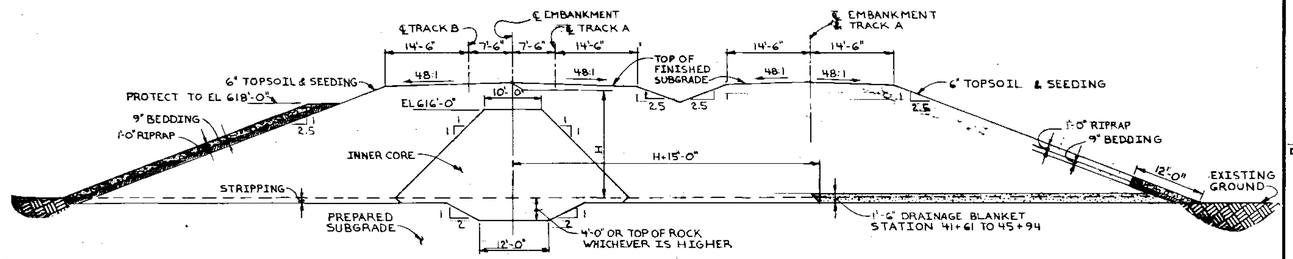
IMPERVIOUS ENBANKMENT SECTION 7



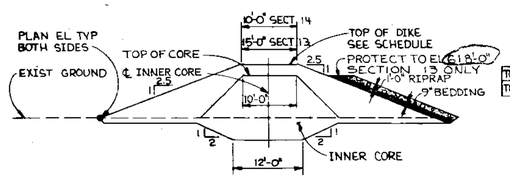
IMPERVIOUS ENBANKMENT SECTION 8



TYPICAL SECTION 9



IMPERVIOUS ENBANKMENT SECTION 10



IMPERVIOUS EMBANKMENT SECTION 13 & 14

SECTION 13 & 14 SCHEDULE		
	WASTE WATER POND	BOTTOM ASH POND
TOP DIKE	EL 618.0	EL 629.0
TOP CORE	EL 616.0	EL 626.0

GENERAL NOTES

1. EACH SECTION IS FACING TOWARD INCREASING STATION NUMBER.
2. FINISHED AND PREPARED SUBGRADE SHALL BE CONSTRUCTED AS REQUIRED BY SPECIFICATION D-2.

				2-12-82	CONFORMED TO CONSTRUCTION RECORDS	8	JR		8-29-75	REV & ISSUED FOR CONTRACT & CONST SPEC D-2	3	NH
				6-1-76	REVISED EMBANKMENT SECTION 7	7	PH		7-17-75	REVISED & ISSUED FOR ADDENDUM 1-SPEC D-2	2	TD
				3-12-76	GENERAL REVISIONS	6	TD		6-13-75	REVISED & ISSUED FOR BIDS, SPEC D-2	1	TD
				1-16-76	GENERAL REVISIONS	5	CB		5-8-75	ISSUED FOR PSO REVIEW	0	TD
				9-29-75	GENERAL REVISIONS	4	JR		DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY

SCALE: 1"=10' (10' 0 10' 20')

DSN REQ CLM
DWN RTM
CHECKED TD
APPROVE SJR

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF OKLAHOMA.
SIGNED
DATE 8/29/75 REG. NO. 8692

BLACK & VEATCH CONSULTING ENGINEERS
PROJECT 6571/6572

PUBLIC SERVICE COMPANY OF OKLAHOMA
NORTHEASTERN STATION-UNITS 3 & 4

EMBANKMENT DETAILS

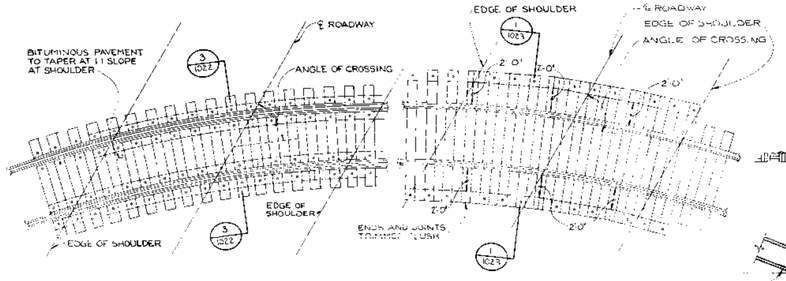
B.V. UNITS NO. PS1024
REV NO. 8
P.S.C. DWG. NO. 85127-E
SHT. 1024

NE34P000008

APPENDIX A

Document 8

Site Details 1

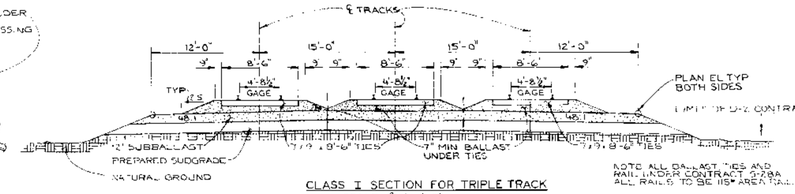


TYPE II A
CURVES 12°30' OR LESS

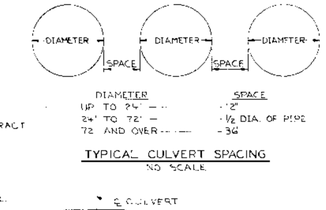
CURVED TRACK
NO SCALE

TYPE III
CURVES GREATER THAN 12°30'

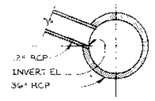
TYPICAL RAILROAD CROSSINGS



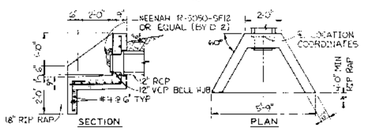
CLASS I SECTION FOR TRIPLE TRACK
SCALE: 3/16" = 1'-0"



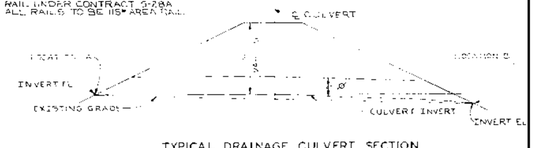
TYPICAL CULVERT SPACING
NO SCALE



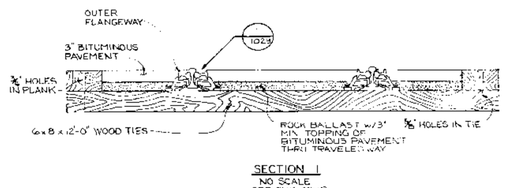
STORM SEWER "Y" CONNECTION
SCALE: 3/16" = 1'-0"



ASH WATER PUMPHOUSE DISCHARGE STRUCTURE
SCALE: 3/8" = 1'-0"
SEE DWG PS014

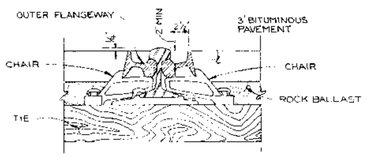


TYPICAL DRAINAGE CULVERT SECTION
NO SCALE

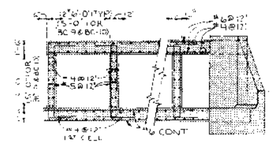


SECTION 1
NO SCALE
SEE TYP. SECTION

NOTES:
1. 6"x8½" x 11'-0 PLANKS
2. ¾" x 10" WASHER HEAD TIMBER DRIVE SPIKE
3. SEE RAILROAD CROSSING NOTES DWG. PS1022.

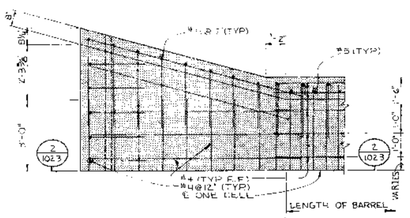


DETAIL 1
NO SCALE

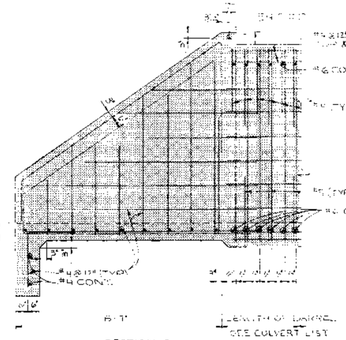


TYPICAL BOX CULVERT SECTION
W/WINGWALL AND APRON
SCALE: 3/16" = 1'-0"

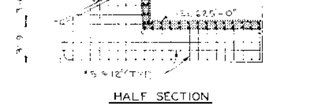
BOX CULVERT NOTES
1. FOR WINGWALL AND APRON DETAILS SEE THIS SHEET
2. CONCRETE SHALL HAVE MIN. 28-DAY COMPRESSIVE STRENGTH OF 3000 PSI.
3. STEEL REINFORCEMENT SHALL CONSIST OF DEFORMED BARS, GRADE 60.
4. CONSTRUCTION SHALL CONFORM TO AREA MANUAL CHAPTER 6.
5. BOX 2 TO HAVE 3" CROWN W/FLOAT FINISH



BOX CULVERT
WINGWALL & APRON PLAN
SCALE: 1/2" = 1'-0"



SECTION 2
SCALE: 1/4" = 1'-0"
SEE THIS DWG.



HALF SECTION
ANTI-SEEP COLLAR
SCALE: 1/4" = 1'-0"

DRAINAGE CULVERT LIST

DWG NO	SHEET NO	CULVERT NO	CENTERLINE LOCATION SOUTH	CENTERLINE LOCATION E-W	Ø DIAM.	NO. OF UNITS	NOTES	SIZE GAGE	SIZE CORR SIZE	SIZE LG'TH	END TYPE	INVERT ELEV. LOCATION A	INVERT ELEV. LOCATION B
D2	D2	ER-1	365.00	180.95	42	2		16	3x1	60	2	634.20	632.30
D2	D2	FR-2	922.00	1165.00	24	2		16	5x1	48	1	636.70	636.50
D2	D2	LR-3	1371.00	1140.00	42	1		16	5x1	46	1	637.70	637.50
D2	D2	FR-4	1962.00	1126.00	24	2		16	5x1	28	1	637.00	636.80
D2	D2	AT	2150.00	250.00	48	3		16	3x1	56	2	634.80	634.00
D2	D2	TR-1	3310.00	1107.00	48	3		16	5x1	52	3	633.80	633.00
D2	D2	TR-2	3302.00	1060.00	48	3		16	5x1	55	2	632.80	632.00
D2	D2	ER-2	3093.00	934.00	18	1		18	5x1	51	1	633.50	633.00
D2	D2	ER-3	4552.00	1772.00	24	1		16	5x1	57	1	640.00	638.00
D2	D2	AT	4093.00	1862.00	24			16	5x1	75	1	[illegible]	[illegible]
D2	D2	[illegible]	4872.00	1602.00	36	1	ASBESTOS	16	3x1	76	1	627.00	626.00
D2	D2	ER-2	3300.00	1493.00	48	3		16	3x1	76	2	628.50	628.00
D2	D2	[illegible]	3586.00	1966.00	36	1		16	3x1	48	3	[illegible]	[illegible]
D2	D2	ER-1	4800.00	2262.00	36			16	3x1	60	3	[illegible]	[illegible]
D2	D2	ER-2	5170.00	2300.00	42	1	RELOCATED FROM EXIST			60	3	[illegible]	[illegible]
D2	D2	[illegible]	5160.00	1350.00	42		RELOCATED FROM EXIST			54	3	[illegible]	[illegible]
D2	D2	ER-4	5118.75	2288.00	12			16	STD	46	3	623.50	623.00
D2	D2	[illegible]	3040.00	1800.00	24			16	STD	54	3	627.00	626.40
D2	D2	[illegible]	5760.00	1860.00	12			8	STD	76	3	639.20	637.80
D2	D2	[illegible]	638.00	962.00	2			16	STD	76	3	637.80	636.30
D2	D2	[illegible]	[illegible]	[illegible]	60			16	[illegible]	146	2	630.00	628.5
D2	D2	P-3	5435.00	1950.00	18	1		16	STD	55	3	636.00	630.50
D2	D2	[illegible]	[illegible]	[illegible]	18	1		16	STD	50	3	[illegible]	[illegible]
D2	D2	RR-1	5731.00	2355.00	60	2		16	3x1	140	2	607.90	606.40
D2	D2	RR-5	1015.00	1047.00	24	2		16	STD	65	3	[illegible]	[illegible]
D2	D2	LR-1	951.00	2675.00	36	1		16	3x1	20	1	607.80	607.30
D2	D2	RR-3	686.00	2750.00	36	1		16	3x1	155	1	612.00	610.00
D2	D2	[illegible]	[illegible]	765.00	[illegible]	1		16	[illegible]	75	1	[illegible]	[illegible]
D2	D2	[illegible]	5180.00	268.00	24	1		16	STD	75	1	622.80	622.00
D2	D2	RR-5	5535.00	1894.00	18	1		16	STD	48	1	635.00	634.20
D2	D2	MR-4	6325.00	1885.00	15	2	ASBESTOS	16	STD	42	1	633.00	632.00
D2	D2	MR-5	7215.00	1889.00	12	1		16	STD	79	3	631.00	630.00
D-12	D-2	WWT-2	5182.25	W 3+27.75	50×31	1	METAL ARCH	12	3x1	44	3	622.20	622.00
D4	D4	BC-4	5535.00	E 940.00	6x2-9	1	FOR DETAILS	SEE		50'	1	632.50	631.30
D4	D4	BC-5	6180.00	E 1084.37	6x2-9	1	DWG PS1043			75'	1	633.44	633.22
D2	D2	RC-1	7208.00	N 60.00	6x6	4	FOR BC DETAILS	SEE		40'	1	625.90	625.40
D2	D2	RC-2	3410.00	N 235.00	6x6	4	THIS DWG			40'	1	619.90	619.40
D2	D2	BC-3	2985.00	W 1193.00	6x6	5	SEE THIS DWG			100'	1	639.00	638.00
D4	D4	BC-1	[illegible]	[illegible]	6x2-9	1	SEE DWG PS1043			46			

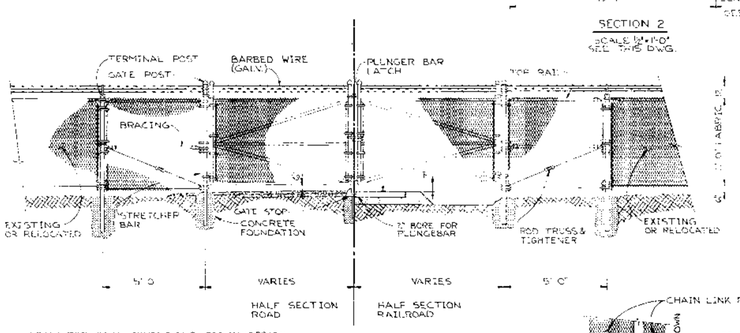
FOR CONTINUATION OF CULVERT LIST SEE DWG PS1043

LEGEND
- CR - CONTRACT ROAD
- PR - PROJECT ROAD
- TR - TEMPORARY RR
- PR - PLANT RR
- CTR - COOLING TOWER ROAD
- MR - MAINTENANCE ROAD
- MAR - MANAGER'S ROAD
- CPR - CONSTR PARKING RD
- BPR - BATCH PLANT ROAD
- [illegible]
- [illegible]
- TR - TEMPORARY CULVERT
- RR - RAILROAD
- [illegible] - [illegible] ROAD
- BC - BOX CULVERT
- AFR - AFR PUMP ROAD

CULVERT CORRUGATION 2½" x ½"

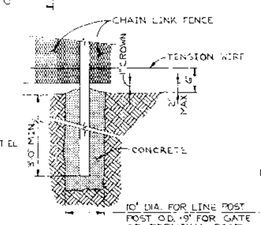
END TYPES:
1 - BEVELED
2 - FLARED
3 - SQUARE

NOTE:
END SECTIONS INCLUDED IN PIPE LENGTH



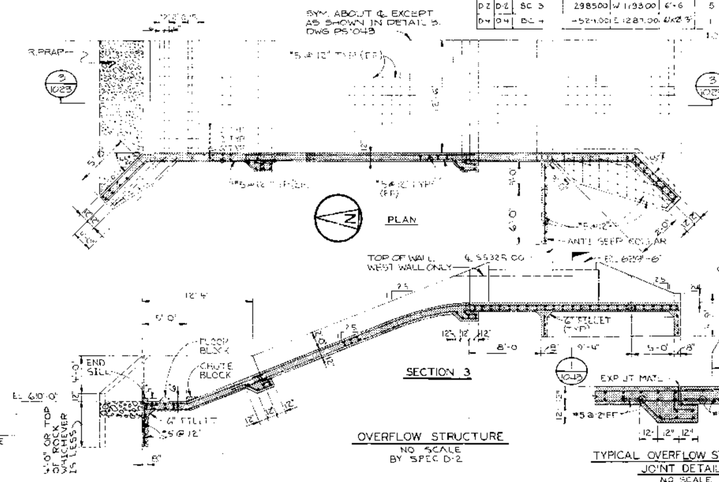
NOTE: FOR GATE DIMENSIONS SEE DWG PS1011

CHAIN LINK SWING GATE
NO SCALE



TYPICAL FENCE POST FOUNDATION
NO SCALE

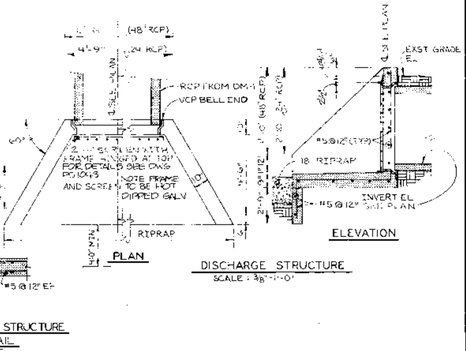
DRAINAGE CULVERT RIPRAP
ELEVATION & SECTION
NO SCALE



OVERFLOW STRUCTURE
NO SCALE
BY SPEC D-2

OVERFLOW STRUCTURE NOTES
1. CONCRETE SHALL HAVE MIN. 28 DAY STRENGTH OF 3000 PSI.
2. STEEL REINFORCEMENT SHALL CONSIST OF DEFORMED BARS, GRADE 60.
3. CONSTRUCTION SHALL [illegible]

TYPICAL OVERFLOW STRUCTURE
JOINT DETAIL
NO SCALE



DISCHARGE STRUCTURE
SCALE: 3/8" = 1'-0"

11-3-78	ADDED CULVERT WWT-1 & REVISED LOCATION BC-5	13	JR	JG	68	11-16	REVISED AS CIRCLED	10	[illegible]										
6-16-78	REVISED MR-4 & INVERT ELEV.	12	JM	TC	68	11-16	GENERAL REVISIONS	7	CB	[illegible]	68								
6-16-78	REVISED AS CIRCLED	11	JM	TC	68	11-16	GENERAL REVISIONS	6	CB	[illegible]	68								
4-27-78	REVISED AS CIRCLED	10	TD	[illegible]	68	11-16	GENERAL REVISIONS	5	CB	[illegible]	68	2-12-80	CONFORMED TO CONSTRUCTION RECORDS	14	[illegible]	[illegible]	[illegible]		
3-27-78	REVISED OVERFLOW STRUCTURE	9	PS	JR	68	8-24-78	REV & ISSUED FOR CONTRACT & CONST. SPEC D2	4	[illegible]	[illegible]	68	DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP		

SCALE: AS NOTED

PERF REVIEW CLM
DES ENG [illegible]
REVIEWED [illegible]
DRAWN SJR

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF OKLAHOMA.
SIGNED _____
DATE _____ REG. NO. _____

BLACK & VEATCH
CONSULTING ENGINEERS
PROJECT 6571/6572

PUBLIC SERVICE COMPANY OF OKLAHOMA
NORTHEASTERN STATION—UNITS 3 & 4

MISCELLANEOUS RAILROAD AND SITE GRADING DETAILS

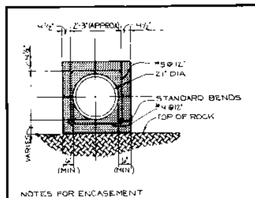
DWG NO. PS1023
REV. [illegible]
FSO ENG. NO. 85127-E
SHT. 1023

NE34P000002

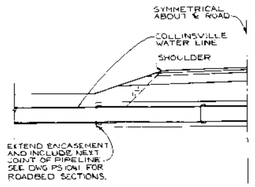
APPENDIX A

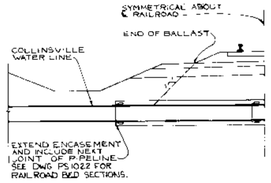
Document 9

Site Details 2



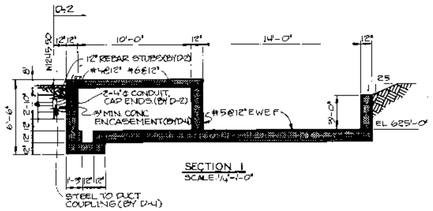
NOTES FOR ENCASEMENT
1. USE 3000 PSI CONCRETE AND GRADE 60 REBARS
2. CONSTRUCTION SHALL BE ACCORDING TO ACI 318-71.
3. BOTTOM OF CASING SHALL BE POURED TO TOP OF ROCK
4. ALL LONGITUDINAL REINFORCING SHALL BE #4 BARS PLACED AS SHOWN.



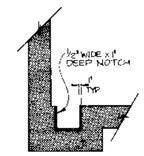


COLLINSVILLE WATER LINE ENCASEMENT DETAILS

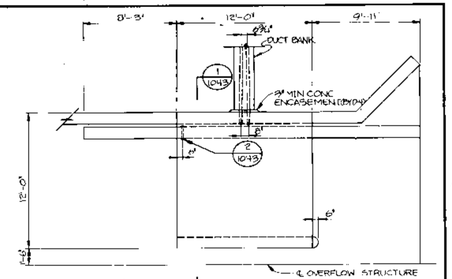
NO SCALE



SECTION 1
SCALE 1/4"=1'-0"



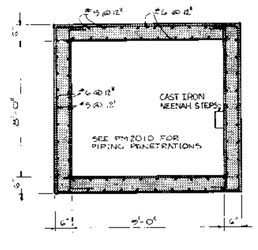
DETAIL 2
SCALE ½"=1'-0"



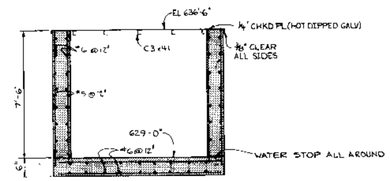
DETAIL 3
SCALE 1/4"=1'-0"

HOSE HOUSE LIST					
NO.	CORNER LOCATION SOUTH	CORNER LOCATION E. OR W.	ELEVATION	TURNISH	INSTALL
1					
2	3919.00	E 1066.00		D-6	D-4
3	3919.00	E 1488.00		D-6	D-4
4	4472.00	E 886.00		D-6	D-4
5	4504.00	E 1532.00		D-6	D-4
6	4805.00	E 1609.00		D-6	D-4
7	4805.00	E 1732.50		D-6	D-4
8	5530.00	E 1282.00		D-6	D-4
9	5200.00	E 1091.00		D-6	D-4
10	6165.00	E 1198.50		D-6	D-4
11	6590.00	E 1210.00		D-6	D-4
12	6973.00	E 1673.00		D-6	D-4
13	4650.00	E 2097.50		D-6	D-4
14	4650.00	E 2191.00		D-6	D-4

YARD & FIRE HYDRANT LIST					
NO.	CENTERLINE LOCATION SOUTH	CENTERLINE LOCATION E. OR W.	ELEVATION	TURNISH	INSTALL
FH 1	4542.00	E 1083.00	633.58		D-4
FH 2	4475.00	E 886.00	631.50		D-4
FH 3	NOT USED				
FH 4	4075.00	E 886.00	629.50		D-4
FH 5	3909.00	E 1046.00	637.58		D-4
FH 6	3909.00	E 1250.00	637.58		D-4
FH 7	3909.00	E 1460.00	637.58		D-4
FH 8	3980.00	E 1492.00	636.00		D-4
FH 9	4170.00	E 1463.50	637.50		D-4
FH 10	4420.00	E 1492.00	637.50		D-4
FH 11	4502.00	E 1262.50	634.50		D-4
FH 12	4790.00	E 1615.00	638.58		D-4
FH 13	4790.00	E 1735.00	639.58		D-4
FH 14	5040.00	E 1615.00	639.58		D-4
FH 15	5040.00	E 1735.00	639.58		D-4
FH 16	5200.00	E 1106.00	637.50		D-4
FH 17	5550.00	E 1083.00	639.50		D-4
FH 18	5527.00	E 1279.50	644.50		D-4
FH 19	5080.00	E 1207.00	641.50		D-4
FH 20	6170.00	E 1077.00	641.50		D-4
FH 21	6798.00	E 1210.00	641.50		D-4
FH 22	6857.75	E 1170.00	637.75		D-4
FH 23	6954.00	E 1665.00	637.75		D-4
FH 24	4635.00	E 2185.00	638.58		D-4
FH 25	4635.00	E 2065.00	638.58		D-4
FH 26	4885.00	E 2185.00	638.58		D-4
FH 27	4885.00	E 2065.00	638.58		D-4
YH 1	4695.50	E 1645.00		D-4	D-4
YH 2	4605.00	E 1895.00		D-4	D-4
YH 3	4540.50	E 2154.00		D-4	D-4
FH 28	5460.00	E 1782.00			



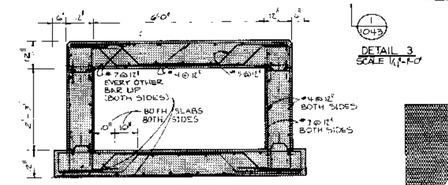
PLAN



PIPING & FOR LOCATION COORDS. & INSIDE DETAILS SEE DWG FM 2010

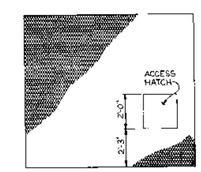
ELEVATION

BOILER DRAIN VALVE PIT
SCALE ⅛"=1'-0"

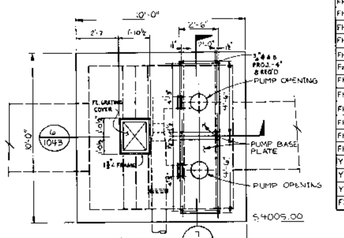


ASH LINE BOX CULVERT

NOTES FOR CONSTRUCTION OF BOX CULVERT
1. CONCRETE CONSTRUCTION ACCORDING TO ACI 318-71
2. MAINTAIN 2" COVER ON ALL STEEL EXCEPT #7 ON BOTTOM OF BOTTOM SLAB
3. FOR WINGWALL AND APRON DETAILS SEE THIS SHEET

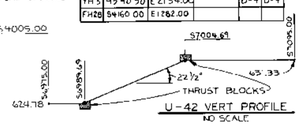


PLAN
CHECKERED PLATE



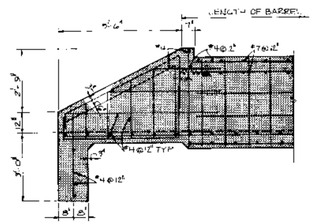
PLAN

SITE RUNOFF PUMP PIT STRUCTURE
SCALE: 3/16"=1'-0"

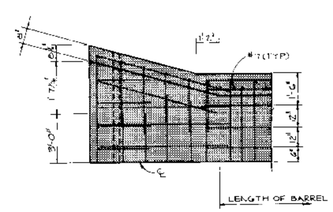


U-42 VERT PROFILE

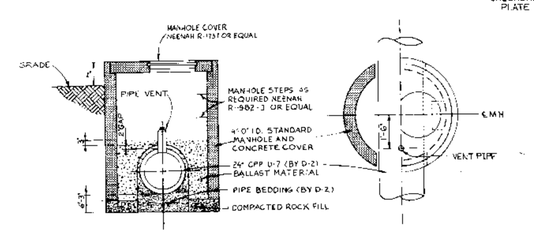
NO SCALE



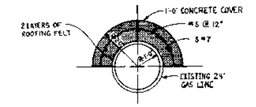
ASH LINE BOX CULVERT WINGWALL
SCALE: ½"=1'-0"



ASH LINE BOX CULVERT APRON
SCALE: ½"=1'-0"

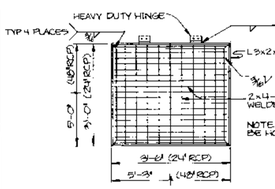


MAKE UP WATER MANHOLE
SCALE: ½"=1'-0"

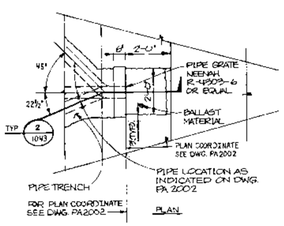


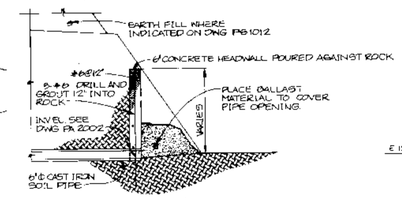
SECTION 3
SCALE ½"=1'-0"

DRAINAGE CULVERT LIST (CONT. FROM DWG. PS1023)												
TURNISH	INSTALL	CULVERT NO	CENTERLINE LOCATION SOUTH	CENTERLINE LOCATION E-W	Ø DIAM	NO. OF UNIT	NOTES	SIZE GAGE	SIZE CORR SIZE	SIZE LGTH	END TYPE	INVERT ELEV. LOCATION A	INVERT ELEV. LOCATION B
D-4	D-4	CTR-2	4524.00	L2028	24"	1		18	STD	70'	1	639.50	639.00
D-4	D-4	CTR-3	4715.00	E1772.00	12"	1		18	STD	55'	1	641.50	641.00
D-4	D-4	CTR-4	4576.00	E1630.00	24"	1		18	STD	65'	1	638.00	632.50
D-4	D-4	BC-9	6920.00	E1545.00	5'x5'	2	FOR BC DWG. PS1023	DETAILS	SEE	35'		629.60	629.50
D-4	D-4	BC-10	6905.00	E1772.00	5'x5'	2				25'		629.80	629.70
D-4	D-4	TR-2	3659.00	E1210.00	12"			16	STD	91'	3	637.10	636.90
D-4	D-4	TR-5	4780.00	E1200.00	12"			16	STD	80	3	636.20	635.80
		PR6-6	5355.0	970.	12	1						633.25	632.75
		PR7-7	5300.0	810	12	1						634.0	633.5



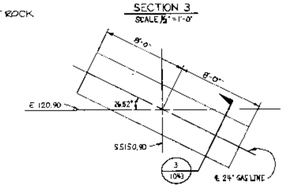
DETAIL OF FRAME AND SCREEN AT DISCHARGE STRUCTURE
SEE DWG. PS1023
SCALE: 3/8"=1'-0"



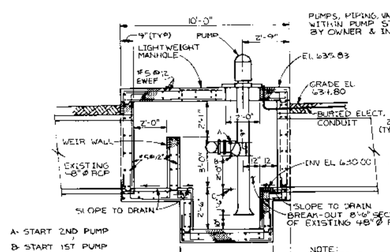


SECTION 2

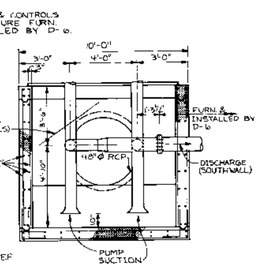
TRENCH DRAIN HEADWALL
SCALE ½"=1'-0"



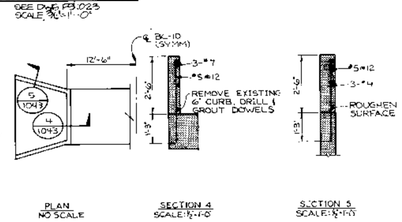
CONCRETE COVER FOR E-6
SCALE ¼"=1'-0"



SECTION 6, LOOKING NORTH
SCALE: 3/8"=1'-0"
SEE THIS DWG



SECTION 7, LOOKING EAST
SCALE: 3/8"=1'-0"
SEE THIS DWG

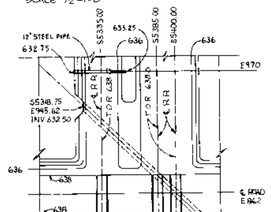


PLAN
NO SCALE

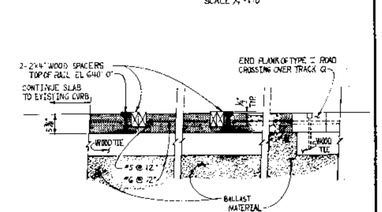
SECTION 4
SCALE: ½"=1'-0"

SECTION 5
SCALE: ½"=1'-0"

BOX CULVERT 10 COAL RETENTION WALL



ASH LINE BOX CULVERT
SCALE 1"=40'



CONCRETE ROAD CROSSING
SCALE: 1"=1'-0"

A	2-12-82	CONFORMED TO CONSTRUCTION RECORDS	13	GP	RH	LK	10-8-76	REVISED AS CIRCLED	8	UM	RP	LK	4-3-76	REVISED AS CIRCLED	3	ES	TA	LK
	4-24-03	REVISED STORM WATER PUMP PIT	12	CWS	RP	LK	6-23-76	REVISED AS CIRCLED	7	JM	TA	LK	3-24-76	REVISED OVERFLOW STRUCTURE	2	FH	LR	LK
	3-6-00	ADDED STORM WATER PUMP PIT.	11	CWS	RP	LK	6-1-76	REVISED AS CIRCLED	6	FH	TA	LK	3-12-76	REVISED AS CIRCLED	1	DD	TA	LK
	1-21-77	REVISED AS CIRCLED	10	ES	TA	LK	5-24-76	REVISED AS CIRCLED	5	FH	TA	LK	2-16-76	ISSUED FOR CONSTRUCTION	0	TA	TA	
	11-12-76	REVISED AS CIRCLED	9	JM	TA	LK	4-27-76	REVISED AS CIRCLED	4	CB	TA	LK	DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP

SCALE: AS NOTED

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF OKLAHOMA.
SIGNED: Louis A. Klecka
DATE: 1/6/76 REG. NO. 10738

BLACK & VEATCH CONSULTING ENGINEERS
PROJECT 8571/8572

PUBLIC SERVICE COMPANY OF OKLAHOMA
NORTHEASTERN STATION-UNITS 3 & 4

MISCELLANEOUS SECTIONS AND DETAILS

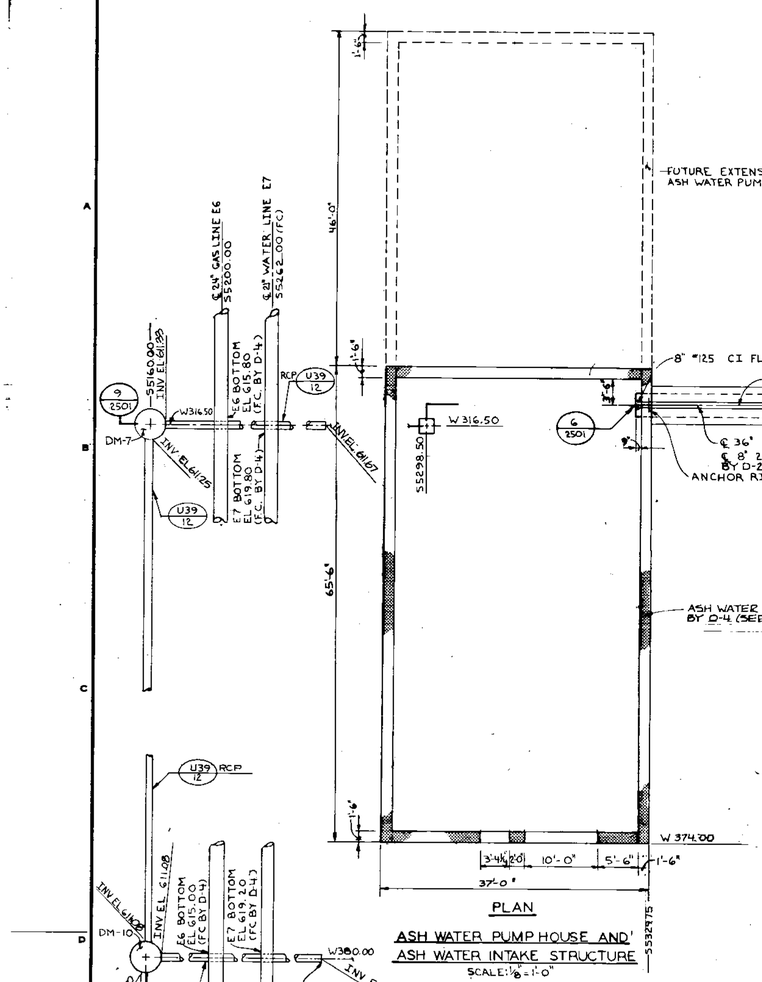
DWG. NO. PS1043
SHT. 13 OF 13
85127-E
SHT. 1043

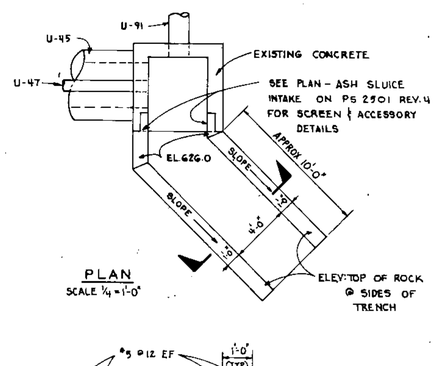
NE34P000003

APPENDIX A

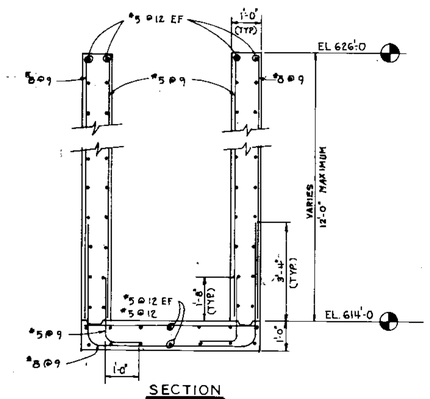
Document 10

Site Details 3

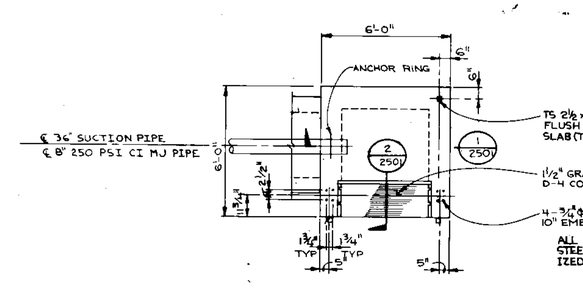




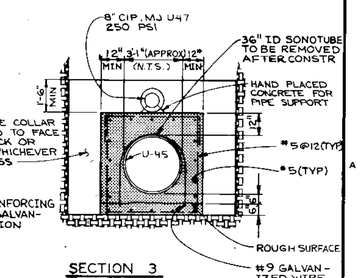
PLAN
SCALE 1/4" = 1'-0"



SECTION
ASH WATER INTAKE RETAINING WALL



PLAN-ASH SLUICE INTAKE
SCALE: 3/8" = 1'-0"



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SCALE: 3/8" = 1'-0"
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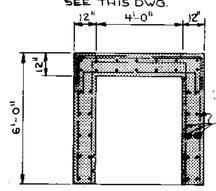

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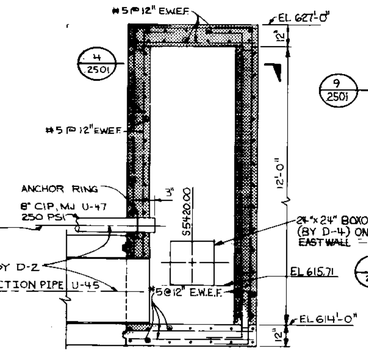

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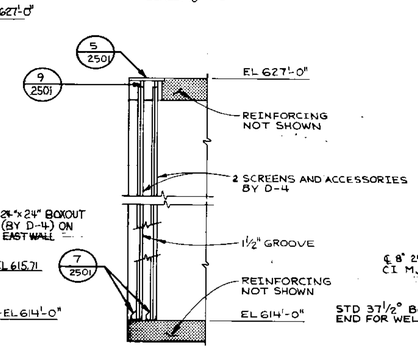

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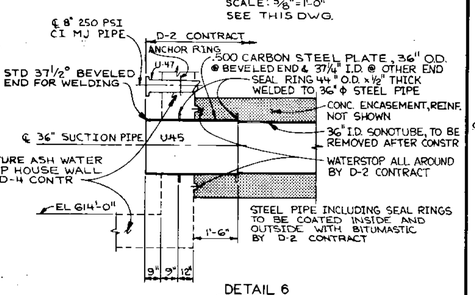

DETAIL 6
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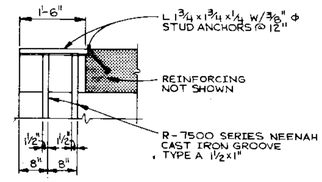
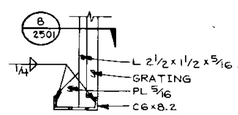
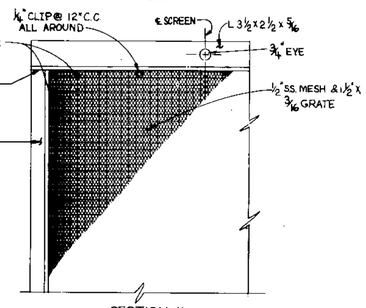


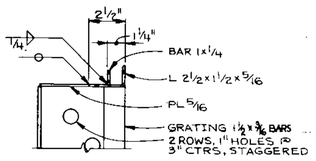
DETAIL 5
SCALE: 3/4" = 1'-0"
SEE THIS DWG.



DETAIL 7
SCALE: 1½" = 1'-0"
SEE THIS DWG.



SECTION 11
NO SCALE
SEE THIS DWG



SECTION 8
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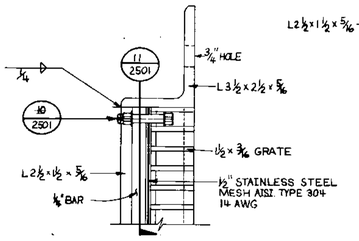

DETAIL 9
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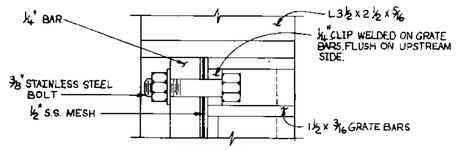
SEE THIS DWG



DETAIL 10
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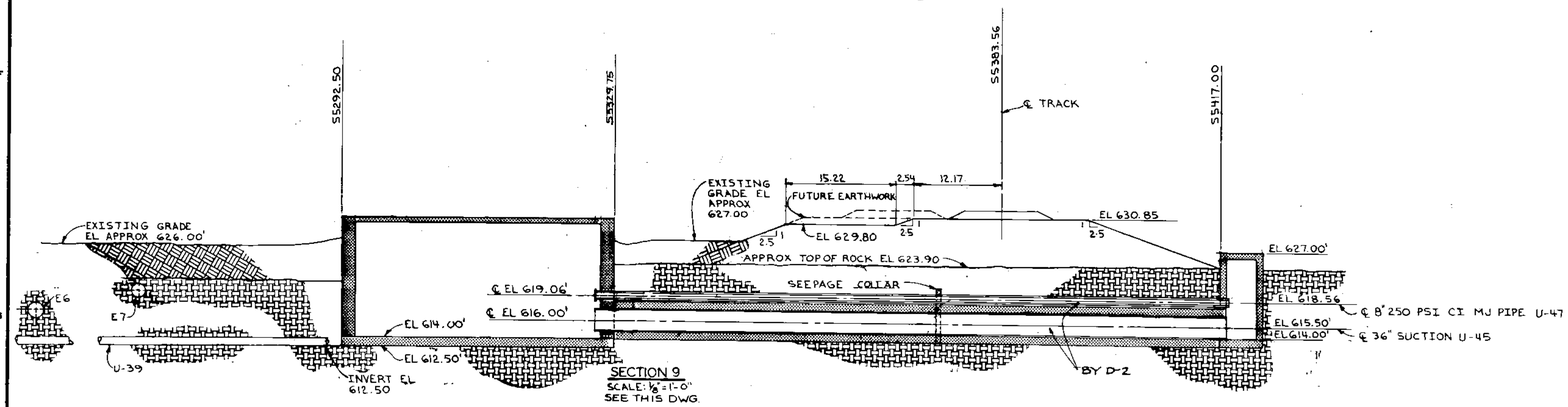
SEE THIS DWG.



SECTION 9
SCALE: 1/8" = 1'-0"
SEE THIS DWG.

▲ 2-12-82	CONFORMED TO CONSTRUCTION RECORDS	5	JV				
10-8-76	REVISED AS CIRCLED	4	JM				
5-14-76	REVISED AS CIRCLED	3	FH				
3-12-76	REVISED AS CIRCLED	2	CB				
1-16-76	ISSUED FOR CONSTRUCTION	1					
11-11-75	ISSUED FOR PSO REVIEW	0	JR				
DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP		

SCALE: AS NOTED

DFT'T HEAD CLM
DES ENGR
CHECKED
DRAWN GWH

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF OKLAHOMA.
SIGNED
DATE 1/16/76 REG. NO. 10232

BLACK & VEATCH
CONSULTING ENGINEERS
PROJECT 6571/6572

PUBLIC SERVICE COMPANY OF OKLAHOMA
NORTHEASTERN STATION—UNITS 3 & 4

MISCELLANEOUS YARD STRUCTURES
PLAN SECTIONS AND DETAILS

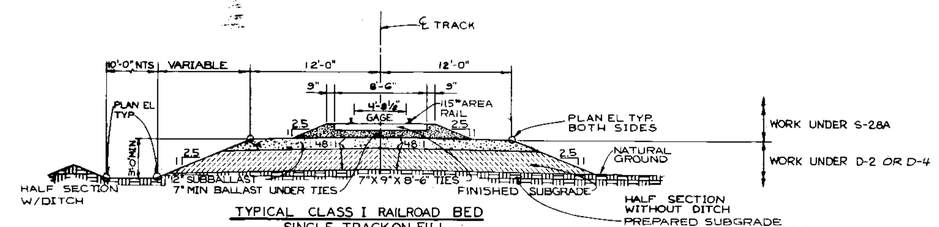
B&V DWG NO. PS2501
REV NO. 5
PSO DWG NO. 85127-E
SH. 2501

NE34P000004

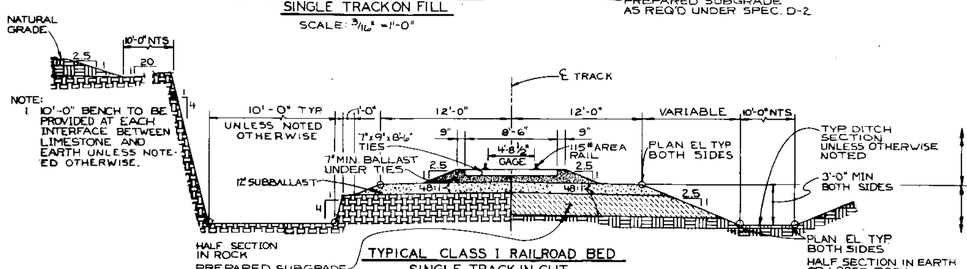
APPENDIX A

Document 11

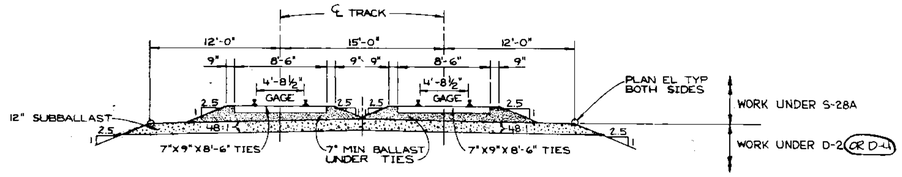
Site Details 4



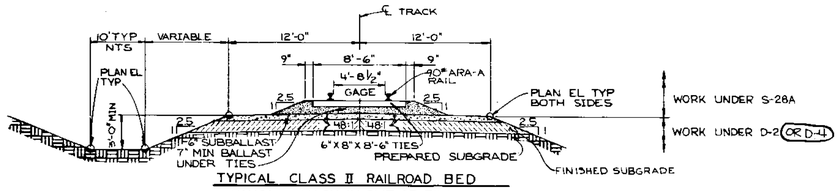
TYPICAL CLASS I RAILROAD BED
SINGLE TRACK ON FILL
SCALE: 3/16" = 1'-0"



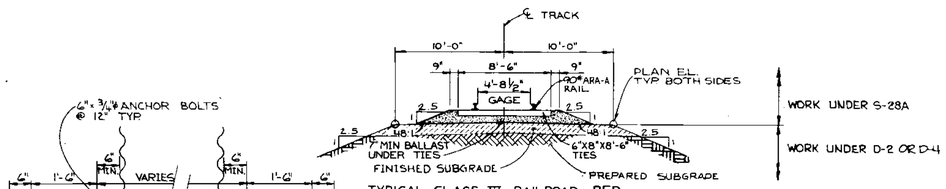
TYPICAL CLASS I RAILROAD BED
SINGLE TRACK IN CUT
SCALE: 3/16" = 1'-0"



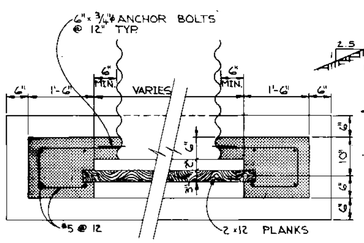
CLASS I BALLAST SECTION FOR DOUBLE TRACK
SCALE 3/16" = 1'-0"



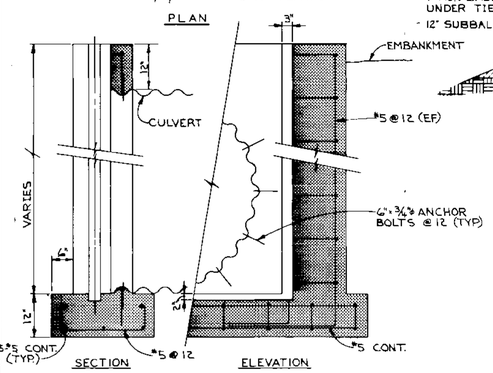
TYPICAL CLASS II RAILROAD BED
SINGLE TRACK IN CUT OR FILL
SCALE: 3/16" = 1'-0"



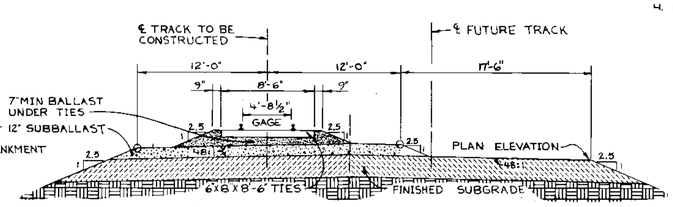
TYPICAL CLASS III RAILROAD BED
SCALE: 3/16" = 1'-0"



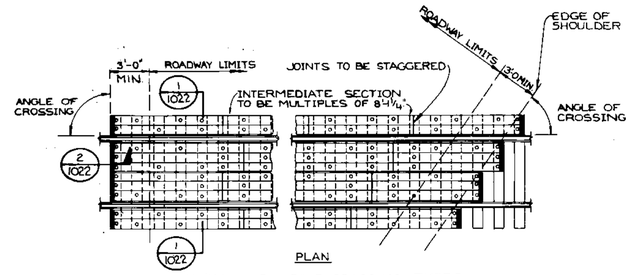
PLAN



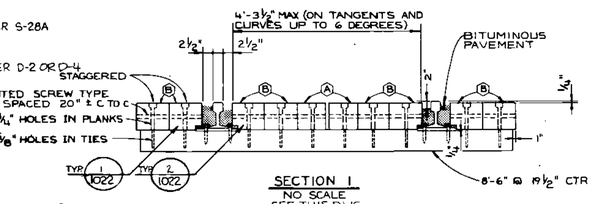
CULVERT HEADWALL
SCALE: 3/16" = 1'-0"



CLASS I BALLAST SECTION FOR DOUBLE TRACK
NEW AND FUTURE TRACK
SCALE 3/16" = 1'-0"

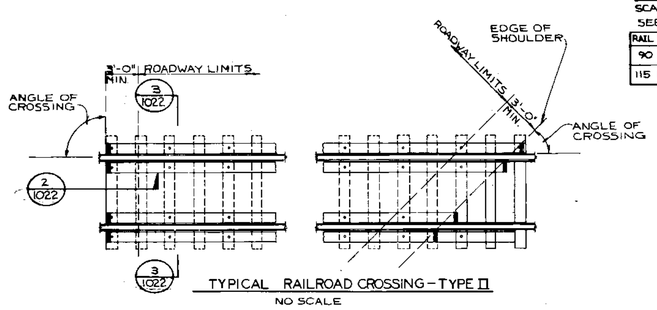


TYPICAL RAILROAD CROSSING – TYPE I
NO SCALE

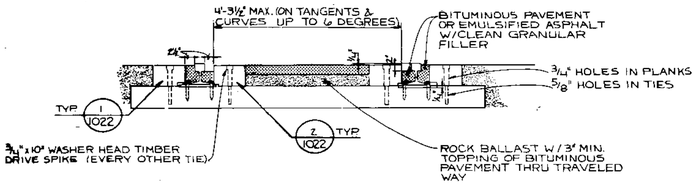


SECTION 1
NO SCALE
SEE THIS DWG.

NOTES:
1. Ⓐ 6⅞" x 7¾" PLANKS (115 AREA-RAIL) 5¼" x 7¾" PLANKS (90 ARA-A RAIL)
2. Ⓑ 6⅞" x 8¾" PLANKS (115 AREA-RAIL) 5¼" x 8¾" PLANKS (90 ARA-A RAIL)
3. ANY PREBORED HOLES NOT USED SHOULD BE PLUGGED AND SEALED.



TYPICAL RAILROAD CROSSING – TYPE II
NO SCALE

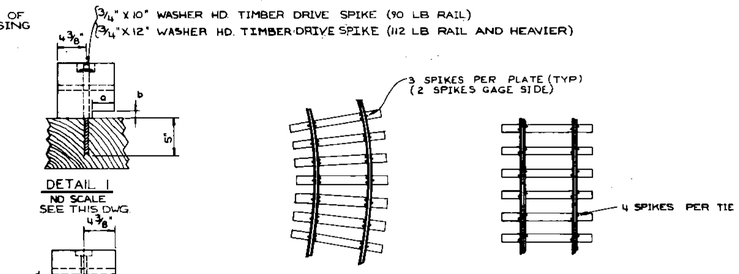


SECTION 3
NO SCALE
SEE THIS DWG.

NOTES FOR SECTION 3 ONLY:
1. LENGTH OF END PLANKS MAY VARY, BUT NOT LESS THAN 3 TIE SPACES PLUS ½ WIDTH OF TIE. INCREASE LENGTH OF PLANKING IF NECESSARY.
2. PROVIDE INTERLOCKING NOTCHES ON ENDS OF ALL PLANKS EXCEPT BEVELED END OF OUTSIDE PLANK.
3. INTERLOCKED JOINTS TO BE CENTERED OVER TIE.
4. LENGTH OF INTERMEDIATE PLANKS TO BE 8'-5¼"

RAILROAD CROSSING NOTES

1. PLANKS TO BE PREFRAMED CREOSOTED RED OAK, GUM, MAPLE, OR BIRCH.
2. PLANKS TO BE PREDRILLED WITH ¾" HOLES.
3. TIES WITHIN LIMITS OF CROSSING SHALL BE SAWED, PRE-ADZED, CREOSOTED AND TIE PLATED.
4. TIE SPACING SHALL BE 19½".
5. FIELD DRILL ⅝" HOLES INTO TIES TO ACCOMMODATE LENGTH OF DRIVE SPIKES.
6. WHERE UNAVOIDABLE ADZING AND CUTTING OF MATERIAL IS NECESSARY, TREAT CUT SURFACES WITH CREOSOTE. TREAT HOLES DRILLED IN FIELD WITH CREOSOTE.
7. RAIL ANCHORS NORMALLY LOCATED WITHIN LIMITS OF CROSSING MAY BE DIVIDED EQUALLY ON ADJACENT APPROACH RAILS.
8. TRACK BETWEEN ENDS OF PLANKING AND SHOULDER LINE OF HIGHWAY SHALL BE FILLED WITH BALLAST MATERIAL.
9. WHERE PRACTICABLE, NO JOINTS SHALL BE PERMITTED IN THE CROSSING NOR WITHIN 6 FEET OF THE ENDS OF THE CROSSING. JOINTS WHICH ARE UNAVOIDABLE WITHIN THESE LIMITS SHALL BE PRESSURE WELDED OR LAID TIGHT AND FROZEN. BUILD UP RAIL ENDS AND GRIND TO EQUAL HEIGHT WHERE REQUIRED.
10. EMULSIFIED ASPHALT WILL BE APPLIED AT A RATE OF 1 GALLON PER SQUARE YARD OVER BOTH THE FIRST 3" LIFT OF BALLAST AND ALSO OVER THE BALLAST SECTION WHEN DRESSED. PRIOR TO PLACING IN SERVICE, INSTALLATION WILL BE SEALED WITH A LIGHT COATING OF EMULSIFIED ASPHALT AND SPRINKLED WITH CLEAN SAND, CHAT OR SCREENING.

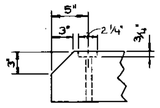


DETAIL 1
NO SCALE
SEE THIS DWG.

DETAIL 2
SCALE: 1½" = 1'-0"
SEE THIS DWG.

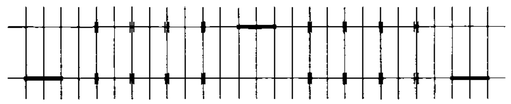
ALL CLASS TRACKS

WOOD TIE SPIKING DETAIL
SCALE: 3/16" = 1'-0"



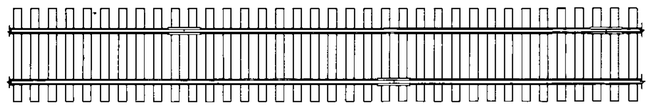
SECTION 2
SCALE: 1½" = 1'-0"
SEE THIS DWG.

RAIL WT	a	b	c	d
90 LB	2"	1"	⅞"	½"
115 LB	3½"	1 1/16"	2½"	1"



8 FORWARD AND 8 BACK-UP RAIL ANCHORS PER RAIL LENGTH (39' RAIL LENGTH)

TYPICAL RAIL ANCHOR DETAIL
SCALE: 3/16" = 1'-0"



NOTES:
1. TIE SPACING ACCORDING TO SPECIFICATION 6571-S-28A.
2. JOINT BAR ACCORDING TO SPECIFICATION 6571-S-28A.
3. RAIL WEIGHT ACCORDING TO TYPICAL SECTION THIS DWG.
4. TIE SIZE ACCORDING TO TYPICAL SECTION THIS DWG.
5. SEE WOOD TIE SPIKING DETAIL FOR SPIKE DISTRIBUTION.

TYPICAL TRACKAGE
ALL CLASSES
NO SCALE

GENERAL NOTES

1. TIES, RAILS AND TRACK HARDWARE TO BE FURNISHED AND INSTALLED UNDER CONTRACT S-28A.
2. BALLAST TO BE FURNISHED AND STOCKPILED UNDER CONTRACT D-2, AND INSTALLED UNDER S-28A.
3. FOR FINISHED SUBGRADE DETAILS, SEE DWG. PS1024.

12" 9" 6" 3" 0 1'
1 1/2" = 1'-0"
6' 4' 2' 0 5' 10'
3/16" = 1'-0"
8' 4' 0 8' 16'
1/8" = 1'-0"
SCALE: AS NOTED

						2-12-82	CONFORMED TO CONSTRUCTION RECORDS	8	SB			8-20-75	REVISED AND ISSUED FOR BID - SPEC S-28A	3	TD
						5-14-76	REVISED AS CIRCLED	7	GH			7-17-75	REVISED AND ISSUED FOR ADDENDUM 1 - SPEC D-2	2	TD
						3-12-76	DWG NO. AND REF. DWG NOS.	6	TD			6-13-75	REVISED AND ISSUED FOR BID - SPEC D-2	1	TD
						9-29-75	GENERAL REVISIONS	5	CB			5-8-75	ISSUED FOR PSO REVIEW	0	TD
						8-29-75	REV & ISSUED FOR CONTRACT & CONSTR - SPEC. D-2	4	WH			DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY CK APP

DOT ROAD CLM
DES ENG
DRAWN TD
DESIGN SJR

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF OKLAHOMA.
SIGNED
DATE 8/29/75 REG. NO. 5377

BLACK & VEATCH CONSULTING ENGINEERS
PROJECT 6571/6572

PUBLIC SERVICE COMPANY OF OKLAHOMA
NORTHEASTERN STATION—UNITS 3 & 4
MISCELLANEOUS RAILROAD DETAILS

B&V DWG NO. PS1022
REV NO. 8
PSO DWG NO. 85127-E
SHT. 1022

Scanned 5/97

NB34P000007

APPENDIX A

Document 12

Original Specifications

SPECIFICATIONS
AND
DOCUMENTS

PUBLIC SERVICE COMPANY OF OKLAHOMA
NORTHEASTERN STATION

SITE PREPARATION

SPECIFICATION 6571/6572 – D-2

CONTRACT ISSUE

MARTIN K. EBY CONSTRUCTION CO., INC
P.O. Box 1679
610 North Main
Wichita, Kansas 67201

BLACK & VEATCH
Consulting Engineers
Kansas City, Missouri

1975

operate as a waiver of any provision of this Contract, or of any power herein reserved to the Company, or any right to damages herein provided, nor shall any waiver of any breach in this Contract be held to be a waiver of any other or subsequent breach

GC.13 ENGINEER'S STATUS The Engineer will be the Company's representative to direct and coordinate all project contracts. The Contractor shall be responsible to the Engineer to perform this Contract. The Engineer at all times shall have free access to the work or the shops of the Contractor for inspection of the work or any part thereof. He shall make all necessary explanations as to the meaning and intent of the contract and shall give all explanations and directions which shall be necessary to the performance of the work required under the contract, including interpretation of contract documents to Contractor's supervisory personnel.

If, in the opinion of the Contractor, a decision made by the Engineer is not in accordance with the meaning and intent of the contract, the Contractor may file with the Engineer and the Company, within 5 days after receipt of the decision, a written objection to the decision. Failure to file an objection within the allotted time will be considered acceptance of the Engineer's decision and the decision shall become final and conclusive

The Engineer's decision and the filing of the written objection thereto shall be a condition precedent to the right to request arbitration or to start action in court.

It is the intent of this agreement that there shall be no delay in the execution of the work and the decision of the Engineer as rendered shall be promptly observed

GC.14 INSPECTION. The Engineer may inspect the work directly or require Contractor's affidavit certifying compliance with the contract documents. The Contractor shall furnish all reasonable assistance required by the Engineer for the proper inspection and examination of the work.

The Contractor shall conform to the directions of the Engineer when they are consistent with the obligations of this Contract.

Inspectors and other properly authorized representatives of the Company or Engineer shall be free at all times to perform their duties.

Such inspection shall not relieve the Contractor from his obligation to perform the work strictly in accordance with the contract documents.

NE34P000204

Section 1A - GENERAL DESCRIPTION AND SCOPE OF THE WORK

1A.1 GENERAL. This section covers the general description and scope of the work for Site Preparation at the Public Service Company of Oklahoma's Northeastern Station Unit 3 and Unit 4 site

The Northeastern Station is located near Oologah, Oklahoma. A railroad siding will be available at the plant site for delivery of equipment and materials.

1A.2 WORK INCLUDED UNDER THESE SPECIFICATIONS. The work under these specifications shall include furnishing all equipment and materials; except those listed to be furnished by the Company; providing all labor, supervision, administration and management; and supplying all construction equipment, materials, and services necessary to perform the Site Preparation work complete and in accordance with the Contract Documents as defined in the GENERAL CONDITIONS.

Major components of the work under these specifications for Site Preparation include:

- Site clearing, grubbing and tazing
- Earthwork and trenching
- Coal retention berm and stacker-reclaimer berm construction
- Permanent and temporary roadway construction
- Railroad embankment construction
- Blasting
- Rock crushing and stockpiling
- Construction of concrete retaining wall and overflow channel
- Seeding, fertilizing, and mulching
- Furnish materials and install the following:
  - Corrugated metal pipe culverts
  - Reinforced concrete drainage pipe and catch basins
  - VCP sewer line and manholes
  - Service water line and demineralized water line
  - Sewage lift station
  - Crushed rock surfacing
  - Riprap and riprap bedding
  - Railroad subballast
  - Soil cement
  - Chain link fencing
  - Electrical duct bank and manholes

The above explanation and listing is intended to give a general definition of the scope of the work under these specifications, and shall not be construed to be an itemized listing of each element of work required. The Contractor shall be responsible for construction of complete facilities, conforming in all respects to the details and requirements of the Contract Documents.

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Section 2A - CLEARING, GRUBBING, AND RAZING

2A.1 GENERAL. This section covers clearing and grubbing for the plant site area within the limits indicated on the drawings.

Before clearing work is accepted, any regrowth of vegetation or tree shoots which have grown after initial cutting shall be cut and removed as specified in Article 2A.2. Tree shoots shall be removed to the level specified for tree removal in that area. All regrowth of vegetation shall be mowed, raked and burned. The finished work at the time of final acceptance shall leave completely cleared and grubbed areas as specified.

This section also covers razing of existing structures and facilities within the clearing limits.

2A.2 CLEARING AND GRUBBING. Clearing shall include clearing and removing all trees and stumps flush with the original ground surface; the cutting and removal of all brush, shrubs, debris and all vegetation to approximately flush with the ground surface; and the disposal of all cuttings and debris. Mowing will be considered adequate for the cutting of light vegetation

Grubbing shall include the removal and disposal of all stumps and roots larger than 2 inches in diameter, including matted roots regardless of size. Grubbing shall extend to a minimum depth of 12 inches below the natural surrounding ground surface or as otherwise required by the detail specifications.

The Contractor shall not remove or damage trees outside the construction area limits specified to be cleared or grubbed

Clearing operations shall be conducted without damage to trees which are designated to remain. Trees shall be protected and preserved as specified in Article 2B.9. Equipment utilized in the clearing and grubbing work shall be kept within the specified construction area limits.

2A 2.1 Limits of Work The limits of the clearing and grubbing under this section shall include all areas to be graded within the limits of construction as indicated on the drawings including, but not limited to, the following:

Clearing and grubbing of all areas to be occupied by buildings as designated on the drawings

Clearing and grubbing of the entire coal storage area, the bottom ash storage area, the waste water pond and all areas designated as borrow areas

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Clearing and grubbing of all areas to be occupied by roads and railroad.

Clearing and grubbing of all additional areas as indicated on the drawings

2A.2.2 Disposal of Waste All logs, trees, stumps, roots, brush, tree trimmings and other materials resulting from clearing and grubbing operations shall become the property of the Contractor and shall be entirely removed from the property of the Company or shall be stacked and burned at locations acceptable to the Engineer. Disposal shall be such that upon completion the area shall be entirely void of all loose stumps, trimmings, brush, vegetation, and other debris.

All materials to be burned shall be piled and when in suitable condition shall be burned completely. All burning shall be so thorough that the materials are completely reduced to ashes. Piling for burning shall be done in such a manner and in such locations as to cause the least fire risk. Great care shall be taken to prevent the spread of fire. Fire guards of adequate width shall be provided wherever there is surface vegetation around any brush pile, by backfiring or other surface removal or by burying all surface vegetation within fire guard limits. No burning of trimmings or brush shall be done when the direction or velocity of the wind is such that there would be any danger of fire being carried to adjacent areas. Any and all governmental or statutory requirements or regulations relative to fire prevention in general and burning trimmings and brush in particular shall be complied with.

All burning of waste materials shall be by controlled burning under favorable atmospheric conditions and at such a time and manner to minimize smoke and air pollution to meet the requirements of regulatory authorities.

The disposal of noncombustible materials shall be the responsibility of the Contractor. Noncombustible materials shall be hauled off the site and shall be disposed of by and at the expense of the Contractor in a manner that will meet the requirements of regulatory authorities.

All vegetation cleared by mowing shall be raked into windrows and burned.

2A.3 EXISTING FENCES. All existing fences within the limits of construction shall be removed unless designated otherwise by the Engineer. Removal shall include the complete removal of posts and wire. Metal and wooden posts and wire shall be disposed of as specified for disposal of noncombustibles. Post holes shall be backfilled and lightly tamped.

2A.4 EXISTING DAMS. All existing dams so indicated on the drawings shall be removed. The earth materials of the dams shall be broken up and graded and compacted to blend in with the adjacent natural contours.

Section 2B - EARTHWORK

2B.1 GENERAL. This section covers general earthwork and shall include the necessary preparation of the construction areas; removal and disposal of all debris; excavation and trenching as required; the handling, storage, transportation, and disposal of all excavated material; all necessary sheeting, shoring, and protection work; preparation of subgrades; pumping and dewatering as necessary or required; protection of adjacent construction; backfilling; pipe embedment; construction of fills and embankments; railroad upgrading; surfacing and grading; and other appurtenant work.

The Contractor shall locate and stake all existing underground utilities before any earthwork is started. Earthwork and blasting operations in the vicinity of these underground utilities shall be performed in a manner that will not damage these facilities.

2B.2 SHEETING AND SHORING. The stability of previously constructed structures and facilities shall not be impaired or endangered by excavation work. Previously constructed structures and facilities include both structures and facilities existing when this construction began and structures and facilities already provided under these specifications.

Hazardous and dangerous conditions shall be prevented and the safety of personnel shall be maintained. Adequate sheeting and shoring shall be provided as required to protect and maintain the stability of previously constructed structures and facilities and the sides of excavations and trenches until they are backfilled. Sheeting, bracing, and shoring shall be designed and built to withstand all loads that might be caused by earth movement or pressure, and shall be rigid, maintaining shape and position under all circumstances.

2B.3 REMOVAL OF WATER. The Contractor shall provide and maintain adequate dewatering equipment to remove and dispose of all surface and ground water entering excavations and other parts of the work. Each excavation shall be kept dry during subgrade preparation and continually thereafter until the construction to be provided therein under these specifications is completed to the extent that no damage from hydrostatic pressure, flotation, or other cause will result. Ground water level shall be maintained at least 12 inches below the bottom of each excavation.

2B.4 BLASTING. The Contractor shall comply with the provisions of Section 2C regarding the use of explosives.

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2B.5 CLASSIFICATION OF EXCAVATED MATERIALS. Classification of excavated materials will be made as follows:

a. Rock. Rock is defined as being limestone, hard shale or similar material in masses more than 1/2 cubic yard in volume; or in ledges 4 inches or more in thickness which would require blasting for excavation.

b. Earth. All material not classified as rock

The term "excavated materials", as used herein, shall mean either material removed by cutting or material deposited as fill.

Soil identification shall be in accordance with Table I of the Unified Soil Classification System which is bound herewith at the end of this section. Identification and classification shall be based upon visual examination and simple manual tests performed by qualified personnel furnished by the Contractor. Classification of material shall be subject to acceptance of the Engineer.

2B.6 FREEZING WEATHER RESTRICTIONS. Backfilling and construction of fills during freezing weather shall not be done except by permission of the Engineer. No earth material shall be placed on frozen surfaces, nor shall frozen materials, snow, or ice be placed in any backfill, fill or embankment.

2B.7 MAINTENANCE OF TRAFFIC. The Contractor shall conduct his work so as to interfere as little as possible with the Company's operations and the work of other contractors. Whenever it is necessary to cross obstruct, or close roads and parking areas, the Contractor shall provide and maintain suitable and safe bridges, detours, or other temporary expedients at his own expense.

2B.8 PROTECTION OF UNDERGROUND CONSTRUCTION. The Contractor shall locate, protect, shore, brace, support, and maintain all existing underground pipes, conduits, drains, and other underground construction which may be uncovered or otherwise be affected by the work.

2B.8.1 Protection of Existing Gas Piping. The Contractor will be required to construct road or railroad roadbeds above existing gas pipelines as indicated on the drawings. A minimum cover of 3 feet shall be maintained at all times for all grading and compaction operations at these locations.

Casing for the gas lines has been installed by the Company where deemed necessary.

2B.9 PRESERVATION OF TREES. Trees shall be preserved and protected as much as possible. Unless specifically authorized by the Engineer, trees shall be removed from only those areas which will be excavated, filled, or built upon. Consideration will be given to the removal of additional trees only where essential, in the opinion of the Engineer, for the safe, effective execution of the work.

Trees left standing shall be adequately protected from permanent damage by construction operations. Trimming of standing trees, where required, shall be as directed by the Engineer.

2B.10 STABILIZATION. Subgrades for structures and the bottom of trenches shall be firm, dense, and thoroughly compacted and consolidated.

Subgrades for structures and trench bottoms which are otherwise solid but which become mucky on top due to construction operations, shall be reinforced with one or more layers of crushed rock or gravel.

The finished elevation of stabilized structure subgrades shall not be above the subgrade elevations indicated on the drawings. Over excavation shall be replaced by concrete as directed by the Engineer and at the expense of the Contractor.

Not more than 1/2 inch depth of mud or muck shall be allowed to remain on stabilized trench bottoms when the pipe embedment material is placed thereon.

All stabilization work shall be performed by and at the expense of the Contractor.

2B.11 TESTING. All field and laboratory testing required to determine compliance with the compaction and moisture requirements of this section will be provided by a testing laboratory retained and paid for by the Company. The Contractor shall provide the services of one or more employees as necessary to assist the Company's field testing representative. The Contractor will be furnished one copy of the test results.

Maximum density for cohesive compacted materials placed under this section will be determined in accordance with ASTM D1557. The terms "maximum density" and "optimum moisture content" shall be as defined in ASTM D1557.

Relative density for noncohesive compacted materials placed under this section will be determined in accordance with ASTM D2049. The term "relative density" shall be as defined in ASTM D2049.

2B.12 SITE PREPARATION. Major clearing and grubbing work shall be performed as described in Section 2A. In addition, all subgrades for permanent construction, including subgrades for fills shall be stripped

of surface vegetation, sod, debris, and organic topsoil. Surface vegetation shall be removed complete with roots to a depth of not less than 4 inches below the ground surface.

All combustible and other waste materials shall be removed from the construction areas and disposed of by and at the expense of the Contractor. Fire regulations and other safety precautions shall be observed when waste materials are burned.

All organic topsoil which is free of trash, vegetation, rocks, and roots shall be stockpiled at locations selected by the Engineer for later use under these specifications and under separate specifications. The Contractor shall stockpile, for use under separate specifications, 10,000 cubic yards of organic topsoil in excess of the amount required under these specifications.

28.13 ROADWAY AND RAILROAD ROADBEDS. Roadway and railroad roadbed construction shall include subgrade preparation, materials, placement and compaction, subgrade finishing, slope protection and maintenance of roadbed fills.

28.13.1 Subgrade Preparation. The roadbed site shall be prepared as specified in Article 28.12. Prior to placement of roadbed fill, part of the subgrade shall be removed, as indicated on the drawings, and backfilled with material suitable for embankment construction. The subgrade shall then be thoroughly compacted. After compaction, the areas shall be proof rolled by a single pass of a vibratory roller to test for uniformity and any loose soils detected shall be recompacted as specified for roadbed fills. No material shall be placed in the roadbed until the subgrade has been properly prepared and acceptable to the Engineer.

In excavated roadbed areas, overburden shall be removed and the subgrade shall be shaped to the lines, grades and cross sections indicated on the drawings. If the subgrade is in overburden it shall be further removed to a depth of at least 24 inches and compacted to a minimum of 92 per cent of maximum density with moisture content between 0 to 4 per cent above optimum. This operation shall include any scarifying, reshaping and wetting required to obtain the specified moisture and density. After compaction the subgrade shall be proof rolled as previously specified. Soft or otherwise unsuitable material shall be removed from the subgrade and replaced with material specified hereinafter for roadbed fills.

Removal of the overburden to a depth of 24 inches may be waived by the Engineer if the insitu material has the specified moisture and density.

2B.13.1.1 Special Subgrade Preparation. Special subgrade preparation is required when any of the following conditions are encountered:

1. Continuous overburden cover consists only of topsoil.
2. Continuous overburden cover is less than 6 inches thick after stripping.
3. Overburden is not continuous and rock is exposed at the ground surface

The special subgrade preparation shall consist of the following:

1. All overburden shall be removed.
2. Loose rock and overhanging ledges shall be removed.
3. The exposed rock surface shall be brushed clean.
4. Foundation area shall be wetted prior to placement of first lift
5. The first lift shall be placed a minimum of one foot thick at a moisture content between 4 and 5 percent above optimum.

Special subgrade preparation shall be limited to a distance of h plus 15 feet on either side of the embankment center line, where H is the height of the embankment as indicated on the drawings.

2B.13.2 Materials. To the maximum extent available, suitable earth materials obtained from excavations classified "excavated materials" shall be used for construction of roadbed fills. Additional material, if required, shall be obtained from borrow areas as designated on the drawings.

All materials placed in roadbed fills shall be free from brush, stumps, logs, roots, debris, and organic or other objectionable material. No rocks or boulders shall be placed in the upper 24 inches of any roadbed fill. Rocks or stones less than 4 inches in their greatest dimension may be incorporated in the remainder of the fill provided they are distributed so that they do not interfere with proper compaction.

All material within the finished subgrade, in both cut and fill sections, shall be material classified as Group CL, SC or GC as indicated on the Unified Classification chart bound at the end of this section. Crushed rock material may also be used, provided it meets the requirements for maximum size and those of Article 2B.13.3 for compaction.

Roadway and railroad roadbeds indicated as impervious embankments shall meet the requirements specified in Article 2B.14.2.

** 2B.13.3 Placement and Compaction. All roadbed fill materials shall be placed in approximately horizontal layers not to exceed 8 inches in

* Refer to Item 6 of Addendum 1.
** Refer to Item 7 of Addendum 1.

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* uncompacted thickness. Material deposited in windrows or piles by excavating or hauling equipment shall be spread and leveled before compaction.

Each layer of material being compacted shall be uniformly compacted using equipment and materials which will achieve the specified density and moisture content. The Contractor shall add water and harrow, disc, blade, or otherwise work the material in each layer as required to ensure uniform moisture content and adequate compaction. If the material fails to meet the specified density and moisture content requirements the lift shall be broken up and reprocessed until the specified requirements are met.

The upper portion of the finished subgrade shall consist of the upper 4 feet for railroad roadbeds and of the upper 2 feet for roadway roadbeds.

All material placed in the upper portion of the finished subgrade shall be compacted to a density of 95 per cent of maximum density at optimum moisture content. The final in-place moisture content shall be within a range of 0 to 4 per cent above optimum

All material placed in roadbed fills below the upper portion of the finished subgrade shall be compacted to a density of 92 per cent of maximum density at optimum moisture content. The final in-place moisture content shall be within a range of 0 to 4 per cent above optimum.

2B.13.4 Subgrade Finishing. The finished subgrade shall be compacted to a true surface and no depression shall be left that will hold water or prevent proper drainage. The finished subgrade shall be within 0.1 foot of the elevation indicated on the drawings. Any deviation of the subgrade surface in excess of one inch as indicated by a 16 foot straightedge, or template cut to finished section, shall be corrected by loosening, adding or removing material, reshaping, and recompacting.

Drains and ditches along the subgrade shall be maintained as required for effective drainage. Whenever cuts of 2 inches or more in depth are formed, the subgrade shall be brought to grade, reshaped, and recompacted. Storage or stock piling of materials on the subgrade will not be permitted.

2B.13.5 Slope Protection. The slopes of all roadway and railroad roadbed areas shall be protected by placing 6 inches of topsoil and seeding as indicated on the drawings. Ditches, where required next to the roadbeds, shall have 3 inches of topsoil and shall be seeded. Seeding, fertilizing and mulching are covered in Section 2K.

All slope protection work shall be performed as soon after completion of the roadbed as possible.

* Refer to Item 7 of Addendum 1.

2B.13.6 Maintenance. Railroad and roadway finished subgrade shall be maintained throughout the work under these specifications Roadway surfacing shall be as specified in Sections 2D and 2G and as indicated on the drawings. Railroad subballast shall be as specified in Sections 2D and 2F and as indicated on the drawings. Railroad trackwork will be performed under separate specifications

2B.14 IMPERVIOUS EMBANKMENTS Impervious embankment construction shall include subgrade preparation, materials, installation of drainage blanket, placement and compaction, subgrade finishing, slope protection with riprap or by seeding, and maintenance.

2B.14.1 Subgrade Preparation. The embankment site shall be prepared as specified in Article 2B.12. Prior to placement of embankment fill, part of the subgrade shall be removed, as indicated on the drawings, and backfilled with material suitable for embankment construction. The subgrade shall then be thoroughly compacted. After compaction, the areas shall be proof rolled by a single pass of a vibratory roller to test for uniformity and any loose soils detected shall be recompacted as specified. No material shall be placed in the embankment until the subgrade has been properly prepared and is acceptable to the Engineer.

Soft or otherwise unsuitable material shall be removed from the subgrade to the depth authorized by the Engineer and replaced with material hereinafter specified for impervious embankment.

If the impervious embankment is also a roadway, a railroad roadbed, or requires special subgrade preparation, the subgrade shall be further prepared as specified in Article 2B.13.1.

2B.14.2 Materials. To the maximum extent available, suitable earth materials obtained from excavations classified "excavated materials" shall be used for construction of the impervious embankments. Additional material, if any, shall be obtained from borrow areas as indicated on the drawings.

All material placed in the embankment fill, inner core and drainage blanket shall be free from trash, concrete and other foreign material.

* Classification of material to be used in the inner core shall be CL, material to be used in the remainder of the embankment shall be CL, SC or SM. Crushed rock may also be used provided it meets the compaction requirements of Article 2B.14.3. Drainage blanket material, as well as material for riprap and riprap bedding shall meet the requirements of Section 2D.

Where the impervious embankment is also a roadway or railroad roadbed, materials shall conform to the requirements of Article 2B 13.2.

* Refer to Item 8 of Addendum 1.

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2B.14.3 Placement and Compaction. The entire body of the fill, including upstream and downstream portions, shall be placed and carried up at the same rate, with provision being made to bond the layers of adjoining sections together. Where it is impractical, in the opinion of the Engineer, to carry up each layer of fill over the entire area at the same time, the slope of any existing fill, or the slope of the natural ground, against which new fill material is placed, shall be cut or plowed into benches having level beds and vertical sides, and each layer of new fill shall terminate in such a bench. In no case shall the horizontal width of the bench be less than the depth of the layer of fill to be bedded therein nor shall the vertical side of the bench be greater in height than one foot.

All fill material shall be placed in the embankment parallel to the axis of the embankment in approximately horizontal layers not to exceed 8 inches in uncompacted thickness over the prepared foundation or fill. The embankment fill shall be constructed by placing the material as indicated on the drawings. Proper equipment shall be used on each lift to remove mounds and ridges caused by dumping operations and to obtain uniform thickness prior to compacting, as well as to provide a reasonably smooth riding surface for equipment. After each layer has been properly spread, it shall be sprinkled or wetted if necessary to provide the required amount of water for proper compaction and worked to ensure uniform moisture content, after which the layer shall be compacted to the required density before the next layer is placed thereon. Combined excavation, hauling, and placing operations shall be such that the materials, when compacted in the embankment, will be blended sufficiently to secure the best practicable degree of compaction, impermeability, and stability.

The Contractor will be required to break up the earthfill materials, either at the place of excavation or on the embankment, to such maximum size as is determined necessary by the Engineer to secure the specified density of the material in the embankment. Equipment on the embankment shall spread out and not track each other to such an extent as to make ruts. The top surface of the fill shall be kept crowned, with grades not to exceed 2 per cent, to ensure free drainage toward the slopes. The rolled surface of each lift shall be roughened or loosened by scarifying to the satisfaction of the Engineer, before the succeeding layer is placed thereon, in order to provide the necessary bond between each lift.

Prior to and during the compacting operations, the material in each layer of the embankment shall have the best practicable moisture content, and the moisture content shall be uniform throughout the layer. To obtain the best practicable moisture content the Contractor will be required to perform such operations as are necessary. Supplementary water, as required, shall be added to the material on the earthfill. If

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the fill material in borrow areas or other excavations contains an excess of moisture prior to excavation, the Contractor will be required to excavate drainage channels or perform such work as may be necessary to reduce the moisture content of the material. Working of the material on the embankment may be required to produce the required uniformity of water content.

Water required to bring the material to the moisture content necessary for maximum compaction shall be evenly applied and it shall be the Contractor's responsibility to secure a uniform moisture content throughout the layer by such methods as may be necessary. Compaction shall commence immediately after the layer has been brought to the uniform moisture content required, and shall continue, with or without additional watering, until each layer has been uniformly compacted to not less than the specified density. Density tests will be made as necessary. If the material fails to meet the density specified the compaction methods shall be altered to obtain the specified density.

In restricted areas successive passes of the compaction equipment need not overlap but uniform compaction is required. Where new material is placed adjacent to old material, either original ground or embankment fill, the old material shall be cut or broken by machine or hand methods until it shows the characteristic color of undried materials. The compaction equipment shall then work on both materials, bonding them together.

The embankment material including the inner core shall be compacted to a density of 92 per cent of maximum density at optimum moisture content. The final in place moisture content shall be within a range of 0 to 4 per cent above optimum.

Where the impervious embankment is also a roadway or railroad roadbed, the compaction requirements of Article 2B.13.3 shall be met.

The drainage blanket, where required, shall be placed in horizontal layers not more than 6 inches in thickness, shall be compacted to 70 per cent relative density as determined by ASTM D2049 and shall have a compacted depth as indicated on the drawings.

Riprap and riprap bedding shall have minimum in-place depths as indicated on the drawings and shall conform to the requirements of Section 2E.

2B.14.4 Subgrade Finishing. Subgrade finishing shall be performed in accordance with the requirements of Article 2B.13.4.

2B.14.5 Slope Protection. The slopes of all impervious embankments shall be protected by placing riprap and riprap bedding or 6 inches of topsoil and seeding as indicated on the drawings. The downstream toes

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of the embankments shall be protected with riprap and riprap bedding where indicated on the drawings. Seeding, fertilizing and mulching are covered in Section 2K. Riprap and riprap bedding are covered in Sections 2D and 2E.

All slope protection work shall be performed as soon after completion of the embankment as possible.

2B.14.6 Maintenance. The finished impervious embankment shall be maintained throughout the work under these specifications. Where the impervious embankment also serves as a railroad or roadway roadbed, the requirements of Article 2B.13.6 shall also apply.

2B.15 STACKER-RECLAIMER BERM. Construction of the stacker-reclaimer berm shall include subgrade preparation, materials, placement and compaction, subgrade finishing and soil cement application.

2B.15.1 Subgrade Preparation. The berm site shall be prepared as specified in Article 2B.12. Preparation of the subgrade shall be as specified in Article 2B.13.1.

2B.15.2 Materials. To the maximum extent available, suitable earth materials obtained from excavations classified "excavated materials" shall be used for construction of the stacker-reclaimer berm. Additional material, if any, shall be obtained from borrow areas as designated on the drawings.

All material placed in the embankment shall be free from trash, concrete, and other foreign material.

No rocks or stones shall be placed in the upper 24 inches of the embankment. * Rocks or stones less than 4 inches in their greatest dimension may be incorporated in the remainder of the embankment provided they are distributed so that they do not interfere with proper compaction.

All material within the finished subgrade shall meet the requirements of Article 2B.13.2.

2B.15.3 Placement and Compaction. All embankment fill material shall be placed and compacted as specified in Article 2B.13.3 for railroad roadbeds.

2B.15.4 Soil-cement. Soil-cement preparation, placing and compaction shall be as specified in Section 2H.

2B.16 GENERAL FILLS. Construction of general fills shall include materials, subgrade preparation, and placement and compaction.

* Deleted in accordance with Item 9 of Addendum 1.

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2B.16.1 Materials. To the maximum extent available, suitable earth materials obtained from excavations classified "excavated materials" shall be used for construction of general fills. Additional material, if any, shall be obtained from borrow areas as indicated on the drawings.

* [illegible]

All onsite available earth material, except objectionable material specified above, may be utilized in construction of general fills including material classified as Groups CL, ML, SM-SC, ML-CL, CL-CH and SM.

2B.16.2 Subgrade Preparation. After preparation of the general fill site, the subgrade shall be leveled and rolled so surface materials of the subgrade will be as compact and well bonded with the first layer of the general fill as specified for subsequent layers.

** 2B.16.3 Placement and Compaction. All general fill materials shall be placed in approximately horizontal layers not to exceed 8 inches in uncompacted thickness. Material deposited in piles or windrows by excavating and hauling equipment shall be spread and leveled before compaction.

Each layer of material being compacted shall be uniformly compacted using equipment and methods which will achieve the specified density and moisture content. The Contractor shall add water and harrow, disc, blade, or otherwise work the material in each layer as required to ensure uniform moisture content and adequate compaction. Each layer shall be thoroughly compacted by rolling or other acceptable methods to a density of 85 per cent of maximum density at optimum moisture content. The final in-place moisture content shall be within the limits of 2 per cent below to 5 per cent above optimum moisture. If the material fails to meet the moisture density requirements the lift shall be broken up and reprocessed until the specified requirements are met.

2B.17 COAL RETENTION BERM. Construction of the coal retention berm shall include subgrade preparation, materials, placement and compaction, subgrade finishing and soil cement application.

2B.17.1 Subgrade Preparation. The berm site shall be prepared as specified in Article 2B.12. Preparation of the subgrade shall be as specified in Article 2B.16.2.

* Refer to Item 10 of Addendum 1.
** Refer to Item 11 of Addendum 1.

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Duct bank backfill shall be compacted backfill. Backfill material for duct banks shall be suitable job excavated material.

Compacted backfill material shall be finely divided and free from debris, organic material, and stones larger than 3 inches in greatest dimension. Compacted backfill material shall be placed in uniform layers not exceeding 8 inches in uncompacted thickness. Increased layer thickness may be permitted for noncohesive material if the Contractor demonstrates to the satisfaction of the Engineer that the specified compacted density will be obtained The method of compaction and the equipment used shall be appropriate for the material to be compacted and shall not transmit damaging shocks to the duct bank. Trench backfill shall be compacted to not less than 95 per cent of maximum density. Moisture content of backfill material shall be adjusted as required to obtain the specified density with the compaction equipment used.

2B.26 PAVEMENT REMOVAL AND REPLACEMENT. Cuts in concrete and asphalt pavement shall be no larger than necessary to provide adequate working space for proper installation of pipe and appurtenances. Cutting shall be started with a concrete saw in a manner which will provide a clean groove at least 1-1/2 inches deep along each side of the trench.

Concrete and asphalt pavement over trenches excavated for pipelines shall be removed so that a shoulder not less than 6 inches in width at any point is left between the cut edge of the pavement and the top edge of the trench. Trench width at the bottom shall not be greater than at the top and no undercutting will be permitted Pavement cuts shall be made to and between straight or accurately marked curved lines which, unless otherwise required, shall be parallel to the center line of the trench.

2B.27 MAINTENANCE AND RESTORATION OF FILLS, EMBANKMENTS, AND BACKFILLS. Fills, embankments and backfills that settle or erode before final acceptance of the work under these specifications, and structures and other facilities damaged by such settlement or erosion, shall be repaired. The settled or eroded areas shall be refilled, compacted, and graded to conform to the elevation indicated on the drawings or to the elevation of the adjacent ground surface. Damaged facilities shall be repaired in a manner acceptable to the Engineer.

2B.28 FINAL GRADING. After all construction work under these specifications has been completed, all ground surface areas disturbed by this construction or construction plant and operations shall be graded. The grading shall be finished to the contours and elevations indicated on the drawings or, if not indicated, to the matching contours and elevations of the original, undisturbed ground surface. In any event, the final grading shall provide smooth uniform surfacing and effective drainage of the ground areas.

Topsoil shall be furnished in the areas and to the depths indicated on the drawings for the soil erosion protection work. Topsoil shall be provided as specified under Article 2B.12.

2B.29 DISPOSITION OF MATERIALS. Excavated earth material shall be used to construct fills, embankments and backfills to the extent required. Excavated rock shall be crushed as specified in Section 2D. Surplus earth, if any, and materials which are not suitable for fills, embankments, and backfills shall be spoiled on the site in a manner and location as directed by the Engineer.

Materials shall be deposited in the disposal areas and leveled and compacted in 12 inch maximum layers. Compaction shall be by three passes of a bulldozer.

2B.30 RAILROAD UPGRADING. Railroad upgrading work on the existing railroad tracks indicated on the drawings shall be performed according to the following requirements.

2B.30.1 Existing Track Removal. Existing trackage removal shall be performed as specified in Article 2A.6.

2B.30.2 Roadbed Construction. The existing roadbed shall be regraded and constructed as specified in Article 2B.13.

2B.30.3 Trackage. Railroad trackage will be installed under separate specifications.

Section 2E - RIPRAP AND RIPRAP BEDDING

2E.1 GENERAL. This section covers procedures for the installation of dumped riprap and riprap bedding.

Riprap and riprap bedding shall be required at the locations indicated on the drawings. Thickness of riprap and riprap bedding shall be as indicated on the drawings.

2E.2 MATERIALS. Riprap and riprap bedding materials shall be in accordance with the requirements of Section 2D.

2E.3 PLACEMENT. Dumped riprap and riprap bedding materials shall be placed on slopes designated on the drawings. Earth slopes shall be compacted as specified in the section covering construction of the slope.

Where required by the drawings, a riprap bedding blanket shall be placed on the prepared slope or area to the full specified thickness of each layer in one operation, using methods which will not cause segregation of particle sizes within the bedding. The surface of the finished layer should be reasonably even and free from mounds or windrows. Additional layers of bedding material, when required, shall be placed in the same manner, using methods which will not cause mixture of the material in different layers.

Stone for riprap shall be placed on the prepared slope or area in a manner which will produce a reasonably well graded mass of stone with the minimum practicable percentage of voids. The entire mass of stone shall be placed in conformance with the lines, grades, and thicknesses indicated on the drawings. Riprap shall be placed to its full course thickness in one operation and in such a manner as to avoid displacing the underlying material. Placing of riprap in layers, or by dumping into chutes, or by similar methods likely to cause segregation will not be permitted.

The larger stones shall be well distributed and the entire mass of stone shall conform to the gradation specified. All material placed as riprap protection shall be so placed and distributed that there will be no large accumulations of either the larger or smaller sizes of stone.

It is the intent of these specifications to produce fairly compact riprap protection in which all sizes of material are placed in their proper proportions. Stone fragments in riprap shall be dumped and graded off in a manner which will insure that the larger rock fragments are uniformly distributed and that the smaller rock fragments fill the spaces between the large rock fragments. The result shall be a compact, uniform riprap layer of the specified thickness. Hand placing will be required only to the extent necessary to obtain the results specified above.

NE34P000221

APPENDIX A

Document 13

Inspection Report 04.30.09

Report

REPORT FOR THE INSPECTION OF THE BOTTOM ASH POND AT NORTHEASTERN STATION RESERVOIR

ROGERS COUNTY, OKLAHOMA

Submitted To: American Electric Power

Submitted By: Golder Associates Inc.

Distribution: 3 – American Electric Power
3 – Golder Associates Inc.

Date April 2009

Project No. 09390068-20

A world of capabilities delivered locally

Golder Associates

NE34P000095

Golder Associates Inc.
2730 Chamblee Tucker Road
Atlanta, GA USA 30341
Telephone (770) 496-1893
Fax (770) 934-9476

Golder Associates

April 30, 2009

Our Ref.: 09390008-20

American Electric Power (AEP)
1 Riverside Plaza
Columbus, OH 43215-2373

Attn: Mr. Pedro J. Amaya, P.E., Senior Engineer – Geotechnical Engineering

RE: FINAL REPORT FOR THE INSPECTION OF THE BOTTOM ASH POND AT NORTHEASTERN STATION ROGERS COUNTY, OKLAHOMA

Dear Mr. Amaya:

Golder Associates Inc. (Golder) is pleased to submit the attached visual inspection report for the Public Service Company of Oklahoma's, Bottom Ash Pond at Northeastern 3 and 4 Power Station. The inspection was performed by Mr. Michael T. Chilson and Mr. Rafael I. Ospina, P.E., under the direction of David L. O'Sadnick, P.E. Mr. William R. Smith and Mr. David R. Lee (Plant Inspection Coordinator) with AEP were present during the inspection. This work was performed in accordance with our proposal dated February 23, 2009 and Service Agreement 194880X198 signed March 5, 2009.

We appreciate this opportunity to provide engineering services to AEP. Please do not hesitate to contact one of the undersigned if you have any further questions, require additional information, or would like to discuss the conclusions presented in this report.

Very truly yours,

GOLDER ASSOCIATES INC.

Rafael I. Ospina, P.E.
Principal and Senior Consultant

David L. O'Sadnick, P.E. OK Lic# 15971
Principal and Practice Leader

RIO/DLO/mte/sdp

Distribution: 3 Copies – American Electric Power
3 Copies – Golder Associates Inc.

DAM & DIKE INSPECTION REPORT

BOTTOM ASH POND AT NORTHEASTERN 3 & 4 STATION ROGERS COUNTY, OK

INSPECTION DATE March 31, 2009

PREPARED BY Michael T. Chilson DATE 4/29/09

REVIEWED BY Rafael I. Ospina, P.E. DATE 4/29/09

APPROVED BY David L. O'Sadnick, P.E. DATE 4-29-09

REGISTERED PROFESSIONAL ENGINEER DAVID L. O'SADNICK 15971 OKLAHOMA

PROFESSIONAL ENGINEER

SEAL & SIGNATURE

PUBLIC SERVICE COMPANY OF OKLAHOMA

BOTTOM ASH POND AT NORTHEASTER 3 & 4 STATION

Annual Inspection and Engineering Evaluation

CERTIFICATION

I hereby certify that I (or engineer working under my direction) have inspected and evaluated the facility, and being familiar with the provisions of Oklahoma Water Resources Board Rules in OAC Title 785:25 (as amended through July 1, 2004), attest this report has been prepared in accordance with good engineering practices.

Daniel L. O'Sullivan

Printed Name of Registered Professional Engineer

Date: 4-29-09 Registration No.: 15971 State: OK

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1.2 General Description of Dam 1

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3.0 VISUAL OBSERVATIONS **4**

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3.2 Upstream Slope 4

3.3 Crest 4

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4.0 CONCLUSIONS AND RECOMMENDATIONS **6**

In order

Following

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FIGURE 1-2 Plan View with Aerial Photograph
FIGURE 3-1 Identified Deficiencies

APPENDICES

APPENDIX A Inspection Checklist
APPENDIX B Photographs of Dam
APPENDIX C Documentation Provided by AEP

1.0 INTRODUCTION

1.1 Background

American Electric Power (AEP) Service Corporation Civil Engineering administers the Dam Inspection and Maintenance Program at AEP facilities. AEP contracted with Golder Associates Inc. (Golder) to complete the annual inspection of the Bottom Ash Pond at the Northeastern Units 3 and 4 Power Station. This inspection was completed to fulfill, in part, the requirements of the Oklahoma Water Resources Board in Oklahoma Administrative Code Title 785:25, and to provide AEP an evaluation of the facility to assist in the prioritization of maintenance activities. This report contains Golder's observations, photographs, conclusions and recommendations with inspection certification of AEP's Bottom Ash Pond at Northeastern Units 3 and 4 Power Station. A completed checklist for the dam was submitted to AEP on April 6, 2009 and a copy is included in Appendix A.

Mr. Rafael I. Ospina, P.E., and Mr. Michael T. Chilson, of Golder, under the direction of Mr. David L. O'Sadnick, P.E., with Mr. William R. Smith, P.E., and Mr. David R. Lee of AEP visually inspected the dam on March 31, 2009. At the time of inspection, the temperature was in the 60's with partly cloudy skies and high winds. The severity of noted deficiencies and the adequacy of freeboard and spillway capacities were assessed based on the operation of the dam at the time of visit. No analytical assessment of the hydrologic or hydraulic performance of the dam and components was made.

The following documentation, provided by AEP, was reviewed and utilized during the preparation of this report, and is included in Appendix C:

- Public Service Company of Oklahoma: Northeastern Station Units 3 & 4, Ash Disposal Site Figure 3, Drawing Number 85014-4. Date is illegible.
- Public Service Company of Oklahoma: Northeastern Station Units 3 & 4, Site Grading Plant Site Area IV, Drawing Number 85127-E. Last revision dated 1985

1.2 General Description of Dam

See Figure 1-1 for the location of the Bottom Ash Pond, and Figure 1-2 for the site plan view and aerial photograph. The dam is a 4,200-foot long cross-valley impoundment on an unnamed tributary to Fourmile Creek

GENERAL INFORMATION

Dam or Reservoir:	Bottom Ash Pond at Northeaster Power Station
Owner:	Public Service Company of Oklahoma
Type of Dam:	Earth-Fill Structure
Date of Construction:	1979
D/S Hazard:	Unclassified

LOCATION

County:	Rogers County
General Location:	Approximately 22 miles north-northeast of Tulsa, OK
Stream and Basin:	Unnamed tributary to Fourmile Creek.
	Verdigris River Basin

SIZE

Dam Crest Elevation[1]:	~	630	feet-MSL (low point near emergency spillway)
Maximum Water Level[2]:	~	626	feet-MSL (elevation of emergency spillway weir)
Current Water Level[2]:	~	623	feet-MSL
Height[1]:	~	20	feet
Surface Area:		34	acres
Reservoir Capacity			
at Normal Water Level:	Depth and volume unknown		

Notes: 1.) Elevation of crest and toe were estimated from a site plan provide by AEP titled: Ash Disposal Site, Figure 3, the date on which is illegible. 2.) Elevations calculated based on visually estimated offsets from the dam crest.

2.0 SUMMARY OF VISUAL INSPECTION TERMS

The summary of the visual observations presented herein uses terms to describe the general appearance or condition of an observed item, activity or structure. Their meaning is understood as follows:

CONDITION OF DAM COMPONENT

Good: A condition or activity that is generally better or slightly better than what is minimally expected or anticipated from a design or maintenance point of view.

Fair: A condition or activity that generally meets what is minimally expected or anticipated from a design or maintenance point of view.

Poor: A condition or activity that is generally below what is minimally expected or anticipated from a design or maintenance point of view.

SEVERITY OF DEFICIENCY

Minor: A reference to an observed deficiency (e.g., erosion, seepage, vegetation, etc.) where the current maintenance condition is below what is normal or desired, but which is not currently causing concern from a structure safety or stability point of view.

Significant: A reference to an observed deficiency (e.g. erosion, seepage, vegetation, etc.) where the current maintenance program has neglected to improve the condition. Usually these conditions have been identified in previous inspections, but have not been corrected.

Excessive: A reference to an observed deficiency (e.g., erosion, seepage, vegetation, etc.) where the current maintenance condition is above or worse than what is normal or desired, and which may have affected the ability of the observer to properly evaluate the structure or particular area being observed or which may be a concern from a structure safety or stability point of view.

3.0 VISUAL OBSERVATIONS

See Figure 3-1 for the location of structures and deficiencies itemized below.

3.1 Inflow and Outflow Structures

The primary outflow structure, emergency spillway, sewer inflow, and inflow culverts were inspected and depicted in Photographs 1 through 5. These concrete structures are structurally in good condition. The flow-way and discharge area of the primary outflow structure extends off site and were not inspected.

The concrete chute emergency spillway has been modified with a 16-inch-high metal plate weir installed across the control section of the spillway.

3.2 Upstream Slope

The upstream slope along the north and west shorelines, depicted in Photograph 6, is generally in fair condition with a minor extent of woody vegetation within the riprap shore protection.

The upstream slope along the south shoreline, depicted in Photograph 7, becomes steeper (~1:1) and higher than the north and west shorelines. The riprap shore protection is sporadic or not present in the area east of the main pond, but not necessarily required due to the shorter fetch length. Significant surface irregularities, causing concentrated storm flows and erosion gullies were observed.

3.3 Crest

The crest of the dam is generally in good condition except were a couple of minor ruts have developed at the north end of the reservoir.

3.4 Downstream Slope

The downstream slope is in fair condition. No signs of sloughing or other instabilities were observed. Trees and undesirable vegetation was observed on the lower half of the dam and among the riprap when present.

3.5 Toe

Standing water was observed at the toe in two locations on the west end of the reservoir. An active seep with approximately 0.01 cfs of discharge was observed on the south end of the reservoir. This seep occurs where the embankment is the highest within the pre-existing natural drainageway. No signs of sloughing in any of these areas were observed. All flowing water was clear.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Table 5-1 summarizes the deficiencies and recommendations for the Bottom Ash Pond at Northeastern Units 3 and 4 Power Station identified by Golder.

The dam is generally in fair condition, with some individual components in poor condition. No signs of sloughing or other embankment instabilities were observed. The emergency spillway is partially obstructed, undesirable vegetation exists on the upstream and downstream slope, and active seepage was observed at the downstream toe.

To address the deficiencies identified at the Bottom Ash Pond at Northeastern Units 3 and 4 Power Station, Golder recommends the following remedial actions:

- Confirm the modified emergency spillway does not create a risk for stages higher than the design peak stage. Clear the brush away from the emergency spillway exit and side walls.
- Remove all trees and undesirable vegetation from the upstream and downstream slopes to 30 feet beyond the toe of the dam. A grass cover should be established and maintained less than 6 inches in height. Herbicide should be applied per all applicable environmental standards.
- Regrade, seed and mulch the southern upstream slope, east of the main pool and along the inlet channel, to prevent the development of further erosion.
- Regrade the crest on the north end to remove any ruts or depressions that may pond water.
- Install weir or other measuring device at locations where active seepage was identified, and monitor all wet areas for an increase in flow rate, and for signs of embankment instability due to saturated soils.

Golder also recommends that an updated Emergency Action Plan (EAP) be developed highlighting emergency procedures and contacts in the event of a probable, immanent or occurring breach. Golder understands the Bottom Ash Pond is currently unclassified. As part of the development of an EAP, a classification study of the dam should be performed that identifies regions at risk of inundation should the dam fail.

GOLDER ASSOCIATES INC.

Michael T. Chilson
Project Engineer

Rafael I. Ospina, P.E.
Principal and Senior Consultant

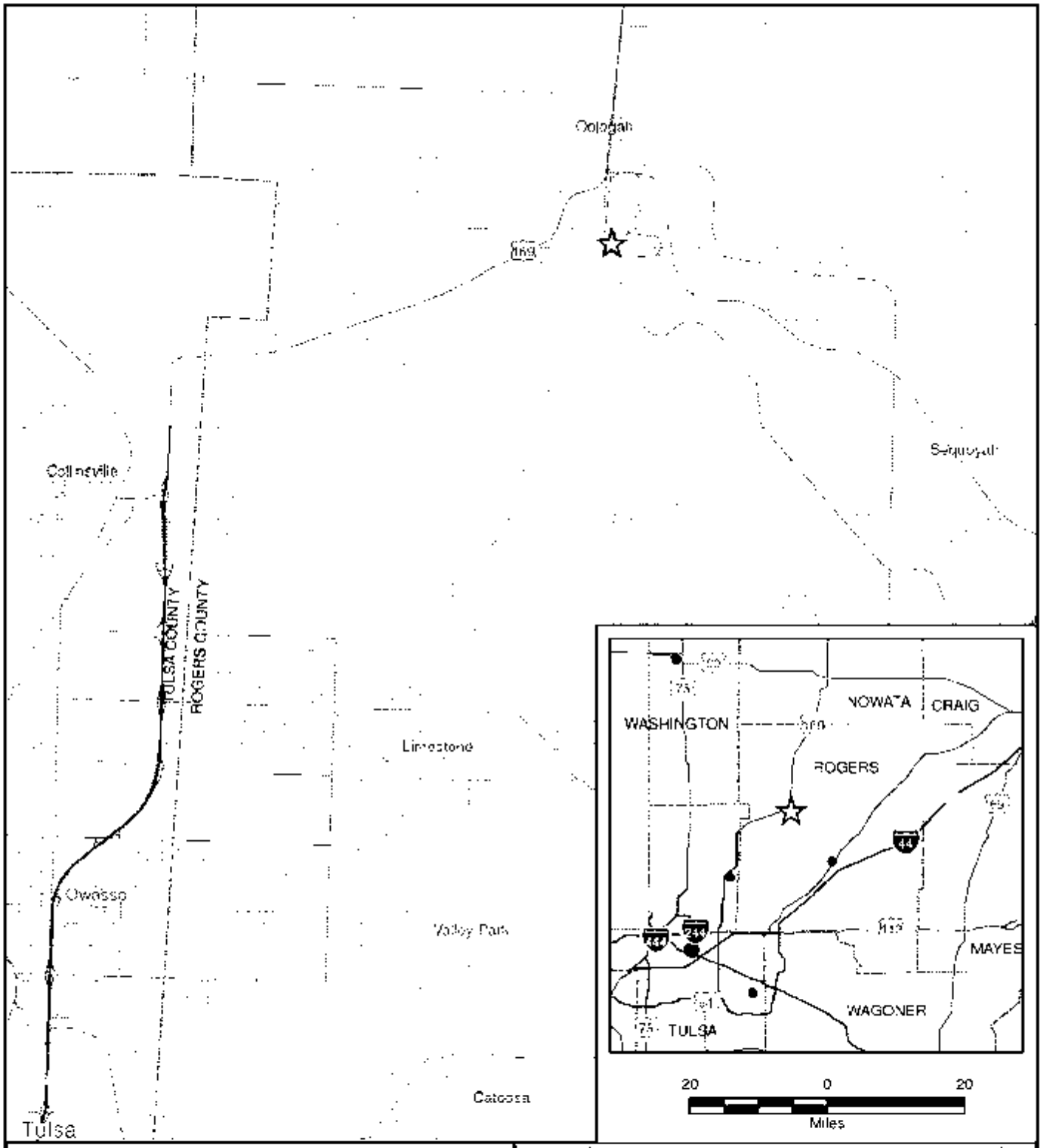
David L. O'Sadnick, P.E.
Principal and Practice Leader

Tables

TABLE 5-1
SUMMARY OF DAM DEFICIENCIES

Component of Dam	Condition	Deficiency	Severity	Recommendation
Primary Spillway	Good	None	NA	Continue to monitor and maintain structure
Emergency Spillway	Fair	Obstruction	Minor	Clear vegetation and maintain riprap at entrance, and remove debris from exit channel. Confirm spillway capacity after modification.
Riprap Shore Protection	Fair	Undesirable Vegetation	Minor	Clear and herbicide woody vegetation within the riprap
Upstream Slope	Poor to Fair	Undesirable Vegetation	Significant	Clear, establish and maintain a grass cover less than 6 inches in height.
		Surface Irregularities	Significant	Regrade, seed and mulch surface to remove irregularities and prevent further erosion
Crest	Fair to Good	Rutting	Minor	Regrade crest surface at north end of reservoir to remove ruts or depressions.
Downstream Slope	Fair	Undesirable Vegetation	Significant	Clear slope to 30 feet beyond toe, establish and maintain a grass cover less than 6 inches in height. Remove vegetation from within riprap
Toe	Poor	Seepage	Significant	Install weir to measure flows. Monitor for increased flow rates and signs of surface instability due to soil saturation.

Figures



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Miles

N

☆ Northeastern Station Bottom Ash Pond

REV	DATE	BY	REVISION DESCRIPTION	DR	CHK	PM

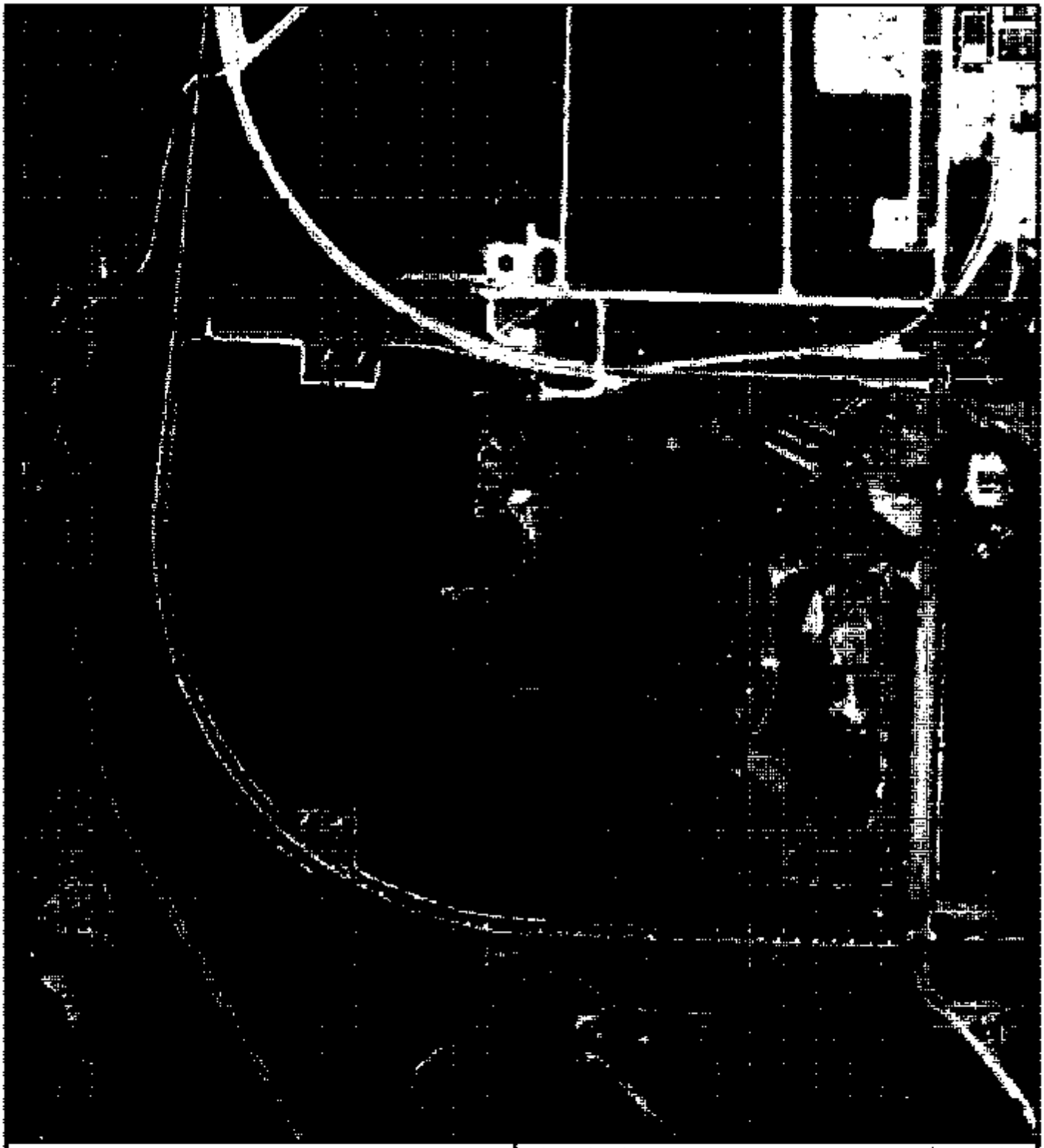
PROJECT
AMERICAN ELECTRIC POWER
NORTHEASTERN STATION BOTTOM ASH POND

TITLE
LOCATOR MAP

Geiger Associates
Atlanta, Georgia

1-1

NE34P000110



400 0 400

N

REFERENCES

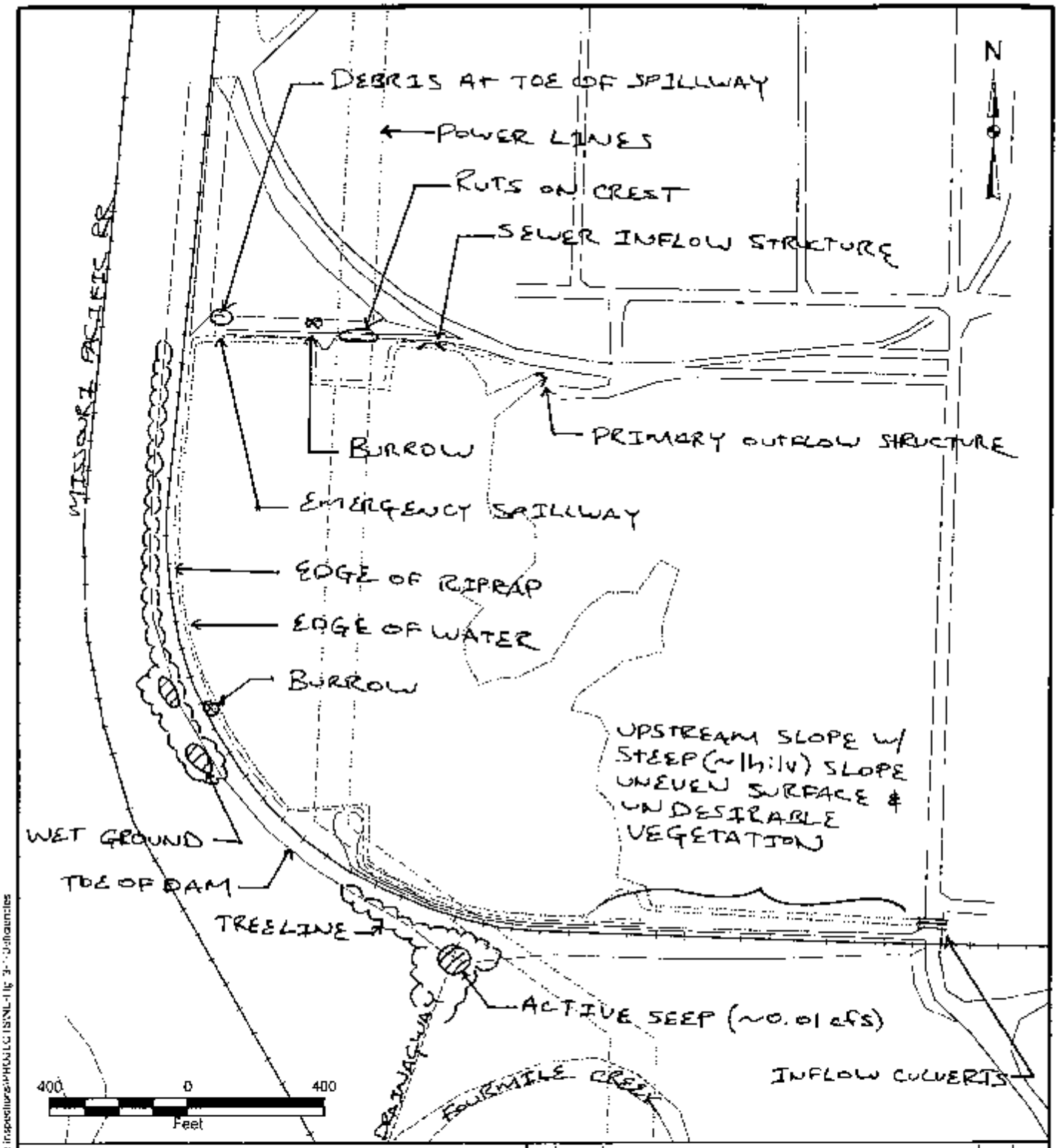
USDA FSA-APFO Aerial Photography Field Office (2006). National Agriculture Imagery Program (NAIP) Orthoimagery for Zone 15 Oklahoma State Plane Quadrangle COLOGAH SE

AMERICAN ELECTRIC POWER
NORTHEASTERN STATION BOTTOM ASH POND

PLAN VIEW WITH AERIAL PHOTOGRAPH

Golder Associates

1-2



NOTES

⊗ - BURROW > 6"ϕ. MANY SMALLER BURROWS (< 6"ϕ) ARE SCATTERED THROUGHOUT SITE.

PLACEMENT OF IDENTIFIED DEFICIENCIES IS APPROXIMATE.

REV.	DATE	DES	REVISION DESCRIPTION	GS	CHK	RAW

PROJECT: AMERICAN ELECTRIC POWER NORTHEASTERN STATION BOTTOM ASH POND

TITLE: IDENTIFIED DEFICIENCIES

Golder Associates
Atlanta, Georgia

PROJECT No.	0386604-20	FIG. No.	N/A
DESIGN		SCALE: 1"=400'	REV. 0
DRAWN	WID	04/13/10	3-1
CHECK	RCD	04/13/10	
REVIEW	DD	4/23	

Appendix A

Inspection Checklist

NE34P000113

Golder Associates Inc.

3730 Chamblee Tucker Road
Atlanta, GA USA 30341
Telephone (770) 496-1893
Fax (770) 934-9476

Golder Associates

April 6, 2009

Our Ref: 093-90068-20

American Electric Power Corporation (AEP)
1 Riverside Plaza
Columbus, OH 43215-2373

Attention: Mr. Pedro J. Amaya, P.E., Senior Engineer - Geotechnical Engineering

RE: NORTHEASTERN PLANT
2009 ANNUAL DIKE AND DAM INSPECTION
NORTHEASTERN 3&4 ASH POND
TULSA, OKLAHOMA

Dear Mr. Amaya:

Golder Associates Inc. (Golder) is pleased to submit the attached Inspection Checklist Forms for the annual safety inspection of the Public Service Company of Oklahoma, Northeastern 3&4 Ash Pond performed on March 31, 2009. The inspection was performed by Mr. Mike Chilson and Rafael Ospina, P.E. under the direction of Dave O'Sadnick, P.E. Mr. Will G. Smith and Mr. David Lee (Plant inspection coordinator) with AEP were present during the inspection.

The enclosed forms are to be submitted to the Oklahoma Water Resources Board Planning and Management Division. The full report of the inspection will be submitted to you under a separate cover. The work was performed in accordance with our Proposal dated February 23, 2009 and Service Agreement 194880X198.

If you have any questions, please do not hesitate to contact us.

Very truly yours,

GOLDER ASSOCIATES INC.

Rafael I. Ospina, P.E.
Principal and Senior Consultant

Dave O'Sadnick, P.E., Oklahoma #15971
Principal and Practice Leader

REGISTERED PROFESSIONAL ENGINEER
DAVID O'SADNICK
15971
4-6-09
OKLAHOMA

Attachments: Inspection Checklists

RIO/DO/rio

cc: W.R. Smith – AEP – Engineer – Geotechnical Engineering
M. T. Chilson – Golder Associates Inc. Project Engineer

X:\Clients\American Electric Power\093-0068-20 Northeastern Plant Dam Inspections\2009 Reports\2009 Northeastern 2009 Dam Inspection Report Northeastern Dam 3&4 Dry Cover Letter 4-6-09.docx

OKLAHOMA WATER RESOURCES BOARD
PLANNING & MANAGEMENT DIVISION

DAM INSPECTION CHECKLIST

NAME OF DAM: Northeast Station Bottom Ash Pond
COUNTY: Rogers
OWNER & ADDRESS:
Public service Company of Oklahoma
PO Box 201, Tulsa, OK 74102-0201
OWNER APPLICATION #:
OWNER PLAN #:
IDENTIFICATION #:
PURPOSE OF DAM: Bottom Ash Settlement
INSPECTED BY: Rafael Ospina, Mike Chilson
LEGAL Section ____ Township ____ Range: ____
HAZARD CLASS: Not classified
WEATHER: Windy, Clear 60's rained previous night
INSPECTION DATE: 03/31/2009

ITEM	Y	N	N/A	REMARKS
1. General Conditions				
a. Alterations to dam?		✓		
b. Development in downstream floodplain?		✓		
C. Grass cover adequate?		✓		Grass excessively high in areas
D. Settlements, misalignments or cracks?		✓		
E. Recent high water marks		✓		
2. Upstream Slope				
A. Erosion?	✓			Steep irregular surface causing gullies
B. Trees?	✓			Small trees at south waterline
C. Rodent holes?	✓			
D. Cracks, settlements or bulges?		✓		
E. Adequate and sound rip rap?	✓			
3. Intake Structure concrete	✓	metal	✓	Pump-out structure
A. Spalling, cracking, scaling?		✓		
B. Exposed reinforcement?		✓		
C. Corrosion present?		✓		
D. Coating adequate?	✓			
E. Leakage?		✓		
F. Trash rack adequate?	✓			
G. Obstacles to inlet?		✓		
H. Drawdown operative? closed		open		NA
4. Abutment Contacts				Clear brush from groins
A. Erosion, cracks or slides?		✓		
B. Seepage?		✓		
5. Emergency Spillway				
A. Obstructions?	✓			Clear brush obstructing exit channel
B. Erosion?		✓		
C. Rodent holes?		✓		
6. Downstream Slope				
A. Erosion?		✓		Irregular surface causing concentrated flows
B. Trees?	✓			Clear trees on lower half of slope
C. Rodent holes?	✓			On north slope
D. Cracks, settlements, bulges?		✓		
E. Drains or wells flowing?			✓	
F. Seepage or boils?	✓			In original drainage feature at south slope
7. Conduit & Outlet concrete		metal		NA
A. Spalling, cracking, scaling?			✓	
B. Exposed reinforcement?			✓	
C. Joints displaced or offset?			✓	
D. Joint material lost?			✓	

ITEM	Y	N	N/A	REMARKS
E. Leakage?			✓	
F. Earth erosion?			✓	
G. Conduit misaligned?			✓	
H. Outlet channel obstructed?			✓	
8. Stilling Basin				
A. Spalling, cracking, scaling?			✓	
B. Exposed reinforcement?			✓	
C. Joints displaced or offset?			✓	
D. Joint material lost?			✓	
E. Joints leak?			✓	
F. Rock adequate?			✓	
G. Dissipater deteriorating?			✓	
H. Dissipater clean of debris?			✓	
9. Concrete Spillway				
A. Spalling, cracking, scaling?		✓		
B. Exposed reinforcement?		✓		
C. Joints displaced or offset?		✓		
D. Joint material lost?		✓		
E. Leakage?		✓		
F. Dissipater deteriorating?			✓	No energy dissipater
G. Dissipater clean of debris?			✓	No energy dissipater
H. Earth erosion?		✓		
I. Outlet channel eroding?		✓		
10. Gates				
A. Floodgates broken or bent?			✓	
B. Floodgates eroded or rusted?			✓	
C. Floodgates operational?			✓	
11. Reservoir				
A. Developed?	✓			Industrial Uses
B. Slides or erosion on banks?		✓		
C. Reservoir managed?	✓			
12. Instruments				
A. Structure instrumented?		✓		
B. Monitoring performed?			✓	
**Reevaluate Hazard Classification	✓			Hazard Classification Unknown

REMARKS:

- 9) Excessive debris in concrete spillway exit channel. Clear exit channel.
- 6F) Monitor active flow in natural drainage feature on south slope at highest point of the dam. Additional wet but firm area at toe of west slope – rained previous night, reinspect after several days of no rain.
- 2A) Steep (1:1) slope w/ irregular surfaces extending ~ 2,000' from east abutment. Monitor for concentrated flows causing erosion gullies.
- 6B) Cut and maintain grass cover to 6". Clear trees to 25' off toe.

NAME OF ENGINEER: David O'Sadnick, P.E., Principal and Vice President Central Region

DATE: April 6, 2009

ENGINEERING FIRM: Golder Associates Inc.

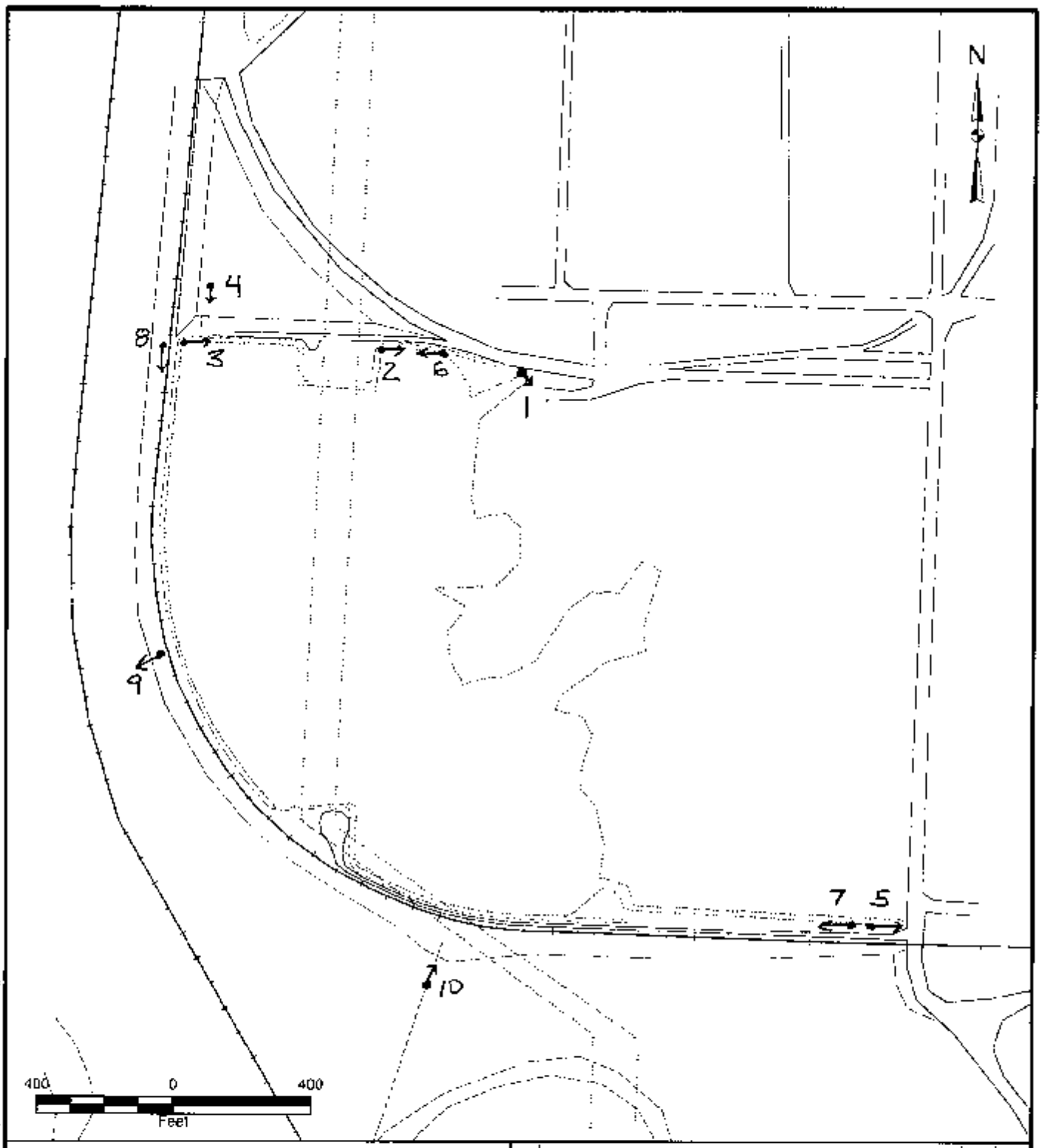
SIGNATURE: David L. O'Sadnick

REGISTERED PROFESSIONAL ENGINEER
DAVID L. O'SADNICK
15971
PROFESSIONAL ENGINEERING SEAL

Appendix B

Photographs of Dam

NE34P000117



NOTES

REV.	DATE	ERS	REVISION DESCRIPTION	GIS	CHK	RVW

PROJECT

AMERICAN ELECTRIC POWER
NORTHEASTERN STATION BOTTOM ASH POND

TITLE

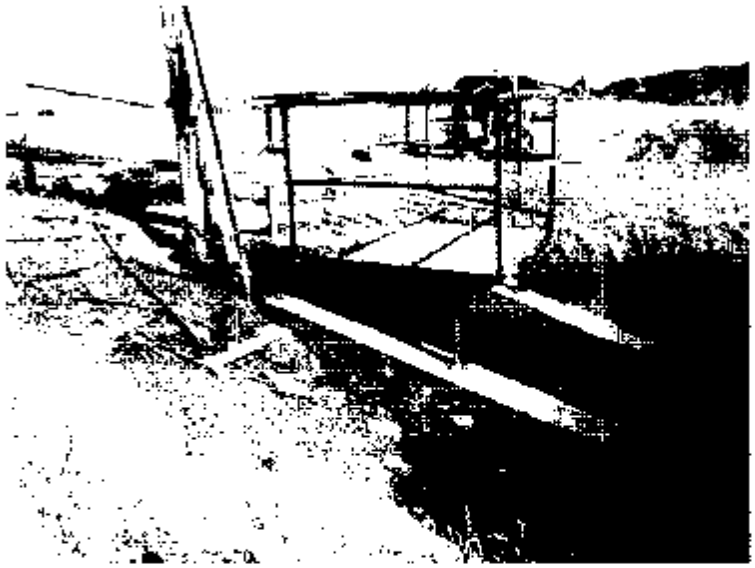
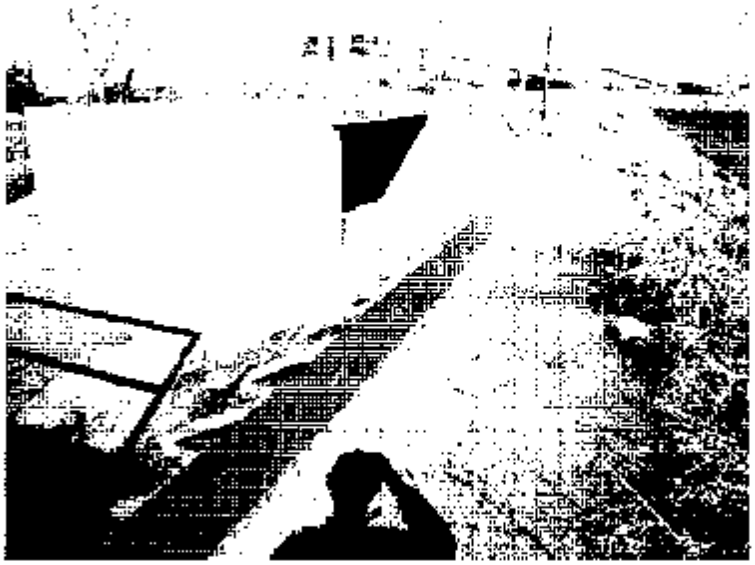
LOCATION OF PHOTOGRAPHS

Golder Associates
Atlanta, Georgia

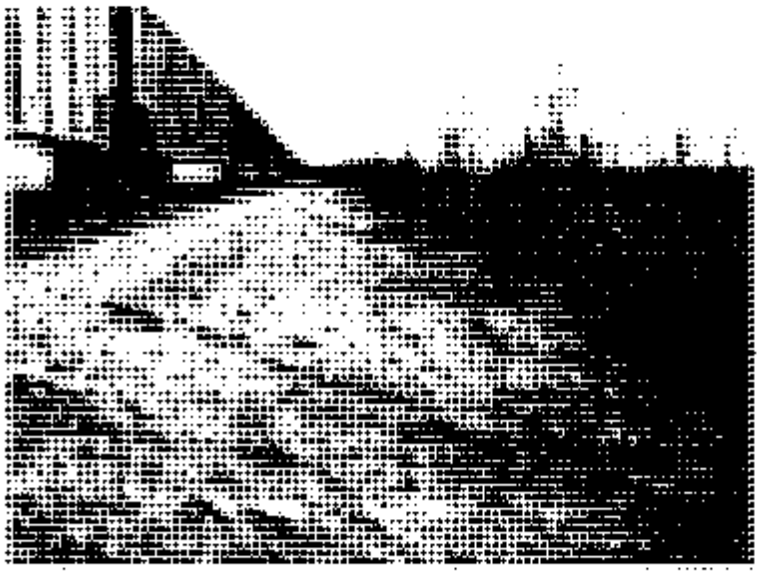
PROJECT No.	[illegible]	FILE No.	
DESIGN	--	SCALE	REV.
GIS	MTD		
CHECK	DJO		B-1
REVIEW	DJU		

D:\GIS\American Electric Power\0350066 Ash and Dike Inspections\PROJECT\BNE Fig. B-1 Deliverables

NE34P000118

1.) Primary outflow structure; Good condition; Flow-way and exit area extend off-site and were not observed.	
2.) Sewer inflow structure; Fair condition.	
3.) Emergency spillway and crest; Fair condition. Maintain the riprap apron at the inlet free from vegetation.	

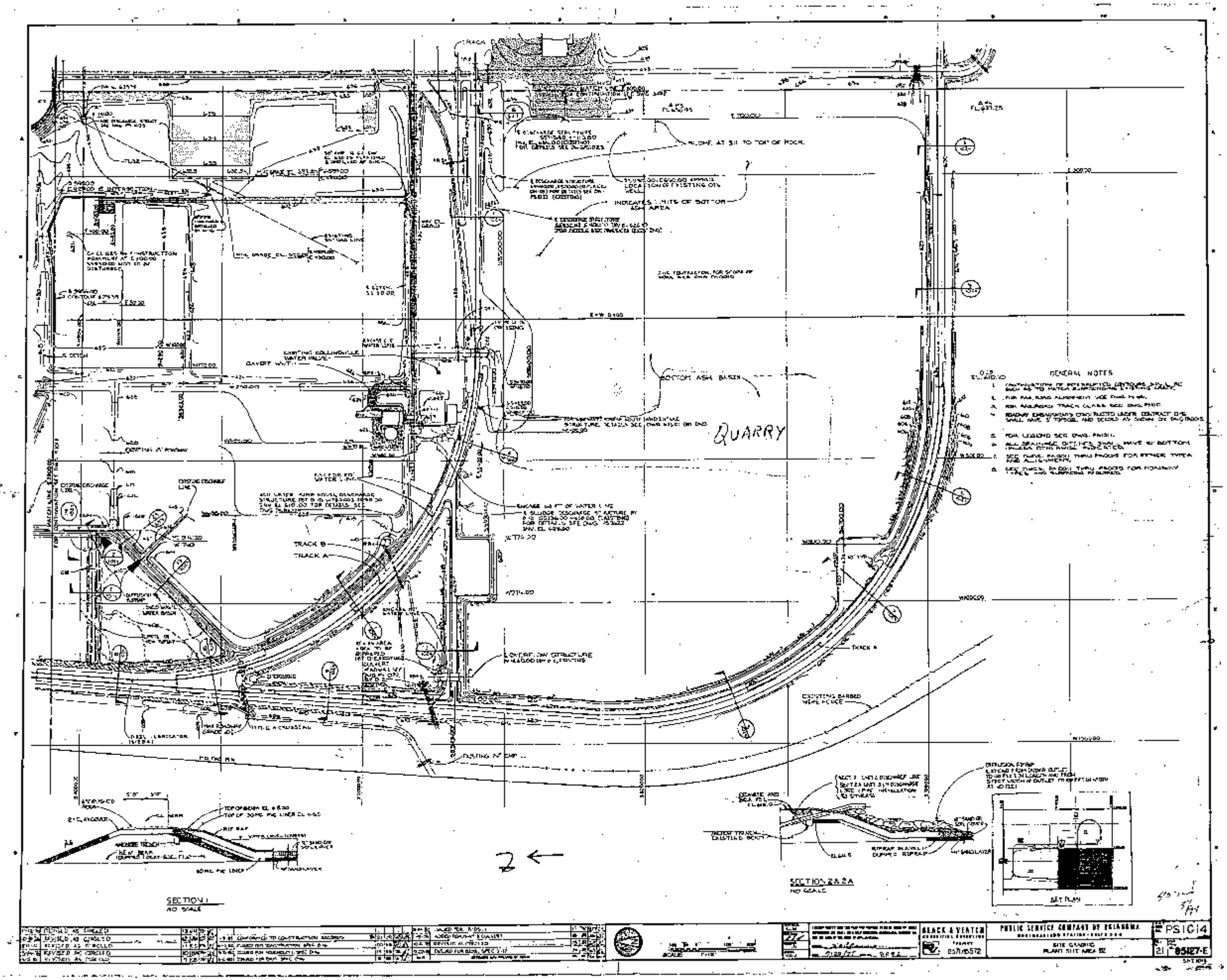
4.) Emergency spillway exit channel; Fair condition. Minor obstructions were observed within the exit channel. Clear debris from the spillway and along the outside of the training walls.	
5.) Inflow culverts; Fair condition. Clear and maintain vegetation at culvert openings.	
6.) Upstream slope, north and west ends; Fair condition, with a minor extent of woody vegetation. Riprap is generally in fair condition. Clear and herbicide per applicable environmental standards all woody vegetation from the riprap shore protection.	

7.) Upstream slope, south end; Poor condition due to significant surface irregularities, and undesirable vegetation. Riprap shore protection is sporadic. Significant surface irregularities were observed in the steep (~1:1) slopes. Concentrated storm flows and gully erosion are developing.	
8.) Downstream slope, west end; Fair condition, with significant undesirable vegetation. Clear trees and undesirable vegetation from all slopes to 25 feet beyond the toe. Establish and maintain grass cover at < 6" in height.	
9.) Downstream toe, west end; Locally in poor condition due to significant standing water. Significant standing water at toe of dam.	

10.) Downstream toe, south end; Locally in poor condition due to significant seepage. Significant seepage from toe at natural drainageway (~0.01 cfs)	

Appendix C

Documentation Provided by AEP



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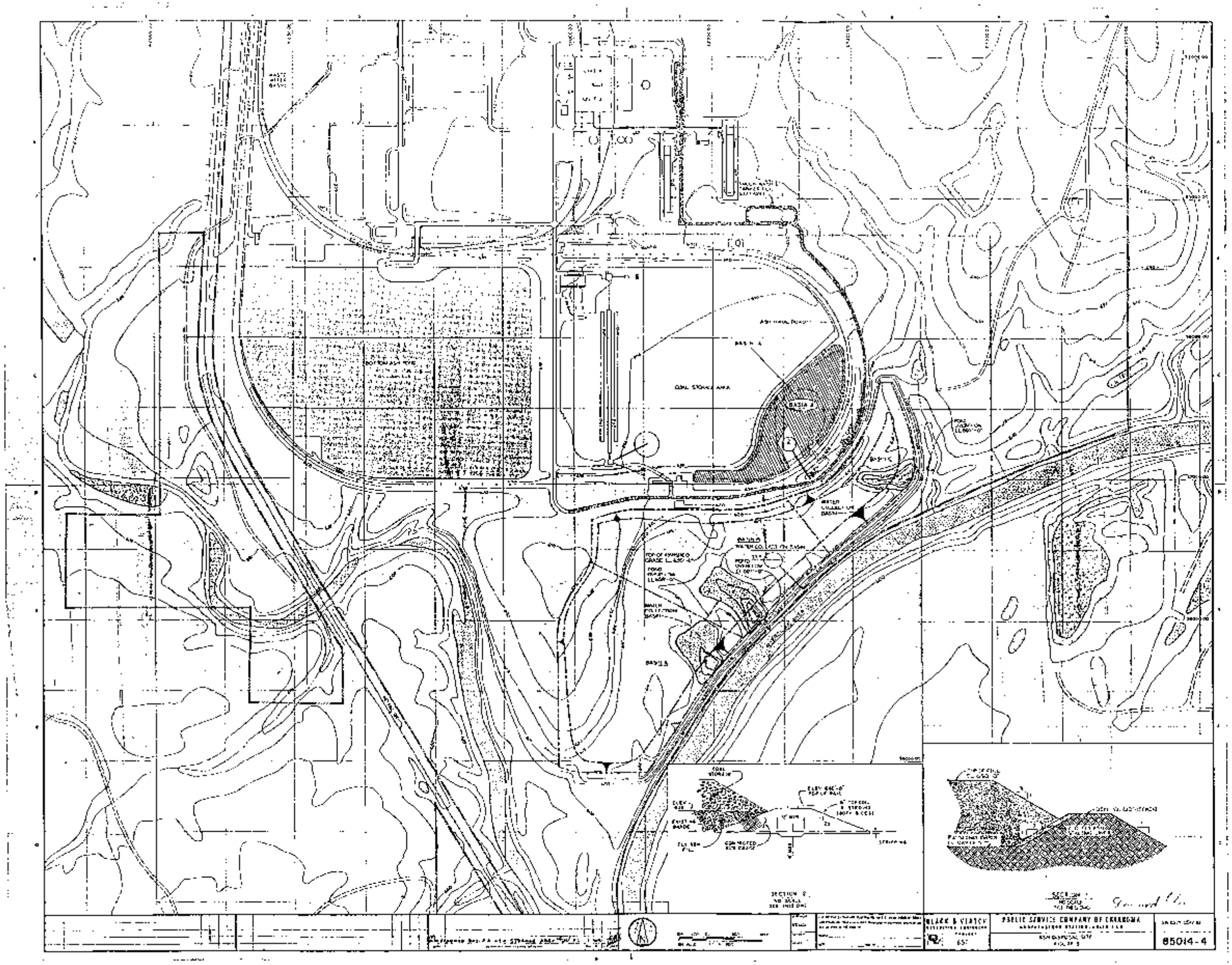
David R Lee 3/6/2009 11:27 AM
NE34P000124


COAL STORAGE AREA
BASIN 4
BASIN 5
BLACK & VEATCH
PUBLIC SERVICE COMPANY OF OKLAHOMA
85014-4

APPENDIX A

Document 14

Inspection Report 09.17.09

DAM & DIKE INSPECTION REPORT

BOTTOM ASH POND AT
NORTHEASTERN 3 & 4 POWER STATION
ROGERS COUNTY, OK

INSPECTION DATE September 17, 2009

PREPARED BY William R. Smith, P.E. **DATE** 6-28-2010

REVIEWED BY Gary F. Zych, P.E. **DATE** 6/29/10

APPROVED BY Pedro J. Amaya, P.E. **DATE** 6/30/2010

LICENSED PROFESSIONAL ENGINEER
WILLIAM R. SMITH
23225
OKLAHOMA

PROFESSIONAL ENGINEER

SEAL & SIGNATURE

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APPENDIX C Bottom Ash Dam Site Plan
APPENDIX D Guidelines for Herbicide Use on Earthen Dams

NE34P000010

INTRODUCTION

AEPSC (American Electric Power Service Corporation) Civil Engineering administers the Dam Inspection and Maintenance Program (DIMP) at AEP facilities. As part of the DIMP, staff from the geotechnical engineering section conducts dam and dike inspections annually. Mr. William R. Smith, P.E., performed the 2009 inspection of the bottom ash pond at the Northeastern 3&4 Power Station. This report is a summary of the inspection and an assessment of the general condition of the facility. Appendix A presents photos that were taken during the inspection. Appendix B contains a completed dam inspection and maintenance Checklist form as provided by the State of Oklahoma Water Resources Board summarizing inspection findings. A blank copy of the form is provided at the end of the appendix for use during periodic inspections by plant personnel. Appendix C provides site plans overlaid on satellite imagery to assist plant personnel in performing periodic inspections. Appendix D contains recommended guidelines on herbicide use to control the growth of brush and woody vegetation near earthen dams.

Mr. David R. Lee of AEP Plant Engineering, Region 4 and Mr. Gary Merkle, plant operations specialist, joined Mr. Smith in the inspection. Mr. Tom Morris, plant energy production superintendent, was the facility contact. The inspection was performed on September 17, 2009. Weather conditions were overcast with light to moderate winds, no precipitation, and temperatures in the low to mid 70's (°F). Plant personnel reported that a moderate amount of rain had fallen in the week leading up to the inspection.

Figure 1 provides a plan view, in the form of a satellite image, of the bottom ash pond, its embankment or dam, pertinent dam features, and the dam's appurtenances. The dam is a 4,200-foot long cross-valley impoundment on an unnamed tributary to Fourmile Creek. The dam is roughly U-shaped and has been divided into north, west, and south embankments for this inspection.

GENERAL INFORMATION

Dam or Reservoir:	Bottom Ash Pond at Northeaster Power Station
Owner:	Public Service Company of Oklahoma
Type of Dam:	Zoned Earth Embankment Structure

NE34P000011

Date of Construction:	1979
D/S Hazard:	Unclassified

LOCATION

County:	Rogers County
General Location:	Approximately 22 miles north-northeast of Tulsa, OK
Stream and Basin:	Unnamed tributary to Fourmile Creek: Verdigris River Basin

SIZE

Dam Crest Elevation[1]:	~	628.5	feet-MSL (low point near emergency spillway)
Emergency Spillway: Crest Elevation[1]		625	feet-MSL
Current Water Level[2]:	~	622	feet-MSL
Height[1]:	~	24.5	feet
Surface Area:		34	acres

Notes: 1.) Estimated from construction drawings; 2.) Visually estimated during inspection.

SUMMARY OF VISUAL OBSERVATIONS

The summary of the visual observations presented herein uses terms to describe the general appearance or condition of an observed item, activity or structure. Their meaning is understood as follows:

CONDITION OF DAM COMPONENT

Good:	A condition or activity that is generally better or slightly better than what is minimally expected or anticipated from a design or maintenance point of view.
Fair or Acceptable:	A condition or activity that generally meets what is minimally expected or anticipated from a design or maintenance point of view.

NE34P000012

Poor: A condition or activity that is generally below what is minimally expected or anticipated from a design or maintenance point of view.

SEVERITY OF DEFICIENCY

Minor: A reference to an observed deficiency (e.g., erosion, seepage, vegetation, etc.) where the current maintenance condition is below what is normal or desired, but which is not currently causing concern from a structure safety or stability point of view.

Significant: A reference to an observed deficiency (e.g. erosion, seepage, vegetation, etc.) where the current maintenance program has neglected to improve the condition. Usually these conditions have been identified in previous inspections, but have not been corrected.

Excessive: A reference to an observed deficiency (e.g., erosion, seepage, vegetation, etc.) where the current maintenance condition is above or worse than what is normal or desired, and which may have affected the ability of the observer to properly evaluate the structure or particular area being observed or which may be a concern from a structure safety or stability point of view.

Emergency Spillway

There is no principal spillway at the bottom ash pond; water is typically recirculated. The emergency spillway at the bottom ash pond is a concrete overflow structure with a design crest elevation of 625.0 ft. The control section of the spillway was modified with a 16-inch-high metal plate weir installed across its full width at the time of inspection as shown in Photo 1. The plant has since removed the plate to return the spillway to the original design. The concrete elements of the spillway were in good condition. Photo 2 shows the discharge chute with the concrete in good condition, but with some significantly overgrown vegetation at the downstream end and some debris in the chute. Overflow from the spillway discharges

to a basin and then flows through a culvert under a railroad and off site. Photo 3 shows the relative positions of the spillway overflow discharge chute, basin, and culvert. Figure 1 also shows the spillway and discharge culvert locations. The outflow end of the discharge culvert was partially blocked by a minor amount of overgrown vegetation as shown in Photo 4. The culvert itself was not inspected.

Upstream Slope

The upstream slope of the dam was observed to be in generally good to fair condition. The slope along the northern and western embankments was overgrown in a few areas with a minor extent of vegetation as shown in Photos 5 and 6. The riprap shore protection was in good condition. Some slope areas on the western embankment above the riprap were overgrown with significantly high vegetation, making a thorough inspection of these areas difficult, as shown in Photo 7.

The slope along the western portion of the southern embankment, shown in Photo 8, was in generally good to fair condition with a few areas of minor vegetative overgrowth within the riprap and the riprap itself in good condition. The slope along the eastern portion of the southern embankment was in fair condition. This slope was previously steepened by the plant in order to provide a wider dam crest for vehicular access next to the railroad track on the crest. The resulting slope angle along approximately the upper 15 feet of the slope in this area (approximately 1000 feet of embankment length) is about 1:1 instead of the design slope of 2.5:1 (H:V). This area was observed to be overgrown with significantly to excessively high vegetation including woody vegetation as shown in Photos 9 and 10. This area also has significant surface irregularities that have caused the concentration of storm water flows and erosion gullies have begun to form on the slope as shown in Photo 11. The plant has cleared the vegetation from the slope and groins and controlled further growth since the time of inspection. The plant has also regraded the steepened upper portion of the slope to eliminate the surface irregularities and installed riprap with underlying geotextile fabric to prevent further erosion of the steepened slope.

Crest

The crest of the entire west and south embankments of the dam is also used for railroad access to the plant. The crest of the north embankment is used for vehicular access except for the area containing the spillway. The crest was in generally good condition with no evidence of misalignment, settlement, or cracking. There was minor rutting and some ponded water on the north embankment crest as shown in Photo 12. The plant has regraded this portion of the crest and eliminated the rutting and ponding of water since the time of inspection.

Downstream Slope

The downstream slope of the dam was noted to be in generally fair condition. No apparent signs of sloughing, erosion, or slope instability were observed, but portions of the slope were obscured by significantly overgrown vegetation.

The downstream slope of the north embankment is shown in Photo 13. This portion of the dam was overgrown by significantly high vegetation, and some large trees on the slope had been recently cut as shown in Photo 14. One animal burrow (Photo 15) was observed on the north embankment. The downstream slope of the west embankment was in fair condition, but the condition was difficult to observe in some areas because of significantly overgrown vegetation as shown in Photos 16 and 17. Typical views of the downstream slope at the south embankment are shown in Photos 18, 19, and 20. Photo 18 also shows the left downstream groin and a portion of the crest. This portion of the dam was also overgrown with significantly high vegetation in some areas (see Photos 18 and 20), and some large trees on the slope had been recently cut (Photo 19). Two animal burrows were observed on the south embankment. One of the burrows is shown in Photo 21. The plant has filled all animal burrows, cleared all high vegetation from the slopes and groins, and controlled further vegetative growth since the time of inspection.

Downstream Toe

The downstream toe of the dam was designed with a toe drain along the west and south embankments. This drainage system consists of a 1.5-foot thick sand and gravel drainage

NE34P000015

blanket layer at the dam subgrade that extends upstream a distance of about 1.5 times the embankment height and is connected to a 9-inch thick gravel and sand bedding layer at the toe that runs 12 feet up the slope from the toe and is overlain by a 1-foot layer of riprap. The toe drain was designed to allow seepage from the dam to exit at any point along its length; i.e., there are no seepage collection pipes to discharge seepage at specific locations. As a consequence, seepage will tend to collect and discharge at the lowest elevation along the toe. This point is near the western end of the south embankment at the location of the pre-existing natural streambed (see Figure 1). A general view of this low point at the downstream toe is shown on Photo 22. Closer views of the area, one showing point of seepage discharge from the toe drain and another showing a recently installed culvert that is used as a pipe weir to periodically measure the seepage flow rate, are shown in Photos 23 and 24, respectively. The seepage flow rate at the time of inspection was 1.75 gallons per minute (gpm). Measurements by plant personnel over the past year have ranged between 1 and 3 gpm. No signs of sloughing were observed in the area and all flowing water was clear.

Approximately 1000 feet of the top of riprap at the toe drain along the south embankment was inadvertently partially covered with soil by plant personnel. (Note that the riprap appears absent in Photos 18 and 19.) Since this soil was placed on top of a system that drains subsurface seepage, it is not expected to affect the ability of the system to function as designed; however we recommend that this process not be continued.

Standing water was observed in a depression just downstream of the toe near the south end of the west embankment. The area was about 150 ft. by 30 ft. and is shown on Photo 25. No seeps were noted that may be feeding the ponded area and this may simply be a low area where precipitation accumulates. Plant personnel reported that a moderate amount of rain had fallen in the week leading up to the inspection.

CONCLUSIONS AND RECOMMENDATIONS

Based on our visual inspection, it is concluded that the bottom ash pond dam was generally in fair condition at the time of inspection with no signs of distress that would indicate possible instability, excessive settlement, misalignment, sloughing, or cracking of the dam.

A summary of our recommendations for general maintenance and continued monitoring, as well as any recommendations for remedial activities, is provided as follows:

Recommendations for General Maintenance and Monitoring Activities

- Regularly clear any excess vegetation or blockage and maintain free flow at the emergency spillway inlet and discharge.
- Regularly clear any excess vegetation or blockage and maintain free flow capability at the discharge culvert just northwest of the emergency spillway.
- Maintain vegetation by cutting at least twice per year. At areas where it is not feasible to use mowing equipment, such as areas with riprap, control vegetation with use of appropriate herbicide or weed trimmers, power brush cutters, or similar equipment. General vegetation control should extend to 30 feet beyond the toe and groins. Appendix D contains recommended guidelines on herbicide use to control the growth of brush and woody vegetation near earthen dams. Note that a licensed applicator may be required.
- Maintain a grass cover at areas without riprap to prevent erosion. Note that the Oklahoma Administrative Code rule regarding prohibited vegetation has been changed, effective May 27, 2010, to include provisions for preventing and repairing erosion and now states as follows:

  > 785:25-3-10. Prohibited vegetation and erosion
  >
  > Trees and heavy vegetation shall be removed from the slopes and crest of earthen embankments and emergency spillway area. Trees and heavy vegetation shall also be removed from an area a minimum distance from the toe of the embankment of 30 feet. Dams shall be maintained such that internal or external erosion is prevented. If erosion is present it shall be repaired utilizing appropriate engineering practices.
- Backfill any noted animal burrows on a regular basis with compacted fill, then seed and mulch to establish grass cover.
- The dam should be inspected by plant personnel quarterly and within 24 hours of unusual events such as seismic activity or a significant storm event with the

inspection documented in accordance with AEP Circular Letter CI-M-CL-010C. For the purpose of these inspections, a "significant storm event" is defined as a storm that results in three inches or more of rainfall in 24 hours. A blank copy of the dam inspection checklist form as provided by the Oklahoma Water Resources Board is provided at the end of Appendix B and site plans overlaid on satellite imagery are provided in Appendix C to assist plant personnel in performing periodic inspections.

Recommendations for Remedial Activities

- The low area just downstream of the toe near the south end of the west embankment where standing water pools should be regraded to provide positive drainage and allow any standing water to drain off site.

Submitted By:

American Electric Power Service Corporation

Civil/Geotechnical Engineering

William R. Smith, P.E.
Geotechnical Engineer
AEP Service Corporation
Oklahoma P.E. #23225

NE34P000018

Figure 1. Satellite image of bottom ash pond dam, features, and appurtenances at Northeastern 3&4 Power Station.

APPENDIX A

Inspection Photographs

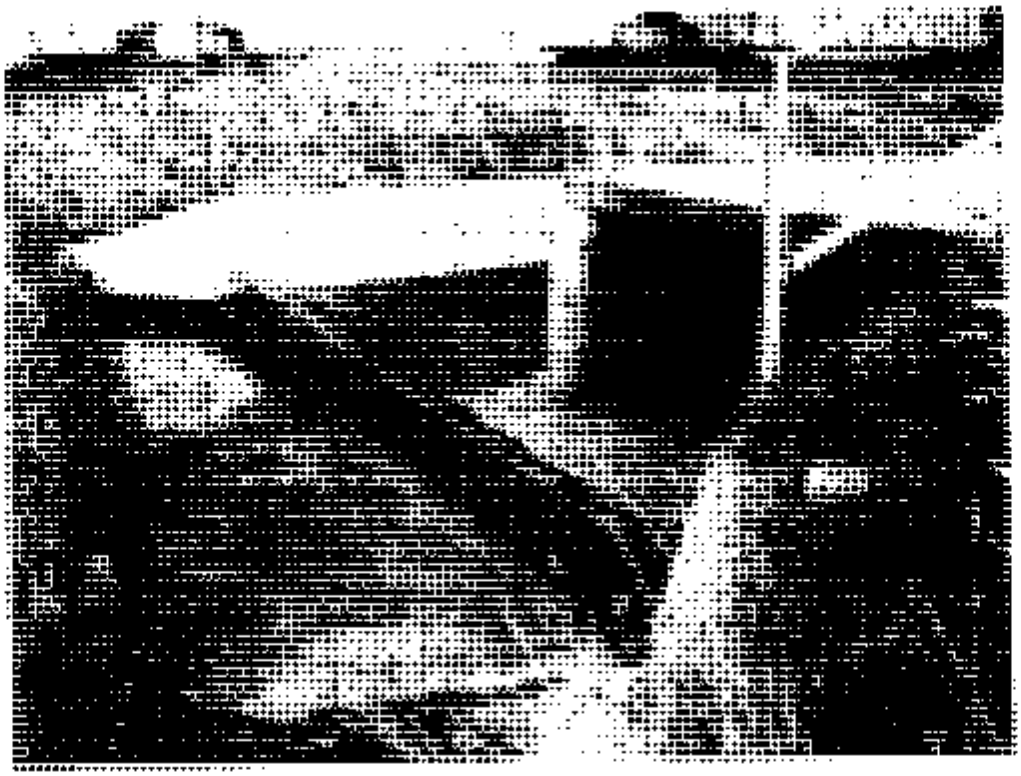


Photo 1. Bottom ash pond emergency spillway entrance with metal plate blocking flow. The plate has reportedly been removed since the inspection.

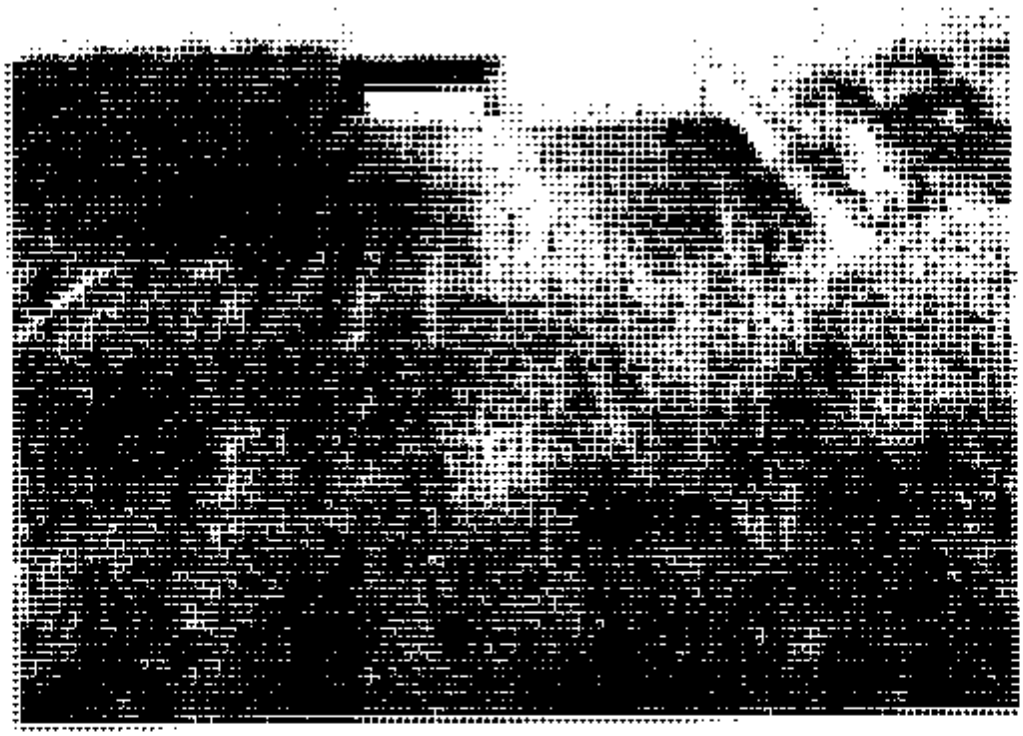


Photo 2. Discharge chute at spillway with significantly high vegetation growing downstream and minor debris.

Photo 3. Relative positions of emergency spillway discharge chute, basin, and culvert that conveys overflow off site.

Photo 4. Outflow of the culvert that conveys emergency spillway discharge flow off site was partially blocked with minor vegetation.

Photo 5. Upstream slope of north embankment with a few areas of minor vegetative overgrowth and riprap shoreline protection in good condition.

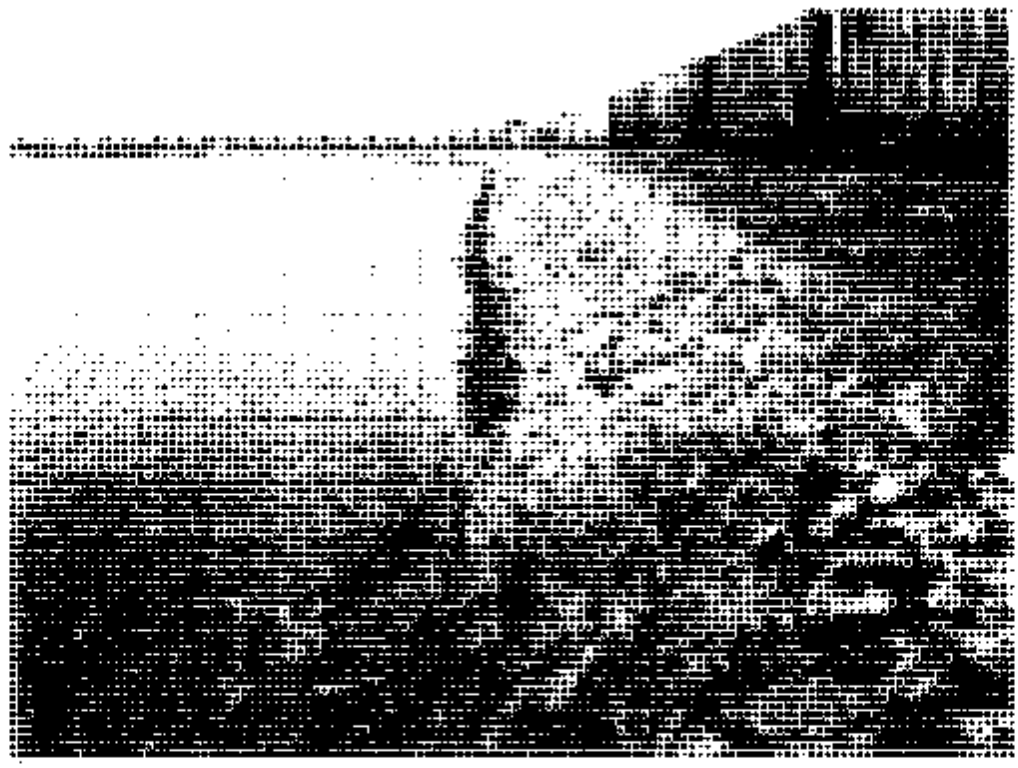


Photo 6. Upstream slope of west embankment with a few areas of minor vegetative overgrowth and riprap in good condition.

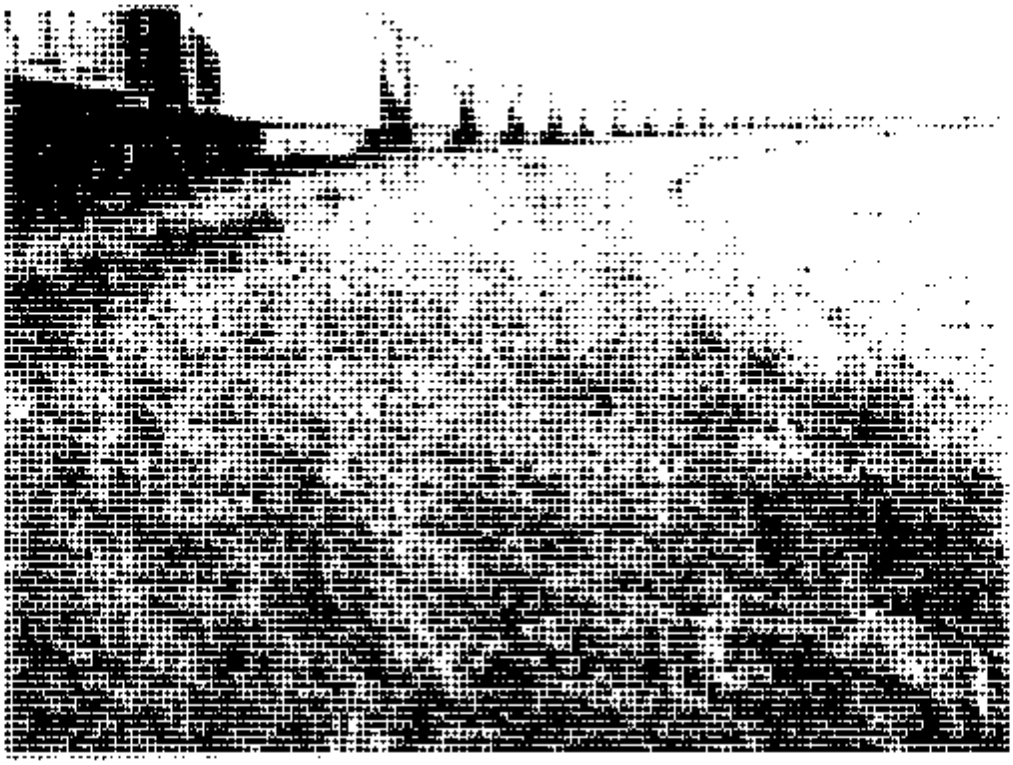


Photo 7. Upstream slope of west embankment with significantly overgrown vegetation above the riprap shore protection.

Photo 8. Upstream slope at western portion of south embankment with a few areas of minor vegetative overgrowth and riprap in good condition.

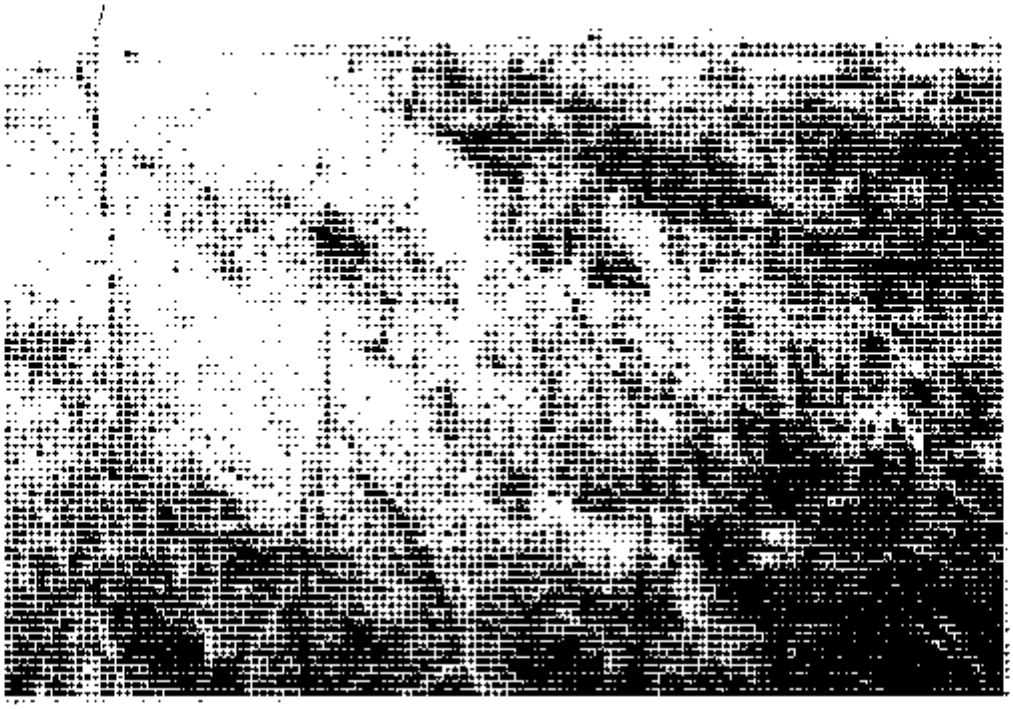


Photo 9. Upstream slope at eastern portion of south embankment with significantly to excessively high vegetation and erosion gully forming on the steepened slope.

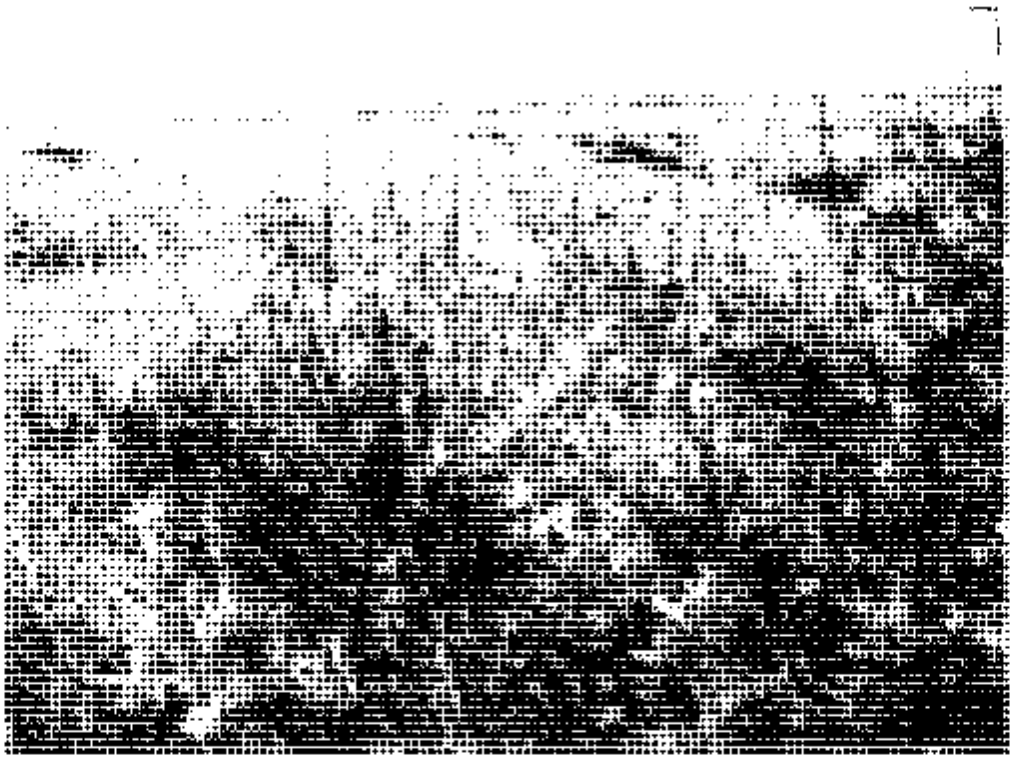


Photo 10. Upstream slope at eastern portion of south embankment with significantly to excessively high vegetation.

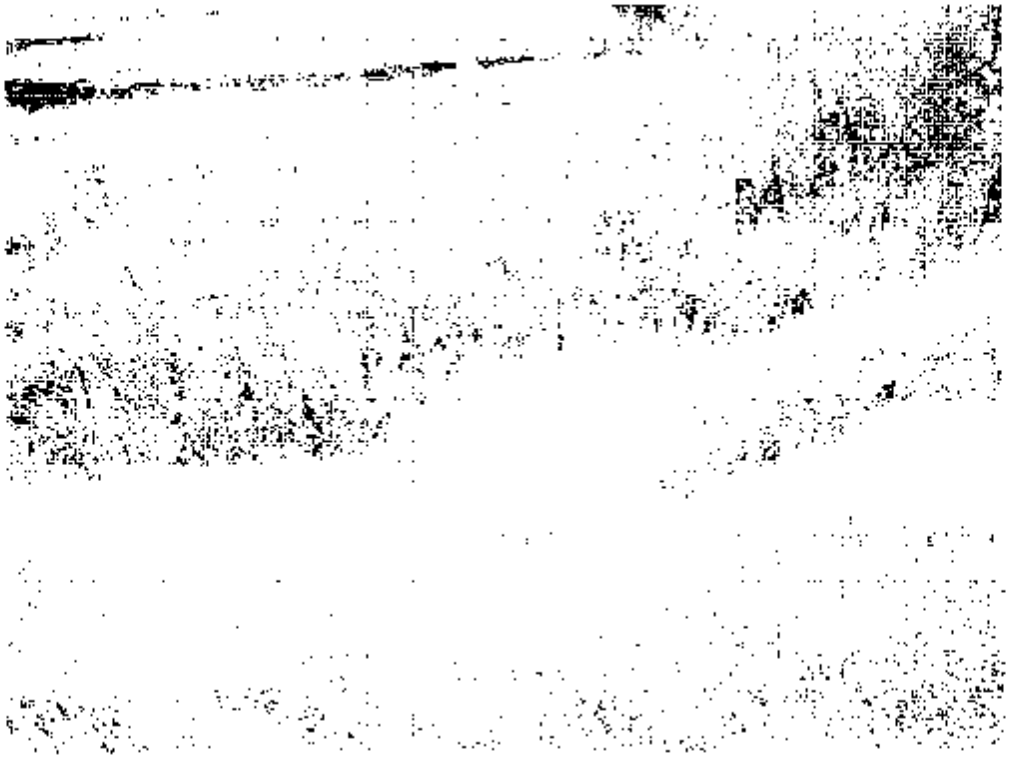


Photo 11. Upstream slope at eastern portion of south embankment with incipient gully formation near crest and high vegetation.

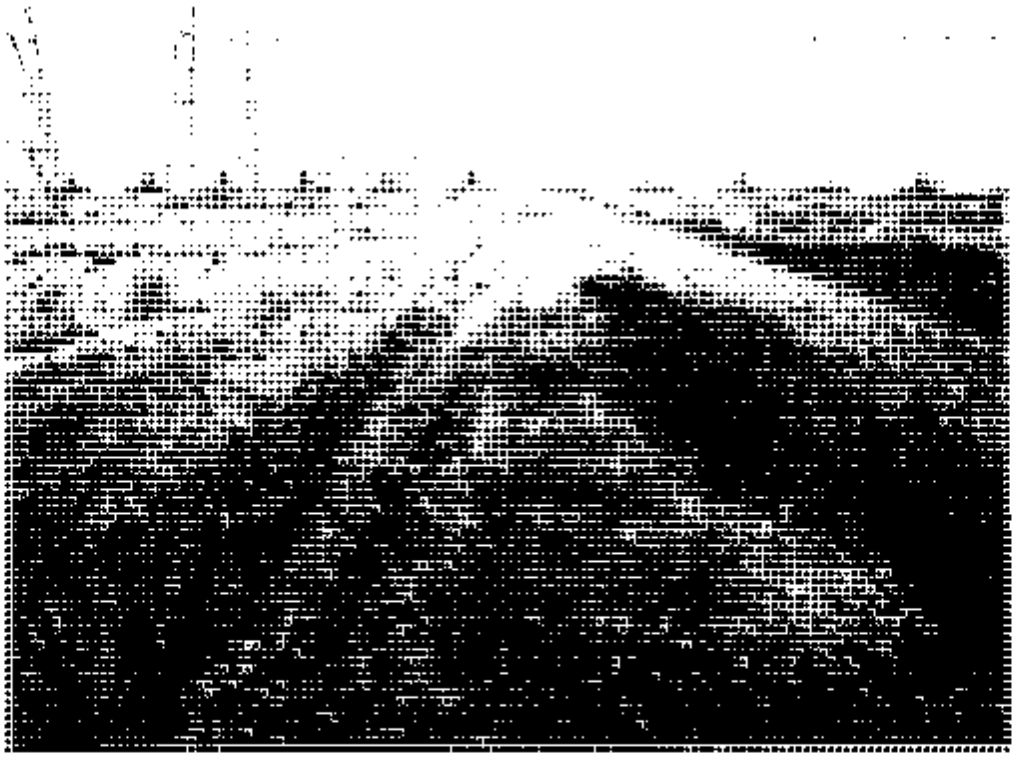


Photo 12. Minor rutting and ponding of water was noted on the crest of the north embankment.

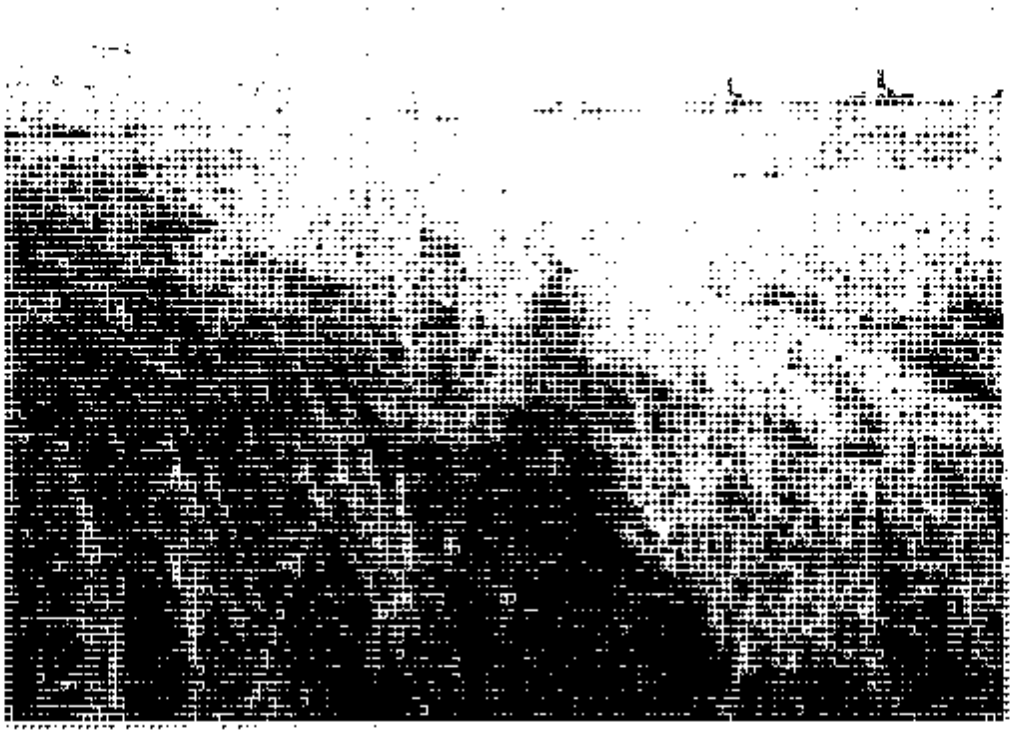


Photo 13. Downstream slope of north embankment covered with significantly overgrown vegetation.

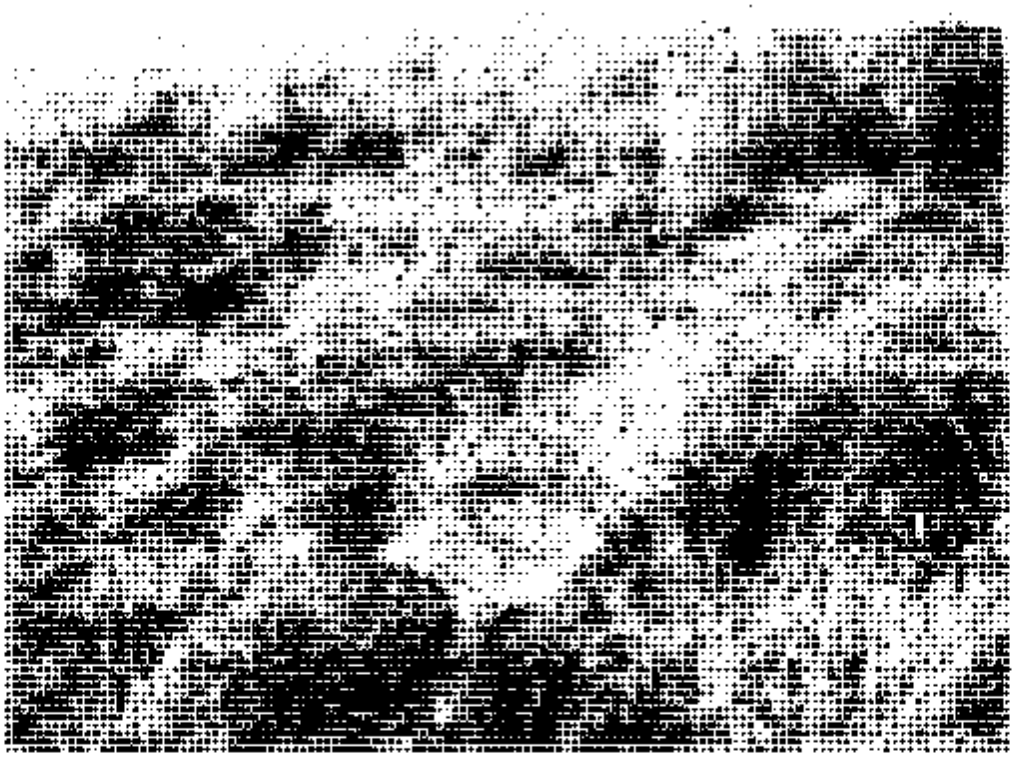


Photo 14. Downstream slope of north embankment with remnant of recently cut large tree and significantly overgrown vegetation.

Photo 15. One animal burrow on the downstream slope of the north embankment was observed.

Photo 16. Downstream slope of west embankment in fair condition but with significantly overgrown vegetation.

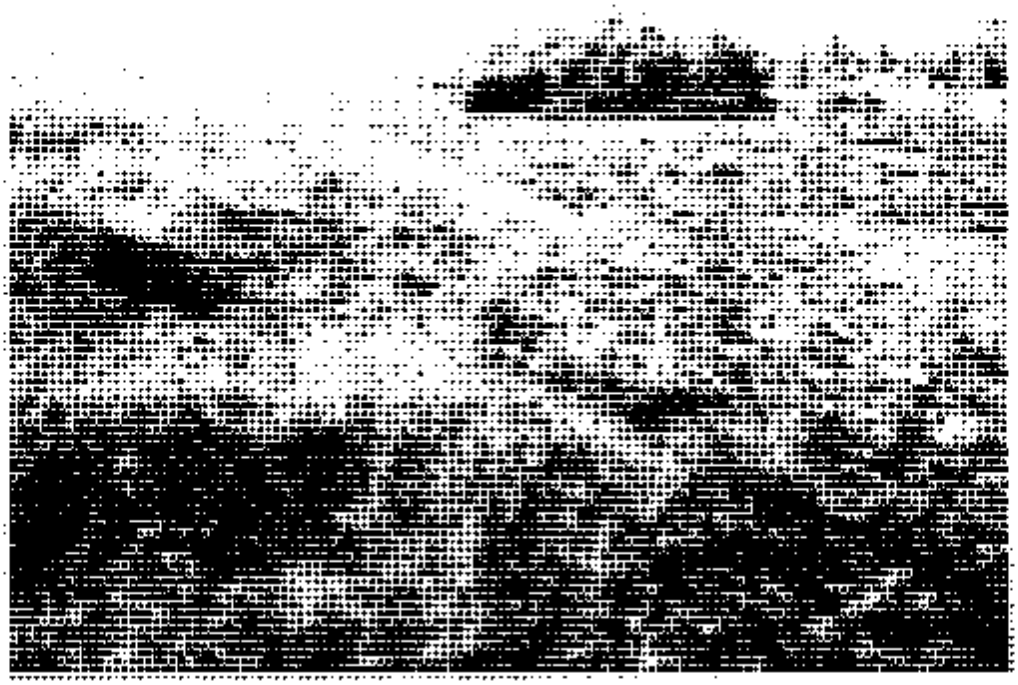


Photo 17. Downstream slope of west embankment in fair condition but with significantly overgrown vegetation in some areas.

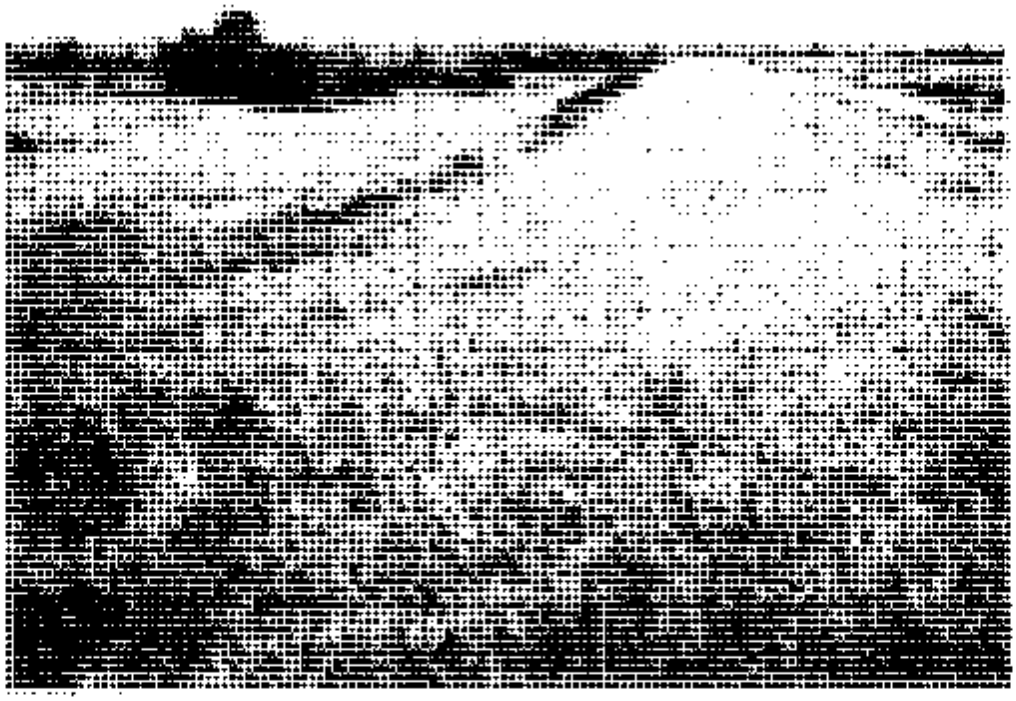


Photo 18. Downstream slope and left groin of south embankment with significantly high vegetation and in fair condition.

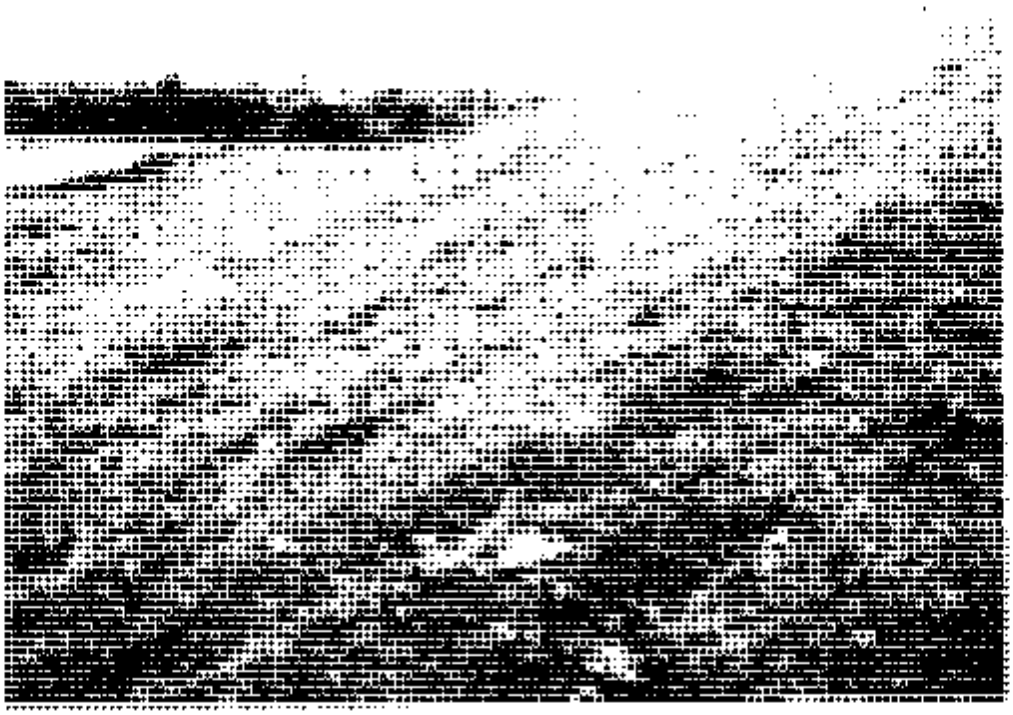


Photo 19. Downstream slope of south embankment with remnant of recently cut large tree and some significantly high vegetation.

Photo 20. Western portion of south embankment downstream slope with overall significantly high vegetation.

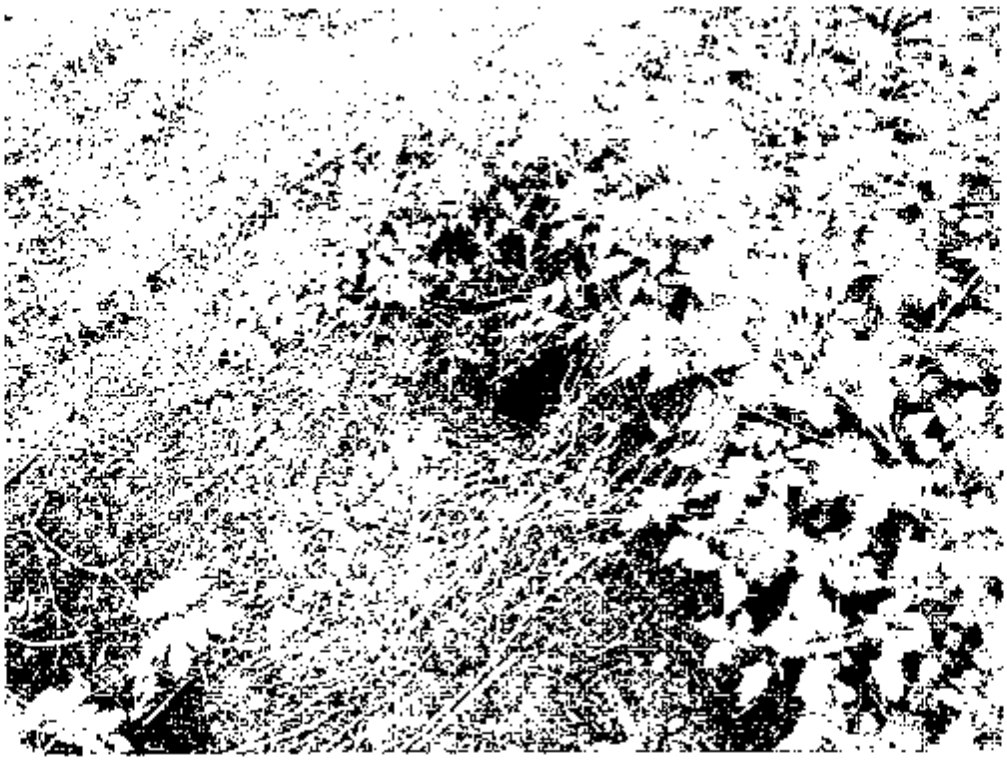


Photo 21. One of two animal burrows observed on the downstream slope of the north embankment.

Photo 22. General view of lowest point along downstream toe where seepage from the toe drain consistently emerges and is periodically measured.

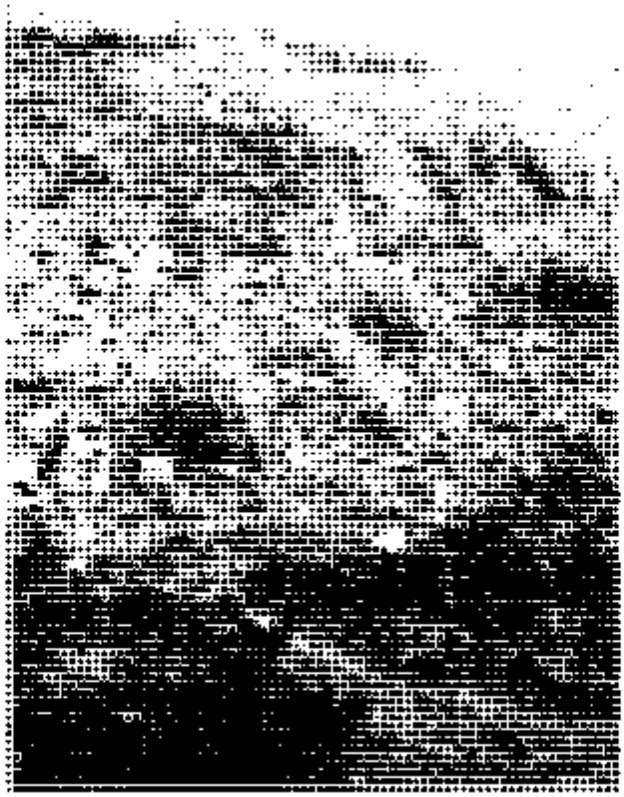


Photo 23. Discharge point of seepage from the toe drain at the location of the pre-existing natural streambed.

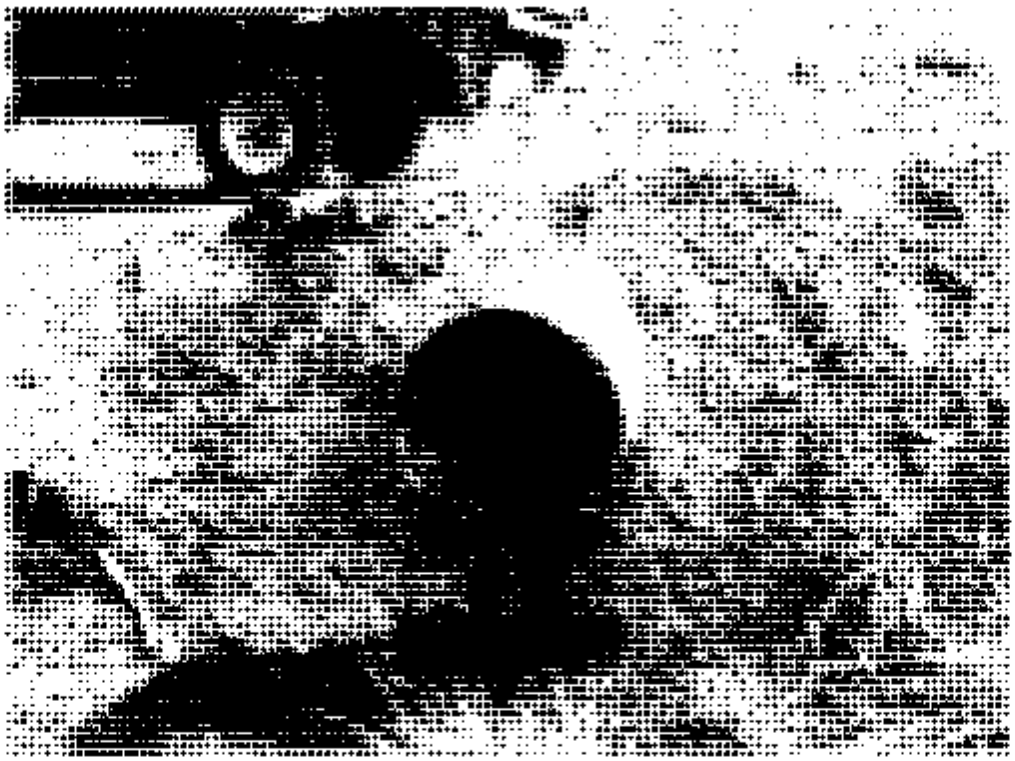


Photo 24. A culvert is used as a pipe weir to periodically measure the flow rate of the seepage shown in Photo 23.

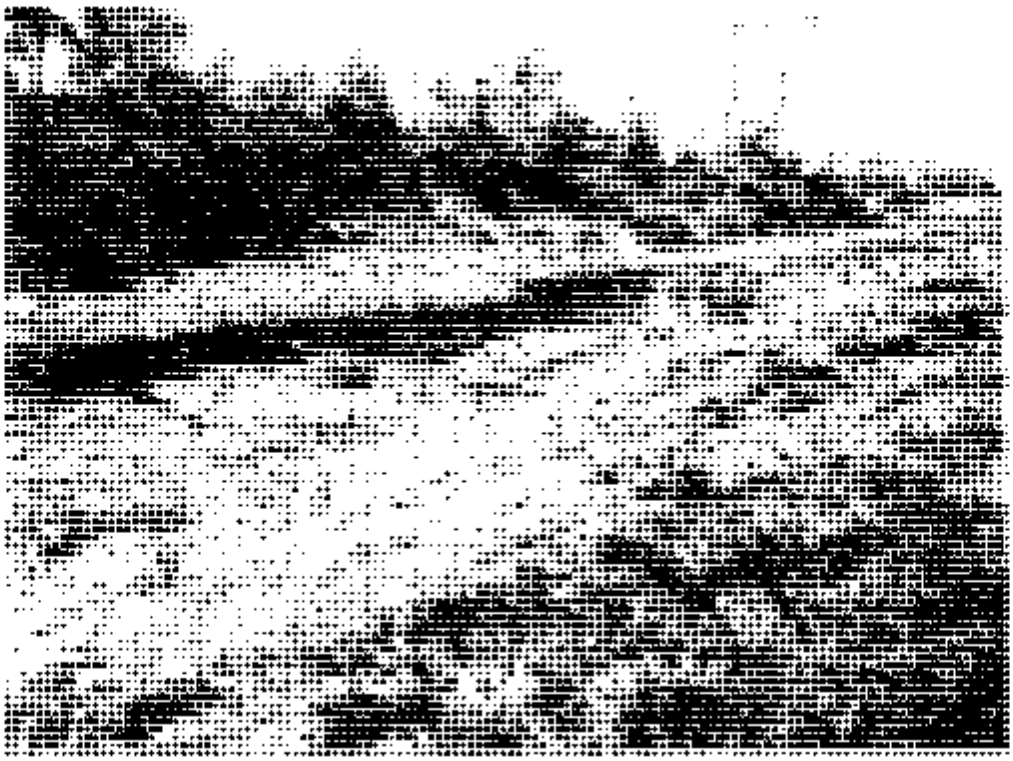


Photo 25. Standing water was observed just beyond the toe near the south end of the west embankment .

APPENDIX B

Oklahoma Dam inspection Checklist Forms

OKLAHOMA WATER RESOURCES BOARD
PLANNING & MANAGEMENT DIVISION - DAM SAFETY PROGRAM

DAM INSPECTION CHECKLIST

Name of Dam: Northeastern 3&4 Bottom Ash Pond Dam
State Inventory ID: N/A
Owner of Dam: AEP/PSO
Purpose of Dam: Bottom Ash Settlement
Address: 7500 E. Hwy 88
Hazard Classification: Unclassified
City/State/ZIP: Oologah, OK 74053
County: Rogers
Inspected By: William R. Smith, P.E.
Legal Location:
Date of Inspection: 9-17-2010
Latitude: 36.420 N
Longitude: 95.708 W
Weather Conditions: Overcast, Temp: mid 70's

	Item	Yes	No	N/A	[1]Condition (Check Acceptable or Deficiencies Exist)	Remarks
1	**General Conditions of Dam**					
A	Alterations to the dam?		X			
B	Development in downstream floodplain?		X			
C	Grass cover adequate?		X		Acceptable	Significantly high in many areas, corrected after inspection
D	Settlements, misalignments, or cracks?		X			
E	Recent high water marks?		X			Elevation: N/A
2	**Upstream Slope of Dam**					
A	Erosion?	X				Corrected after insp
B	Trees?		X			
C	Rodent holes?		X		Acceptable	
D	Evidence of livestock on dam?		X			
E	Cracks, settlement, or bulges?		X			
F	Adequate and sound riprap?	X				
3	**Downstream Slope of Dam**					
A	Erosion?		X			
B	Trees?		X			
C	Rodent holes?	X				Repaired after insp
D	Evidence of livestock on dam?		X		Acceptable	
E	Cracks, settlement, or bulges?		X			
F	Drains or wells flowing?	X				Estimated gpm: 1.75 at toe drain
G	Seepage or boils?		X			Estimated gpm: N/A
4	**Abutment Contacts**					
A	Erosion, cracks, or slides?		X		Acceptable	
B	Seepage?		X			Estimated gpm: N/A
5	**Inlet Structure**					
A	Concrete? ___ Metal? ___			X		
B	Spalling, cracking, or scaling?			X		
C	Exposed reinforcement?			X	N/A	
D	Corrosion present?			X		
E	Coating adequate?			X		
F	Leakage?			X		
G	Trash rack adequate?			X		
H	Obstructions in inlet?			X		
I	Drawdown operative? Opened & closed			X		
6	**Conduit & Outlet**					
A	Concrete? ___ Metal? ___			X		
B	Spalling, cracking, or scaling?			X		
C	Exposed reinforcement?			X		
D	Joints displaced or offset?			X		
E	Joint material lost?			X	N/A	
F	Leakage?			X		Estimated gpm: N/A
G	Earth erosion?			X		
H	Conduit misaligned?			X		
I	Outlet channel obstructed?			X		

Revised March 2010

NE34P000035

	Item	Yes	No	N/A	*Condition (Good, Acceptable, Deficient, Poor)	Remarks
7	**Concrete Spillway**					
A	Spalling, cracking, or scaling?		X		Acceptable	
B	Exposed reinforcement?		X			
C	Joints displaced or offset?		X			
D	Joint material lost?		X			
E	Leakage?		X			
F	Dissipater deteriorating?		X			
G	Dissipaters clean of debris?	X				
H	Earth erosion?		X			
I	Outlet channel scouring?		X			
8	**Emergency Spillway**					
A	Obstruction?	X			Acceptable	High veg. downstream of dam
B	Erosion?		X			
C	Rodent holes?		X			
D	Evidence of livestock on spillway?		X			
9	**Stilling Basin**					
A	Spalling, cracking, or scaling?			X	N/A	
B	Exposed reinforcement?			X		
C	Joints displaced or offset?			X		
D	Joint material lost?			X		
E	Joints leak?			X		
F	Rock adequate?			X		
G	Dissipater deteriorating?			X		
H	Dissipaters clean of debris?			X		
10	**Gates**					
A	Floodgates broken or bent?			X	N/A	
B	Floodgates corroded or rusted?			X		
C	Floodgates operational?			X		
11	**Instruments**					
A	Structure instrumented?		X		N/A	
B	Monitoring performed?			X		
**	**Should Hazard-Potential Classification be reevaluated?**			X		N/A

REMARKS:

Six piezometers were installed after the inspection and will be monitored in the future.

For High and Significant Hazard-Potential Dams Only:

Professional Engineer Seal

Name of Engineer: _____

Date: _____

Engineering Firm: _____

Address _____

City, State, ZIP _____

Telephone Number: _____

Signature: _____

Condition: Please rate the condition of sections 1 – 11 on inspection form as: Good, Acceptable, Deficient, or Poor.

Good - No evidence of potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or acceptable risk guidelines.

Acceptable - No existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.

Deficient - A dam safety deficiency is recognized for loading conditions which may realistically occur. Remedial action is necessary. Poor may also be used when uncertainties exist as to critical analysis parameters which identify a potential dam safety deficiency. Further investigations and studies are necessary.

Poor - A dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.

OKLAHOMA WATER RESOURCES BOARD
PLANNING & MANAGEMENT DIVISION - DAM SAFETY PROGRAM

DAM INSPECTION CHECKLIST

Name of Dam: _____ State Inventory ID: _____

Owner of Dam: _____ Purpose of Dam: _____

Address: _____ Hazard Classification: _____

City/State ZIP _____

County: _____ Inspected By _____

Legal Location: _____ Date of Inspection: _____

Latitude: _____

Longitude _____ Weather Conditions _____

	Item	Yes	No	N/A	Condition (Good-Acceptable Deficient/Poor)	Remarks
1	**General Conditions of Dam**					
A	Alterations to the dam?					
B	Development in downstream floodplain?					
C	Grass cover adequate?					
D	Settlements, misalignments, or cracks?					
E	Recent high water marks?					
2	**Upstream Slope of Dam**					
A	Erosion?					
B	Trees?					
C	Rodent holes?					
D	Evidence of livestock on dam?					
E	Cracks, settlement, or bulges?					
F	Adequate and sound riprap?					
3	**Downstream Slope of Dam**					
A	Erosion?					
B	Trees?					
C	Rodent holes?					
D	Evidence of livestock on dam?					
E	Cracks, settlement, or bulges?					
F	Drains or wells flowing?					Describe gpm
G	Seepage or boils?					Describe gpm
4	**Abutment Contacts**					
A	Erosion, cracks, or slides?					
B	Seepage?					Describe gpm
5	**Inlet Structure**					
A	Concrete? ☐ Metal? ☐					
B	Spalling, cracking, or scaling?					
C	Exposed reinforcement?					
D	Corrosion present?					
E	Coating adequate?					
F	Leakage?					
G	Trash rack adequate?					
H	Obstacles to inlet?					
I	Drawdown operative? Opened & closed					
6	**Conduit & Outlet**					
A	Concrete? ☐ Metal? ☐					
B	Spalling, cracking, or scaling?					
C	Exposed reinforcement?					
D	Joints displaced or offset?					
E	Joints material lost?					
F	Leakage?					Describe gpm
G	Earth erosion?					
H	Conduit misaligned?					
I	Outlet channel obstacles?					

Revised March 2010

NE34P000037

	Item	Yes	No	N/A	[1]Condition (Circle A, B, C, or D) Deficient Poor	Remarks
7	**Concrete Spillway**					
A	Spalling, cracking, or scaling?					
B	Exposed reinforcement?					
C	Joints displaced or offset?					
D	Joint material lost?					
E	Leakage?					
F	Dissipater deteriorating?					
G	Dissipaters clean of debris?					
H	Earth erosion?					
I	Outlet channel eroding?					
8	**Emergency Spillway**					
A	Obstruction?					
B	Erosion?					
C	Rodent holes?					
D	Evidence of livestock on spillway?					
9	**Stilling Basin**					
A	Spalling, cracking, or scaling?					
B	Exposed reinforcement?					
C	Joints displaced or offset?					
D	Joint material lost?					
E	Joints leak?					
F	Rock dislodged?					
G	Dissipater deteriorating?					
H	Dissipaters clean of debris?					
10	**Gates**					
A	Floodgates broken or bent?					
B	Floodgates corroded or rusted?					
C	Floodgates operational?					
11	**Instruments**					
A	Structure instrumented?					
B	Monitoring performed?					
**	**Should Hazard-Potential Classification be reevaluated?**					

REMARKS:

For High and Significant Hazard-Potential Dams Only

Professional Engineer Seal

Name of Engineer: _____

Date: _____

Engineering Firm: _____

Address _____

City, State, ZIP _____

Telephone Number: _____

Signature: _____

[1]**Condition.** Please rate the condition of sections 1 – 11 on inspection form either: Good, Acceptable, Deficient, or Poor.

Good - No existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or tolerable risk guidelines.

Acceptable - No existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.

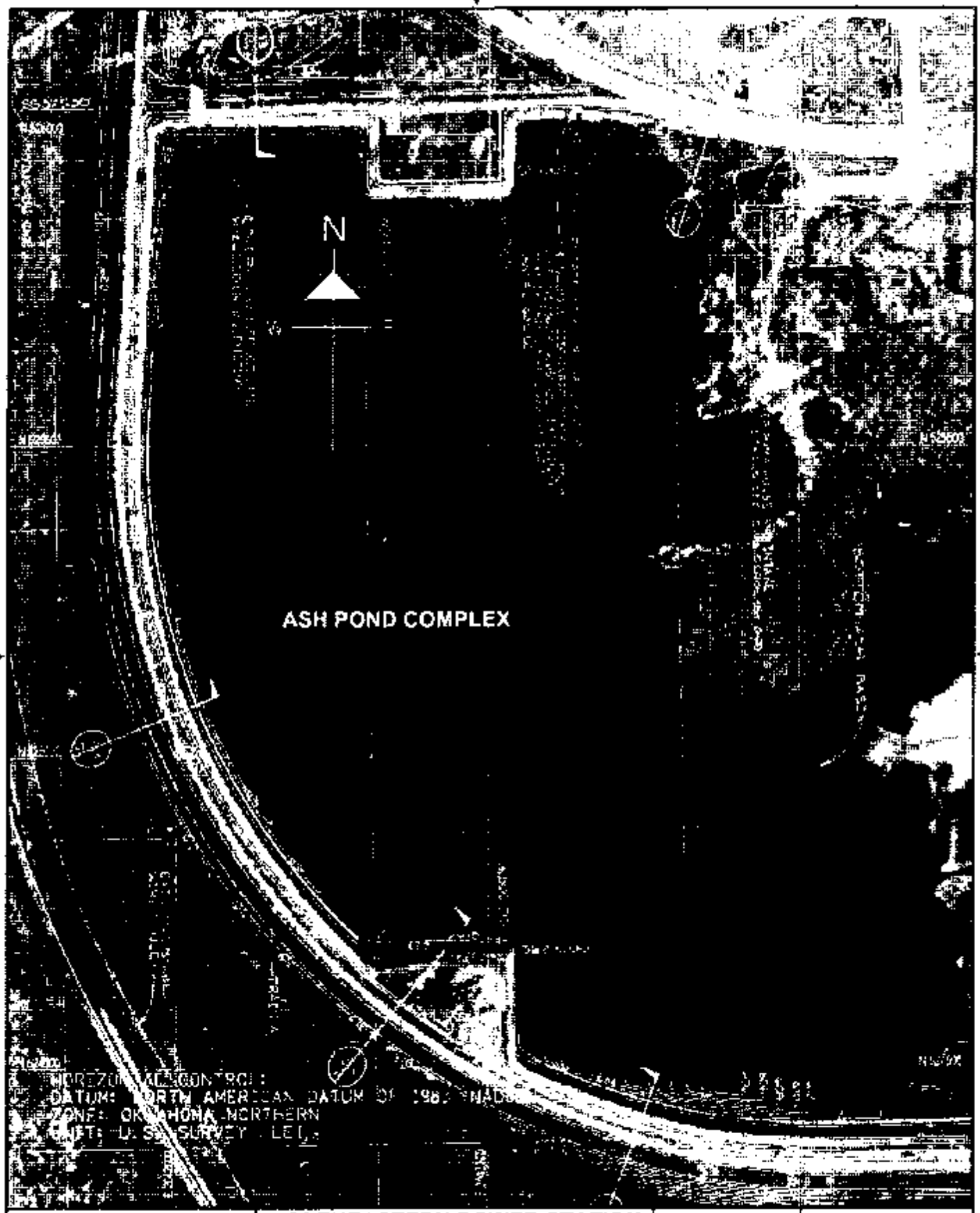
Deficient - A dam safety deficiency is recognized for loading conditions which are seasonally or rare. Remedial action is necessary. Poor may also be used when uncertainties exist as to critical analysis parameters which identify a potential dam safety deficiency. Further investigations and studies are necessary.

Poor - A dam safety deficiency is recognized that requires immediate or emergency remedial action for protection of downstream.

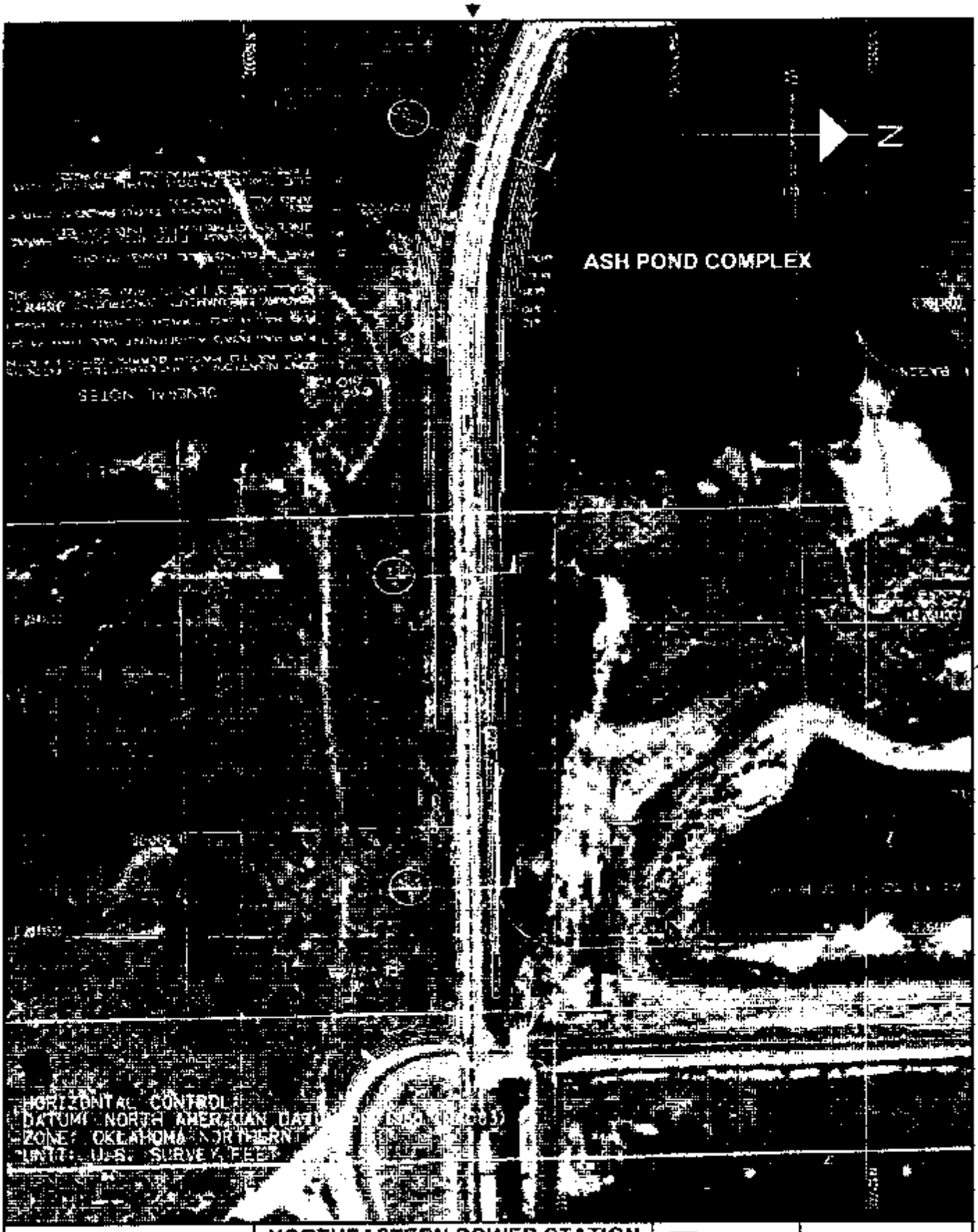
APPENDIX C

Bottom Ash Dam Site Plan

Rev. to:	NORTHEASTERN POWER STATION	AMERICAN ELECTRIC POWER	AEP SERVICE CORP. 1 RIVERSIDE PLAZA COLUMBUS, OH 43215
Date:	INDEX - SHEET 1 of 3		
Scale: 1"=300'	BOTTOM ASH POND	FIGURE 1	



	NORTHEASTERN POWER STATION INDEX - SHEET 3 of 3	AEP AMERICAN ELECTRIC POWER	AEP SERVICE CORP. 1 RIVERSIDE PLAZA COLUMBUS, OH 43215
1"=200'	BOTTOM ASH POND	FIGURE 3	



	NORTHEASTERN POWER STATION	AMERICAN ELECTRIC POWER	AEP SERVICE CORP 1 RIVERSIDE PLAZA COLUMBUS, OH 43216
DATE:	INDEX - SHEET 2 of 3		
SCALE: 1"=200'	BOTTOM ASH POND	FIGURE 2	

APPENDIX D

Guidelines for Herbicide Use on Earthen Dams

RECOMMENDATIONS ON HERBICIDE USE TO CONTROL VEGETATION ON EARTHEN DAMS

HERBICIDE APPLICATION RECOMMENDATIONS

Wind direction and speed should be monitored during application of the herbicides to minimize drift into areas of concern. Drift of herbicides into non-target areas is also dependent on the evaporation rate of the pesticide; therefore, avoid application of the herbicides during the hottest part of the day, when evaporation is highest. It is recommended that the largest droplet size consistent with adequate coverage of the herbicide be used to further reduce drift. Higher spray volumes typically reduce drift as well. The application of herbicides on the earthen dams should be delayed if rainfall is expected within 24 hours to further reduce the runoff of herbicides into the adjacent water bodies. The herbicides should be mixed and loaded into the spray units far enough away from the dam locations to ensure that potential spills won't enter the aquatic systems. When feasible, utilize individual plant treatments. The treatment of individual plants would reduce the volume of herbicide required in the control of dam vegetation which could result in lower costs associated with the vegetation management plan. In addition, adverse impacts to beneficial non-target plant species and aquatic species would be minimized due to the avoidance of exposure and the lower potential for drift and runoff. Once an earthen dam has been treated with herbicide, establish a maintenance plan to reduce the potential for future large scale herbicide applications. The establishment of a mowing and trimming schedule could be beneficial to the establishment of native grasses, forbs, and wildflowers on the earthen dams. The promotion of grasses through these methods would reduce the invasion of woody vegetation and reduce the need for additional herbicide applications. Should the use of herbicides be required in the future, applications should be made during the early successional stages so that individual plant treatments would be economically and logistically feasible.

THREATENED AND ENDANGERED SPECIES CONCERNS

According to the *Federal Insecticide, Fungicide, and Rodenticide Act*, the use of herbicides must comply with the Endangered Species Act. Although the measures proposed herein should minimize adverse impacts to fish and wildlife resources in general, special precautions should be taken to ensure that adverse impacts to rare, threatened, and endangered species are avoided

BRUSH CONTROL HERBICIDES FOR USE ON DAMS (EXCEPT AS NOTED)

The following list of herbicides contains chemicals and formulations known to be effective in the control of vegetation typically found growing on open and previously disturbed habitats, similar to the vegetation associations expected to be growing on dams. These herbicides are also known to have low toxicity to terrestrial and aquatic organisms and are not known to leach into ground and surface waters. The implementation of the recommendations herein, during the application of the following herbicides in a manner consistent with the herbicide's label, should minimize adverse impacts to fish and wildlife resources on and around the dam. The following list of herbicides is certainly not all-inclusive as new herbicides are consistently being introduced.

2,4-D (American Brand 2,4-D, DMA 4 IVM, Weedar 64)

2,4-D (2,4-Dichlorophenoxyacetic acid) was introduced in 1946 and is the most widely used herbicide in the world. Many different manufacturers produce 2,4-D and the list of formulations above are included only to provide examples. 2,4-D is a selective herbicide that is used to control broadleaf herbaceous plants. The salt formulations of 2,4-D are relatively non-toxic to fish and wildlife species. However, the ester formulations of 2,4-D are toxic to fish. Therefore, avoid the use

of the ester formulations of 2,4-D in the control of vegetation on dams. The 2,4-D salt formulations are used to control box elder (*Acer negundo*), willow (*Salix spp.*), thistle (*Cirsium* spp.), morning glory (*Ipomoea* spp.), poison ivy (*Toxicodendron radicans*), wild rose (*Rosa* spp.), Virginia creeper (*Parthenocissus quinquefolia*), ragweed (*Ambrosia* spp.), cocklebur (*Xanthium* spp.), Russian thistle (*Salsola kali*), and sunflower (*Helianthus* spp.).

Glyphosate (Accord, Aquamaster, Glypro, Pondmaster, Rodeo)

Glyphosate is a broad-spectrum, nonselective, systemic herbicide used to control grasses, broadleaf weeds, and woody plants. Because glyphosate is a broad-spectrum herbicide, care should be taken during applications to minimize adverse impacts to grasses and native vegetation important for erosion control and stabilization of earthen dams. Glyphosate is used to control dogwood (*Cornus* spp.), maple (*Acer* spp.), oak (*Quercus* spp.), giant reed (*Arundo donax*), salt cedar (*Tamarix* spp.), sweet gum (*Liquidambar styraciflua*), sycamore (*Platanus occidentalis*), willow, cocklebur, sunflower (*Helianthus* spp.), alligatorweed (*Alternanthera philoxeroides*), cattail (*Typha* spp.), blackberry (*Rubus* spp.), kudzu (*Pueraria lobata*), honeysuckle (*Lonicera* spp.), black locust (*Robinia pseudoacacia*), persimmon (*Diospyros spp.*), wild rose, Russian olive (*Elaeagnus angustifolia*), Chinese tallow (*Sapium sebiferum*), wax myrtle (*Morella cerifera*), and sumac (*Rhus* spp.).

Imazapyr (Arsenal, Chopper, Habitat, Stalker)

Imazapyr is a broad-spectrum, nonselective, systemic herbicide used to control annual and perennial grasses, broadleaf herbaceous plants, woody plants, and riparian and aquatic plants. Because imazapyr is a broad-spectrum herbicide, care should be taken during applications to minimize adverse impacts to grasses and native vegetation important for erosion control and stabilization of earthen dams. Imazapyr is used to control giant reed, ragweed, thistle, cocklebur, saltbush (*Atriplex* spp.), greenbriar (*Smilax* spp.), honeysuckle, morning glory, poison ivy, wild rose, kudzu, trumpet creeper (*Campsis radicans*), wild grape (*Vitis* spp.), ash (*Fraxinus* spp.), maple, black locust, box elder, chinaberry (*Melia azedarach*), Chinese tallow, cottonwood (*Populus deltoides*), dogwood, elm (*Ulmus* spp.), hawthorn (*Crataegus spp.*), mulberry (*Morus* spp.), oak, persimmon (*Diospyros* spp.), pine (*Pinus* spp.), privet (*Ligustrum japonicum*), Russian olive, saltcedar, sumac, sweetgum, tree-of-heaven (*Ailanthus altissima*), *Vaccinium* spp., waxmyrtle, willow, and yaupon (*Ilex vomitoria*).

Fosamine Ammonium (Krenite)

Fosamine ammonium is used to control brush along highway rights-of-way, railroad rights-of-way, industrial sites, storage areas, and utility and pipeline rights-of-way. It is used to control woody species such as oak, pine, sumac, sweetgum, Chinese tallow, elm, wild grape, wild rose, sycamore, and tree-of-heaven. It is also used in combination with metsulfuron methyl (Escort XP) to control eastern red cedar (*Juniperus virginiana*), tree-of-heaven, ash, elm, and maple. Fosamine ammonium is also used with imazapyr (Arsenal) to control American beautyberry (*Callicarpa americana*), baccharis (*Baccharis neglecta*), *Vaccinium* spp., waxmyrtle, box elder, black locust, dogwood, elm, maple, sassafras (*Sassafras sassafras*), and willow.

Metsulfuron Methyl (Escort XP)

Escort XP is a selective pre- and postemergence herbicide used to control broadleaf herbaceous and woody species. It has been used to control cocklebur, blackberry (*Rubus* spp.), thistle, sunflower, honeysuckle, wild rose, ash, black locust, cottonwood, eastern red cedar, elm, hackberry (*Celtis* spp.), hawthorn, mulberry, wild grape, oak, Osage orange (*Maclura pomifera*), maple, sweetgum, tree-of-heaven, *Vaccinium* spp., and willow.

Diquat (Reward)

Diquat is a non-selective contact herbicide used to control aquatic and terrestrial vegetation. Although diquat is toxic to aquatic invertebrates, it is acceptable for aquatic use because it quickly binds to soil and suspended sediments in the water. However, care should be taken while applying diquat so that direct contact with water bodies is avoided. In addition, diquat can be toxic to many grass species and other vegetation that may be beneficial in the control of dam erosion. Diquat should be applied to minimize impacts to desired, beneficial vegetation.

BRUSH CONTROL HERBICIDES TO <u>AVOID</u> ON DAMS

The following list of herbicides contains chemicals and formulations known to be effective in the control of upland vegetation in habitats similar to those found on earthen dams. However, because they are known to leach through the soil and accumulate in ground and surface waters or are known to be toxic to aquatic organisms, their use should be avoided in the control of dam vegetation.

Clopyralid (Reclaim, Stinger, and Transline)

Although clopyralid exhibits a low toxicity to terrestrial and aquatic organisms, it is highly mobile in the soils and can contaminate surface and ground water which may be used for irrigation and drinking purposes. Because of the proximity of dams to water, it is recommended that the use of clopyralid be avoided in the control of vegetation on dams.

Clopyralid with 2,4-D or MCPA-EHE (Curtail and Curtail M)

Curtail and Curtail M are herbicide formulations which use clopyralid as an active ingredient. Curtail contains clopyralid with 2,4-D while Curtail M contains clopyralid with MCPA-EHE. Because both formulations contain clopyralid, it is recommended that the use of Curtail and Curtail M be avoided in the control of vegetation on dams.

Glyphosate

Although glyphosate is practically non-toxic to aquatic organisms, certain surfactants added to some terrestrial formulations of glyphosate have been shown to be highly toxic to aquatic species and amphibians. Non-aquatic formulations of glyphosate (Accord SP, Accord XRT, Glyphomax, Glypro Plus, Honcho, Roundup, Touchdown) should be avoided in the control of vegetation on dams. In addition, other formulations containing glyphosate combined with 2,4-D or dicamba (Campaign, Fallowmaster, Landmaster II) should be avoided unless labeled for aquatic use.

Picloram (Tordon 22K, Tordon K)

Although picloram exhibits a low toxicity to terrestrial and aquatic organisms, it is highly mobile in the soils and can contaminate surface and ground water which may be used for irrigation and drinking purposes. Because of the proximity of dams to water, it is recommended that the use of picloram be avoided in the control of vegetation on dams.

Picloram with 2,4-D (Grazon P+D, Pathway, Tordon RTU, Tordon 101)

Because picloram is extremely mobile in the soil profile and is known to leach into surface and ground water, it is recommended that the use of Grazon P+D, Pathway, Tordon RTU, and Tordon 101 be avoided in the control of vegetation on dams.

Triclopyr (Garlon 3A, Garlon 4, Pathfinder II, Remedy)

Although triclopyr exhibits a low toxicity to terrestrial and aquatic organisms, it is highly mobile in the soils and can contaminate surface and ground water which may be used for irrigation and drinking purposes. Because of the proximity of dams to water, it is recommended that the use of triclopyr be avoided in the control of vegetation on dams.

Triclopyr with 2,4-D (Crossbow)

Crossbow is toxic to fish and drift or runoff could adversely impact fish and aquatic plants adjacent to dams. Avoid the use of Crossbow in the control of vegetation on dams.

Triclopyr with Clopyralid (Redeem R&P)

Because triclorpyr and clopyralid are extremely mobile in the soil profile and are known to leach into surface and ground water, it is recommended that the use of Redeem R&P be avoided in the control of vegetation on dams.

APPENDIX A

Document 15

Inspection Report 09.23.10

DAM & DIKE INSPECTION REPORT

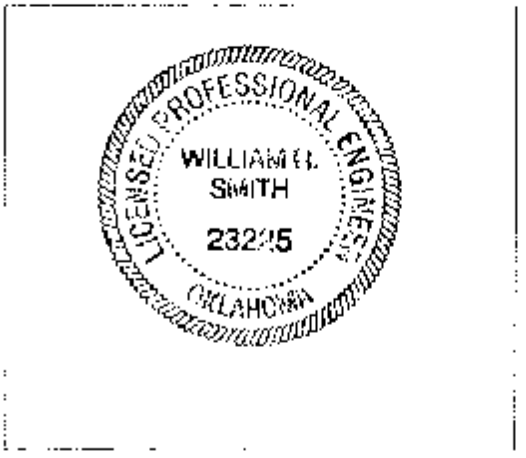
BOTTOM ASH POND AT
NORTHEASTERN 3 & 4 POWER STATION
ROGERS COUNTY, OK

INSPECTION DATE September 23, 2010

PREPARED BY _____ **DATE** _____
William R. Smith, P.E.

REVIEWED BY _____ **DATE** _____
Gary F. Zych, P.E.

APPROVED BY _____ **DATE** _____
Gary F. Zych, P.E.



PROFESSIONAL ENGINEER
SEAL & SIGNATURE

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SUMMARY OF VISUAL OBSERVATIONS **2**

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UPSTREAM SLOPE 4

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DOWNSTREAM TOE 5

RECENT TESTING AND INSTRUMENTATION DATA **7**

CONCLUSIONS AND RECOMMENDATIONS **7**

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APPENDIX A Inspection Photographs
APPENDIX B Oklahoma Dam Inspection Checklist Form
APPENDIX C Guidelines for Herbicide Use on Earthen Dams, Controlling Woody Vegetation, and Dam Inspection

NE34P000049

INTRODUCTION

AEPSC (American Electric Power Service Corporation) Civil Engineering administers the Dam Inspection and Maintenance Program (DIMP) at AEP facilities. As part of the DIMP, staff from the geotechnical engineering section conducts dam and dike inspections at AEP facilities. Mr. William R. Smith, P.E., performed the 2010 inspection of the bottom ash pond at the Northeastern 3&4 Power Station. This report is a summary of the inspection and an assessment of the general condition of the facility. Appendix A presents photos that were taken during the inspection. Appendix B contains a completed dam inspection and maintenance checklist form as provided by the State of Oklahoma Water Resources Board (OWRB) summarizing inspection findings. Appendix C contains recommended guidelines on herbicide use to control the growth of brush and woody vegetation near earthen dams along with new guidelines from the OWRB on the control of woody vegetation and dam inspection.

Mr. Gary Merkle, plant operations specialist, joined Mr. Smith in the inspection and was the facility contact. The inspection was performed on September 23, 2010. Weather conditions were partly cloudy with 10 to 15 mph winds, no precipitation, and temperatures in the low to mid 80's (°F).

Figure 1 provides a plan view, in the form of a satellite image, of the bottom ash pond, its embankment structure or dam, pertinent dam features, and the dam's appurtenances. The dam is a 4,200-foot long cross-valley impoundment on an unnamed tributary to Fourmile Creek. The dam is roughly U-shaped and has been divided into north, west, and south embankments, as shown on Figure 1, for this inspection.

GENERAL INFORMATION

Dam or Reservoir:	Bottom Ash Pond at Northeaster Power Station
Owner:	Public Service Company of Oklahoma
Type of Dam:	Zoned Earth Embankment Structure
Date of Construction:	1979
D/S Hazard:	Unclassified

NE34P000050

LOCATION

County:	Rogers County
General Location:	Approximately 22 miles north-northeast of Tulsa, OK
Stream and Basin:	Unnamed tributary to Fourmile Creek; Verdigris River Basin

SIZE

Dam Crest Elevation[1]:	628.5 feet-MSL (low point near emergency spillway)
Emergency Spillway: Crest Elevation[1]	625.0 feet-MSL
Current Water Level[2]:	~ 622.6 feet-MSL
Height[1]:	~ 24.5 feet
Surface Area:	39 acres

Notes: 1.) Estimated from construction drawings; 2.) From staff gauge during inspection.

SUMMARY OF VISUAL OBSERVATIONS

The summary of the visual observations presented herein uses terms to describe the general appearance or condition of an observed item, activity or structure. Their meaning is understood as follows:

CONDITION OF DAM COMPONENT

Good:	A condition or activity that is generally better or slightly better than what is minimally expected or anticipated from a design or maintenance point of view.
Fair or Acceptable:	A condition or activity that generally meets what is minimally expected or anticipated from a design or maintenance point of view.
Poor:	A condition or activity that is generally below what is minimally expected or anticipated from a design or maintenance point of view.

NE34P000051

SEVERITY OF DEFICIENCY

Minor: A reference to an observed deficiency (e.g., erosion, seepage, vegetation, etc.) where the current maintenance condition is below what is normal or desired, but which is not currently causing concern from a structure safety or stability point of view.

Significant: A reference to an observed deficiency (e.g. erosion, seepage, vegetation, etc.) where the current maintenance program has neglected to improve the condition. Usually these conditions have been identified in previous inspections, but have not been corrected.

Excessive: A reference to an observed deficiency (e.g., erosion, seepage, vegetation, etc.) where the current maintenance condition is above or worse than what is normal or desired, and which may have affected the ability of the observer to properly evaluate the structure or particular area being observed or which may be a concern from a structure safety or stability point of view.

Emergency Spillway

There is no principal spillway at the bottom ash pond; water is typically recirculated. The emergency spillway at the bottom ash pond is a concrete overflow structure with a design crest elevation of 625.0 ft. Overflow from the spillway discharges to a basin and then flows through a culvert under a railroad and off site. Figure 1 shows the spillway and discharge culvert locations.

The concrete control section and discharge chute were in good condition and clear of any vegetation or debris that would restrict flow. However, a large debris pile had been placed at the far end of the discharge basin that could drift toward the entrance to the discharge culvert during spillway activation and block flow. Photos 1 and 2 show the control section and discharge chute, respectively. Photo 2 also shows the relative positions of the spillway discharge chute, basin, and culvert along with the large debris pile in the background. The entrance and exit to the dual-

pipe discharge culvert was partially blocked with a minor amount of vegetation as shown in Photos 3 and 4. The corrugated metal culvert pipes were excessively corroded from the springline to the pipe bottom and in poor condition as shown in Photos 3 and 5. The overall condition of the emergency spillway system was fair.

Upstream Slope

The upstream slope of the dam was observed to be in generally good condition. The slope along the north and west embankments had a few areas with minor vegetative overgrowth, as shown in Photos 6 through 8, but was in overall good condition. The riprap shore protection was noted in good condition over the entire slope. Some local areas on the south embankment within and just above the riprap were overgrown with significantly high vegetation making a thorough inspection of these areas difficult as shown in Photo 9. The photo also shows an area of significant rutting with exposure of the soil presumably due to mowing during wet conditions.

The slope along the eastern portion of the southern embankment was previously steepened by the plant in order to provide a wider dam crest for vehicular access next to the railroad track on the crest. The resulting slope angle along approximately the upper 15 feet of the slope in this area (approximately 1000 feet of embankment length) is about 1:1 instead of the design slope of 2.5:1 (H:V). During the 2009 inspection, this portion of the slope was noted with significant surface irregularities and erosion gullies formed from the concentration of storm water flows. Prior to the 2010 inspection the area was regraded, to remove the surface irregularities and erosion gullies, and lined with riprap underlain with geotextile to prevent further erosion of the steepened slope. The repaired slope was in good condition and is shown in Photo 10.

Crest

The crest of the entire west and south embankments of the dam is used for railroad access to the plant. The crest of the north embankment is used for vehicular access except for the area containing the spillway. As discussed in the previous report section, the slope along the eastern portion of the southern embankment was previously steepened by the plant in order to provide a wider dam crest for vehicular access next to the railroad track on the crest.

NE34P000053

The crest was in generally good condition with no evidence of misalignment, rutting, settlement, cracking, or other indications of distress. The minor rutting and ponded water observed on the north embankment crest during the 2009 inspection had been repaired by regrading and leveling with bottom ash compacted by tracked earthwork equipment. This area is shown in Photo 11. A typical view of the crest along the west embankment is shown in Photo 12.

Downstream Slope

The downstream slope of the dam was noted to be in generally good condition. Vegetation control was good and allowed for a thorough inspection. No apparent signs of sloughing, erosion, or slope instability were observed. Minor deficiencies included the exposure of soils in some small areas, the covering of a portion of the riprap toe drain system with coarse, granular material (bottom ash) and using the area to sprout Bermuda grass, and a very small amount of burrowing animal activity.

The downstream slope and groin of the north embankment, shown in Photo 13, were in good condition with well maintained vegetation. Typical views of the west and south embankments are shown in Photos 14 through 16. Photo 14 shows the west embankment, in good condition, at the right end of the toe drain (discussed further in the next report section). Photo 15 shows the western portion of the south embankment in generally good condition with some moderately overgrown vegetation at upstream limit of the toe drain. Photo 16 shows the eastern portion of the south embankment, near the left groin, in good condition with well-maintained vegetation. One area in the midsection of the south embankment had a sparse ground cover with some exposed soils and an animal burrow as depicted in Photo 17. The sparseness of the ground cover may have been due to allowing the vegetation to grow too high, which tends to decrease stem density, as indicated by the long grass clippings in the photo. A close-up view of the animal burrow included in Photo 17 is shown in Photo 18.

Downstream Toe

The downstream toe of the dam was designed with a toe drain along the west and south embankments. This drainage system consists of a 1.5-foot thick sand and gravel drainage blanket layer at the dam subgrade that extends upstream a distance of about 1.5 times the

NE34P000054

embankment height and is connected to a gravel and sand bedding layer, 9-inches in thickness, at the toe that runs 12 feet up the slope from the toe and is overlain by a 1-foot layer of riprap. The toe drain was designed to drain seepage from the dam at any point along its length; i.e., there are no seepage collection pipes to discharge seepage at specific locations. As a consequence, seepage will tend to collect and discharge at the lowest elevation along the toe. This area is near the western end of the south embankment at the location of the pre-existing natural streambed (see Figure 1). Photo 19 shows this area of seepage discharge from the toe drain. Photo 20 shows the culvert, immediately downstream of the seepage area, that is used as a pipe weir to periodically measure the seepage flow rate. The flow rate of seepage through the culvert at the time of inspection was visually estimated in the range of ½ to 1 gallon per minute. Measurements by plant personnel over the past year have ranged between 1 and 3 gallons per minute. No signs of erosion or soil instability were observed in the area and all flowing water was clear.

Approximately 1000 feet of the toe drain's top surface along the south embankment, from its left end to its lowest elevation at the location of the pre-existing natural streambed, was partially covered with bottom ash inadvertently by plant personnel in 2009. A view of the embankment showing a portion of the covered toe drain is provided in Photo 21. (Note that the riprap also appears absent in Photos 17 and 19.) Since this material was placed on top of a system that drains subsurface seepage, and is also a coarse-grained, granular bottom ash material, it is not expected to affect the ability of the system to function as designed; however the plant was advised in the 2009 inspection report that this process not be continued. No further placement of material covering the toe drain was noted during the 2010 inspection. Two small mounds of significantly tall Bermuda grass were observed on the toe drain near the seepage discharge area as depicted in Photo 22. Photos from the 2009 inspection show that the mounds were present then, but the grass on them was not significantly tall at the time and they did not stand out from the tall vegetation in the area. Plant personnel reported that the mounds were being used to sprout the Bermuda grass prior to transplanting to areas of the dam with sparse vegetation.

RECENT TESTING AND INSTRUMENTATION DATA

A geotechnical investigation and stability evaluation for the dam was performed in January through March 2010. Six borings were drilled in pairs, three at the crest and three just beyond the toe, spaced approximately equally along the length of the dam with one pair at the maximum dam height. The two borings at the maximum dam height were converted into 2-inch monitoring wells to provide data on the phreatic surface across the dam. Water-level measurements are collected quarterly. The wells were dry upon completion of the drilling. The two measurements collected since well installation are provided in Table 1, below. MW-1 is at the crest, and MW-2 is just beyond the toe. The conclusion of the geotechnical report was that the soil conditions can safely support the design embankment slope with the surcharge from the railroad loading.

Table 1. Water-level at Northeastern Plant Bottom Ash Pond

Date	Reservoir Elev. (ft)	MW-1 GW Elev. (ft)	MW-2 GW Elev. (ft)
8/16/2010	622.5	607.4	599.52
11/3/2010	623.2	608.5	596.52

CONCLUSIONS AND RECOMMENDATIONS

Based on our visual inspection, it is concluded that the bottom ash pond dam was generally in good condition at the time of inspection with no signs of distress that would indicate possible instability, excessive settlement, misalignment, sloughing, or cracking of the dam.

The condition of this dam has greatly improved since inspections began in March 2009. Items that have been addressed to accomplish this improvement include the following:

- Elimination of all woody vegetation at the dam, including any within 30 feet of the toe and groins,
- Clearing of vegetation and debris from the emergency spillway, the discharge chute, and discharge culvert,
- The regrading and lining of upstream slope, with riprap, at the south embankment to prevent further erosion of the steepened slope,
- Regrading of the crest at the north embankment to remove ruts and depressions and leveling with compacted bottom ash.

- Installation of the pipe weir at the lowest elevation of the toe drain to monitor seepage flow,
- Installation of two wells to monitor the phreatic surface across the dam,
- Ongoing elimination of weeds followed by the establishment of native, perennial grasses such as Bermuda grass.

A summary of our recommendations for general maintenance and continued monitoring, as well as any recommendations for remedial activities, is provided as follows:

Recommendations for General Maintenance and Monitoring Activities

- Regularly clear any excess vegetation or blockage and maintain free flow at the emergency spillway inlet and discharge.
- Regularly clear any excess vegetation or blockage and maintain free flow capability at the discharge culvert just northwest of the emergency spillway.
- Maintain vegetation by mowing at least twice per year. At areas where it is not feasible to use mowing equipment, such as within and adjacent to riprap, control vegetation with use of weed trimmers, power brush cutters, or similar equipment or by the select application of appropriate herbicide. Vegetation control by cutting is preferred over herbicide use. Appendix C contains recommended guidelines on herbicide use to control the growth of brush and woody vegetation near earthen dams and a new guidance document from the OWRB on controlling woody vegetation. Note that a licensed applicator may be required. General vegetation control should extend to 30 feet beyond the toe and groins.
- Maintain a grass cover at areas without riprap to prevent erosion. Note that the Oklahoma Administrative Code rule regarding prohibited vegetation has been changed, effective May 27, 2010, to include provisions for preventing and repairing erosion and now states as follows:

  785:25-3-10. Prohibited vegetation and erosion

  Trees and heavy vegetation shall be removed from the slopes and crest of earthen embankments and emergency spillway area. Trees and heavy vegetation shall also be removed from an area a minimum distance from the toe of the embankment of

30 feet. Dams shall be maintained such that internal or external erosion is prevented. If erosion is present it shall be repaired utilizing appropriate engineering practices.

- Backfill any noted animal burrows on a regular basis with compacted fill, then seed and mulch to establish grass cover.
- The dam should be inspected by plant personnel quarterly and within 24 hours of unusual events such as seismic activity or a significant storm event with the inspection documented in accordance with AEP Circular Letter CI-M-CL-010C. For the purpose of these inspections, a "significant storm event" is defined as a storm that results in three inches or more of rainfall in 24 hours.

Recommendations for Remedial Activities

- The excessively corroded double-pipe discharge culvert just downstream of the emergency spillway and beneath the plant railroad track should be repaired or replaced.
- A ground cover of native, non-invasive perennial grasses should be established on the sparsely vegetated areas of the downstream slope of the south embankment .
- The two mounds near the lowest elevation of the toe drain, used for sprouting Bermuda grass, should be relocated off the embankment.

Submitted By:

American Electric Power Service Corporation

Civil/Geotechnical Engineering

William R. Smith, P.E.
Geotechnical Engineer
AEP Service Corporation
Oklahoma P.E. #23225

NE34P000058

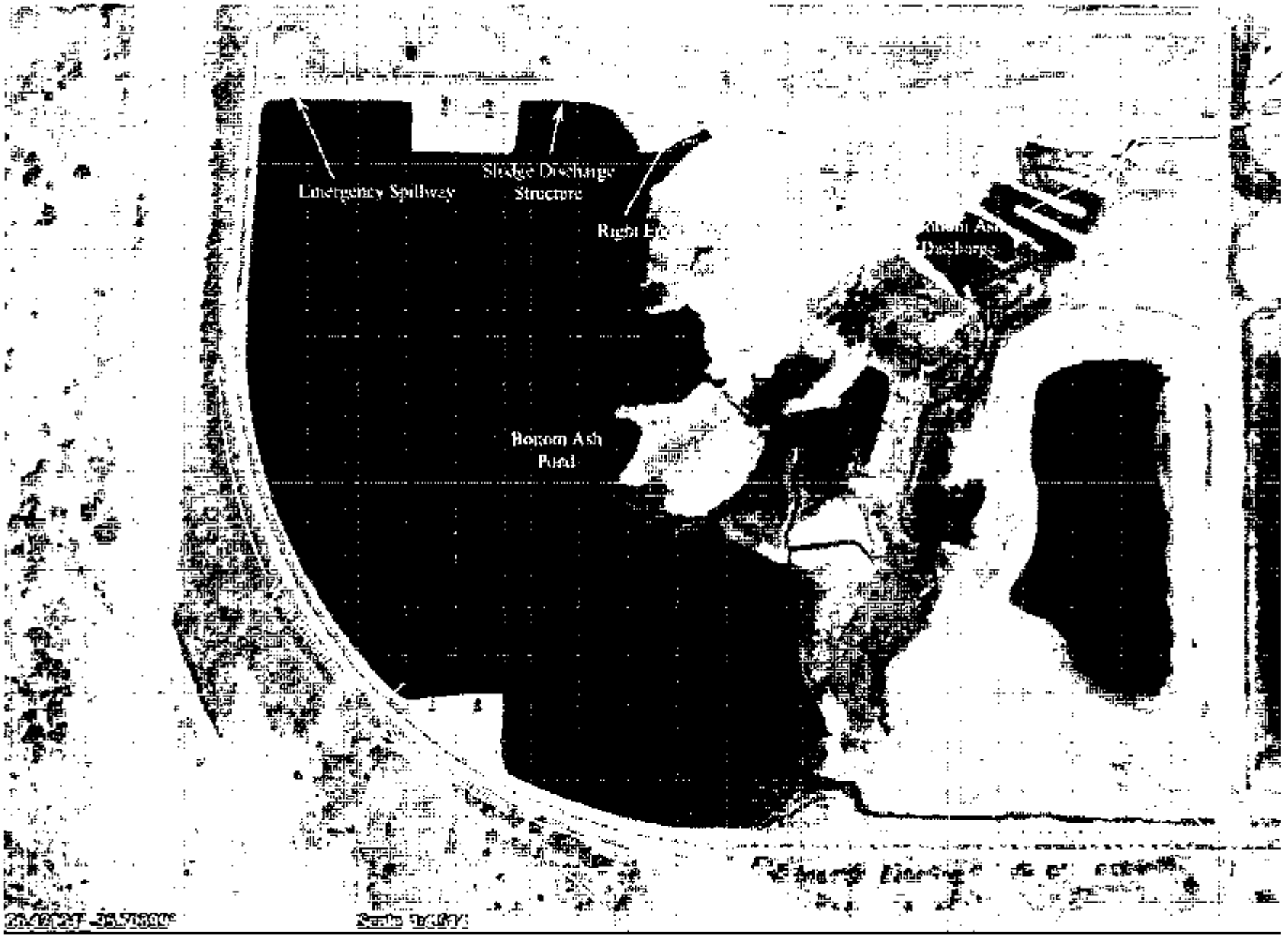

Figure 1. Satellite image of bottom ash pond dam, features, and appurtenances at Northeastern 3&4 Power Station.

APPENDIX A

Inspection Photographs

Photo 1. Bottom ash pond emergency spillway entrance and control section in good condition.

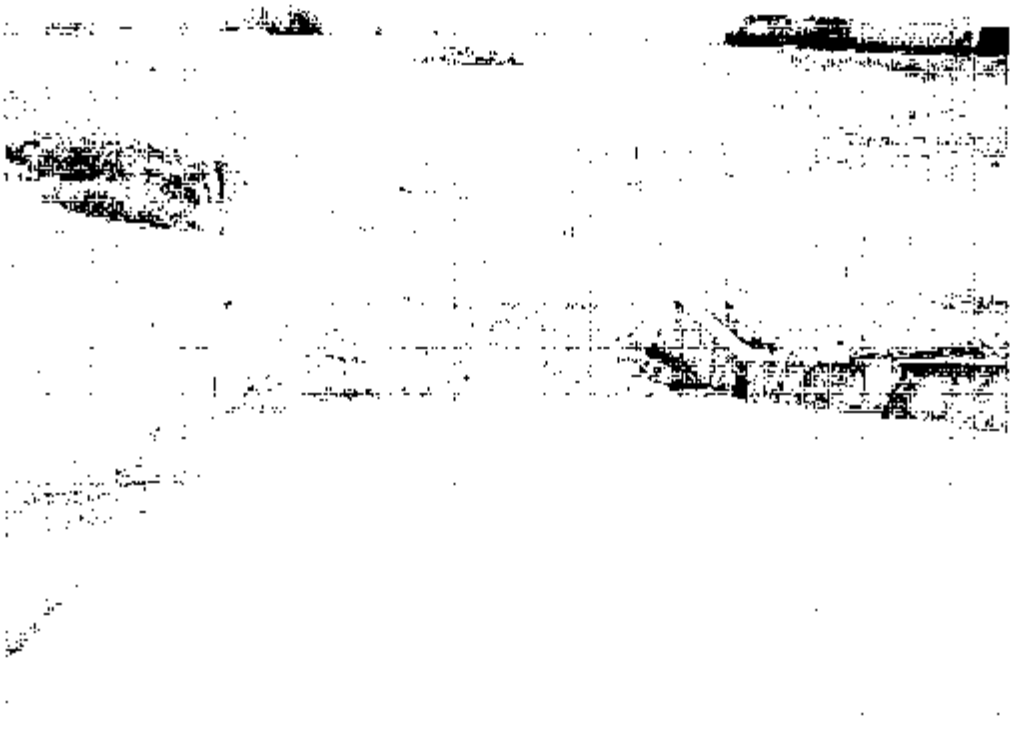

Photo 2. Discharge chute and basin at spillway in generally good condition, but with a debris pile at far end of basin that could drift and block outflow.

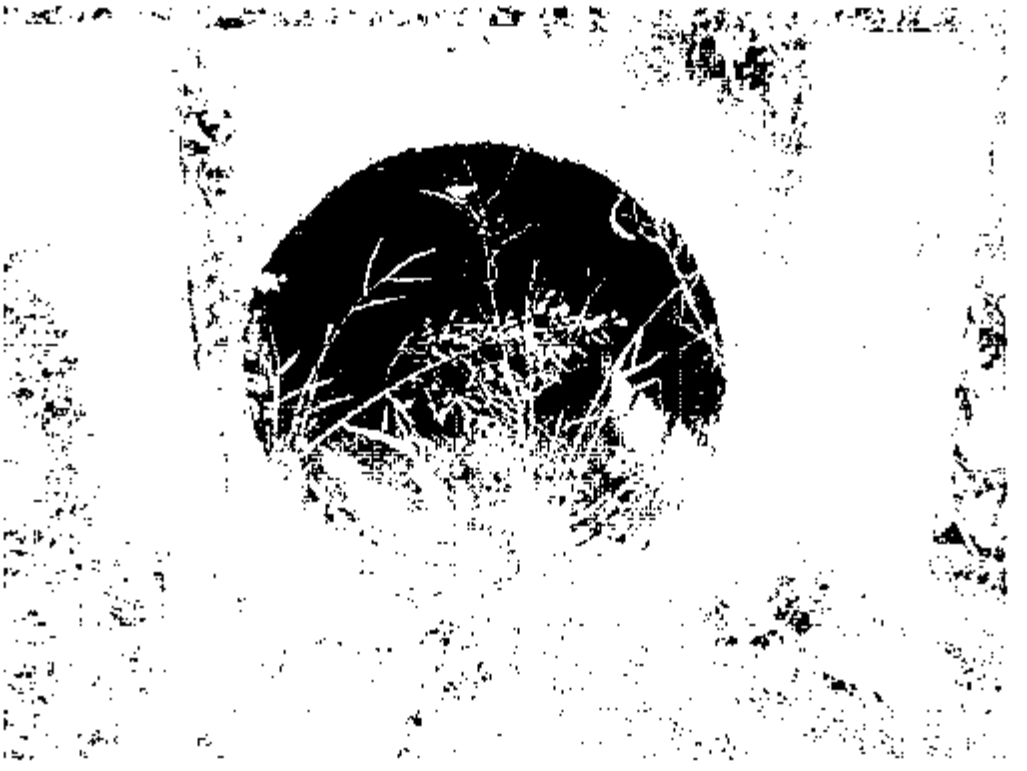

Photo 3. The entrance to the spillway discharge culvert had a minor amount of vegetative overgrowth and the pipe was excessively corroded.

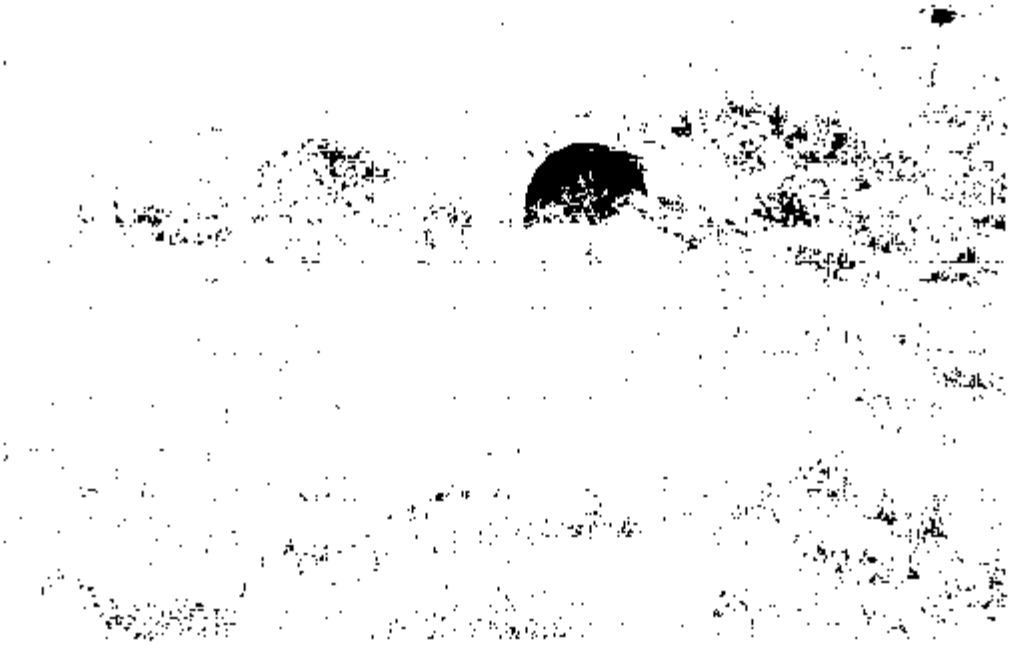

Photo 4. The discharge culvert outflow was partially blocked with minor vegetation.

Photo 5. Spillway discharge culvert exit with excessive corrosion from the springline to the pipe bottom.

Photo 6. Upstream groin and slope of north embankment with minor vegetative overgrowth, but in overall good condition.

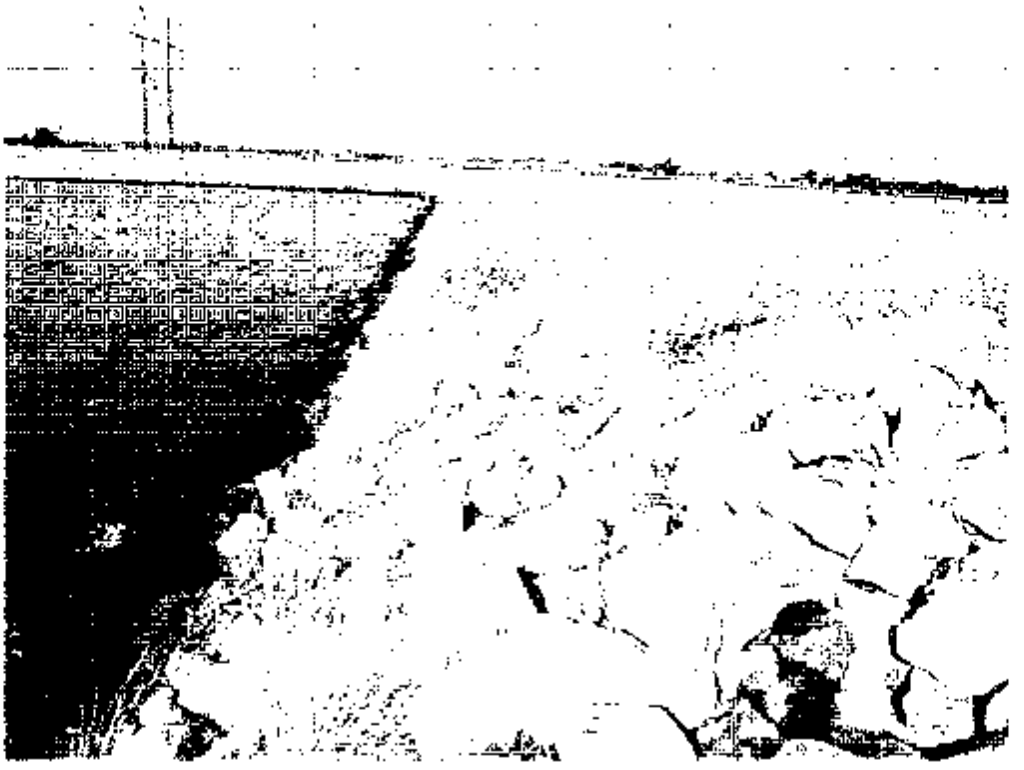

Photo 7. Upstream slope of north embankment with a few areas of minor vegetative overgrowth and riprap in good condition.

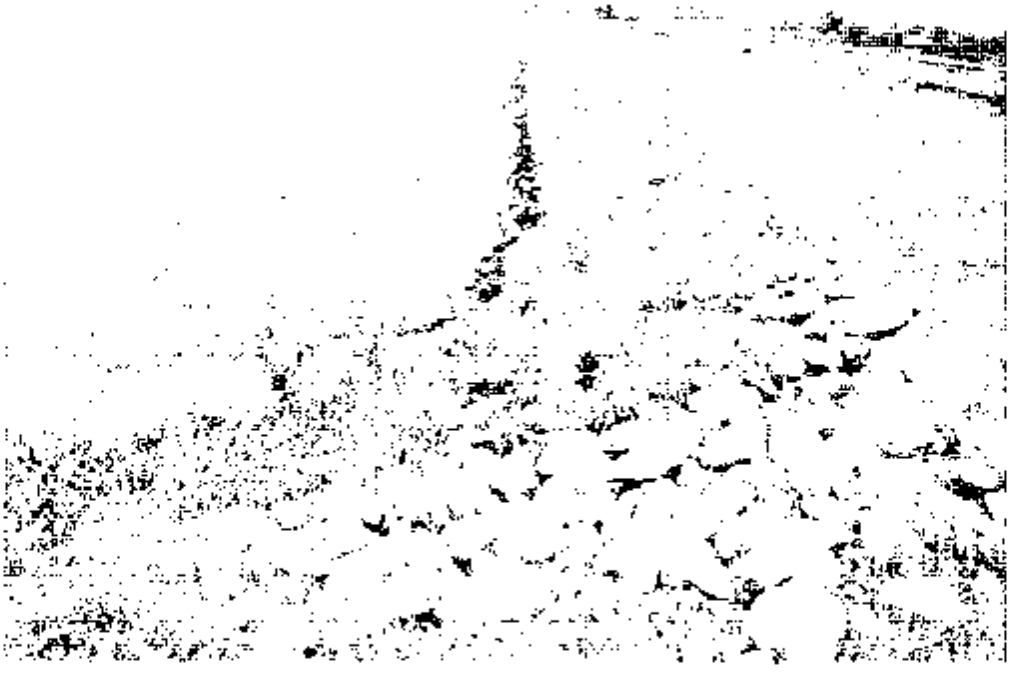

Photo 8. Upstream slope of west embankment with a few areas of minor vegetative overgrowth and riprap in good condition.

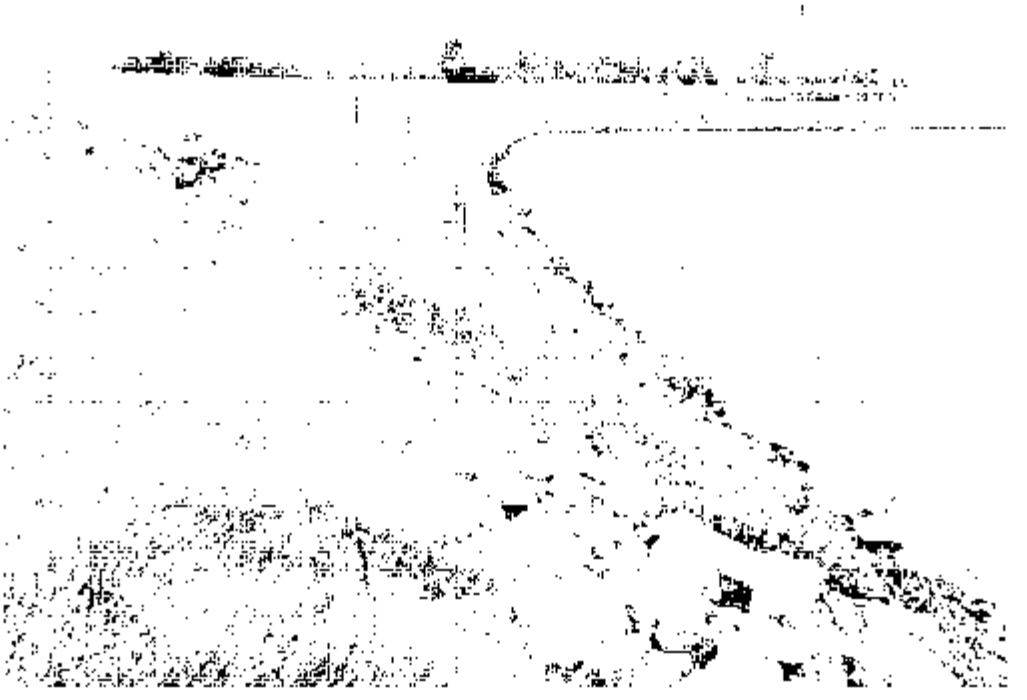

Photo 9. Upstream slope with local areas of significantly high vegetation and significant rutting with exposure of soil.

Photo 10. Repaired upstream slope at eastern portion of south embankment in good condition.

Photo 11. Crest of north embankment in good condition with formerly rutted areas regraded and repaired with a surface course of compacted bottom ash.

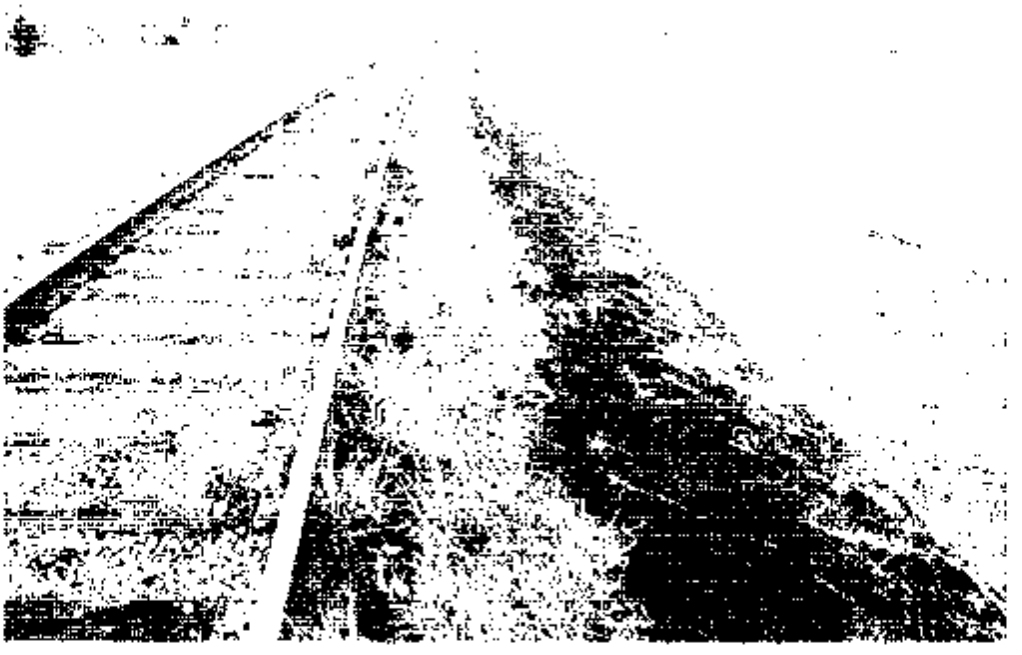

Photo 12. Typical view of crest, in good condition, along the west embankment.

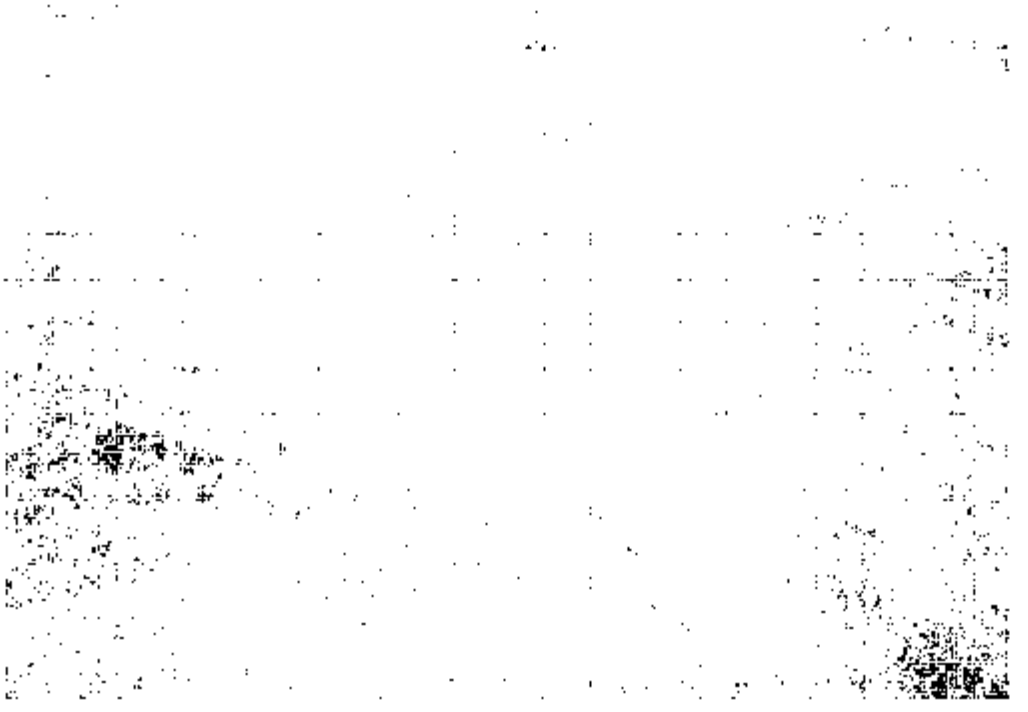

Photo 13. Downstream slope and groin of north embankment in good condition and with good vegetation control.

Photo 14. Typical view of downstream slope at west embankment in good condition showing the right end of the toe drain.

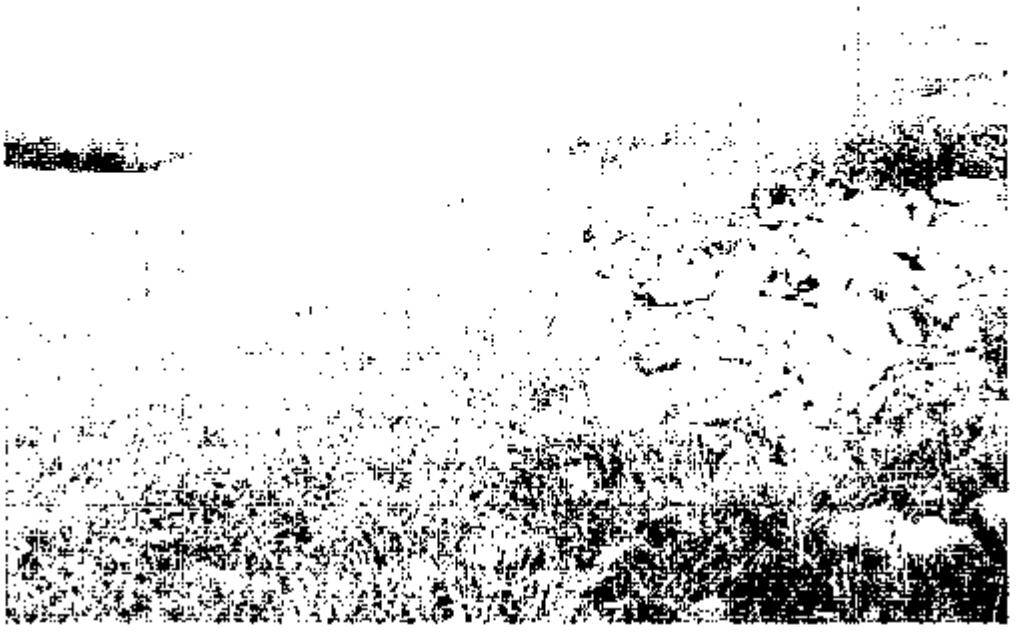

Photo 15. Typical view of downstream slope at south embankment in good condition but with some moderately overgrown vegetation near the toe drain.

Photo 16. Typical view of the downstream slope near the left groin at the south embankment in good condition with well-maintained vegetation.

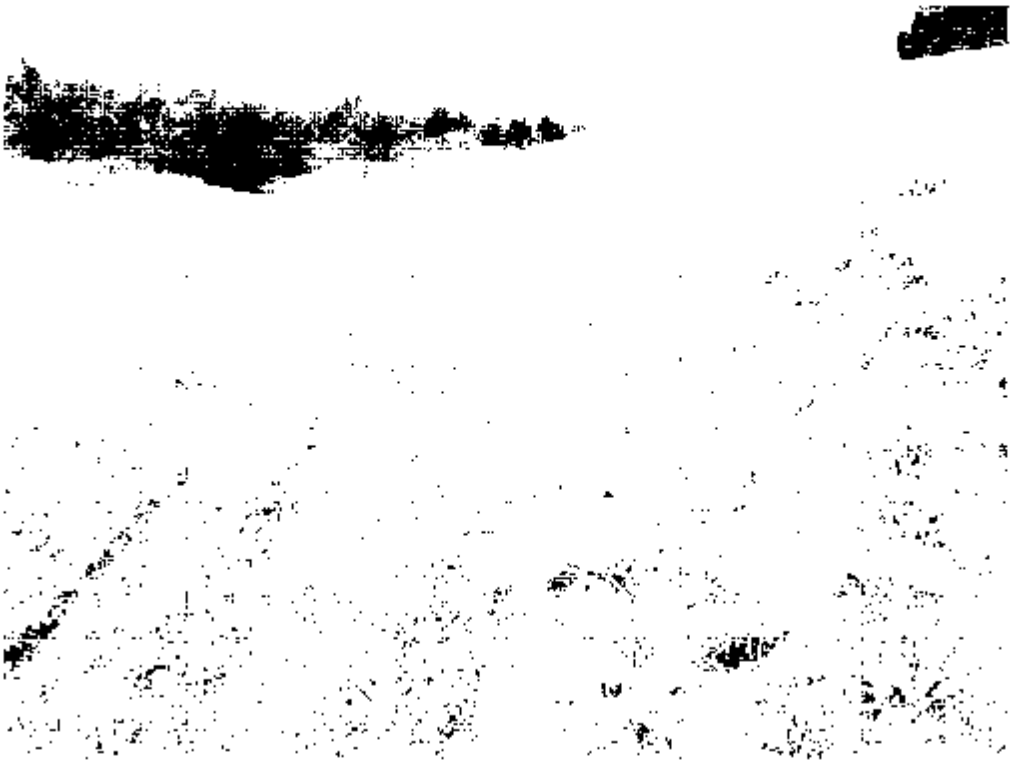

Photo 17. Sparse ground cover, exposed soils, and an animal burrow on the downstream slope of the south embankment.

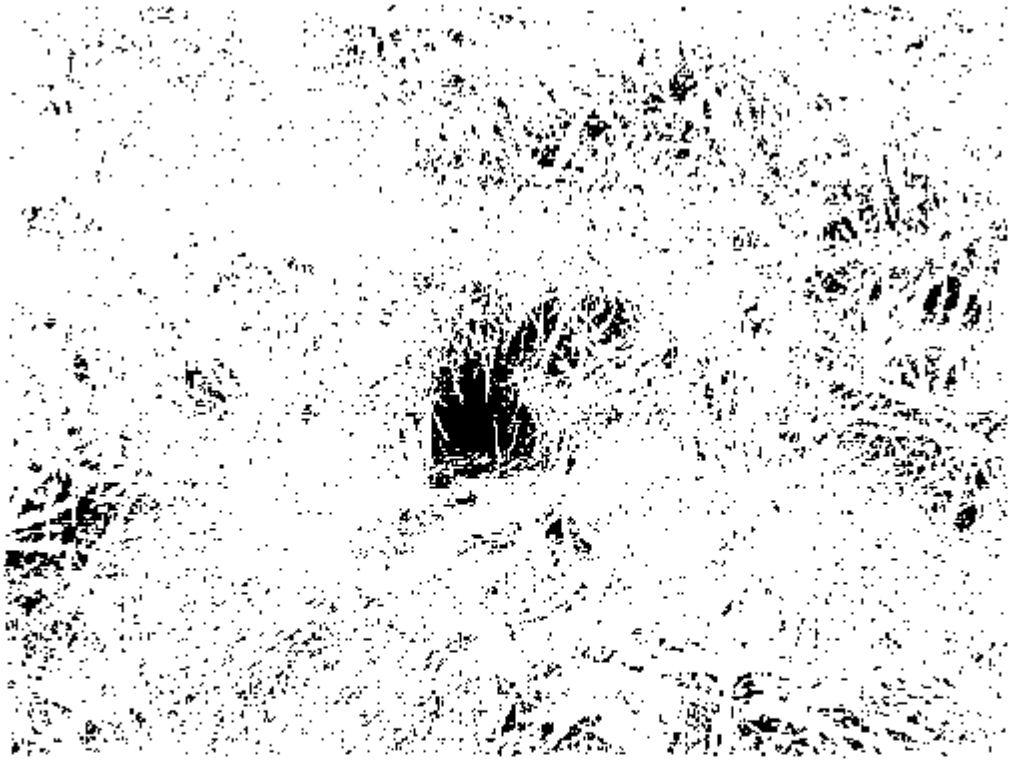

Photo 18. A close-up view of the animal burrow shown in Photo 17.

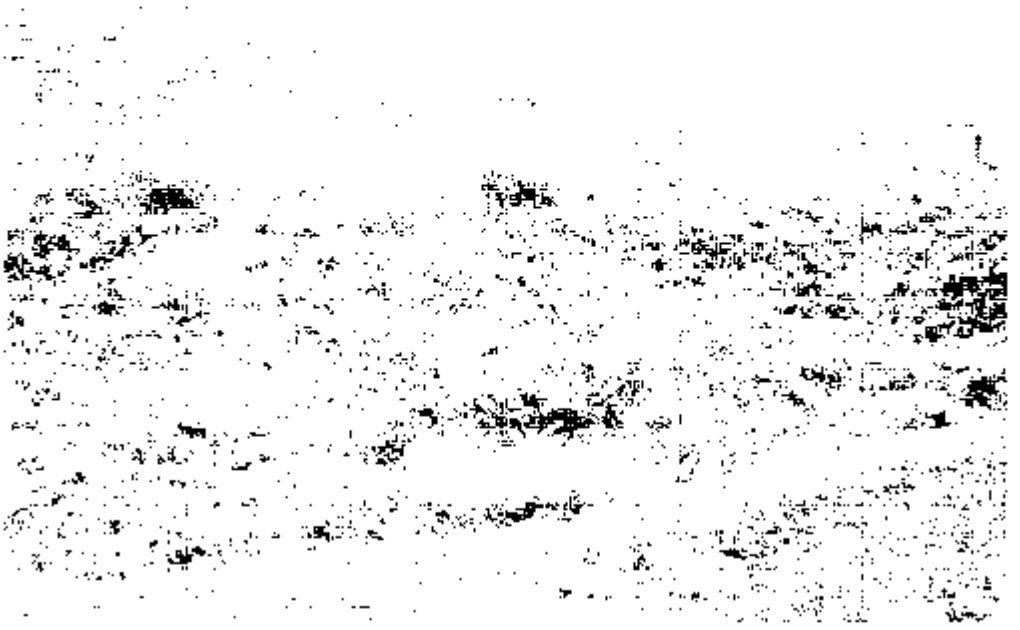

Photo 19. Seepage discharge from the toe drain, observed only at the location of the pre-existing, natural streambed, was minimal and clear.

Photo 20. A culvert immediately downstream of the seepage discharge area shown in Photo 19 is used as a pipe weir to measure the seepage flow rate.

Photo 21. View of south embankment downstream slope riprap in good condition with toe drain riprap covered with bottom ash and some Bermuda grass.

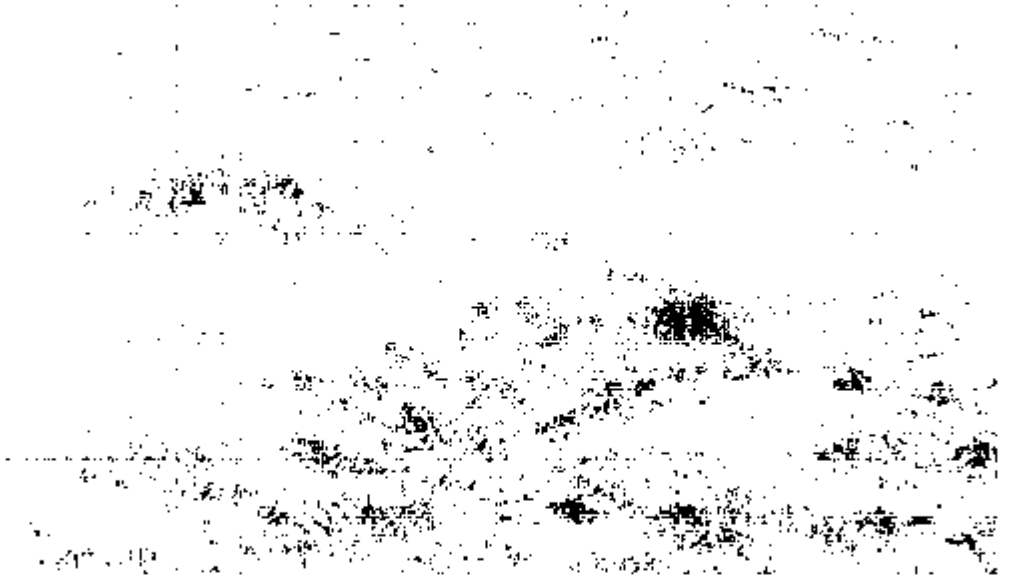

Photo 22. Two mounds of bottom ash used to sprout Bermuda grass on the toe drain near the seepage discharge area should be relocated off the dam.

APPENDIX B

Oklahoma Dam Inspection Checklist Form

OKLAHOMA WATER RESOURCES BOARD
PLANNING & MANAGEMENT DIVISION - DAM SAFETY PROGRAM

DAM INSPECTION CHECKLIST

Name of Dam: Northeastern A&M Bottom Ash Pond Dam
State Inventory ID: N/A
Owner of Dam: NRPSO
Purpose of Dam: Bottom Ash Sedimentation
Address: 7300 E. Hwy 88
Hazard Classification: Unclassified
City, State/ZIP: Oologah, OK 74053
County: Rogers
Inspected By: William R. Smith, P.E.
Legal Location:
Date of Inspection: September 23, 2010
Latitude: 36-420 N
Longitude: 95-708 W
Weather Conditions: Partly Cloudy, 80-85°F

	Item	Yes	No	N/A	Condition (Good, Acceptable, Deficiency)	Remarks
1	**General Conditions of Dam**					
A	Alterations to the dam?		X			
B	Development in downstream floodplain?		X			
C	Grass cover adequate?	X			Good	Small areas of sparse vegetation
D	Settlements, misalignments, or cracks?		X			
E	Recent high water marks?		X			Erosion
2	**Upstream Slope of Dam**					
A	Erosion?		X			
B	Trees?		X			
C	Rodent holes?		X			
D	Evidence of livestock on dam?		X		Good	
E	Cracks, settlement, or bulges?		X			
F	Adequate and sound riprap?	X				
3	**Downstream Slope of Dam**					
A	Erosion?		X			
B	Trees?		X			
C	Rodent holes?	X				Some burrows at toe
D	Evidence of livestock on dam?		X		Good	
E	Cracks, settlement, or bulges?		X			
F	Drains or wells flowing?	X				Drainage pipe [illegible]
G	Seepage or boils?		X			Drainage pipe
4	**Abutment Contacts**					
A	Erosion, cracks, or slides?		X		Good	
B	Seepage?		X			Drainage pipe
5	**Inlet Structure**					
A	Concrete? ☐ Metal? ☐					
B	Spalling, cracking, or scaling?			X		
C	Exposed reinforcement?			X		
D	Corrosion present?			X		
E	Coating adequate?			X	N/A	
F	Leakage?			X		
G	Trashrack adequate?			X		
H	Obstacles to inlet?			X		
I	Drawdown operative? Opened & closed			X		
6	**Conduit & Outlet**					
A	Concrete? ☐ Metal? ☐					
B	Spalling, cracking, or scaling?			X		
C	Exposed reinforcement?			X		
D	Joints displaced or offset?			X		
E	Joint material lost?			X	N/A	
F	Leakage?			X		
G	Earth erosion?			X		
H	Conduit misaligned?			X		
I	Outlet channel obstructed?			X		

Rev. [illegible]

	Item	Yes	No	N/A	[1]Condition (Good, Acceptable, Deficient, Poor)	Remarks
7	**Concrete Spillway**					
A	Spalling, cracking, or scaling?		X			
B	Exposed reinforcement?		X			
C	Joints displaced or offset?		X			
D	Joint material lost?		X			
E	Leaking?		X		Good	
F	Dissipater deteriorating?			X		
G	Dissipaters clean of debris?			X		
H	Earth erosion?		X			
I	Other distress? eroding?		X			
8	**Emergency Spillway**					
A	Obstruction?		X			
B	Erosion?		X		Acceptable	Repair [illegible]
C	Rodent holes?		X			
D	Evidence of livestock on spillway?		X			
9	**Stilling Basin**					
A	Spalling, cracking, or scaling?			X		
B	Exposed reinforcement?			X		
C	Joints displaced or offset?			X		
D	Joint material lost?			X	N/A	
E	Joints leak?			X		
F	Rock adequate?			X		
G	Dissipater deteriorating?			X		
H	Dissipaters clean of debris?			X		
10	**Gates**					
A	Flow gates broken or bent?			X		
B	Flow gates corroded or rusted?			X		
C	Flow gates operational?			X		
11	**Instruments**					
A	Structure instrumented?	X			Good	Two piezometers
B	Monitoring performed?	X				Water Levels Measured Quarterly
**	**Should Hazard-Potential Classification be reevaluated?**			X		

REMARKS:

N/A - Not Applicable

11 A, B -- Flow through pipe were at lowest elevation of the drain measured quarterly

For High and Significant Hazard-Potential Dams Only Professional Engineer Seal

Name of Engineer:

Date:

Engineering Firm:

Address

City, State, ZIP

Telephone Number:

Signature:

[1]Condition: Please rate the condition of sections 1 - 11 on inspection form either: Good, Acceptable, Deficient, or Poor.

Good - No existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or industry practice.

Acceptable - No existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.

Deficient - A dam safety deficiency is recognized for loading conditions which may realistically occur. Remedial action is necessary. Poor may also be used when uncertainty exists as to critical analyses. Supplemental data or analysis may confirm a safety deficiency. Further investigations and studies are necessary.

Poor - A dam safety deficiency is recognized that requires immediate or extensive remedial action for problem resolution.

APPENDIX C

Guidelines for Herbicide Use on Earthen Dams, Controlling Woody Vegetation, and Dam Inspection

RECOMMENDATIONS ON HERBICIDE USE TO CONTROL VEGETATION ON EARTHEN DAMS

HERBICIDE APPLICATION RECOMMENDATIONS

When feasible, utilize individual plant treatments. The treatment of individual plants would reduce the volume of herbicide required in the control of dam vegetation which could result in lower costs associated with vegetation management. In addition, adverse impacts to beneficial non-target plant species and aquatic species would be minimized due to the avoidance of exposure and the lower potential for drift and runoff.

Application of herbicides on the earthen dams should be delayed if rainfall is expected within 24 hours to further reduce the runoff of herbicides into the adjacent water bodies. Application during periods of high humidity should be avoided since plant uptake is lowest during this period. The herbicides should be mixed and loaded into the spray units far enough away from the dam locations to ensure that potential spills won't enter the aquatic systems.

Wind direction and speed should be monitored during application of the herbicides to minimize drift into areas of concern. Drift of herbicides into non-target areas is also dependent on the evaporation rate of the pesticide; therefore, avoid application of the herbicides during the hottest part of the day, when evaporation is highest. It is recommended that the largest droplet size consistent with adequate coverage of the herbicide be used to further reduce drift. Higher spray volumes typically reduce drift as well. However, the manufacturer's label directions should always be followed to apply the correct amounts and concentrations.

Once an earthen dam has been treated with herbicide, establish a maintenance plan to reduce the potential for future large scale herbicide applications. The establishment of a mowing and trimming schedule could be beneficial to the establishment of native grasses, forbs, and wildflowers. Grasses are recommended for structural stability of earthen dams because of their ability to tightly bind soil with their root systems. The promotion of native grasses through these methods would reduce the invasion of woody vegetation and reduce the need for additional herbicide applications. Should the use of herbicides be required in the future, applications should be made during the early successional stages so that individual plant treatments would be economically and logistically feasible.

THREATENED AND ENDANGERED SPECIES CONCERNS

According to the *Federal Insecticide, Fungicide, and Rodenticide Act*, the use of herbicides must comply with the Endangered Species Act. Although the measures proposed herein should minimize adverse impacts to fish and wildlife resources in general, special precautions should be taken to ensure that adverse impacts to rare, threatened, and endangered species are avoided.

BRUSH CONTROL HERBICIDES FOR USE ON DAMS (EXCEPT AS NOTED)

The following list of herbicides contains chemicals and formulations known to be effective in the control of vegetation typically found growing on open and previously disturbed habitats, similar to the vegetation associations expected to be growing on dams. These herbicides are also known to have low toxicity to terrestrial and aquatic organisms and are not known to leach into ground and surface waters. The implementation of the recommendations herein, during the application of the following herbicides in a manner consistent with the herbicide's label, should minimize adverse impacts to fish and wildlife resources on and around the dam. The following list of herbicides is certainly not all-inclusive as new herbicides are consistently being introduced.

2,4-D (American Brand 2,4-D, DMA® 4 IVM, Weedar® 64)

2,4-D (2,4-Dichlorophenoxyacetic acid) was introduced in 1946 and is the most widely used herbicide in the world. Many different manufacturers produce 2,4-D and the list of formulations above are included only to provide examples. 2,4-D is a selective herbicide that is used to control broadleaf herbaceous plants. The salt formulations of 2,4-D are relatively non-toxic to fish and wildlife species. However, the ester formulations of 2,4-D are toxic to fish. Therefore, avoid the use of the ester formulations of 2,4-D in the control of vegetation on dams. The 2,4-D salt formulations are used to control box elder (*Acer negundo*), willow (*Salix spp.*), thistle (*Cirsium* spp.), morning glory (*Ipomoea* spp.), poison ivy (*Toxicodendron radicans*), wild rose (*Rosa* spp.), Virginia creeper (*Parthenocissus quinquefolia*), ragweed (*Ambrosia* spp.), cocklebur (*Xanthium* spp.), Russian thistle (*Salsola kali*), and sunflower (*Helianthus* spp.).

Glyphosate (Accord®, Aquamaster®, Glypro®, Pondmaster®, Rodeo®)

Glyphosate is a broad-spectrum, nonselective, systemic herbicide used to control grasses, broadleaf weeds, and woody plants. Because glyphosate is a broad-spectrum herbicide, care should be taken during applications to minimize adverse impacts to grasses and native vegetation important for erosion control and stabilization of earthen dams. Glyphosate is used to control dogwood (*Cornus* spp.), maple (*Acer* spp.), oak (*Quercus* spp.), giant reed (*Arundo donax*), salt cedar (*Tamarix* spp.), sweet gum (*Liquidambar styraciflua*), sycamore (*Platanus occidentalis*), willow, cocklebur, sunflower (*Helianthus* spp.), alligatorweed (*Alternanthera philoxeroides*), cattail (*Typha* spp.), blackberry (*Rubus* spp.), kudzu (*Pueraria lobata*), honeysuckle (*Lonicera* spp.), black locust (*Robinia pseudoacacia*), persimmon (*Diospyros spp.*), wild rose, Russian olive (*Elaeagnus angustifolia*), Chinese tallow (*Sapium sebiferum*), wax myrtle (*Morella cerifera*), and sumac (*Rhus* spp.).

Imazapyr (Arsenal®, Chopper®, Habitat®, Stalker®)

Imazapyr is a broad-spectrum, nonselective, systemic herbicide used to control annual and perennial grasses, broadleaf herbaceous plants, woody plants, and riparian and aquatic plants. Because imazapyr is a broad-spectrum herbicide, care should be taken during applications to minimize adverse impacts to grasses and native vegetation important for erosion control and stabilization of earthen dams. Imazapyr is used to control giant reed, ragweed, thistle, cocklebur, saltbush (*Atriplex* spp.), greenbrier (*Smilax* spp.), honeysuckle, morning glory, poison ivy, wild rose, kudzu, trumpet creeper (*Campsis radicans*), wild grape (*Vitis* spp.), ash (*Fraxinus* spp.), maple, black locust, box elder, chinaberry (*Melia azedarach*), Chinese tallow, cottonwood (*Populus deltoides*), dogwood, elm (*Ulmus* spp.), hawthorn (*Crataegus spp.*), mulberry (*Morus* spp.), oak, persimmon (*Diospyros* spp.), pine (*Pinus* spp.), privet (*Ligustrum japonicum*), Russian olive, saltcedar, sumac, sweetgum, tree-of-heaven (*Ailanthus altissima*), *Vaccinium* spp., waxmyrtle, willow, and yaupon (*Ilex vomitoria*).

Fosamine Ammonium (Krenite®)

Fosamine ammonium is used to control brush along highway rights-of-way, railroad rights-of-way, industrial sites, storage areas, and utility and pipeline rights-of-way. It is used to control woody species such as oak, pine, sumac, sweetgum, Chinese tallow, elm, wild grape, wild rose, sycamore, and tree-of-heaven. It is also used in combination with metasulfuron methyl (Escort XP) to control eastern red cedar (*Juniperus virginiana*), tree-of-heaven, ash, elm, and maple. Fosamine ammonium is also used with imazapyr (Arsenal) to control American beautyberry (*Callicarpa americana*), baccharis (*Baccharis neglecta*), *Vaccinium* spp., waxmyrtle, box elder, black locust, dogwood, elm, maple, sassafras (*Sassafras sassafras*), and willow.

Metsulfuron Methyl (Escort XP[26])

Escort XP is a selective pre- and postemergence herbicide used to control broadleaf herbaceous and woody species. It has been used to control cocklebur, blackberry (*Rubus* spp.), thistle, sunflower, honeysuckle, wild rose, ash, black locust, cottonwood, eastern red cedar, elm, hackberry (*Celtis* spp.), hawthorn, mulberry, wild grape, oak, Osage orange, (*Maclura pomifera*), maple, sweetgum, tree-of-heaven, *Vaccinium* spp., and willow.

Diquat (Reward[38])

Diquat is a non-selective contact herbicide used to control aquatic and terrestrial vegetation. Although diquat is toxic to aquatic invertebrates, it is acceptable for aquatic use because it quickly binds to soil and suspended sediments in the water. However, care should be taken while applying diquat so that direct contact with water bodies is avoided. In addition, diquat can be toxic to many grass species and other vegetation that may be beneficial in the control of dam erosion. Diquat should be applied to minimize impacts to desired, beneficial vegetation.

BRUSH CONTROL HERBICIDES TO AVOID ON DAMS

The following list of herbicides contains chemicals and formulations known to be effective in the control of upland vegetation in habitats similar to those found on earthen dams. However, because they are known to leach through the soil and accumulate in ground and surface waters or are known to be toxic to aquatic organisms, their use should be avoided in the control of dam vegetation.

Clopyralid (Reclaim[39], Stinger[40], and Transline[41])

Although clopyralid exhibits a low toxicity to terrestrial and aquatic organisms, it is highly mobile in the soils and can contaminate surface and ground water which may be used for irrigation and drinking purposes. Because of the proximity of dams to water, it is recommended that the use of clopyralid be avoided in the control of vegetation on dams.

Clopyralid with 2,4-D or MCPA-EHE (Curtail[42] and Curtail M[43])

Curtail[42] and Curtail M[43] are herbicide formulations which use clopyralid as an active ingredient. Curtail contains clopyralid with 2,4-D while Curtail M[43] contains clopyralid with MCPA-EHE. Because both formulations contain clopyralid, it is recommended that the use of Curtail[42] and Curtail M[43] be avoided in the control of vegetation on dams.

Glyphosate

Although glyphosate is practically non-toxic to aquatic organisms, certain surfactants added to some terrestrial formulations of glyphosate have been shown to be highly toxic to aquatic species and amphibians. Non-aquatic formulations of glyphosate (Accord SP[44], Accord XRT[45], Glyphomax[46], Glypro Plus[47], Honcho[48], Roundup[49], Touchdown[50]) should be avoided in the control of vegetation on dams. In addition, other formulations containing glyphosate combined with 2,4-D or dicamba (Campaign[51], Fallowmaster[52], Landmaster II[53]) should be avoided unless labeled for aquatic use.

Picloram (Tordon 22K[54], Tordon K[55])

Although picloram exhibits a low toxicity to terrestrial and aquatic organisms, it is highly mobile in the soils and can contaminate surface and ground water which may be used for irrigation and

drinking purposes. Because of the proximity of dams to water, it is recommended that the use of picloram be avoided in the control of vegetation on dams.

Picloram with 2,4-D (Grazon P+D[8], Pathway[8], Tordon RTU[8], Tordon 101[8])

Because picloram is extremely mobile in the soil profile and is known to leach into surface and ground water, it is recommended that the use of Grazon P+D[8], Pathway[8], Tordon RTU[8], and Tordon 101[8] be avoided in the control of vegetation on dams.

Triclopyr (Garlon 3A[8], Garlon 4[8], Pathfinder II[8], Remedy[8])

Although triclopyr exhibits a low toxicity to terrestrial and aquatic organisms, it is highly mobile in the soils and can contaminate surface and ground water which may be used for irrigation and drinking purposes. Because of the proximity of dams to water, it is recommended that the use of triclopyr be avoided in the control of vegetation on dams.

Triclopyr with 2,4-D (Crossbow[8])

Crossbow is toxic to fish and drift or runoff could adversely impact fish and aquatic plants adjacent to dams. Avoid the use of Crossbow[8] in the control of vegetation on dams.

Triclopyr with Clopyralid (Redeem R&P[8])

Because triclopyr and clopyralid are extremely mobile in the soil profile and are known to leach into surface and ground water, it is recommended that the use of Redeem R&P[8] be avoided in the control of vegetation on dams.

NE34P000079

The establishment and control of proper vegetation is an important part of dam maintenance. Properly maintained vegetation can help prevent erosion of embankment and earth channel surfaces and aid in the control of burrowing animals. The uncontrolled growth of vegetation can damage embankments and concrete structures making close inspection difficult. Thick brush and weed growth can obscure seepage problems, which can get progressively worse if left unnoticed.

Trees and brush should not be permitted on embankment surfaces or in vegetated earth spillways. Extensive root systems can provide seepage paths for water. Trees that blow down or fall over can leave large holes in the embankment surface that will weaken the embankment and can lead to increased erosion. Brush obscures the surface, limiting visual inspection (see Figure 1) providing a haven for burrowing animals, and retarding growth of grass vegetation.

Trees and brush growing adjacent to concrete walls and structures may eventually cause damage to the concrete and should be removed.

Stumps of cut trees should be removed, and cavities should be filled and covered with a short grass that can be easily maintained and mowed (see Figure 2). Stumps can be removed either by pulling or with equipment that will grind them down. All woody material should be removed to about six inches below the ground surface. Stumps of trees in rip-rap cannot usually be pulled or ground down, but can be chemically treated prevent them from continually forming new sprouts.

The following guidelines are recommended when removing trees from a dam:

- **Upstream Embankment:** Remove all trees, stumps, rootballs, and root systems; clean rootball cavity; and backfill with properly placed and compacted soil. Install rip-rap for wave erosion protection on the upstream slope from about four feet below normal pool elevation to about three feet above normal pool elevation.

- **Dam Crest:** Cut trees having stump diameters of twelve inches or less flush with the ground and treat the stump with a waterproof sealant to delay stump decay. Completely remove trees having stump diameters of about twelve inches and greater, and backfill rootball cavity with properly compacted backfill soil.

- **Downstream Embankment:** Cut trees having stump diameters of about six inches and less level with the ground and treat the stump with a waterproof sealant to delay stump and rootball decay. Completely remove all trees having stump diameters greater than about eight inches and backfill the cleaned rootball cavity with compacted backfill soil.

- **Lower Portion of Embankment and Toe of Dam:** Cut all trees having stump diameters of about four inches and smaller flush with the ground and treat the stump to delay stump and rootball decay. Install a toe drain or subdrain system to lower the subsurface water level. The drain filter system will collect and discharge the seepage. Incorporate major subdrain with tree rootball and stump removal where possible. Remove all trees located up to 30 feet beyond the toe of the downstream slope having stump diameters greater than about four inches. Install weighted filters and drain systems in rootball cavities where seepage boiling and soil piping are likely to occur.

Figure 1: Tree and brush covered dam

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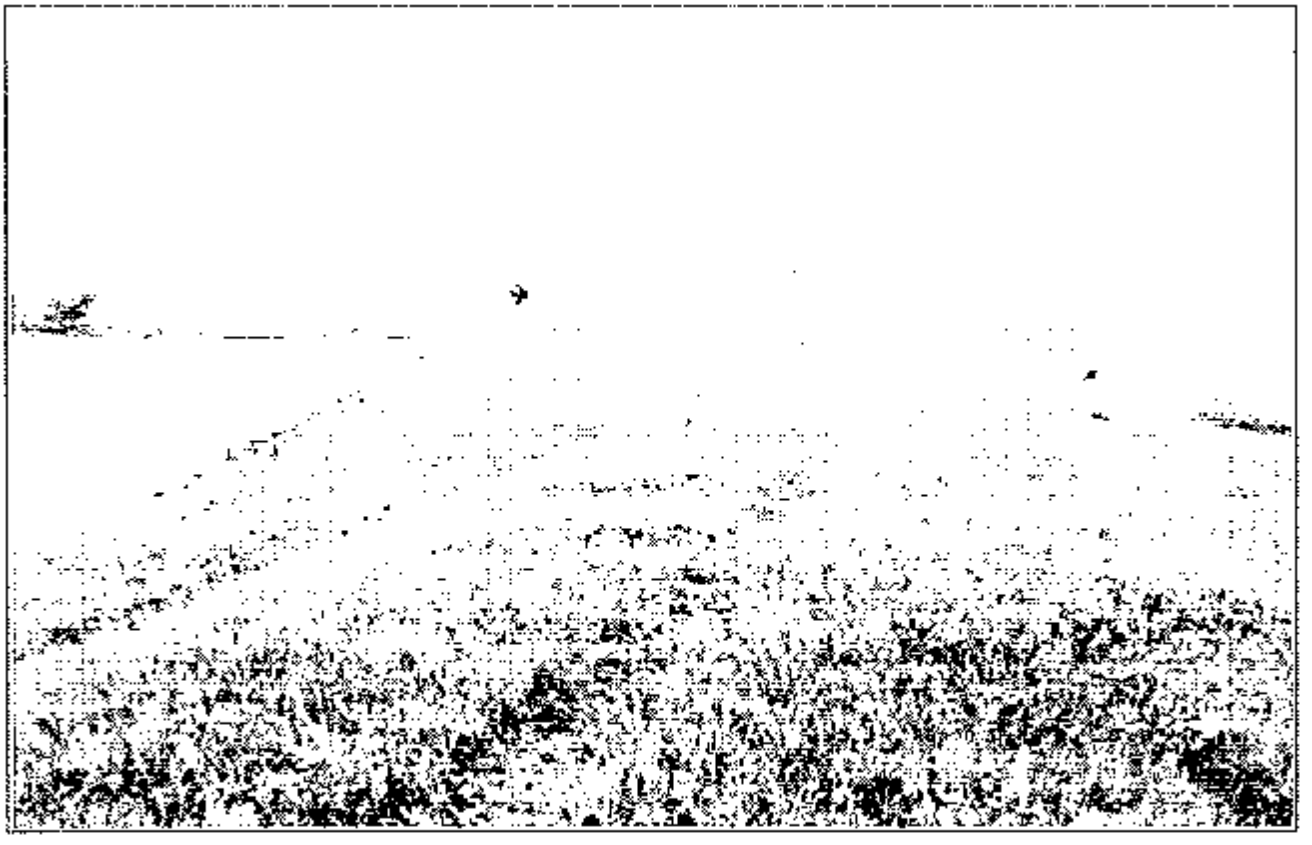
- When cutting trees for removal, at least one to two feet of the stump should be left above the ground, leaving a well-defined stump that can be used in the stump removal process.
- The stump and rootball should then be removed by pulling the stump upward with a track-mounted backhoe (or similar equipment) after loosening the rootball by pulling on the stump from different directions.
- The rootball cavity should be cleaned to remove loose soil and the remaining roots in the cavity using a backhoe. The cutting cavity side slopes are to be no steeper than 1:1 and cutting a horizontal cavity for the bottom.
- Compacted soil should be a cohesive material, compacted in lifts no greater than 8-inches loose lift thickness. Compaction is usually accomplished with manually operated compaction equipment or equipment attached to a backhoe.

Embankments, groins, areas adjacent to spillway structures, vegetated channels, and other areas associated with a dam require continual maintenance of the vegetative cover.

Grass mowing, brush cutting, and removal of woody vegetation (including trees) are necessary for the proper maintenance of a dam, dike, or levee. All embankment slopes and vegetated earth spillways should be mowed at least twice per year. Trees and brush should be removed in all areas within 30 feet of the embankment. Well tended grasses improve aesthetics, simplify inspections, create a non-erodible surface, and discourage burrowing animal habitation.

Chemical spraying and burning for the purpose of regular maintenance are no longer acceptable methods of vegetation control near a water body. More acceptable methods include the use of weed whips or power brush-cutters and mowers. If chemical spraying is used, utmost care should be taken to protect the local environment. To protect the integrity of the embankment, mowing with heavy equipment when wet should be avoided. Only proper equipment designed specifically for the type of slope and vegetation should be utilized following the manufacturer's recommended safe operation procedures.

Figure 2: Properly maintained dam using short grasses and without trees or shrubs



NE34P000081

dam failure can cause considerable loss of capital investment, loss of income, and even the tragic loss of life. People that live or run a business near a dam depend on its owner to properly operate, maintain and inspect it and thereby prevent hazardous conditions downstream.

Notwithstanding the moral obligation of keeping the dam safe, the owner could be subjected to liability claims if the dam fails. Therefore, it is a good business practice to have an effective maintenance program in place for your dam.

The guidelines that follow, while not exhaustive in scope, will provide dam owners with the most essential information necessary to identify common problems with their dams.

Nevertheless, it is important that every dam owner be familiar with the actual rules and regulations set forth by the state of Oklahoma. Detailed information on this and many other relevant topics can be found on OWRB website at www.owrb.ok.gov/damsafety.php.

"High hazard-potential dams" require an *annual* comprehensive inspection by a professional engineer experienced in dam safety. "Significant hazard-potential dams" require the same inspection every *three years*. The owner of a "low hazard-potential dam" is required to conduct a visual inspection for downstream development that could affect the hazard-potential classification once every *five years*.

Dam owners should conduct visual inspections several times each year. Remember that all problems may not be exposed in the course of maintenance and visual inspection.

Do not rely on "home remedies". Call an experienced dam safety engineer to remedy problems.

Dam failures are usually a result of improper design, construction, and maintenance. Owners of older dams often do not have records or a comprehensive understanding of the dam's design and construction. Therefore, conclusions are commonly based on less than comprehensive inspections.

With these older structures it is important to be aware of the major types of failures and their warning signs. Earthen dam failures can generally be grouped into three classifications, briefly described below:

Hydraulic Failure

Hydraulic failure results from the uncontrolled flow of water over, around, and adjacent to a dam. This includes the erosive action of water on the dam and its foundation. Earth dams are particularly susceptible to hydraulic failure since soil will erode at low velocities (See Table 1 on page 6).

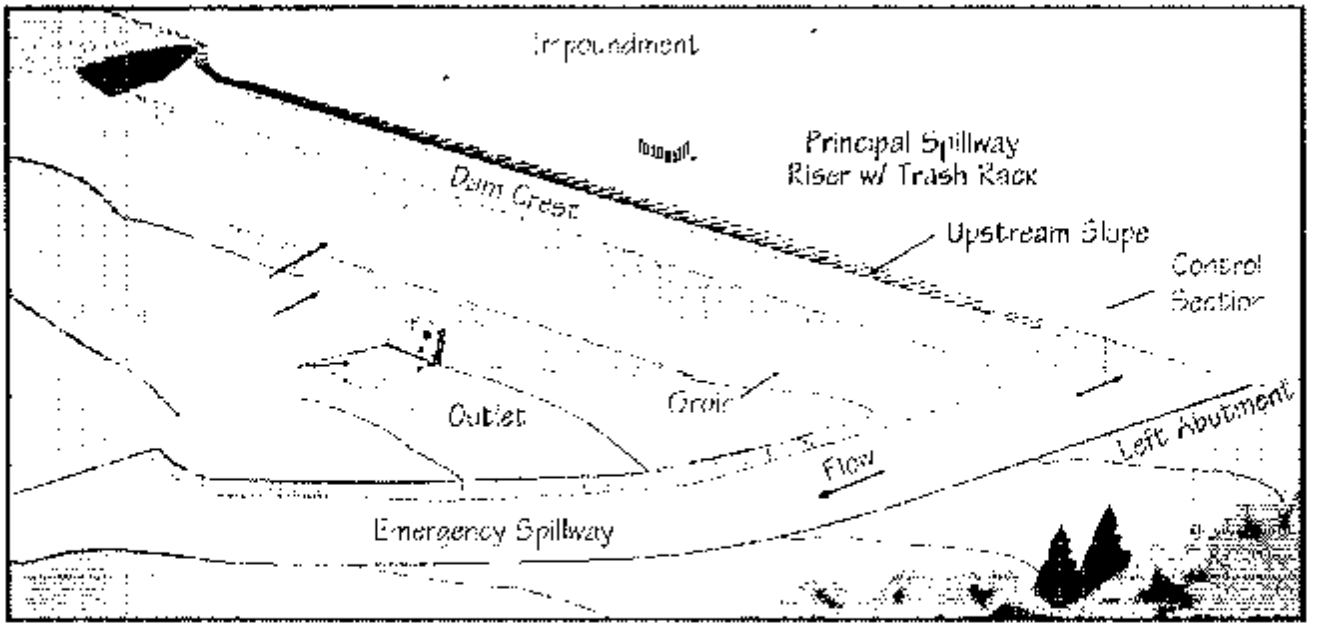


Figure 1 Parts of a Dam

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Seepage Failure

All dams exhibit some seepage; the velocity and amount must be controlled. Seepage occurs both through the dam and at the foundation. If uncontrolled, it can erode material from the foundation of an earth dam to form a conduit through which water can pass. This can lead to a complete failure of the structure or "piping" (See Table 2 on page 6).

Structural Failure

Structural failure involves the rupture of the dam and/or its foundation. This is particularly a hazard for large dams and dams built of low strength materials, such as silts and sandy soils.

In actuality, dam failures generally result from a complex interrelationship of these failure modes. Uncontrolled seepage may weaken the soils and lead to a structural failure. A structural failure may shorten the seepage path and lead to piping failure. Surface erosion may lead to structural or piping failures (See Table 3 on page 7)

The most common elements of an earth-fill dam are illustrated in Figure 1.

Embankments, the primary part of the dam, impound the lake and hold the water. Earth-fill embankments fall into two main classifications: "homogeneous" and "zoned." A homogeneous embankment is composed of the same material throughout, while a zoned embankment uses dissimilar materials, such as rock and clay, in different parts of a dam as shown in Figure 2. Most dams apply the zoned method, often using compacted clay to form an impermeable zone. The impermeable clay zone is surrounded by a more pervious material, which will allow drainage.

Seepage through the dam is collected and controlled by means such as toe drains, rock toes, drainage blankets, relief wells, and chimney drains. All of these seepage control systems involve a means of filtering the clay particles from the seepage and a method of discharging the water in a safe manner. A "cutoff core trench" is used in some dams to prevent the flow of water through the embankment or the foundation material.

The slopes of the embankment must be vegetated to protect from the erosive effects of rain. The upstream slope must have protection from wave action. This is usually accomplished by a rock blanket (rip-rap) or by a berm.

The Foundation is the material upon which a dam is built (Figure 2). This material must have the strength to support the embankment and reservoir behind it safely. Seepage through the foundation must be controlled in such a manner that the embankment will be stable under the design conditions and the dam will store water for its intended purpose.

A Principal Spillway is the path constructed for water flow over a concrete spillway or through a conduit in the dam to maintain the normal level of a lake. This spillway is usually either a metal or concrete pipe through the dam and usually incorporates a stand pipe or riser inlet structure. The principal spillway's function is to pass normal amounts of water past the dam in a safe and non-erosive manner. The inlet structure of a conduit must have provisions to prevent clogging with trash and debris.

An Emergency or Auxiliary Spillway is a water flow route that functions in extreme conditions to prevent overtopping of the dam. The most typical form of emergency spillway is an excavated channel in earth or rock near the dam. The function of the emergency spillway is to pass the storm flows without overtopping the dam. The spillway should always discharge away from the dam and should be constructed in such a manner that the spillway will not fail due to erosion during these high flow events. Failure of the spillway can be as catastrophic as failure of the dam. Discharge of the spillway onto the toe of the dam can rapidly erode the embankment and cause failure of the dam. Many of the smaller dams incorporate the functions of both the principal spillway and emergency spillway into a single structure.

A Valley Floor Drain (Figure 2) is a water discharge point placed at the lowest elevation in the pool to empty the lake if necessary. The valley floor drain is generally a pipe with a valve, which may be operated as needed. All dams should have the ability to control the level of the lake. Lake levels are changed for a variety of reasons, such as killing weeds and mosquitoes, making repairs to the dam, or even draining the lake to avoid dam failure.

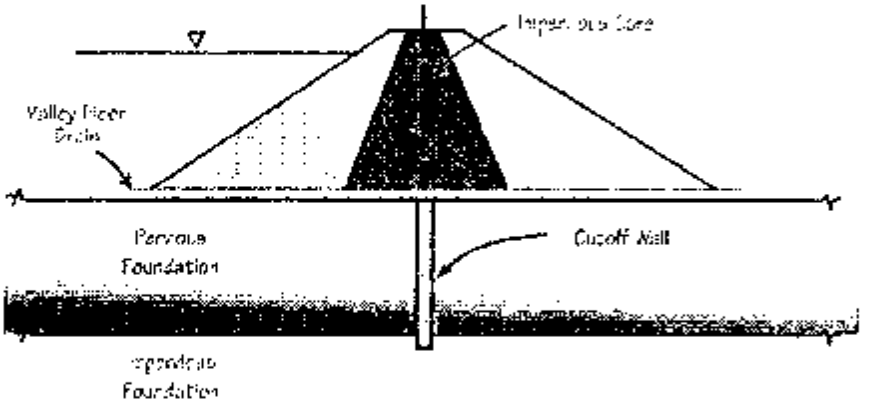

Figure 2. Typical cross section of a dam

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All major portions of a dam need to be maintained collectively rather than maintaining each element separately.

Embankment:

1. Establish and maintain a good cover of grass.

   a. Seed or sod areas that have been repaired, are barren, or are thinly vegetated.

   b. Mow the vegetation as needed. Mowing allows the grasses to establish a thick erosion resistant sod, helps in the control of brushy vegetation, and makes it much easier to detect any potentially dangerous conditions such as seepage, erosion channels, cracks, and burrowing animals.

2. Remove and prevent the growth of trees and brush. These develop large root systems, which can provide seepage paths. When trees fall they can leave large holes, which can weaken the embankment. Brush, vine, and johnson grass obscure the surface, limit inspections, and provide a haven for burrowing animals.

3. Control and repair erosion. Refill and compact all erosion channels on the dam. While erosion channels occur on all areas of the dam, they are frequently most severe along the line of contact at the embankment and abutments.

4. Repair slumps and slides on a dam. A slump occurs for many reasons such as improper compaction, overly steep side slopes, and/or as a result of seepage. Determine the cause of the slump before repair. Correcting the underlying causes will save you time, labor, and expenses over the life of the structure.

5. Keep embankment slopes in good repair, conforming to the appropriate slope design. Embankment slopes are particularly susceptible to weathering. The action of waves, rain, freezing, and mechanical impacts can cause the movement, settlement, and/or erosion of the embankment. The embankment slope should be kept in good repair and should conform to the appropriate slope design.

6. Make sure the dam and surrounding area are free of animal traffic and habitation. Livestock can damage the sod covering, especially if the cover is thin or the dam is wet from rainfall. Overgrazing can result in the increased incidence of erosion. Keep burrowing animals off the dam by whatever means necessary. If animal dens are found, promptly repair them.

Principal Spillway:

1. Take action to ensure the primary purpose of the spillway, passing normal flows of water in a safe manner, is being accomplished.

2. Ensure that the conduit or pipe is sound and watertight. The conduit must have the strength to support the external loads of the embankment and lake. When the pipe is composed of jointed sections, those sections must be properly designed to remain watertight. Immediately repair a collapsed or separated portion of the pipe, this will usually involve drawing down the lake, and probably reconstructing part of the embankment. Corrugated steel pipe is not recommended for use as a conduit.

3. To ensure that all concrete structures are sound and on firm foundations, backfill any undermining of the slab or pipes and tightly seal any open joints.

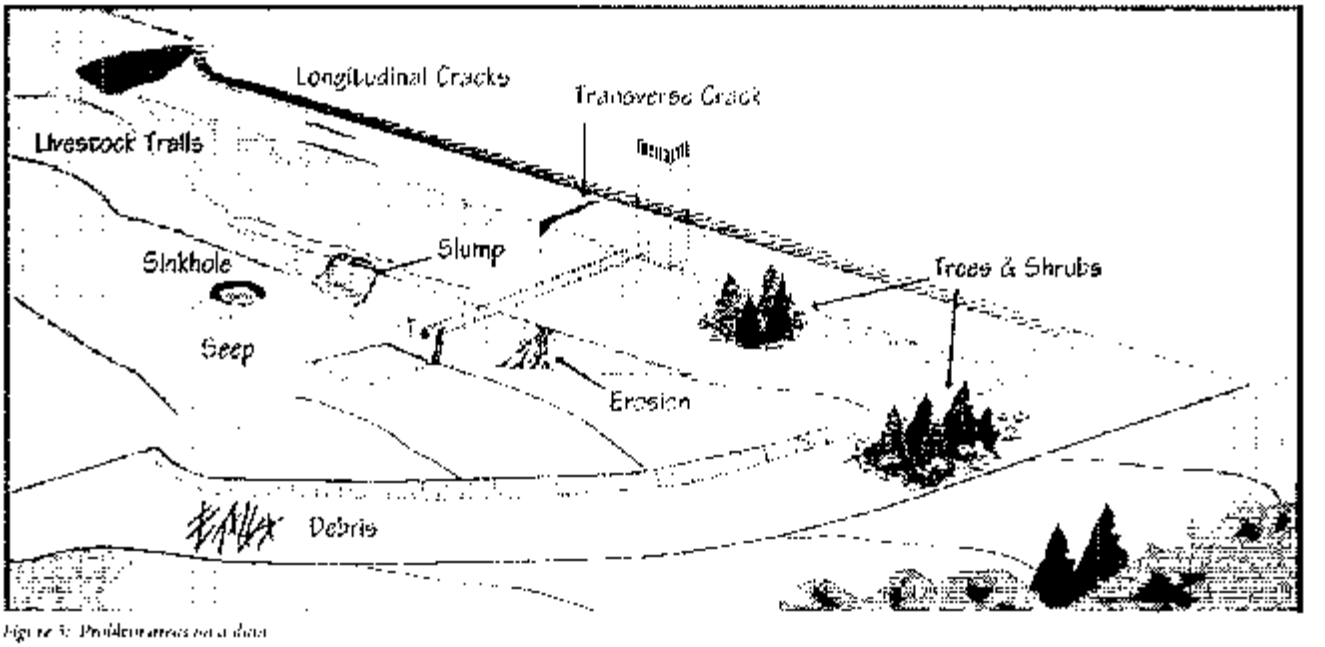

Figure 5: Problem areas on a dam

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Any weep holes or drains associated with concrete structures should be open and functional. Failure to keep drains operative can cause significant damage to the structure and generate a large repair bill.

4. Ensure that the principal spillway passes flows in a manner that is not erosive to the dam, foundation, or the spillway itself. Erosion at the principal spillway outlet is caused by high velocity flow. Unchecked erosion can cause failure of the structure. Use measures such as stilling basins, commonly constructed of rip-rap or concrete baffles, to minimize erosion.

5. Eliminate any obstruction of the principal spillway. Obstructions can cause a reduction of flow and the carrying capacity of the spillway or conduit. Consequently, this increases the use of the emergency spillway. Principal spillways should be equipped with trash racks. These racks must be cleaned as a part of regular maintenance.

Emergency or Auxiliary Spillway

1. Take measures to ensure the proper function of the emergency spillway, which is to convey flood flows past the dam so the dam is not overtopped. This function is essential to the safety of any dam.

2. Ensure that the earthen portion of the spillway is covered by vegetation like that on the embankment. Grasses should be thick with well-bedded sod and mowed regularly. Barren areas and thinly vegetated areas should be reseeded or sodded. Keep the spillway area free of trees and brush.

3. Repair and vegetate all erosion gullies, slides, and slumps as soon as they occur. Erosion repair in earthen spillways is of particular importance after any period of flow in the spillway. The outlet channel and control sections of spillways are prime erosion areas. Their repair is crucial because erosion can expand very rapidly in the spillway.

4. On dams with concrete structures, keep the concrete sound by filling joints and cracks with appropriate filler. Keep drains in concrete structures open and functional. In earth spillways, concrete may be used to form control sections and chutes. Keep this concrete sound and functional.

5. Keep the emergency spillway area clear of trash, debris, and undesirable vegetation, such as trees and brush. Other obstacles are buildings, fences, fish screens, and guardrails. If left in place, all these obstructions can catch trash and reduce the capacity of the spillway, potentially causing hydraulic failure of the embankment.

Valley Floor Drain

1. Test the valley floor drain periodically to make sure it is functioning. It must be operable at all times for a variety of purposes including demands for water downstream and repair of spillway structures or embankment.

2. Handle all drawdowns in a controlled manner to minimize erosion and prevent slumping of the upstream embankment. Valley floor drains typically discharge into stilling basins or other erosion resistant structures.

Regular inspection is the heart of your maintenance program. Only by regular inspection can problems be detected at an early stage and remedied. This is essential to preserve the integrity of the dam. The scope of the inspection should include the dam and spillways, areas downstream, on the abutments, and a general overview of the pool area. The dam and lake areas have to be viewed in the proper perspective with the surrounding terrain. Failure to inspect these areas raises the possibility of unforeseen problems in the valley and dam abutments, often influenced by the dam and lake. For a summary of inspections guidelines see Table 4. A Dam Inspection Checklist is also included on the last page of this guide.

During an inspection, the owner should be aware of various signs of danger. These signs can rarely be seen by simply driving past the dam. Many problems can often not be detected without a thorough examination on a well maintained (mowed and free of woody vegetation) dam.

Some signs of danger to look for are the following:

Seepage

The appearance of seepage on the downstream slope, abutments, or downstream area is cause for concern. The type and quantity of seepage should be studied. If the water is muddy or murky and is coming up from a well-defined hole, material is probably being eroded from inside the embankment and a potentially dangerous situation can develop. This type of problem requires immediate attention to stop the removal of material and control the seepage. Failures due to internal erosion or piping are examples of this type of seepage problem.

If the water is clear, it may be coming from an older hole and should be monitored closely for any changes in color and quantity.

Seepage can also occur on abutments, under spillways, and through the foundation and sometimes can exit some distance from the dam. Generally speaking, the further seepage exits from the dam, the less the probability of danger; however, it is important that all areas of seepage related to the dam be watched for changes.

Erosion

Erosion on the dam and spillway is one of the most evident signs of danger. The size of erosion channels and gullies can increase greatly with slight amounts of rainfall. Early detection of erosion

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channels can greatly facilitate necessary repairs of refilling, re-grading, and re-vegetation. Left unattended erosion can be significant enough to damage the integrity of the dam.

Erosion due to wave action is another easily detected danger sign. Remedies usually involve refilling the area with rock or earth and reseeding with the necessary vegetation.

Erosion from seepage through the dam, foundations, or abutments is a danger signal. This is more difficult to repair due to the seepage water. Repair generally involves refilling of the areas along with measures to collect and filter the seepage water. Repairs usually require the services of an engineer.

Cracks

The entire embankment should be closely inspected for cracks. Short isolated cracks are not usually significant, but larger, well-defined cracks indicate a problem is developing. Cracks are of two types: transverse and longitudinal.

Transverse cracks appear perpendicular to the axis of the dam and indicate settlement of the dam. Such cracks are an available avenue for water. Internal erosion could then develop very quickly.

Longitudinal cracks run parallel to the axis of the dam and may be the signal for a slide or slump on either face of the dam.

Cracks usually call for lowering the lake and taking reconstruction measures. They generally require the consultation of an engineer for remedy. Cracks may be evident in other areas such as spillway.

Slides and Slumps

Slides and slumps are usually the most detectable danger signal. A massive slide can mean catastrophic failure of the dam. Slides occur for many reasons, and their occurrence can mean major reconstruction effort.

Slides and slumps are normally preceded by cracks. Regular inspection can prevent any sudden failure. Repair will usually involve lowering the lake level. This can, if done too rapidly, cause a slide or slumping of the saturated material on the upstream embankment.

Remove any resultant slide material found in the spillway areas immediately since their presence reduces flow capacities.

Subsidence

Subsidence is vertical movement of the foundation materials due to failure of consolidation.

Rate of subsidence may be so slow that its detection can go unnoticed without proper inspection procedures. At its onset subsidence refers to movement over and beyond that anticipated. Subsidence may not have any well-defined cracks or seepage associated with it.

Danger signals of subsidence include conduit displacements or separations at joints, conduit ruptures or any collapses associated with it.

Conduit separations or ruptures can result in water leaking into the embankment and the subsequent weakening of the dam. Pipe collapse can result in hydraulic failures of the dam. It should be noted that rigid pipes, such as concrete pipes, are most likely to separate and crack, while flexible pipes, such as metal or plastic pipe conduits, are more subject to collapse.

Structure movements can be noticeable signs of subsidence. Listing or tilting of structures set in foundation material is a sign of distress. Movements of intake or discharge structures can cause loss of function of conduits and diminished hydraulic capacities. Further, these movements endanger the stability of the dam due to the introduction of water at conduit rupture points.

Subsidence is measured on embankments via permanent reference marker on the dam along with associated structure points off the dams. Check elevations regularly for readings. Changes in elevation can be an indication of subsidence.

Vegetation

A prominent danger signal is the appearance of undesirable types of vegetation such as cattails, reeds, mosses, and other wet area types of vegetation. The "wet environment" types of vegetation can be a sign of seepage. Prominent areas for undesirable vegetation are the toe of the dam, any area immediately downstream, and the abutments. Look closely in these areas for signs of seepage and take appropriate measures as discussed in the above section on seepage. Maintenance on these areas should involve the mowing and clearing of woody debris.

Boils

Boils are a serious danger signal and indicate seepage water exiting under some pressure. Boils typically occur in areas downstream of the dam. In boils, material is being removed, indicating piping in the foundation. Measures must be taken to filter and discharge the seepage in a controlled manner. To determine the cause and provide a permanent remedy, you will usually need to consult an engineer.

Livestock and Vehicle Trails

Trails left by livestock or vehicles can lead to erosion damaging the crest of the dam, its embankments and emergency spillway. Proper road material should be placed on the top of the dam if vehicle traffic is to be allowed. Dam embankments should be fenced off and livestock kept permanently off the dam. Vehicles should not be allowed on embankments or the emergency spillway.

Debris

The collection of debris on the dam and spillways has a potential for danger. Remove debris as soon as possible so it cannot reduce the function of spillways, damage structures and valves, or destroy vegetative cover.

NE34P000086

TABLE 1. Hydraulic Failures			
Form	Characteristics	Causes	Preventive or Corrective Measures
Overtopping	Flow over embankment washing out the dam.	1. Inadequate spillway capacity. 2. Clogging of spillway with debris. 3. Insufficient freeboard due to settlement or poor design.	1. Spillway designed for probable maximum flood. 2. Maintenance; trash booms; better design. 3. Allowance for freeboard and settlement in design; increase crest height.
Wave Erosion	Notching of upstream side of dam by waves.	Lack of rip-rap; too small rip-rap	Properly design rip-rap.
Toe Erosion	Erosion of toe by outlet.	Spillway too close to drain; inadequate rip-rap.	Training walls; properly design rip-rap.
Embankment Erosion	Rainfall erosion on embankment.	Lack of sod or poor drainage control	Grass sod; fine rip-rap; surface drains.

TABLE 2. Seepage Failures			
Form	Characteristics	Causes	Preventive or Corrective Measures
Loss of Water	Excessive loss of water from lake and/or occasionally increased seepage or increased groundwater levels near lake	1. Pervious dam foundation; 2. Pervious dam; 3. Leaking conduits; 4. Settlement cracks in dam; 5. Shrinkage cracks in dam.	1. Use foundation cutoff; grout; or upstream blanket 2. Impervious core; 3. Watertight joints; waterstops; grouting. 4. Remove compressible foundation; avoid sharp changes in abutment slope; compact soils at high moisture. 5. Use low plasticity clays for core; adequate compaction.
Seepage Erosion or Piping	Progressive internal erosion of soils from downstream side of dam or foundation backward toward the upstream side to form an open conduit (pipe). Can lead to a washout of a section of dam.	1. Settlement cracks in dam; 2. Shrinkage cracks in dam; 3. Pervious seams in foundation; 4. Pervious seams, roots in dam; 5. Concentration of seepage at face; Boundary seepage along conduits, walls; Leaking conduits; Animal burrows	1. Remove compressible foundation; avoid sharp changes; internal drainage with protective filters; 2. Low plasticity soil; adequate compaction; internal drainage with protective filters. 3. Foundation relief drain with filter; cutoff. 4. Construction control core; internal drainage with protective filter. 5. Toe drain; internal drainage with filter. 6. Stub cutoff walls, collars; good soil compaction 7. Watertight joints, water stops; durable materials. 8. Rip-rap wire mesh.

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TABLE 3. Structural Failures			
Form	Characteristics	Causes	Preventive or Corrective Measures
Foundation Slide	Sliding of entire dam, one face or both faces in opposite directions; with bulging of foundation in the direction of movement	1. Soft or weak foundation 2. Excess water pressure in confined sand or silt seams.	1. Flatten slope; employ broad berms; remove weak material; stabilize soil. 2. Drainage by deep drain trenches with protective filters; relief wells.
Upstream Slope	Slide in upstream face with little or no bulging in foundation below toe.	1. Steep slope. 2. Weak embankment soil. 3. Sudden drawdown of lake level.	1. Flatten slope or employ berm at toe. 2. Increased compaction; better soil. 3. Flatten slope; rock berms; operating rules.
Downstream Slope	Slide in downstream face.	1. Steep slope. 2. Weak soil. 3. Loss of soil strength by seepage pressure or saturation by seepage or rainfall	1. Flatten slope or employ berm at toe. 2. Increased compaction; better soil. 3. Core; internal drainage with protective filters; surface drainage.
Flow Slide	Collapse and flow of soil in either upstream or downstream direction.	Loose embankment soil of low cohesion triggered by shock, vibration, seepage, or foundation movements.	Adequate compaction.

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TABLE 4. Summary of Inspection Guidelines.

Inspect For	Alignment	Animal Burrows	Cracks	Debris	Deterioration	Erosion	Human Activity	Leakage	Muddy Water	Seepage	Settlement & Slides	Vegetation	Weathering
Embankment Dam													
Upstream slope	X	X	X			X	X				X	X	
Downstream slope	X	X	X			X	X	X	X	X	X	X	
Abutments		X	X			X					X	X	
Crest	X	X				X					X	X	
Seepage areas								X	X	X		X	
Internal drainage					X			X	X				
Relief drains	X		X		X			X	X				
Concrete Dams													
Upstream face		X	X								X		X
Downstream face		X	X					X		X	X		
Abutments		X	X					X		X	X	X	X
Crests	X		X		X						X		X
Spillways													
Approach channel				X									
Stilling basin						X							
Discharge channel				X	X						X	X	
Control features				X	X								
Erosion protection							X				X		
Side slopes		X				X		X			X	X	
Inlets, Outlets, and Drains													
Inlet & Outlets	X			X	X			X				X	
Stilling basin													
Discharge channel			X	X								X	
Trash Racks				X									
Emergency systems					X		X						
General Areas													
Reservoir surface								X					
Shoreline											X	X	
Mechanical systems					X								
Electrical systems					X								
Upstream watershed						X							
Downstream floodplains						X							

NE34P000089

SCS Sugar Creek Site # 44 dam, Caddo Cnty, OK washed out from heavy rains - 2007

NE34P000090

OKLAHOMA WATER RESOURCES BOARD
PLANNING & MANAGEMENT DIVISION - DAM SAFETY PROGRAM

DAM INSPECTION CHECKLIST

Name of Dam _____ State Inventory ID _____

Owner of Dam _____ Purpose of Dam _____

Address _____ Hazard Classification _____

City/State/ZIP _____

County _____ Inspected By: _____

Legal Location: _____ Date of Inspection: _____

Latitude: _____ Estimated Lake Level: _____

Longitude _____ Weather Conditions: _____

Note: Latitude-Longitude should be measured using a GPS and taken on the crest of the dam at the center.

	Item	Yes	No	N/A	Condition (Good/Acceptable/Deficient/Poor)	Remarks
1	**General Conditions of Dam**					
A	Alterations to the dam?					
B	Development in downstream floodplain?					
C	Grass cover adequate?					
D	Settlements, misalignments, or cracks?					
E	Recent high water marks?					elevation
2	**Upstream Slope of Dam**					
A	Erosion?					
B	Trees?					
C	Rodent holes?					
D	Evidence of livestock on dam?					
E	Cracks, settlement, or bulges?					
F	Adequate and sound riprap?					
3	**Downstream Slope of Dam**					
A	Erosion?					
B	Trees?					
C	Rodent holes?					
D	Evidence of livestock on dam?					
E	Cracks, settlement, or bulges?					
F	Drains or wells flowing?					Estimated gpm
G	Seepage or boils?					Estimated gpm
4	**Abutment Contacts**					
A	Erosion, cracks, or slides?					
B	Seepage?					Estimated gpm
5	**Inlet Structure**					
A	Concrete? ☐ Metal? ☐					
B	Spalling, cracking, or scaling?					
C	Exposed reinforcement?					
D	Corrosion present?					
E	Coating adequate?					
F	Leakage?					
G	Trash rack adequate?					
H	Obstacles to inlet?					
I	Drawdown operative? Opened & closed					
6	**Conduit & Outlet**					
A	Concrete? ☐ Metal? ☐					
B	Spalling, cracking, or scaling?					
C	Exposed reinforcement?					
D	Joints displaced or offset?					

NE34P000091

	Item	Yes	No	N/A	[3]Condition (Good-Acceptable-Deficient-Poor)	Remarks
E	Joint material lost?					
F	Leakage?					Estimate Gpm
G	Earth erosion?					
H	Conduit misaligned?					
I	Outlet channel obstructed?					
7	**Concrete Spillway**					
A	Spalling, cracking, or scaling?					
B	Exposed reinforcement?					
C	Joints displaced or offset?					
D	Joint material lost?					
E	Leaking?					
F	Dissipater deteriorating?					
G	Dissipaters clean of debris?					
H	Inlet erosion?					
I	Outlet channel eroding?					
8	**Emergency Spillway**					
A	Obstruction?					
B	Erosion?					
C	Rodent holes?					
D	Evidence of livestock on spillway?					
9	**Stilling Basin**					
A	Spalling, cracking, or scaling?					
B	Exposed reinforcement?					
C	Joints displaced or offset?					
D	Joint material lost?					
E	Joints leak?					
F	Rock riprap?					
G	Dissipater deteriorating?					
H	Dissipaters clear of debris?					
10	**Gates**					
A	Floodgates broken or bent?					
B	Floodgates stuck or rusted?					
C	Floodgates operational?					
11	**Instruments**					
A	Structure instrumented?					
B	Monitoring performed?					
**	**Should Hazard-Potential Classification be Reevaluated?**					

For High and Significant Hazard-Potential Dams Only

Professional Engineer Seal

Name of Engineer: _____

Date: _____

Engineering Firm: _____

Address _____

City, State, ZIP _____ **Telephone Number:** _____

Signature: _____

[3]**Condition** - Please rate the condition of Sections 1 - 11 on inspection form either: Good, Acceptable, Deficient, or Poor.

Good - No existing or potential dam safety deficiencies are recognized. Acceptable performance is expected under all loading conditions (static, hydrologic, seismic) in accordance with the applicable regulatory criteria or tolerable risk guidelines.

Acceptable - No existing dam safety deficiencies are recognized for normal loading conditions. Rare or extreme hydrologic and/or seismic events may result in a dam safety deficiency. Risk may be in the range to take further action.

Deficient - A dam safety deficiency is recognized for loading conditions which may realistically occur. Remedial action is necessary. Poor may also be used when uncertainties exist as to critical analysis parameters which identify a potential dam safety deficiency. Further investigations and studies are necessary.

Poor - A dam safety deficiency is recognized that requires immediate or emergency remedial action for problem resolution.

Revised March 2010

NE34P000092

State of Oklahoma

OWRB

WATER RESOURCES BOARD
the water agency

3800 Classen Blvd, Oklahoma City, OK
(405) 530-8900 • www.owrb.ok.gov

For more information on dams visit
www.damsafety.org/

NRCS
Natural Resources Conservation Service

For information on small ponds visit:
www.nrcs.usda.gov/

Funded by

FEMA

For publications and resources visit
www.fema.gov/plan/prevent/damfailure/

NE34P000093

APPENDIX A

Document 16

Slope Stability Analysis 03.11.10

STANDARD TESTING
AND ENGINEERING COMPANY
Since 1951

CORPORATE OFFICE • OKLAHOMA CITY
3400 N Lincoln Blvd • Oklahoma City, OK 73105-5493
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(918) 459-2700
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(918) 459-2715 FAX

March 11, 2010

AEP / PSO Region 4 Engineering
3600 South Elwood Avenue
Tulsa, Oklahoma 74107

Attn: Mr. David R. Lee
Civil / Structural Engineer

Re: Final Geotechnical Investigation and Stability Evaluation of Bottom Ash Pond
AEP Northeast Station Units 3 & 4
Oologah, Oklahoma
Standard Testing Project No. 8309-3150

Dear Mr. Lee:

This letter report provides the results of geotechnical study for the referenced project. This study includes monitoring well installation, geotechnical drilling, laboratory testing, and slope stability analysis for the existing ash pond embankment. It is understood that the maximum height of the existing ash pond embankment is 30 feet. The train surcharge loading from your document review comment sheet dated March 3, 2010, is 140 tons per car with car length of 53 feet and loading width of 5 feet.

Narrative descriptions of our findings and recommendations ara contained in the body of this report. A vicinity map, a site and boring location plan, the boring logs, and summary of laboratory test results are presented in Attachments "A" through "D" of this report.

Field Work

Monitoring Well Installation

Two (2) borings (B-3 & B-4) were dry drilled with a truck-mounted CME-55 rotary drilling unit equipped with 3.25" I.D. X 7.25" O.D. hollow stem augers (HSA) to the boring termination depths of 10 and 27 feet.

Two (2) 2-inch Schedule 40 PVC monitoring wells were then installed with 2 feet thick of cement grout at both B-3 (MW-1) and B-4 (MW-2), 10 feet thick at B-3 (MW-1) and 2 feet thick at B-4 (MW-2) of bentonite chip seal, 10 feet long at B-3 (MW-1) and 5 feet long at B-4 (MW-2) of Schedule 40

PVC with the slot size of 0.010 inch surrounded with 15 feet thick at B-3 (MW-1) and 6 feet thick at B-4 (MW-2) of 10/20 silica sand pack. Concrete was placed over cement grout at surface. J-Plug caps and locks were also provided for each well. The monitoring well construction diagram is presented in Attachment "E."

Geotechnical Drilling

Four (4) borings (B-1, B-2, B-5 & B-6) were dry drilled with a truck-mounted CME-55 rotary drilling unit equipped with 3.25" I.D. X 7.25" O.D. hollow stem augers (HSA). Standard penetration tests (SPT) used a 1.375" ID split spoon sampler driven by an automatic hammer utilizing a 140 lb. weight falling 30 inches.

Thirteen (13) standard penetration tests were performed in order to estimate the shear strengths of the soils in their natural state. The test was conducted as specified by ASTM D1586, "Penetration Test and Split-Barrel Sampling of Soils." The in-situ bearing strength is related to the N-value from this test. "N" is the number of blows required to drive a split-spoon sampler twelve inches, after a 6 inch seating, into undisturbed soil. The soil samples recovered in the split-spoon barrel were removed from the sample tool in the field, visually classified, and labeled according to boring number and depth. Results of the standard penetration tests are denoted at their respective depths on the boring logs.

Seven (7) thin-walled tube samples were taken in the sandy clay and clay soils, in accordance with ASTM D1587.

Laboratory Testing

Subsurface soil samples were visually classified by a geotechnical engineer according to color, texture, and plasticity.

Moisture content tests were performed on split spoon, thin-walled tube, and bag samples, in accordance with ASTM D2216, to determine the in-situ moisture conditions.

Density tests were performed on intact split spoon and thin-walled tube samples in accordance with AASHTO T233.

Atterberg limits tests were performed on seven (7) soil samples to determine the plasticity characteristics and swell potential of the soil. The tests were performed in accordance with ASTM D4318.

Sieve analyses were performed on eight (8) soil samples, in accordance with ASTM D422, for aid in soil classification. These soils were classified according to the Unified Soil Classification System (USCS) and the American Association of State Highway and Transportation Officials (AASHTO) soil classification system.

An unconsolidated-undrained (UU) multi-stage triaxial shear test was conducted on one (1) thin-walled tube sample from Boring B-5 at a depth of 8 to 10 feet, in accordance with ASTM D 2850. This test was conducted to determine the angle of internal friction and cohesion of soils representative of those at site. The triaxial test graphical result is presented in Attachment "D" and the angle of internal friction (phi) and cohesion (c) of soils are denoted on the boring log.

Triaxial Shear Test Results				
Boring No.	Soil Description	Depth (feet)	Cohesion, c (psi)	Internal friction angle, ϕ (deg)
B-5	Clay	8 - 10	4.8	2.5

Three (3) permeability tests were conducted on three (3) undisturbed thin-walled tube samples from Boring B-1 and B-5 at depths ranging from 8 to 20 feet. This test was performed in accordance with ASTM D5084. The permeability value, "k", was calculated based on the constant-head test which can be expressed as follows:

$$k = \frac{QL}{Ath}$$

Where:

k = permeability
Q = quantity of flow, taken as the average of inflow and outflow
L = length of specimen along path of flow
A = cross-section area of specimen
t = interval of time over which the flow Q occurs
h = difference in hydraulic head across the specimen

The permeability test reports are included in Attachment "D" and the "k" values of the tested samples are denoted at their respective depths on the boring logs.

Permeability Test Results			
Boring No.	Soil Description	Depth (feet)	Permeability (cm/sec)
B-1	Sandy Clay	8 - 10	$2.0X10^{-8}$
B-5	Clay	13 - 15	$1.8X10^{-8}$
	Clay	18 - 20	$1.6X10^{-8}$

Slope Stability Analysis

Using the Methods of Slices with the consideration of train surcharge, and based on the typical soil types of sandy clay and clay with the cohesion of 1075.5 psf and 1296.5 psf, the internal friction angle of 18 degrees and 13 degrees respectively, an average soil unit weight of 124 pcf, and a typical slope height of 30 feet, the analysis results in the computed factors of safety of 1.74 to 1.87 for the 2.5:1 slope. For permanent slopes, a minimum acceptable factor of safety is generally considered to be 1.5. Therefore, these soil conditions can support the designed slope of 2.5:1. The typical cross-section for the analysis is presented in Attachment "F."

We appreciate the opportunity to provide this service on your project. If you have any questions concerning the contents of this letter report, or if we can be of further service, please call us at (405) 528-0541.

Respectfully submitted,
STANDARD TESTING AND ENGINEERING COMPANY

Jieliang Pan, P.E.
Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
MING-CHENG PETER SHAU
22280
3-11-2010
OKLAHOMA

Ming-Cheng Peter Shau, P.E.
Manager, Geotechnical Services

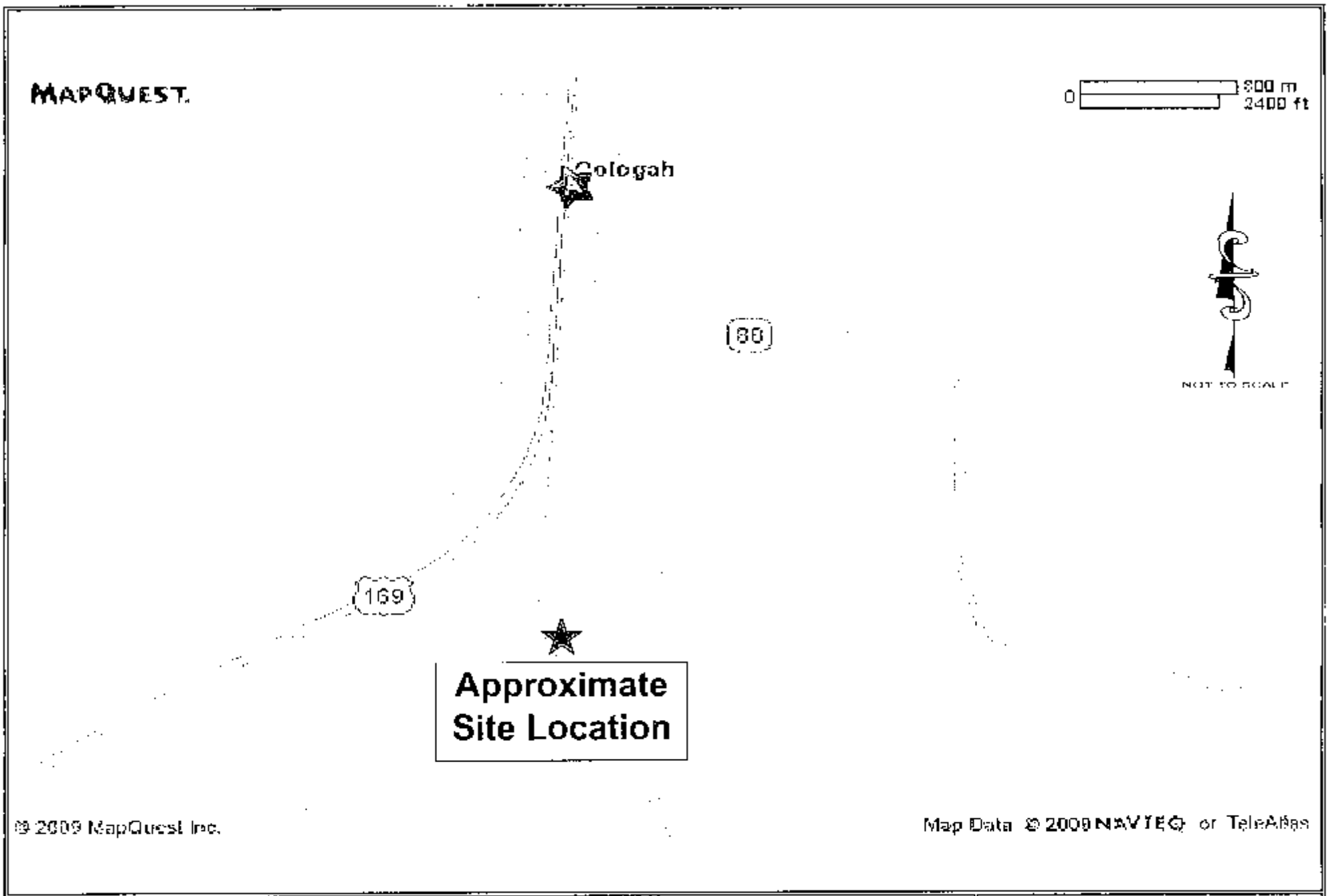
Certificate of Authorization No. 77
Expiration 6/30/11

Attachments (27 pages)

ATTACHMENT A

Vicinity Map

Site and Boring Location Plan

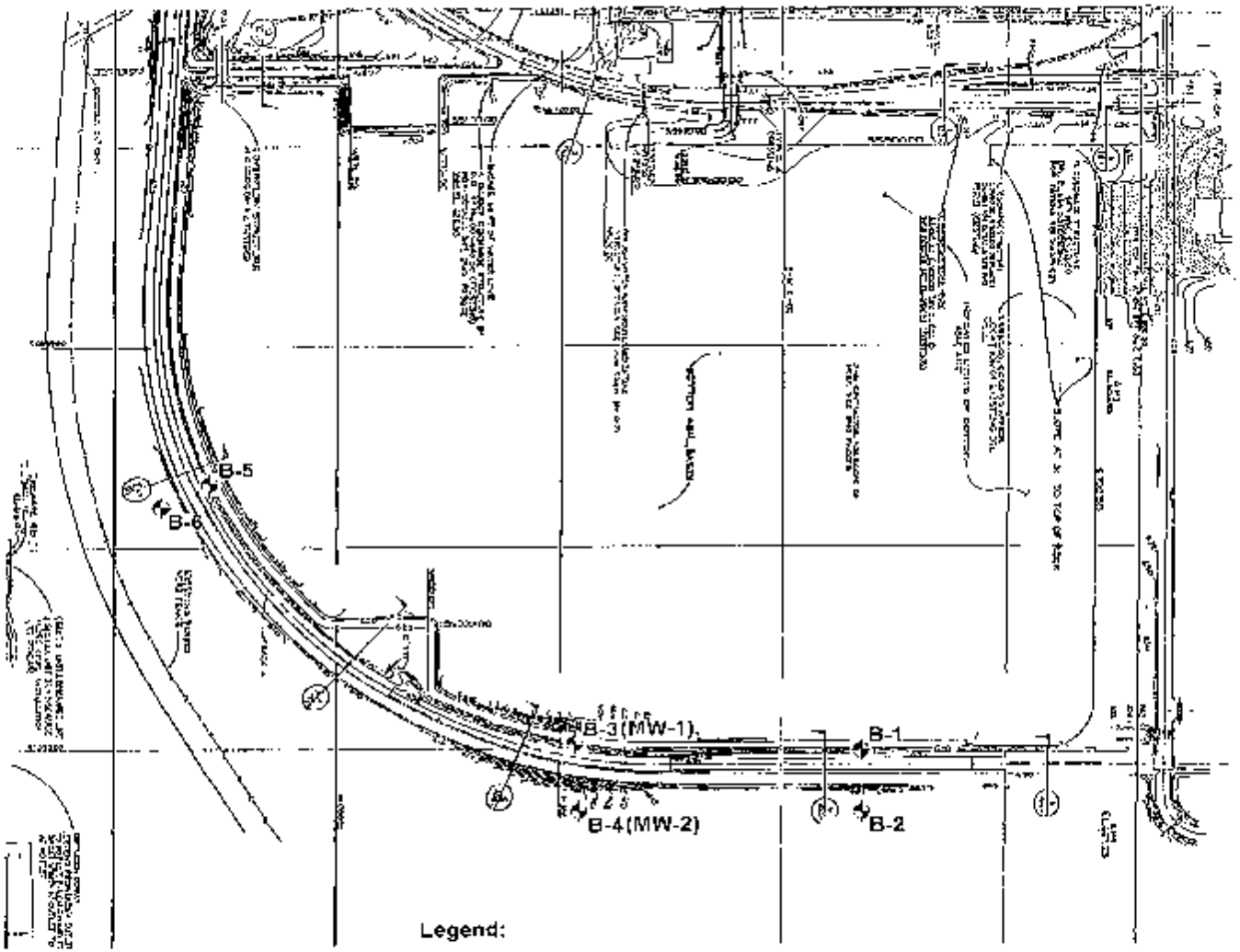


Vicinity Map

Project Name:	Final Geotechnical Investigation and Stability Evaluation of Bottom Ash Pond
Project Location:	Oologah, Oklahoma
Project No.:	8309-3150

STANDARD TESTING AND ENGINEERING COMPANY

NE34P000177



Scale refers to the full size drawing

Legend:

- Approximate Boring Location

MW - Monitoring Well

Site and Boring Location Plan

Project Name:	Final Geotechnical Investigation and Stability Evaluation of Bottom Ash Pond
Project Location:	Oologah, Oklahoma
Project No.:	8309-3150

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NE34P000178

ATTACHMENT B

Boring Logs

Key to Symbols

Definition of Descriptive Terms

STANDARD TESTING AND ENGINEERING COMPANY — GEOTECHNICAL SERVICES

SOIL BORING LOG

Boring No. B-1

Project: Final Geo. Inv. and Stability Evaluation of Bottom Ash Pond — Project No.: 8309-3150

Project Location: Oologah, Oklahoma — Date Drilled.: 1/13/10

Boring Location: East on crest of embankment — Project Engineer: Jieliang Pan, P.E.

Drill Method: CME-55 w/ 3.25" I.D. HSA — Field Logger: Jieliang Pan, P.E.

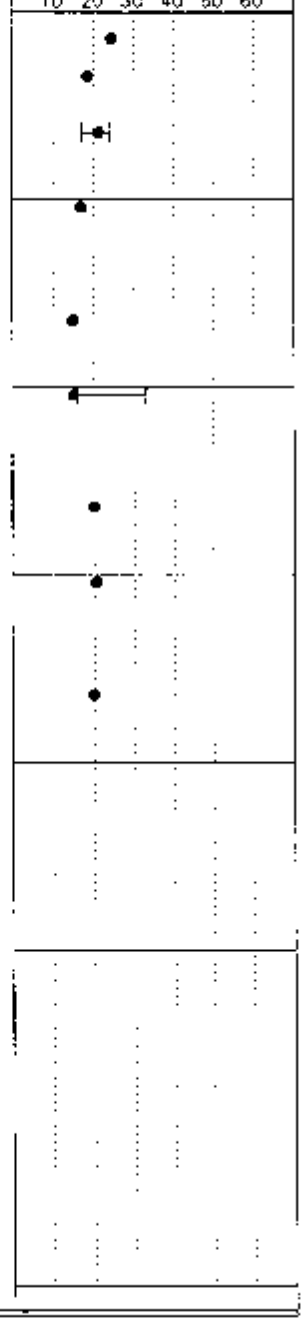
Surface Elevation: 635.45 feet — Water Depth: Dry @ Completion

Remarks: Boring coordinates: S 7016.566; E 213.839

Elev./Depth Feet	Symbol	Samples	SPT Blows/ Increment	Soil Description	Dry Density (pcf)	% Passing #200 Sieve
635 / 0				6" Blk. COAL DUST		31.8
			4/6" 4/6" 2/6"	Dk. Gray SILTY SAND V. Moist, Nonplastic, Loose USCS: SM; AASHTO: A-2-4		
			3/6" 4/6" 1/6"	Lt. Brn. & Lt. Gray SILTY CLAY WITH SAND Moist, Low Plasticity, Firm USCS: CL-ML; AASHTO: A-4(3) LL=24, PI=7	115	74.3
630 / 5			3/6" 4/6" 4/6"	Lt. Brn. & Lt. Gray SANDY CLAY w/ Trace Grave Moist, Med. Plasticity, Firm	108	
				w/ Trace Gravel Permeability Test: k=2.0E-8 cm/sec (8 to 10 ft.)	118	
625 / 10			3/6" 4/6" 5/6"	w/ Trace Gravel, Stiff USCS: CL; AASHTO: A-6(7) LL=33, PI=17	113	60.7
				w/ Trace Gravel	108	
620 / 15			2/6" 3/6" 4/6"	Lt. Brn. & Lt Gray & Reddish Brn.	105	
				Reddish Brn., w/ Gravel	108	
615 / 20			50/1"	(ROCK) Gray LIMESTONE Sl. Moist, Tr. Plasticity, Medium Hard		
610 / 25						
605 / 30						

Moisture/Plasticity: PL ⊢—⊣ LL; 10 20 30 40 50 60

Water Content, % ●: 10 20 30 40 50 60



STANDARD TESTING AND ENGINEERING COMPANY — GEOTECHNICAL SERVICES

SOIL BORING LOG

Boring No. B-2

Project: Final Geo. Inv. and Stability Evaluation of Bottom Ash Pond
Project No.: 8309-3150
Project Location: Oologah, Oklahoma
Date Drilled.: 1/13/10
Boring Location: East on downstream toe of embankment
Project Engineer: Jieliang Pan, P.E.
Drill Method: CME-55 w/ 3.25" I.D. HSA
Field Logger: Jieliang Pan, P.E.
Surface Elevation: 615.30 feet
Water Depth: Dry @ Completion
Remarks: Boring coordinates: S 7115.188; E 208.355

Elev./Depth Feet	Symbol	Samples	SPT Blows/ Increment	Soil Description	Dry Density (pcf)	% Passing #200 Sieve	Moisture/Plasticity (PL — LL; Water Content, %)
615 — 0			4/6" 50/5.1"	Brn. CLAY WITH SAND w/ Trace Gravel Moist, Med. Plasticity, Soft USCS: CL; AASHTO: A-6(13) LL=38, PI=21	100	71.7	
				Dk. Brn. & Grayish Brn. SANDY CLAY V. Moist, Fl. Low Plasticity, Soft			
				(ROCK) Gray LIMESTONE Sl. Moist, Tr. Plasticity, Soft			
610 — 5							
605 — 10							
600 — 15							
595 — 20							
590 — 25							
585 — 30							

Page: 1 of 1 for boring B-2

STANDARD TESTING AND ENGINEERING COMPANY — GEOTECHNICAL SERVICES

SOIL BORING LOG

Boring No. B-5

Project: Final Geo. Inv. and Stability Evaluation of Bottom Ash Pond — Project No.: 8309-3150

Project Location: Oologah, Oklahoma — Date Drilled.: 1/14/10

Boring Location: West on crest of embankment — Project Engineer: Jieliang Pan, P.E.

Drill Method: CME-55 w/ 3.25" I.D. HSA — Field Logger: Jieliang Pan, P.E.

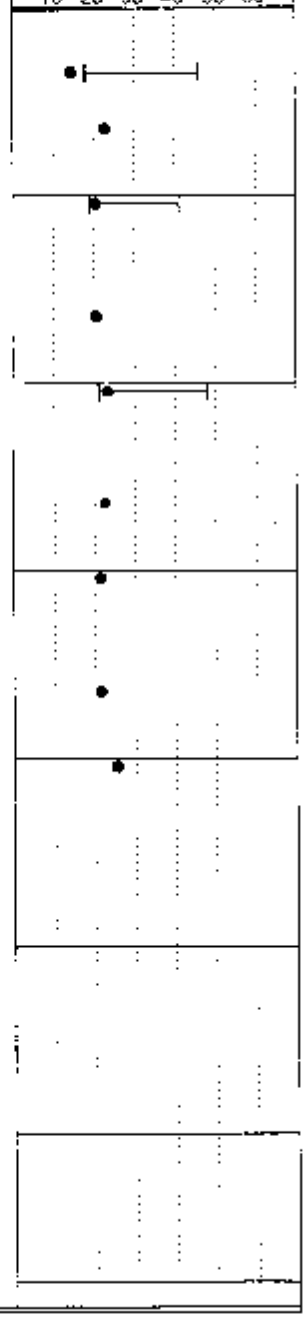
Surface Elevation: 631.56 feet — Water Depth: Dry @ Completion

Remarks: Boring coordinates: S 6295.809; E -1316.211

Elev./Depth Feet	Symbol	Samples	SPT Blows/ Increment	Soil Description	Dry Density (pcf)	% Passing #200 Sieve
0				Gray CRUSHED STONE (Railway Bed)		
630			6/6" 4/6" 3/6"	Lt. Brn. & Lt. Gray CLAYEY SAND w/ Trace Gravel V. Moist, Fl. High Plasticity, Loose USCS: SC; AASHTO: A-2-7(4) LL=46, PI=28	113 104	34.7
5			3/6" 6/6" 7/6"	Lt. Brn. & Lt. Gray SANDY CLAY w/ Trace Gravel Moist, Med. Plasticity, Firm Stiff USCS: CL; AASHTO: A-7-6(10) LL=41, PI=22	112	57.9
625				Lt. Brn. & Gray CLAY Moist, Fl. High Plasticity, Stiff Triaxial Test: c=4.8 psi, phi 2.5 deg (8 to 10 ft.)	103	
10			2/6" 4/6" 6/6"	Lt. Brn. & Gray & Brn. & Reddish Brn. CLAY USCS: CL; AASHTO: A-7-6(28) LL=48, PI=27	101	94.6
620				Brn. & Reddish Brn. Permeability Test: k=1.8E-8 cm/sec (13 to 15 ft.)	105	
15			2/6" 3/6" 5/6"	Lt. Brn. & Lt. Gray, Firm	107	
615				Permeability Test: k=1.6E-8 cm/sec (18 to 20 ft.)	102	
20			3/6" 4/6" 5/6"	Stiff	100	
610				(ROCK) Gray LIMESTONE Sl. Moist, Fl. Plasticity, Soft		
25						
605						
30						
600						

Moisture/Plasticity: PL 10 20 30 40 50 60 LL

Water Content % 10 20 30 40 50 60



Page: 1 of 1 for boring B-5

NE34P000182

STANDARD TESTING AND ENGINEERING COMPANY — GEOTECHNICAL SERVICES

SOIL BORING LOG

Boring No. B-6

Project: Final Geo. Inv. and Stability Evaluation of Bottom Ash Pond — **Project No.:** 8309-3150

Project Location: Oologah, Oklahoma — **Date Drilled:** 1/13/10

Boring Location: West on downstream toe of embankment — **Project Engineer:** Jieliang Pan, P.E.

Drill Method: CME-55 w/ 3.25" I.D. HSA — **Field Logger:** Jieliang Pan, P.E.

Surface Elevation: 611.60 feet — **Water Depth:** Dry @ Completion

Remarks: Boring coordinates: S 6325.333; E -1384.301

Elev./Depth Feet	Symbol	Samples	SPT Blows/ Increment	Soil Description	Dry Density (pcf)	% Passing #200 Sieve	Moisture/Plasticity (PL — LL; Water Content, %)
610 (0)			4/6" 39/6" 50/3.5"	Brn. CLAY WITH SAND w/ Trace Gravel V. Moist, Med. Plasticity, Soft Dk. Brn. & Brn. FAT CLAY WITH SAND V. Moist, F., High Plasticity, Soft USCS: CH; AASHTO: A-7-6(18) LL = 50, PI = 27 (ROCK) Gray LIMESTONE Sl. Moist, Tr. Plasticity, Soft	93	70.6	
605 (5)							
600 (10)							
595 (15)							
590 (20)							
585 (25)							
580 (30)							

KEY TO SYMBOLS

Symbol Description

STRATA SYMBOLS

Coal Dust

Silty Sand

Silty Clay with Sand

Sandy Clay

Limestone

Lean Clay with Sand

Crushed Stone

Clayey Sand with Gravel

Lean Clay

Soil Samplers

Bulk sample taken from auger flights, ASTM D1452

Standard Penetration Test, ASTM D1586

Undisturbed Thin-Walled Tube (Shelby tube), ASTM D1587

DEFINITION OF DESCRIPTIVE TERMS

Consistency of Cohesive Soils (at moisture content near plastic limit):
- Very Soft - Easily penetrated 4" to 6" by fist; tall core will sag under its own weight.
- Soft - Easily molded by fingers.
- Firm - Can be penetrated 2" to 3" by thumb with moderate effort, imprinted with fingers.
- Stiff - Readily indented by thumb but penetrated only with great effort.
- Very Stiff - Readily indented by thumbnail, imprinted very slightly with pressure from fingers.
- Hard - Indented with difficulty by thumbnail, cannot be imprinted with fingers.

Density of Cohesionless Soils:
- Very Loose - less than 4 SPT "N" value corrected for overburden.
- Loose - 5 to 10 SPT "N" value corrected for overburden.
- Medium Dense - 11 to 30 SPT "N" value corrected for overburden.
- Dense - 31 to 50 SPT "N" value corrected for overburden.
- Very Dense - 51 to 50/6" SPT "N" value corrected for overburden.
- Hard - less than 6" penetration in 50 SPT "N" blows corrected for overburden (cemented).

Hardness of Rock:
- Very Soft - can be scratched readily by fingernail
- Soft - can be grooved readily by knife or pick
- Medium - can be grooved 0.05" deep by firm pressure of knife
- Moderately Hard - can be scratched by knife
- Hard - can be scratched by knife or pick only with difficulty
- Very Hard - cannot be scratched by knife or sharp pick

Other Terms Descriptive of Consistency:
- Brittle - Ruptures with little deformation
- Friable - Crumbles or pulverizes easily.
- Elastic - Returns to original length after small deformation.
- Spongy - Is very porous, loose and elastic.
- Sticky - Adheres or sticks to tools or hands.

In Situ Moisture Descriptions:
- Dry - powdery
- Slightly Moist - water not readily absorbed by paper
- Moist - water readily absorbed by paper
- Very Moist - water condenses on sample tray
- Wet - water drips from sample

Degree of Plasticity When Moist to Very Moist:
- Nonplastic - cannot be rolled into a ball
- Trace of Plasticity - can be rolled into a ball but not into a 1/8" thread
- Low Plasticity - barely holds its shape when rolled into a 1/8" thread
- Fairly Low Plasticity - 1/8" thread quickly ruptures when bent
- Medium Plasticity - 1/8" thread withstands considerable deformation without rupture.
- Fairly High Plasticity - difficult to rupture a 1/8" thread by bending.
- High Plasticity - can be kneaded without rupture; greasy texture.

Abbreviations:

V. - Very	Dk. - Dark	Blk. - Black
Tr. - Trace	Lt. - Light	Brn. - Brown
Fl. - Fairly	Med. - Medium	
Sl. - Slightly		

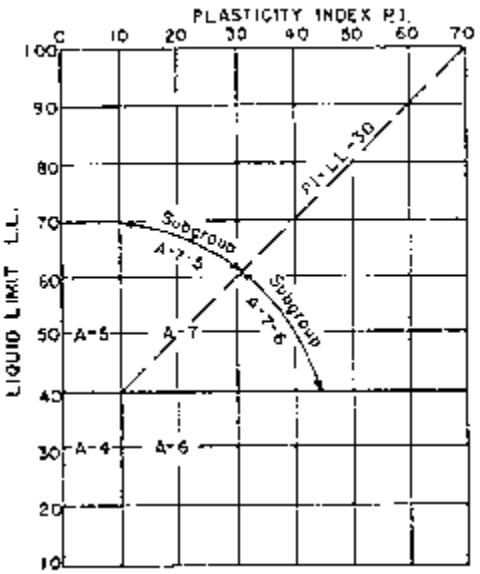
ATTACHMENT C

AASHTO Soil Classification System

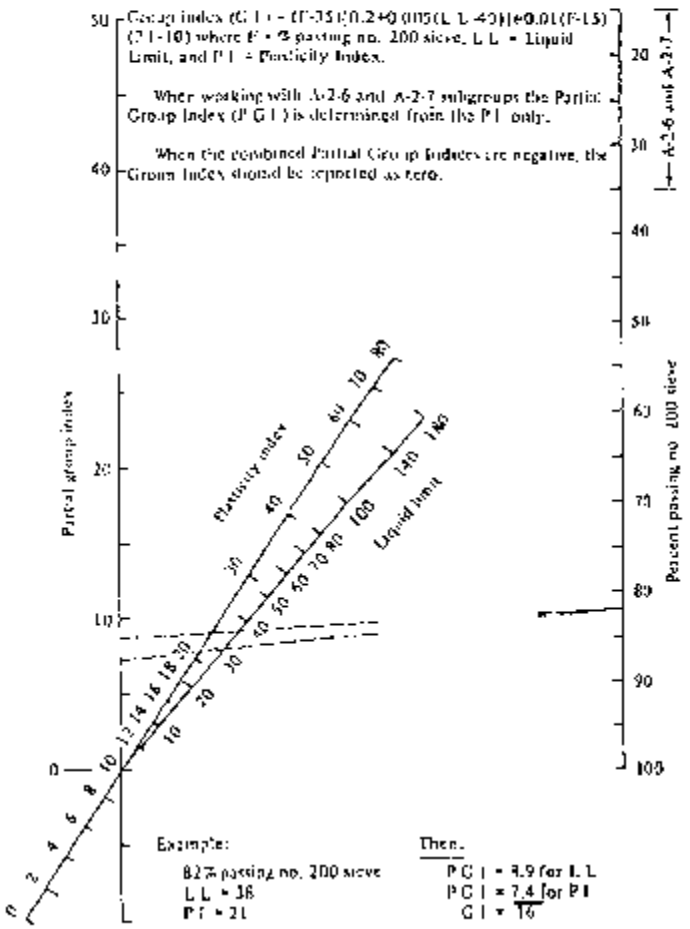
Unified Soil Classification System

Soil Classification System — American Association of State Highway and Transportation Officials

The tables and charts given below are from AASHTO Designation: M 145-83, The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes. More detailed information as to the background and application of the system may be obtained from the report.



Liquid-limit and plasticity-index ranges for the A-4, A-5, A-6 and A-7 subgrade groups.



Group index chart

Classification of Soils and Soil-Aggregate Mixtures (with Suggested Subgroups)

General classification	Granular materials (35 per cent or less passing No. 200)							Silt-clay materials (More than 35 per cent passing No. 200)			
Group classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5; A-7-6
Sieve analysis: Per cent passing.											
No. 10	50 max.	—	—	—	—	—	—	—	—	—	—
No. 40	30 max.	50 max.	51 min.	—	—	—	—	—	—	—	—
No. 200	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.	36 min.	36 min.	36 min.	36 min.
Characteristics of fraction passing No. 40:											
Liquid limit	—		—	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.
Plasticity index	6 max.		NP	10 max.	10 max.	11 min.	11 min.	10 max.	10 max.	11 min.	11 min.*
Usual types of significant constituent materials	Stone fragments, gravel and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	
General rating as subgrade	Excellent to good							Fair to poor			

*P.I. of A-7-5 subgroup is equal to or less than L.L. minus 30. P.I. of A-7-6 subgroup is greater than L.L. minus 30

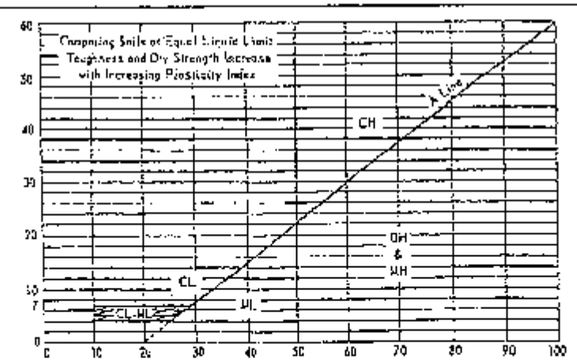
UNIFIED SOIL CLASSIFICATION

(Including identification and Description)

Major Divisions (1)	(2)		Group Symbols (3)	Typical Names (4)	Field Identification Procedures (Excluding particles larger than 3 inches and basing fractions on estimated weights) (5)			Information Required for Describing Soils (6)	Laboratory Classification Criteria (7)
Coarse-grained Soils: More than half of material is larger than No. 200 sieve size. (For visual classification, the 1/4-in. size may be used as equivalent to the No. 4 sieve size.)	Gravels: More than half of coarse fraction is larger than No. 4 sieve size.	Gravels with Fines (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.			For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics.	$C_u = \frac{D_{60}}{D_{10}}$ (Greater than 4); $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between one and 3
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.				Not meeting all gradation requirements for GW
		Gravels with Fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).			Give typical name; indicate approximate percentages of sand and gravel, maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parentheses.	Atterberg limits below "A" line or PI less than 4 — Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols.
			GC	Clayey gravels, gravel-sand-clay mixtures.	Plastic fines (for identification procedures see CL below).				Atterberg limits above "A" line with PI greater than 7
	Sands: More than half of coarse fraction is smaller than No. 4 sieve size.	Clean Sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines.	Wide range in grain size and substantial amounts of all intermediate particle sizes.				$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between one and 3
			SP	Poorly-graded sands, gravelly sands, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.			Example: Silty sand, gravelly; about 20% hard, angular gravel particles 1/2-in. maximum size; rounded and subangular sand grains coarse to fine; about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM).	Not meeting all gradation requirements for SW
		Sands with Fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).				Atterberg limits below "A" line or PI less than 4 — Limits plotting in hatched zone with PI between 4 and 7 are borderline cases requiring use of dual symbols.
			SC	Clayey sands, sand-clay mixtures.	Plastic fines (for identification procedures see CL below).				Atterberg limits above "A" line with PI greater than 7
Fine-grained Soils: More than half of material is smaller than No. 200 sieve size. (The No. 200 sieve size is about the smallest particle visible to the naked eye.)	Silts and Clays: Liquid limit less than 50				Identification Procedures on Fraction Smaller than No. 40 Sieve Size	Dry Strength (Crushing characteristics)	Dilatancy (Reaction to shaking)	Toughness (Consistency near PL)	
			ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.	None to slight	Quick to slow	None	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; color in wet condition, odor if any, local or geologic name, and other pertinent descriptive information; and symbol in parentheses.	Use grain-size curve in identifying the fractions as given under field identification.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	Medium to high	None to very slow	Medium		
			OL	Organic silts and organic silty clays of low plasticity.	Slight to medium	Slow	Slight	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions.	
	Silts and Clays: Liquid limit greater than 50		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	Slight to medium	Slow to none	Slight to medium		
			CH	Inorganic clays of high plasticity, fat clays.	High to very high	None	High		
			OH	Organic clays of medium to high plasticity, organic silts.	Medium to high	None to very slow	Slight to medium	Example: Clayey silt, brown, slightly plastic, small percentage of fine sand, numerous vertical root holes, firm and dry in place, loess, (ML).	
Highly Organic Soils			Pt	Peat and other highly organic soils.	Readily identified by color, odor, spongy feel and frequently by fibrous texture.				

Determine percentages of gravel and sand from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse-grained soils are classified as follows:

Less than 5%	GW, GP, SW, SP.
More than 12%	GM, GC, SM, SC.
5% to 12%	Borderline cases requiring use of dual symbols.



PLASTICITY CHART

For laboratory classification of fine-grained soils

(1) Boundary classifications: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well-graded gravel-sand mixture with clay binder. (2) All sieve sizes on this chart are U. S. standard.

FIELD IDENTIFICATION PROCEDURES FOR FINE-GRAINED SOILS OR FRACTIONS

These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (Reaction to shaking)

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky. Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens, and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (Crushing characteristics)

After removing particles larger than No. 40 sieve size, mold a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun, or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty, whereas a typical silt has the smooth feel of flour.

Toughness (Consistency near plastic limit)

After removing particles larger than the No. 40 sieve size, a specimen of soil about one-half inch cube in size, is molded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eighth inch in diameter. The thread is then folded and rerolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be turned together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolinite clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

Adopted by Corps of Engineers and Bureau of Reclamation, January 1952

NE34P000188

ATTACHMENT D

Summary of Laboratory Test Results

SUMMARY OF LABORATORY TEST RESULTS

STANDARD TESTING AND ENGINEERING COMPANY

GEOTECHNICAL SERVICES

Client: AEP / PSO Region 4 Engineering

Date: March 11, 2010

Project: Bottom Ash Pond Slope Repair, Oologah, Oklahoma

Project No.: 8309-3150

Boring No.	Sample I.D.	Depth (ft.)	Moisture Content (%)	Dry Density (pcf)	Atterberg Limits (% Moisture)			Sieve Analysis (% Passing)									Soil Classification	
					LL	PL	PI	1"	3/4"	1/2"	3/8"	#4	#10	#40	#100	#200	USCS	AASHTO
B-1	A	0.5-1.5	24.5		Nonplastic			100	100	100	100	100	96	72	47	31.8	SM	A-2-4
	B	1.5-3	18.5															
	C	3-5	21.2	115	24	17	7	100	100	100	100	100	100	99	91	74.3	CL-ML	A-4(3)
	D	5-6.5	16.8	108														
	E	8-10	14.8	118														
	F	10-11.5	15.0	113	33	16	17	100	91	88	88	88	88	87	77	60.7	CL	A-6(7)
	G	13-15	19.9	108														
	H	15-16.5	20.5	105														
	I	18-19	19.9	108														
B-2	A	0-1.5	20.0		38	17	21	100	100	97	96	94	90	87	79	71.7	CL	A-6(13)
	B	1.5-2	24.5	100														
B-5	A	1.5-3	14.3	113	46	18	28	100	95	95	86	75	62	54	41	34.7	SC	A-2-7(4)
	B	3-5	22.8	104														
	C	5-6.5	20.4	112	41	19	22	100	100	100	100	100	78	77	66	57.9	CL	A-7-6(10)
	D	8-10	20.5	103														
	E	10-11.5	23.3	101	48	21	27	100	100	100	100	100	100	100	98	94.6	CL	A-7-6(28)
	F	13-15	22.5	105														

SUMMARY OF LABORATORY TEST RESULTS

Client: AEP / PSO Region 4 Engineering

Date: March 11, 2010

Project: Bottom Ash Pond Slope Repair, Oologah, Oklahoma

Project No.: 8309-3150

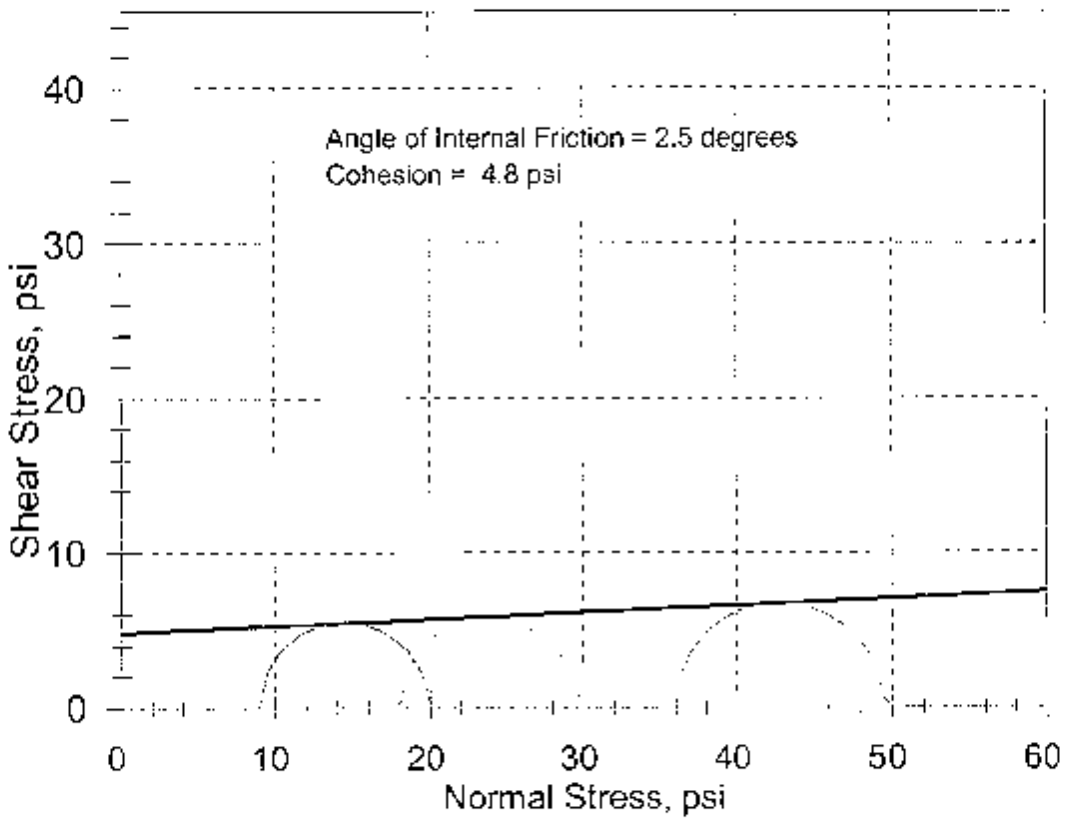
Boring No.	Sample I.D.	Depth (ft.)	Moisture Content (%)	Dry Density (pcf)	Atterberg Limits (% Moisture)			Sieve Analysis (% Passing)									Soil Classification	
					LL	PL	PI	1"	3/4"	1/2"	3/8"	#4	#10	#40	#100	#200	USCS	AASHTO
B-5 (cont.)	G	15 16.5	21.4	107														
	H	18-20	21.4	102														
	I	20-21.5	25.4	100														
B-6	A	0-1.5	28.8															
	B	1.5-2.5	30.3	93	50	23	27	100	100	100	100	96	79	75	73	70 6	CH	A-7-6(18)

STANDARD TESTING AND ENGINEERING COMPANY

GEOTECHNICAL SERV CES

Triaxial Compression Test Results

8309-3150, Boring B-5 @ 8-10 ft.



STANDARD TESTING AND ENGINEERING COMPANY — GEOTECHNICAL SERVICES

CORPORATE OFFICE and CENTRAL LABORATORY
3400 N. Lincoln Blvd., Oklahoma City, OK 73105 (405) 528-0541
CA77 Exp. 06/30/07

Area Offices

5358 S. 125th E. Ave., Ste. B	Tulsa, OK 74134	(918) 459-2700
902 Trails West Loop	Enid, OK 73703	(580) 237-3130
207 SE 11th Ave	Lawton, OK 73501	(580) 353-0872

Report Date: March 11, 2010
Project: Final Geo. Inv. and Stability Evaluation of Bottom Ash Pond
Location: Oologah, Oklahoma

Date Sampled: January 13, 2010
Sampled By: Johnny Jarman
Quantity Represented: Lt. Brn. & Lt. Gray SANDY CLAY

REPORT: MEASUREMENT OF HYDRAULIC CONDUCTIVITY

LAB NO: 6309-3150
Test Method: ASTM D5084

TEST RESULTS

Sample I.D.: B-1E (8-10')
Sample Preparation: Undisturbed
Specific Gravity: 2.750 (assumed)

Sample Parameters	Initial @ 14.7 psia	Final @ 72.0 psia
Diameter, cm	7.247	7.275
Height, cm	4.528	4.545
Moisture, %	23.8	26.1
Dry Unit Weight, pcf	101.0	99.8
Saturation, %	93.6	100.0

Test Parameters

Type of Permeant:	Deaired Water
Back Pressure, psig:	65.0
Maximum Effective Consolidation Stress, psig:	5.0
Minimum Effective Consolidation Stress, psig:	3.0
Hydraulic Gradient:	31.0

Average Hydraulic Conductivity (permeability): **2.0×10^{-8}** cm/sec

STANDARD TESTING AND ENGINEERING COMPANY

GEOTECHNICAL SERVICES

CORPORATE OFFICE and CENTRAL LABORATORY
3400 N. Lincoln Blvd., Oklahoma City, OK 73105 (405) 528-0541
CA77 Exp. 06/30/07

Area Offices

5358 S. 125th E. Ave.	Ste. B	Tulsa, OK 74134	(918) 459-2700
902 Trails West Loop		Enid, OK 73703	(580) 237-3130
202 SE "J" Ave		Lawton, OK 73501	(580) 353-0372

Report Date: March 11, 2010
Project: Final Geo. Inv. and Stability Evaluation of Bottom Ash Pond
Location: Ochogan, Oklahoma

Date Sampled: January 14, 2010
Sampled By: Johnny Jarman
Quantity Represented: Brn. & Reddish Brn. CLAY

REPORT: MEASUREMENT OF HYDRAULIC CONDUCTIVITY

LAB NO: 8309-3150
Test Method: ASTM D5084

TEST RESULTS

Sample I.D.: B 5F (13-15')
Sample Preparation: Undisturbed
Specific Gravity: 2.685 (assumed)

Sample Parameters	Initial @ 14.7 psia	Final @ 72.0 psia
Diameter, cm	7.255	7.282
Height, cm	5.295	5.315
Moisture, %	17.5	18.8
Dry Unit Weight, pcf	112.5	111.3
Saturation, %	95.9	100.0

Test Parameters

Type of Permeant:	Deaired Water
Back Pressure, psig:	55.0
Maximum Effective Consolidation Stress, psig:	5.0
Minimum Effective Consolidation Stress, psig:	3.0
Hydraulic Gradient:	26.5

Average Hydraulic Conductivity (permeability): 1.8×10^{-8} cm/sec

STANDARD TESTING AND ENGINEERING COMPANY — GEOTECHNICAL SERVICES

CORPORATE OFFICE and CENTRAL LABORATORY
3400 N. Lincoln Blvd., Oklahoma City, OK 73105 (405) 528-0541
CA77 Exp. 06/30/07

Area Offices

5358 S. 175th E. Ave. Ste. B	Tulsa, OK 74134	(918) 459-2709
902 Trails West Loop	Enid, OK 73703	(580) 237-3130
202 SE 7th Ave.	Lawton, OK 73501	(580) 353 0872

Report Date: March 11, 2010
Project: Final Geo. Inv. and Stability Evaluation of Bottom Ash Pond
Location: Octogan, Oklahoma

Date Sampled: January 14, 2010
Sampled By: Johnny Jarman
Quantity Represented: Lt. Brn. & Lt. Gray CLAY

REPORT: MEASUREMENT OF HYDRAULIC CONDUCTIVITY

LAB NO: 6309-3150
Test Method: ASTM D5084

TEST RESULTS

Sample I.D.: B-5H (18-20')
Sample Preparation: Undisturbed
Specific Gravity: 2.668 (assumed)

Sample Parameters	Initial @ 14.7 psia	Final @ 72.0 psia
Diameter, cm	7.280	7.278
Height, cm	5.396	5.393
Moisture, %	17.6	19.1
Dry Unit Weight, pcf	110.1	110.3
Saturation, %	91.7	100.0

Test Parameters

Type of Permeant:	Deaired Water
Back Pressure, psig:	55.0
Maximum Effective Consolidation Stress, psig:	5.0
Minimum Effective Consolidation Stress, psig:	3.0
Hydraulic Gradient:	26.1

Average Hydraulic Conductivity (permeability): **1.6×10^{-8}** cm/sec

ATTACHMENT E

Monitoring Well

Construction Diagrams

STANDARD TESTING
AND ENGINEERING COMPANY

WELL NUMBER B-3 (MW-1)

CLIENT AEP/ PSO Region 4 Engineering
PROJECT NAME Geo Inv and Stability Evaluation of Bottom Ash Pond
PROJECT NUMBER 8309-3150
PROJECT LOCATION AEP NE Station Units 3 & 4, Ologah, Oklahoma
DATE STARTED 1/14/10 **COMPLETED** 1/14/10
GROUND ELEVATION 635.15 ft **HOLE SIZE** 3.25"
DRILLING CONTRACTOR Standard Testing Drilling
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING -
LOGGED BY Johnny Jarman **CHECKED BY** Jieliang Pan
AT END OF DRILLING -
NOTES Weather: Cloudy; Boring Coordinates: S 7010.565/E -371.054
-hrs AFTER DRILLING -

DEPTH (ft)	SAMPLE TYPE NUMBER	REMARKS	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
	AU S-1	No groundwater was encountered during drilling		Light Brown CLAY Slightly Moist, Medium Plasticity	4-ft Steel Casing: 3 ft by 2-ft with about 6-inch Concrete Pad Poured at Surface. (0-2' Cement Grout)
5			5.0	630.2	
	AU S-2			Light Brown CLAY Moist, Medium Plasticity	Bentonite Chips: 10' thick
10			10.0	625.2	
	AU S-3				
15				Light Brown CLAY Moist, Medium Plasticity	
	AU S-4				
20			20.0	615.2	Sand Pack: 15' thick
	AU S-5				10-ft Screen (Slot Size 0.010-inch, Schedule 40 PVC)
25				Light Brown CLAY Moist to Very Moist, Medium Plasticity	
	AU S-6		27.0	608.2	Bottom of Borehole @ 27'; Total Length of Casing = 29.5'
	AU S-7		30.0	605.2	

Bottom of hole at 27.0 feet.

GENERAL DRILL TEST WELL 8309-3150WELL GPJ GINT US GDT 3/11/10

STANDARD TESTING
AND ENGINEERING COMPANY

WELL NUMBER B-4 (MW-2)

CLIENT AEP/ PSO Region 4 Engineering
PROJECT NAME Geo. Inv. and Stability Evaluation of Bottom Ash Pond
PROJECT NUMBER 8309-3150
PROJECT LOCATION AEP NE Station Units 2 & 4, Oologah, Oklahoma
DATE STARTED 1/14/10 COMPLETED 1/14/10
GROUND ELEVATION 603.52 ft HOLE SIZE 3.25"
DRILLING CONTRACTOR Standard Testing Drilling
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
AT TIME OF DRILLING -
LOGGED BY Johnny Jarman CHECKED BY Jieliang Pan
AT END OF DRILLING 5.0 ft / Elev 598.5 ft
NOTES Weather: Cloudy; Boring Coordinates: S 7122.093/E -456.39
-hrs AFTER DRILLING -

DEPTH (ft)	SAMPLE TYPE NUMBER	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
	AU S-1		Dark Brown CLAY Moist to Very Moist, Medium Plasticity	4-ft Steel Casing; 3-ft by 3-ft with about 6-inch concrete pad poured at surface. (0-2' Cement Grout)
1.5			LIMESTONE Moist to Very Moist (602.0)	
2.5				Bentonite Chips; 2' thick
5.0	AU S-2			
7.5				Sand Pack; 6' thick; 5-ft screen (Slot Size 0.010-inch, Schedule 40 PVC)
10.0			10.0 Bottom of hole at 10.0 feet. (593.5)	Bottom of Borehole @ 10.0; Total Length of Casing = 12.5'

GENERAL BH / TP / WELL #8309-3150 WELL LOG / GINT US GDT 3/11/10

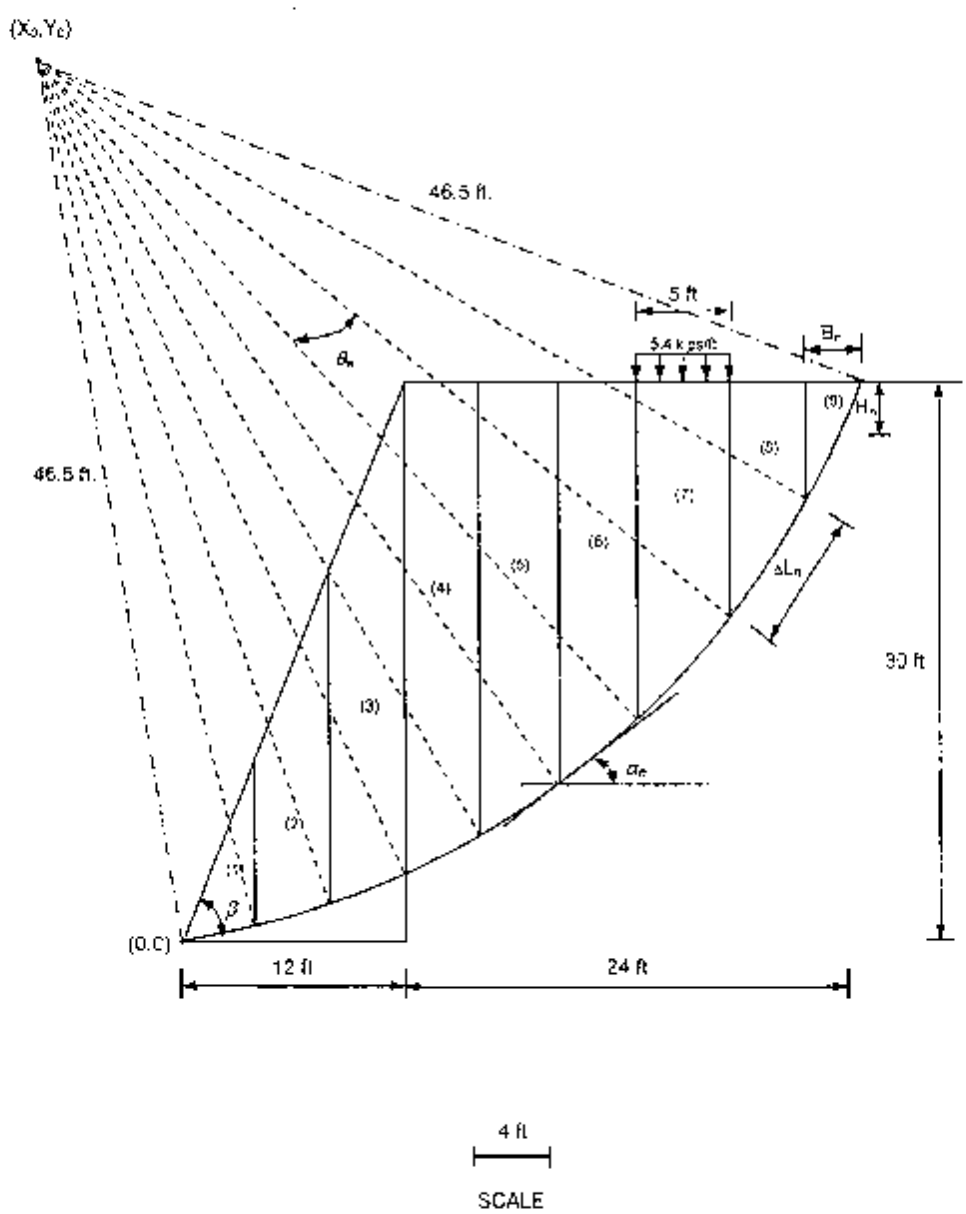
ATTACHMENT F

Typical Cross-Section for Slope Stability Analysis

Stability Analysis Using Ordinary Methods of Slices

Typical Cross-Section for Slope Stability Analysis

Project: Final Geotechnical Investigation and Stability
Evaluation of Bottom Ash Pond
Project No.: 8309-3150



Stability Analysis Using Ordinary Method of Slices

Project: Final Geotechnical Investigation and Stability Evaluation of Bottom Ash Pond

Project No.: 8309-3150

I. Soil Property from Borings B-1, B-2, B-5, & B-6

γ_t = 124.0 pcf

c = 1075.5 psf (Sandy Clay)

ϕ = 18.0 deg

Surcharge Loading = 5.4 klps/ft

Toe Circle: (Slope H = 30 ft)

X_d = -8.4 ft

Y_d = 46.5 ft *(Ref: Naval Design Manual 7.01)*

II. Refer to the attached cross section

III. Stability Analyses

Slice No.	B_n (ft)	H_n (ft)	W_n (kips/ft)	α_n (deg)	θ_n	Sin α_n	Cos α_n	ΔL_n (ft)	W_n Sin α_n (kips/ft)	W_n Cos α_n (kips/ft)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	4	4.5	2.23	11	5.0	0.19	0.98	4.1	0.43	2.19
2	4	14.0	6.94	17	5.0	0.29	0.96	4.1	2.03	6.64
3	4	22.0	10.91	25	5.0	0.42	0.91	4.1	4.61	9.89
4	4	25.0	12.40	28	5.5	0.47	0.88	4.5	5.82	10.95
5	4	22.5	11.16	35	5.5	0.57	0.82	4.5	6.40	9.14
6	4	19.5	9.67	41	6.5	0.66	0.75	5.3	6.35	7.30
7*	5	15.0	14.70	46	9.0	0.72	0.69	7.3	10.57	10.21
8	4	8.5	4.22	55	8.5	0.82	0.57	6.9	3.45	2.42
9	3	3.0	1.12	67	9.0	0.92	0.39	7.3	1.03	0.44

* *W_n with surcharge loading*

$\sum$ **47.90** **40.69** **59.18**

$$FS = \frac{(\sum Col.9)*c + (\sum Col.11)*\tan\phi}{(\sum Col.10)}$$

$$FS = \frac{70.74}{40.69}$$

FS = **1.74** > 1.50 **OK**

NE34P000201

Stability Analysis Using Ordinary Method of Slices

Project: Final Geotechnical Investigation and Stability Evaluation of Bottom Ash Pond

Project No.: 8309-3150

I. Soil Property from Borings B-1, B-2, B-5, & B-6

γ_t = 124.0 pcf

c = 1296.5 psf (Clay)

ϕ = 13.0 deg

Surcharge Loading = 5.4 kips/ft

Toe Circle: (Slope H = 30 ft)

X_0 = -8.4 ft

Y_0 = 46.5 ft *(Ref: Naval Design Manual 7.01)*

II. Refer to the attached cross section

III. Stability Analyses

Slice No.	B_n (ft)	H_n (ft)	W_n (kips/ft)	α_n (deg)	θ_n	Sin α_n	Cos α_n	ΔL_n (ft)	W_n Sin α_n (kips/ft)	W_n Cos α_n (kips/ft)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	4	4.5	2.23	11	5.0	0.19	0.98	4.1	0.43	2.19
2	4	14.0	6.94	17	5.0	0.29	0.96	4.1	2.03	6.64
3	4	22.0	10.91	25	5.0	0.42	0.91	4.1	4.61	9.89
4	4	25.0	12.40	28	5.5	0.47	0.88	4.5	5.82	10.95
5	4	22.5	11.16	35	5.5	0.57	0.82	4.5	6.40	9.14
6	4	19.5	9.67	41	6.5	0.66	0.75	5.3	6.35	7.30
7*	5	15.0	14.70	46	9.0	0.72	0.69	7.3	10.57	10.21
8	4	8.5	4.22	55	6.5	0.82	0.57	6.9	3.45	2.42
9	3	3.0	1.12	67	9.0	0.92	0.39	7.3	1.03	0.44

* *W_n with surcharge loading*

$\sum$ **47.90** **40.69** **59.18**

$$FS = \frac{(\sum Col.9)*c + (\sum Col.11)*\tan\phi}{(\sum Col.10)}$$

$$FS = \frac{75.76}{40.69}$$

FS = 1.87 > 1.50 **OK**

NE34P000202

APPENDIX A

Document 17

Hydrologic Analysis of Northeastern 3 & 4 Bottom Ash Pond

FREESE AND NICHOLS

Innovative approaches
Practical results
Outstanding service

Hydrologic Analysis of Northeastern 3 &4 Power Station Bottom Ash Pond

American Electric Power Company

Prepared by:

FREESE AND NICHOLS, INC.
4055 International Plaza, Suite 200
Fort Worth, Texas 76109
817-735-7300

AEP11201

FREESE AND NICHOLS

Innovative approaches
Practical results
Outstanding service

Hydrologic Analysis of Northeastern 3 &4 Power Station Bottom Ash Pond

American Electric Power Company

REGISTERED PROFESSIONAL ENGINEER
JOHN LEE RUTLEDGE
16255
OKLAHOMA

5-16-11

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AEP11201

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NE34P000222

1.0 INTRODUCTION

In April of 2011, Freese and Nichols, Inc., (FNI) was retained by American Electric Power (AEP) to perform various hydrologic and hydraulic calculations to determine the hydraulic adequacy of the Bottom Ash Pond for the Northeastern 3 & 4 Power Station located near Oologah, Oklahoma. This report summarizes the results of the analysis for the 10-year, 100-year, and 40% PMF events.

The Ash Pond is situated immediately southwest of the Power Plant and west of Oologah Dam. The general location of the power plant and associated reservoirs is shown in Figure 1.

NE34P000222

FH PROJECT NO. AEP11201	FREESE AND NICHOLS	0 0.5 1 2 Miles	FIGURE 1
FILE NAME H:\WR_DESIGN\FIGURES\Figure1_LocationMap.mxd	4055 International Plaza, Suite 200 Fort Worth, TX 76109-4895 817-735-7300	NORTHEASTERN 3 & 4 ASH POND	
DATUM & COORDINATE SYSTEM NAD83 STATE PLANE OKLAHOMA NORTH (FT)		LOCATION MAP	
DATE CREATED APRIL 2011			
PREPARED BY JFN			

2.0 HYDROLOGIC MODEL DEVELOPMENT

2.1 BASIN DELINEATION & CONNECTIVITY

The hydrologic model for the Northeastern 3 & 4 Power Station Bottom Ash Pond was created in HEC-HMS[1] and consisted of two total drainage basins, as shown in Figure 2. The total drainage area modeled is approximately 0.31 square miles, or 199 acres. One basin represents the area that includes most of the power plant facilities and the Bottom Ash Pond itself, while the other represents the area that includes the coal pile and the area east of the coal pile, which is connected to the Bottom Ash Pond via a small channel. The basins were delineated from one-foot contours generated from a March 2010 survey[2] of the area and supplemented with the National Elevation Dataset (NED) 10-meter resolution Digital Elevation Model (DEM).

The Northeastern 3 & 4 Power Station Bottom Ash Pond is connected to multiple segments of the overall plant system and has several inflows and outflows that are assumed to be constant. Stormwater from a retention basin at the fly ash landfill, known as Basin C, is pumped to the bottom ash pond at a maximum rate of 4,000 gpm or 8.91 cfs. Inflow from pumping operations at Basin C, as well as from drains at Units 1, 2, 3, and 4, contribute a combined 6.3 MGD, or 9.75 cfs. The on-site wastewater treatment facility has capacity to pump approximately 1000 gpm, or 2.23 cfs. This capacity is used to regulate the normal pool elevation. Additionally, during emergency or high flood situations, flow may be diverted to the plant's cooling towers at a rate of 2.0 MGD, or 3.09 cfs.

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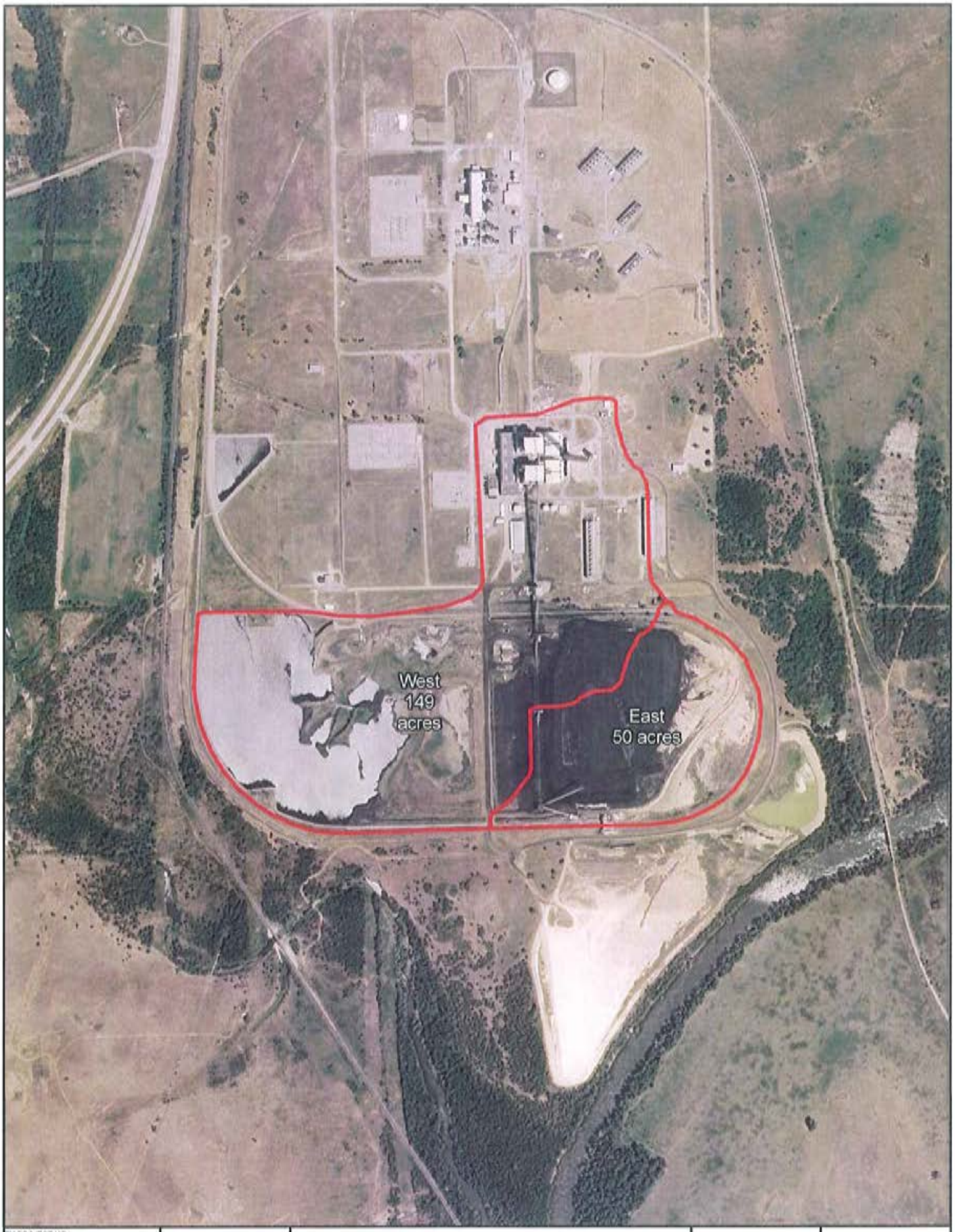

FN PROJECT NO. AEP10431	FREESE NICHOLS	0 500 1,000 2,000 Feet	N	FIGURE
FILE NAME H:\WR_DESIGN\FIGURES\Figure2_Basins.mxd	4055 International Plaza, Suite 200 Fort Worth, TX 76109-4895 817-735-7300	NORTHEASTERN 3&4 ASH POND		2
DATUM & COORDINATE SYSTEM NAD83 STATE PLANE OKLAHOMA NORTH (FT)		DRAINAGE BASIN MAP		
DATE CREATED APRIL 2011				
PREPARED BY JFM				

2.2 HYDROLOGIC PARAMETERS

The HEC-HMS model incorporates the NRCS Curve Number and Unit Hydrograph methods for each basin. In this model, the curve numbers were based on hydrologic soil classifications and land cover. The instantaneous runoff effect of open water surfaces was accounted for in the development of the curve numbers. The soils dataset was obtained from the NRCS Soil Survey Geographic Database[3] (SSURGO), and land use classification was determined from National Agriculture Imagery Program[4] (NAIP) 2010 aerial imagery of the site. Spatial information about soil types and land use classifications is presented in Figures 3 and 4, respectively. Table 1 provides the matrix used in determining the curve number for each basin. All soils in the basin are in Hydrologic Soil Group D. The curve numbers shown in Table 1 represent only these soils and are for Antecedent Moisture Condition (AMC) II. These values were incorporated in the model for the frequency storm events, such as the 10-year storm event. For the PMP events, a higher curve number with AMC III was used to simulate a worst-case scenario with the ground fully saturated.

Table 1 – Curve Number Calculation Matrix

Land Use Classification	Curve Number (AMC II)
Water	100
Open Space	89
Industrial	93
Coal Pile	94

The only input into HEC-HMS for the NRCS Dimensionless Unit Hydrograph is a lag time, which is calculated based on basin conditions, such as hydraulic length and average slope, according to the NRCS TR-55 Method. Table 2 provides a summary of the hydrologic parameters for each basin.

Table 2 – Basin Parameters

Basin	Area (mi^2)	Lag Time (min)	Curve Number (AMC II)	Curve Number (AMC III)
West	0.246	14.75	94.1	97.4
East	0.078	11.99	92.7	96.7

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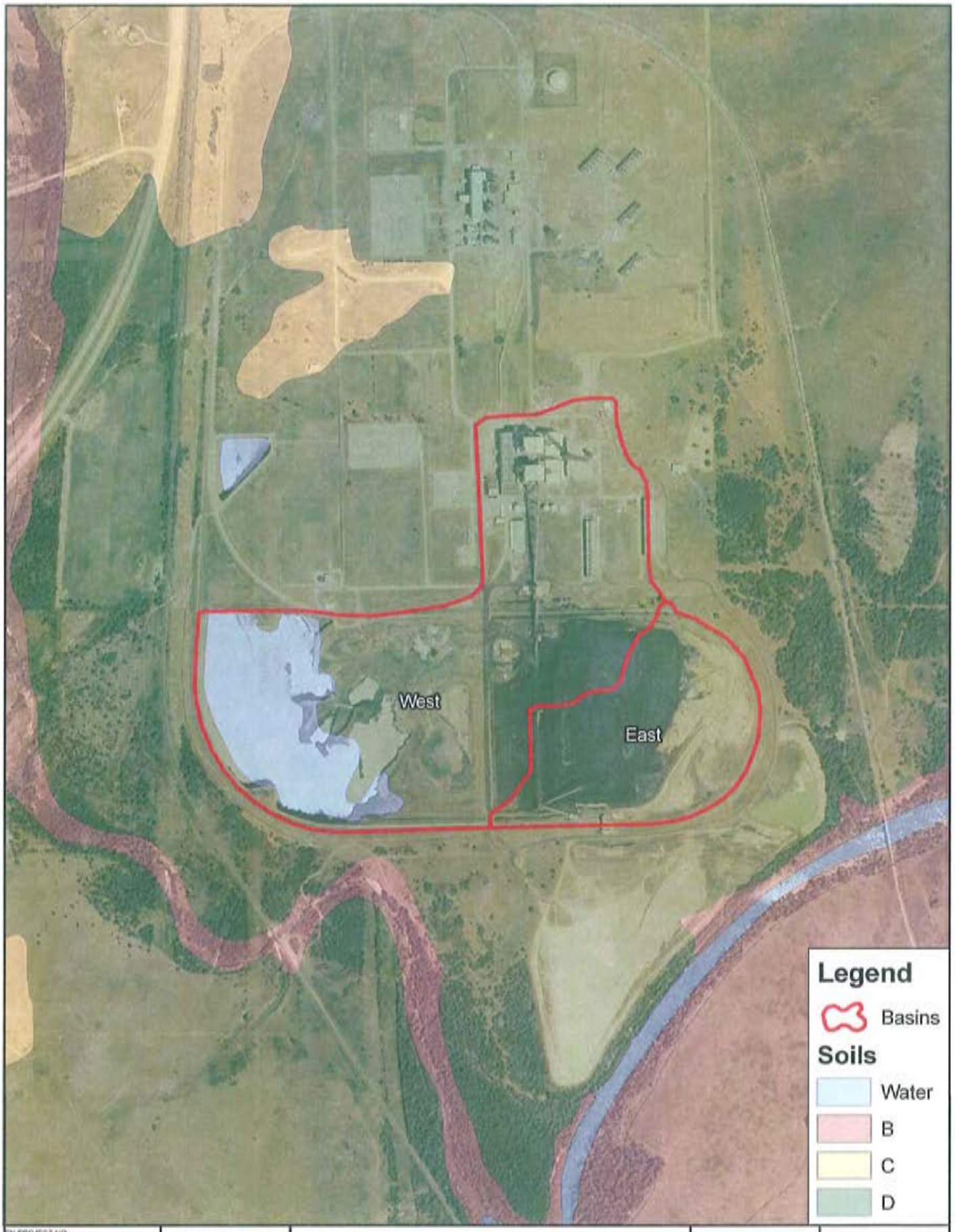

FN PROJECT NO	AEP11201
FILE NAME	H:\WR_DESIGN\FIGURES\Figure3_Soils.mxd
DATUM & COORDINATE SYSTEM	NAD83 STATE PLANE OKLAHOMA NORTH (FT)
DATE CREATED	APRIL 2011
PREPARED BY	JPM

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Fort Worth, TX 76109-4895
817-735-7300

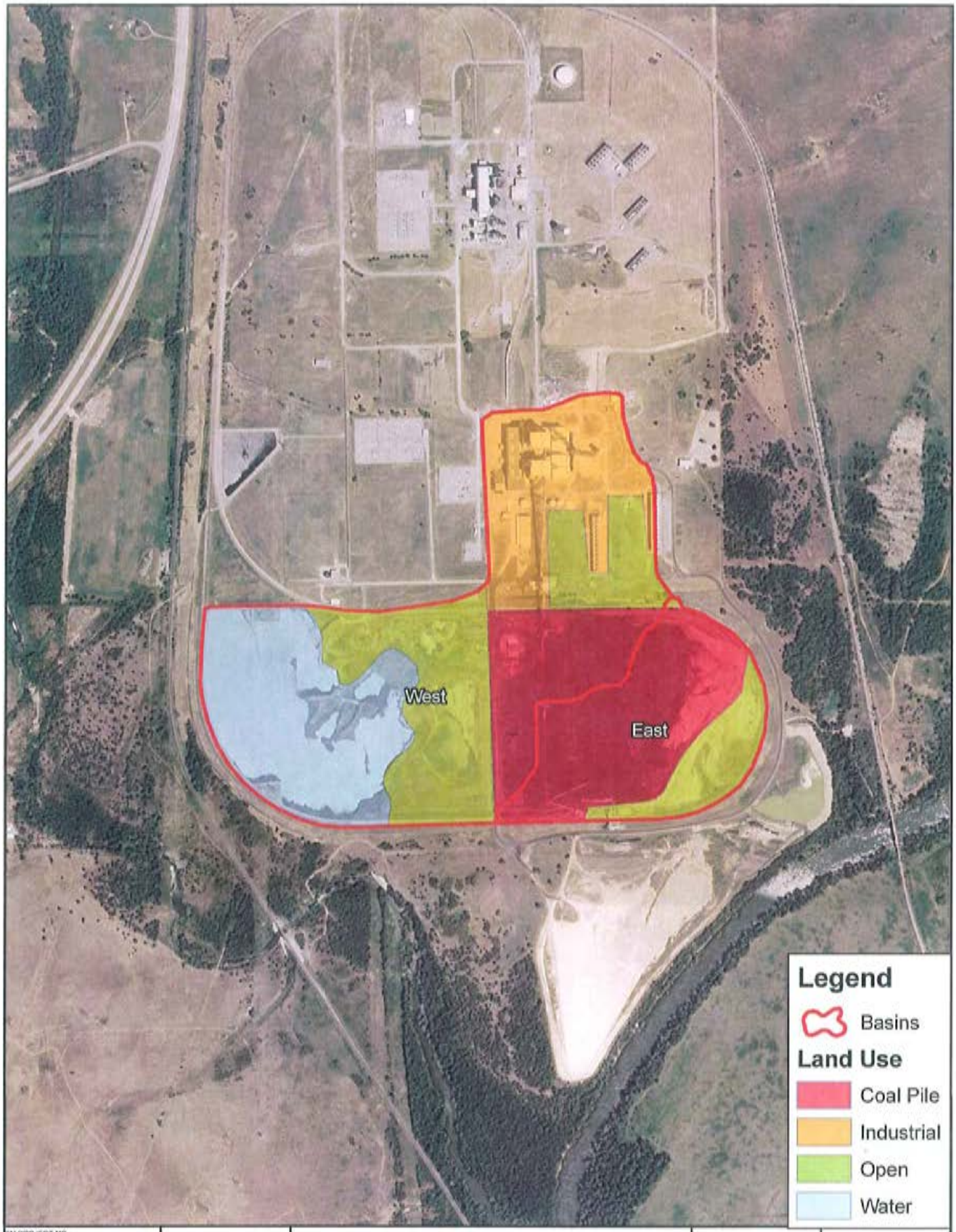
0 500 1,000 2,000 Feet

NORTHEASTERN 3&4 ASH POND

HYDROLOGIC SOIL CLASSIFICATIONS

N

FIGURE 3



FN PROJECT NO. AEP11201	FREESE NICHOLS	0 500 1,000 2,000 Feet	FIGURE
FILE NAME H:\WR_DESIGN\FIGURES\ Figure4_LandCover.mxd	4055 International Plaza, Suite 200 Fort Worth, TX 76109-4895 817-735-7300	NORTHEASTERN 3&4 ASH POND	4
DATUM & COORDINATE SYSTEM NAD83/STATE PLANE OKLAHOMA NORTH (FT)		LAND COVER DATA	
DATE CREATED APRIL 2011			
PREPARED BY JPM			

2.3 ELEVATION-STORAGE DATA

Elevation-storage data for the reservoir was approximated with the NED 10-meter DEM to calculate the available storage up to the nominal top of dam elevation of 630.0 ft-msl. This data is considered an approximation based on the best available information because the general topography of the reservoir has changed, and continues to change, with both sedimentation and excavation and grading of the bottom ash material. The elevation-storage relationship was used in the hydrologic model for routing both the frequency storm events and the PMF and is shown in Table 3 below.

Table 3 – Elevation-Storage Data

Elevation (ft-msl)	Storage (acre-ft)
600.0	0
620.0	72
621.0	93
622.0	117
623.0	147
624.0	183
625.0	223
626.0	266
627.0	311
628.0	360
629.0	412
630.0	469

2.4 DISCHARGE RATING CURVES

The dam has a single spillway structure located on the northwest corner of the embankment. Information regarding the dimensions and elevations of the spillway was taken from a combination of original construction drawings and detailed descriptions from AEP personnel. The principal spillway for the Bottom Ash Pond consists of a broad-crested weir with a total length of 24 feet and crest elevation of 625.0 ft-msl. There is also a 1-foot square notch with crest elevation of 624.0 ft-msl; however, this notch has been filled with concrete and no longer contributes to the discharge capacity of the spillway. A 10-foot section of the spillway is covered by a concrete lid. The spillway discharges down a chute with a slope of 2.5:1 and into a stilling basin with chute blocks. Immediately downstream of the stilling basin is a small

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depressed area contained by the railroad embankment. Two 48-inch HDPE culverts run under the railroad embankment. The original culverts were 60-inch corrugated metal pipe (CMP) culverts, but HDPE slip-liners were recently installed. The overall spillway system, including these downstream culverts, was modeled with a steady-state HEC-RAS[5] model. The HEC-RAS model accounts for submergence of the tailwater from the downstream culverts, which will significantly restrict flow through the spillway. The discharge rating curve for the spillway is shown in Table 4. A photograph of the spillway is shown in Figure 5, along with a photograph of the downstream stilling basin and culverts in Figure 6. Detailed calculations for the discharge rating curve are included in Appendix B.

Table 4 – Discharge Rating Curve

Elevation (ft-msl)	Total Discharge (cfs)
625.0	0
625.5	25
626.0	71
626.5	131
627.0	199
627.5	279
628.0	367
628.5	462
629.0	507
629.5	518
630.0	529

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Figure 5 – Bottom Ash Pond Spillway

Figure 6 – Downstream Basin with Culverts

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2.5 FREQUENCY MODEL RESULTS

The 10-year frequency – or 10% annual chance – storm event was analyzed for the Northeastern 3 & 4 Power Station Ash Pond. The hydrologic model described in the preceding sections was implemented in analyzing this event. Curve numbers were set to Antecedent Moisture Condition II, and initial abstractions were calculated automatically by HEC-HMS. These assumptions represent normal conditions, as would be expected prior to a storm event of this nature. The precipitation data was obtained from the National Oceanic and Atmospheric Administration's Technical Memorandum NWS HYDRO-35[6] and Technical Paper 40.[7] These values are presented in Table 5. Each storm event was assumed to have a duration of 24 hours.

Table 5 – Frequency Precipitation Depths

Frequency (yrs)	Precipitation (in)							
	5 min	15 min	60 min	2 hr	3 hr	6 hr	12 hr	24hr
1	0.39	0.81	1.50	1.77	1.96	2.27	2.76	3.22
5	0.56	1.19	2.34	2.88	3.17	3.76	4.52	5.17
10	0.62	1.32	2.72	3.26	3.67	4.39	5.22	6.09
25	0.71	1.52	3.17	3.81	4.25	5.12	6.10	7.08
50	0.79	1.68	3.56	4.20	4.77	5.71	6.84	7.92
100	0.86	1.84	4.04	4.71	5.35	6.41	7.63	8.85

These precipitation depths serve as input data into the hydrologic model, and were routed through the model as described previously. Normal engineering assumptions would assume that flood routings were started at the lowest spillway crest elevation. However, the power plant operation policy calls for the normal pool of the reservoir to be maintained at elevation 623.0 ft-msl. This water level is regulated with pumping to the on-site wastewater treatment facility, and, in emergency situations, flow may be diverted to the plant's cooling towers. For comparison, the 10-year storm event was computed with initial elevations at both the normal pool and spillway crest. The results of the 10-year storm are shown in Table 6.

Table 6 – 10-Year Frequency Model Results

Initial Elevation (ft-msl)	Peak Elevation (ft-msl)	Peak Inflow (cfs)	Peak Outflow (cfs)
623.0	625.28	798	14
625.0	626.28	798	104

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2.6 PMF MODEL RESULTS

The Probable Maximum Flood (PMF) is defined as the greatest flood to be expected, and the Probable Maximum Precipitation (PMP) is theoretically the greatest depth of rainfall for a given duration that is physically possible over a given size storm area at a particular geographic location. Generally, the rainfall depth is calculated for the ten square miles of the watershed which receive the highest intensity rainfall.

Hydrometeorological Report No. 52 (HMR-52),[8] developed by the U.S. Army Corps of Engineers, was used to determine the rainfall for each basin. PMP estimates were taken from Hydrometeorological Report No. 51[9] and distributed according to HMR-52 to obtain average rainfall depths over the various drainage areas.

HMR-52 calculates rainfall depths for storm durations ranging from five minutes to seventy-two hours. Table 7 lists the point rainfall depths calculated by HMR-52 for storm durations from one hour to 72 hours. Because the total drainage area is less than ten square miles, the same rainfall depths were applied to both basins.HMR-52 also produces a 72-hour, critically stacked temporal distribution by arranging the incremental rainfall depths to produce the rainfall hyetograph shown in Figure 7.

Table 7 – HMR-52 Point Rainfall Depths

Storm Duration (hr)	Depth (in)
1	15.58
2	19.55
3	22.66
6	28.56
12	34.52
24	39.21
48	43.47
72	45.87

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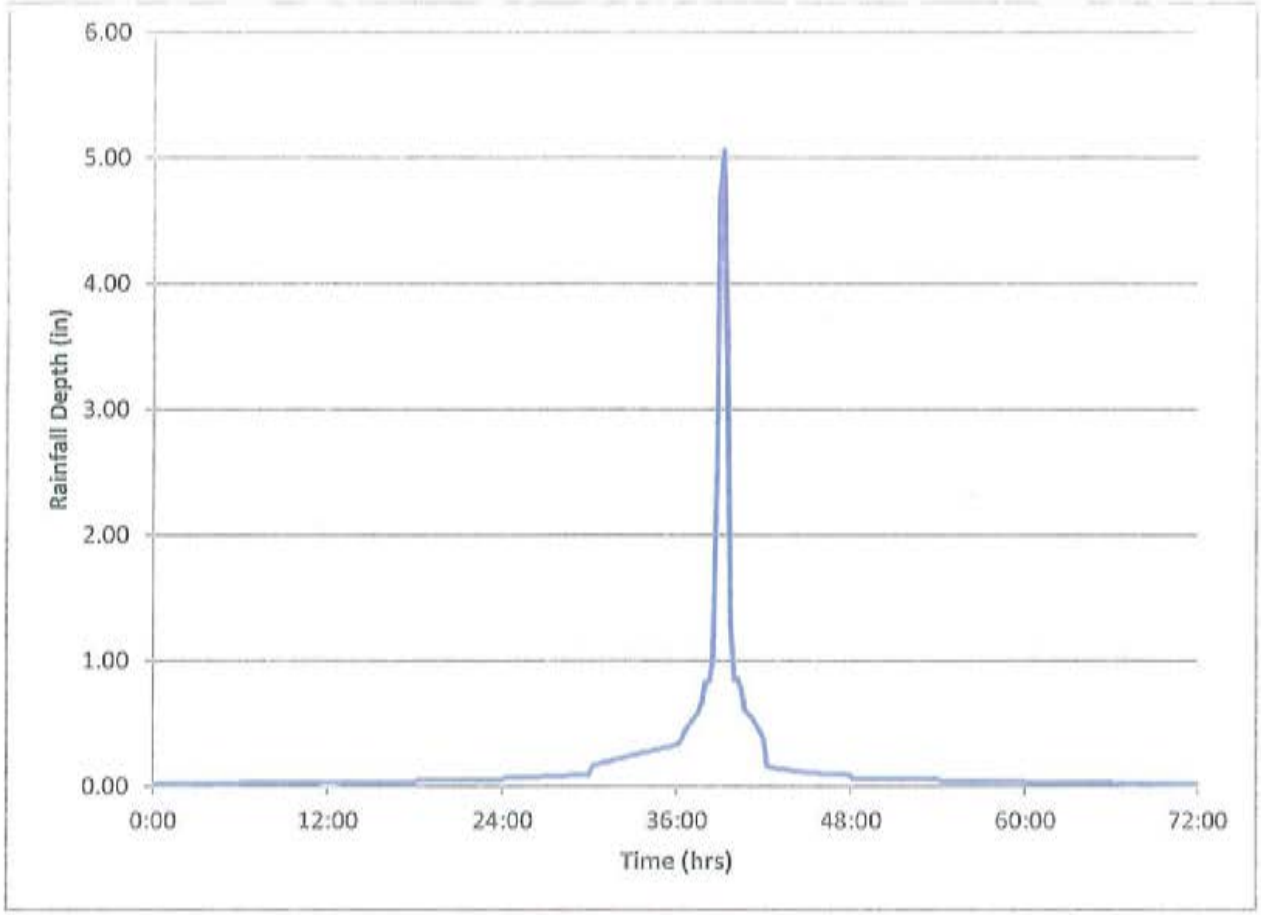

Figure 7 – PMP Rainfall Hyetograph

The PMF was modeled, as described previously, with flood routing started at both elevation 623.0 ft-msl and elevation 625.0 ft-msl. According to the Oklahoma Water Resources Board (OWRB) [10] regulations, the Bottom Ash Pond dam is classified as a small-size dam. The hazard classification may be either low or significant depending on the effects of a dam breach on a railroad bridge downstream. For this analysis, the hazard classification was assumed to be significant. This assumption will be evaluated upon completion of the breach analysis. A dam with a hazard classification of significant is required to pass 40% of the PMF to be in compliance with the OWRB regulations. Table 8 contains the results of these PMF model runs.

Table 8 – 0.4 PMF Model Results

Initial Elevation (ft-msl)	Peak Elevation (ft-msl)	Peak Inflow (cfs)	Peak Outflow (cfs)
623.0	627.87	1,490	344
625.0	628.15	1,490	396

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3.0 SUMMARY AND CONCLUSIONS

Based on the results of the hydrologic analysis, the Bottom Ash Pond Dam is hydraulically adequate for the 40% PMF event. Table 9 lists the pertinent elevation data for the dam, including the top of dam elevation and spillway crest elevation. Comparing these elevations to the maximum water surface elevations shown in Table 10 indicates that the dam would safely contain all flood events up to, and including, the 40% PMF. Additionally, while the normal pool elevation is maintained at elevation 623.0 ft-msl by pumping operations, the spillway is engaged during the 10-year storm event.

Table 9 – Pertinent Dam Information

Top of Dam (ft-msl)	Spillway Crest (ft-msl)	Operating Level (ft-msl)
630.0	625.0	623.0

Table 10 – Summary of Results

Initial Elevation (ft-msl)	10-year	0.4 PMF
623.0	625.28	627.87
625.0	626.28	628.15

It should be noted that these results reflect the best understanding of existing conditions and could be significantly affected by major changes to the reservoir. The assumptions in this analysis represent average reservoir conditions. In its current condition, the Bottom Ash Pond associated with the Northeastern 3 & 4 Power Station is deemed to be hydraulically adequate for any storm event up to, and including, the 40% PMF. Pertinent drawings for existing conditions are included in Appendix C.

NE34P000222

Appendix A
References

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References

1. U.S. Army Corps of Engineers, Hydrologic Engineering Center: *Hydrologic Modeling System HEC-HMS - User's Manual Version 3.5*, Davis, California, August 2010.

2. Henderson Aerial Survey, Inc. *Northeastern Plant*. [computer map]. 1"=50'. Grove City, Ohio, March 31, 2010.

3. "Soil Data Mart." *NRCS Soil Survey Geographic (SSURGO) Database*. <http://soildatamart.nrcs.usda.gov>.

4. U.S. Department of Agriculture, Aerial Photography Field Office: *National Agriculture Imagery Program*, Salt Lake City, UT, 2010. <http://gis.apfo.usda.gov/arcgis/services>.

5. U.S. Army Corps of Engineers, Hydrologic Engineering Center: *River Analysis System - User's Manual Version 4.1*, Davis, California, January 2010.

6. U.S. Department of Commerce, National Oceanic and Atmospheric Administration: *Technical Memorandum NWS HYDRO-35, Five- to 60-Minute Precipitation Frequency for the Eastern and Central United States*, Silver Spring, MD, June 1977.

7. U.S. Department of Commerce, Weather Bureau: *Technical Paper No. 40, Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years*, Washington, D.C., May 1961.

8. U.S. Department of Commerce, National Oceanic and Atmospheric Administration and U.S. Department of the Army, Corps of Engineers: *Hydrometeorological Report No. 52, Application of Probable Maximum Precipitation Estimates, United States East of the 105th Meridian*, Washington, D.C., 1982.

9. U.S. Department of Commerce, National Oceanic and Atmospheric Administration and U.S. Department of the Army, Corps of Engineers: *Hydrometeorological Report No. 51, Probable Maximum Precipitation Estimates, United States East of the 105th Meridian*, Washington, D.C., 1978.

10. Oklahoma Water Resources Board, Dam Safety Program: *Hazard Potential Classification: Guidelines for Dams in Oklahoma*. January 2011.

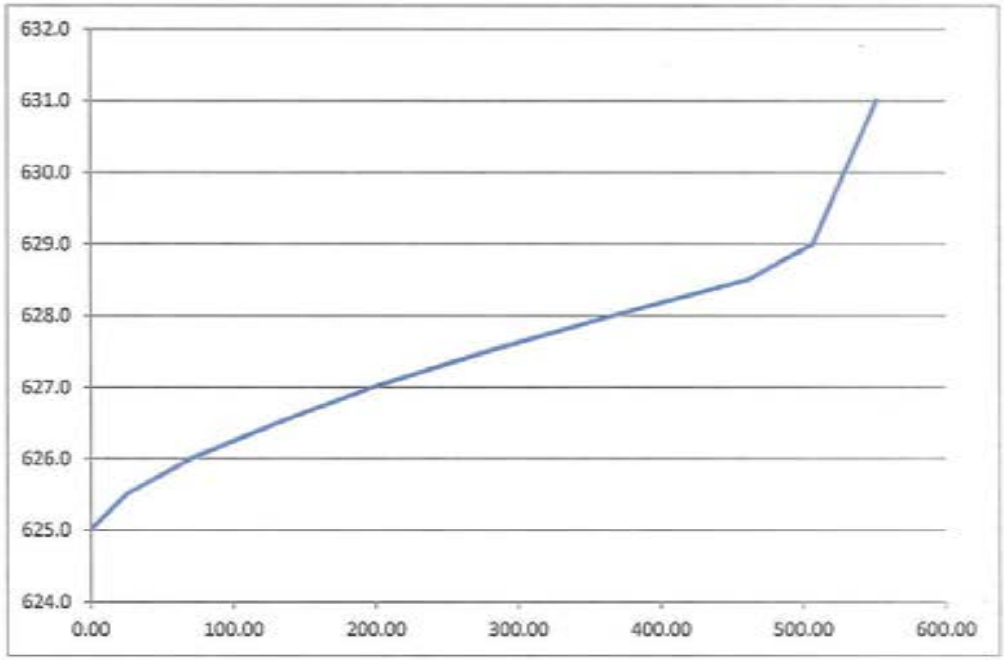
Appendix B
Discharge Rating Curve Calculations and Hydrologic Parameters

NE34P000222

Discharge Rating Curve
Overflow Structure

Elevation [ft-msl]	Discharge [cfs]
625.0	0.00
625.5	24.86
626.0	70.65
626.5	131.08
627.0	198.65
627.5	279.03
628.0	367.27
628.5	461.54
629.0	506.74
629.5	517.98
630.0	529.21
630.5	540.45
631.0	551.69
631.5	562.92

RAS Results	
Elevation [ft-msl]	Discharge [cfs]
625	0
625.07	1
625.2	10
625.44	20
625.81	50
626.27	100
627.01	200
627.63	300
628.18	400
628.7	500
633.15	600
640.02	700



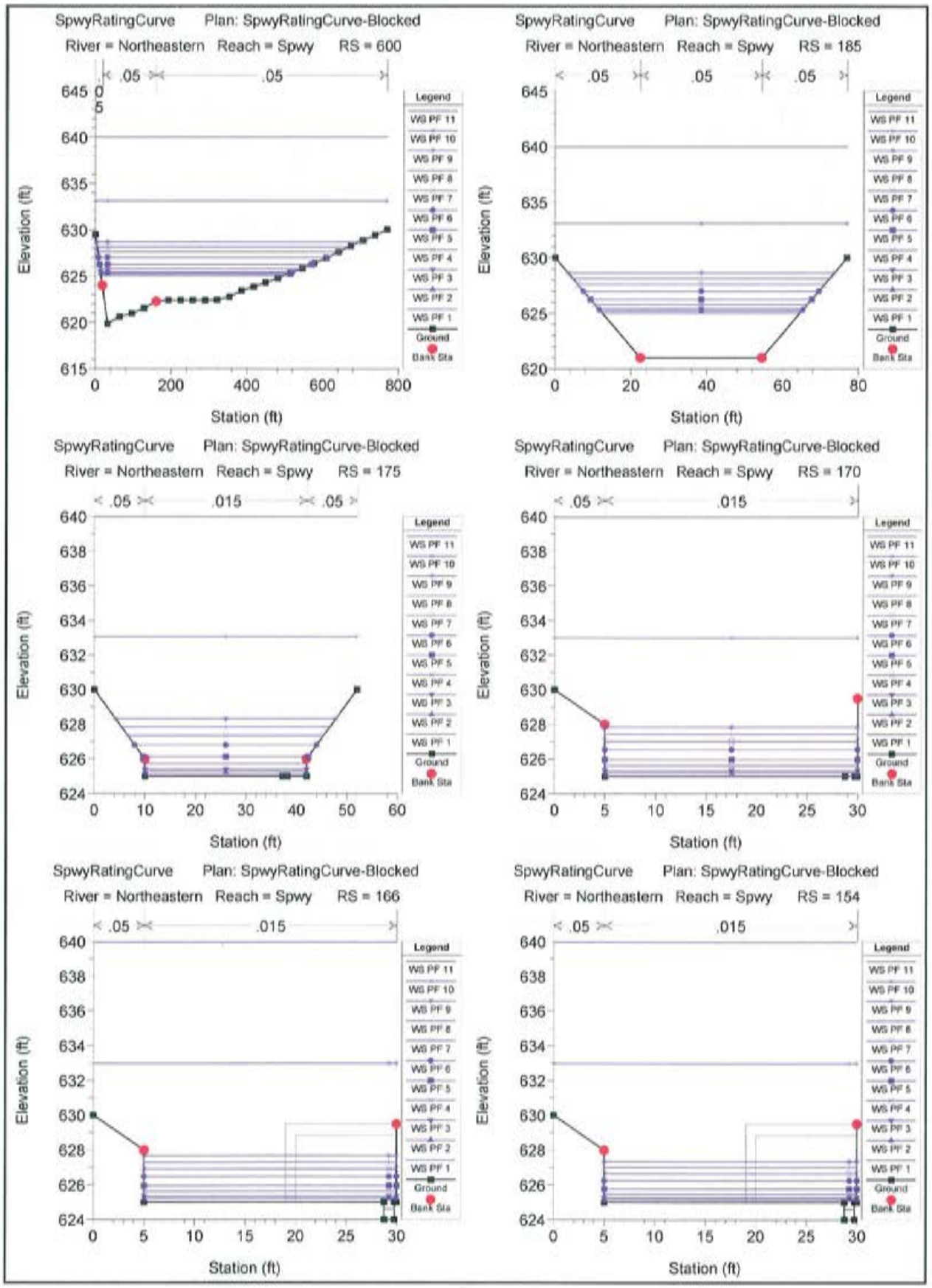
**Accounts for Discharge in DS Culverts*

HEC-RAS Plan: SPRC_BL River: Northeastern Reach: Spwy

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Spwy	600	PF 1	1.00	619.86	625.07		625.07	0.000000	0.00	1231.66	484.24	0.00
Spwy	600	PF 2	10.00	619.86	625.28		625.28	0.000000	0.01	1336.14	496.46	0.00
Spwy	600	PF 3	20.00	619.86	625.44		625.44	0.000000	0.02	1416.77	506.75	0.00
Spwy	600	PF 4	50.00	619.86	625.81		625.81	0.000000	0.04	1606.45	532.03	0.00
Spwy	600	PF 5	100.00	619.86	626.27		626.27	0.000001	0.07	1859.02	560.46	0.01
Spwy	600	PF 6	200.00	619.86	627.01		627.01	0.000001	0.11	2290.88	603.90	0.01
Spwy	600	PF 7	300.00	619.86	627.63		627.63	0.000002	0.14	2674.13	637.24	0.01
Spwy	600	PF 8	400.00	619.86	628.18		628.19	0.000002	0.17	3035.76	666.36	0.01
Spwy	600	PF 9	500.00	619.86	628.70		628.70	0.000003	0.19	3386.70	695.48	0.01
Spwy	600	PF 10	600.00	619.86	633.15		633.15	0.000000	0.11	6765.67	770.65	0.01
Spwy	600	PF 11	700.00	619.86	640.02		640.02	0.000000	0.07	12057.71	770.65	0.00
Spwy	185	PF 1	1.00	621.00	625.07		625.07	0.000000	0.01	171.72	52.36	0.00
Spwy	185	PF 2	10.00	621.00	625.28		625.28	0.000001	0.06	182.96	53.42	0.01
Spwy	185	PF 3	20.00	621.00	625.44		625.44	0.000002	0.12	191.57	54.22	0.01
Spwy	185	PF 4	50.00	621.00	625.81		625.81	0.000010	0.27	211.60	56.04	0.02
Spwy	185	PF 5	100.00	621.00	626.27		626.27	0.000028	0.48	237.89	58.33	0.04
Spwy	185	PF 6	200.00	621.00	627.00		627.01	0.000069	0.81	282.07	62.01	0.06
Spwy	185	PF 7	300.00	621.00	627.61		627.63	0.000107	1.08	320.80	65.05	0.07
Spwy	185	PF 8	400.00	621.00	628.16		628.18	0.000140	1.31	357.11	67.79	0.09
Spwy	185	PF 9	500.00	621.00	628.67		628.69	0.000169	1.50	392.17	70.33	0.10
Spwy	185	PF 10	600.00	621.00	633.13		633.15	0.000039	0.98	731.69	77.00	0.05
Spwy	185	PF 11	700.00	621.00	640.01		640.01	0.000011	0.69	1261.22	77.00	0.03
Spwy	175	PF 1	1.00	625.00	625.07		625.07	0.000792	0.46	2.17	32.00	0.31
Spwy	175	PF 2	10.00	625.00	625.26		625.28	0.000917	1.21	8.29	32.00	0.42
Spwy	175	PF 3	20.00	625.00	625.40		625.44	0.000852	1.55	12.89	32.00	0.43
Spwy	175	PF 4	50.00	625.00	625.73		625.80	0.000755	2.14	23.35	32.00	0.44
Spwy	175	PF 5	100.00	625.00	626.14		626.26	0.000694	2.74	36.58	32.71	0.45
Spwy	175	PF 6	200.00	625.00	626.81		626.99	0.000597	3.45	59.45	36.03	0.45
Spwy	175	PF 7	300.00	625.00	627.36		627.60	0.000544	3.94	80.27	38.82	0.45
Spwy	175	PF 8	400.00	625.00	627.87		628.15	0.000502	4.30	100.48	41.34	0.45
Spwy	175	PF 9	500.00	625.00	628.34		628.66	0.000466	4.59	120.62	43.71	0.44
Spwy	175	PF 10	600.00	625.00	633.07		633.14	0.000032	2.17	359.78	52.00	0.13
Spwy	175	PF 11	700.00	625.00	639.99		640.01	0.000005	1.35	719.30	52.00	0.06
Spwy	170	PF 1	1.00	625.00	625.03	625.03	625.06	0.020524	1.35	0.74	25.00	1.39
Spwy	170	PF 2	10.00	625.00	625.22		625.27	0.002461	1.79	5.59	25.00	0.67
Spwy	170	PF 3	20.00	625.00	625.35		625.43	0.002331	2.31	8.64	25.00	0.69
Spwy	170	PF 4	50.00	625.00	625.63		625.79	0.002041	3.18	15.73	25.00	0.71
Spwy	170	PF 5	100.00	625.00	625.98		626.24	0.001952	4.10	24.41	25.00	0.73
Spwy	170	PF 6	200.00	625.00	626.54		626.96	0.001760	5.18	38.60	25.00	0.73
Spwy	170	PF 7	300.00	625.00	627.02		627.57	0.001730	5.95	50.41	25.00	0.74
Spwy	170	PF 8	400.00	625.00	627.44		628.11	0.001686	6.55	61.06	25.00	0.74
Spwy	170	PF 9	500.00	625.00	627.85		628.61	0.001636	7.02	71.21	25.00	0.73
Spwy	170	PF 10	600.00	625.00	633.00		633.13	0.000090	2.95	220.04	30.00	0.18
Spwy	170	PF 11	700.00	625.00	639.96		640.01	0.000019	1.83	428.79	30.00	0.08
Spwy	166	PF 1	1.00	624.00	624.62	624.32	624.66	0.001489	1.62	0.62	1.00	0.36
Spwy	166	PF 2	10.00	624.00	625.22	625.13	625.26	0.001714	1.58	6.35	24.00	0.54
Spwy	166	PF 3	20.00	624.00	625.34	625.24	625.42	0.001992	2.16	9.25	24.00	0.61
Spwy	166	PF 4	50.00	624.00	625.62	625.47	625.78	0.002088	3.13	16.00	24.00	0.67
Spwy	166	PF 5	100.00	624.00	625.95	625.77	626.23	0.002305	4.19	23.87	24.00	0.74
Spwy	166	PF 6	200.00	624.00	626.48	626.25	626.95	0.002386	5.47	36.57	24.00	0.78
Spwy	166	PF 7	300.00	624.00	626.92	626.65	627.55	0.002464	6.39	46.98	24.00	0.80
Spwy	166	PF 8	400.00	624.00	627.31	627.01	628.09	0.002509	7.10	56.34	24.00	0.82
Spwy	166	PF 9	500.00	624.00	627.67	627.34	628.59	0.002548	7.70	64.96	24.00	0.82
Spwy	166	PF 10	600.00	624.00	632.99	627.64	633.13	0.000235	3.08	209.47	30.00	0.16
Spwy	166	PF 11	700.00	624.00	639.96	627.94	640.01	0.000041	1.86	418.55	30.00	0.08
Spwy	154	PF 1	1.00	624.00	624.60	624.32	624.64	0.001636	1.68	0.60	1.00	0.38
Spwy	154	PF 2	10.00	624.00	625.17	625.13	625.23	0.003413	1.94	5.15	24.00	0.74
Spwy	154	PF 3	20.00	624.00	625.27	625.24	625.38	0.003801	2.63	7.59	24.00	0.82
Spwy	154	PF 4	50.00	624.00	625.48	625.47	625.73	0.004764	4.03	12.41	24.00	0.99
Spwy	154	PF 5	100.00	624.00	625.77	625.77	626.18	0.004351	5.11	19.58	24.00	1.00
Spwy	154	PF 6	200.00	624.00	626.25	626.25	626.90	0.004034	6.46	30.95	24.00	1.00
Spwy	154	PF 7	300.00	624.00	626.65	626.65	627.50	0.003873	7.39	40.61	24.00	1.00
Spwy	154	PF 8	400.00	624.00	627.01	627.01	628.03	0.003766	8.11	49.34	24.00	1.00
Spwy	154	PF 9	500.00	624.00	627.34	627.34	628.53	0.003732	8.73	57.26	24.00	1.00
Spwy	154	PF 10	600.00	624.00	632.99	627.64	633.13	0.000236	3.08	209.38	30.00	0.16
Spwy	154	PF 11	700.00	624.00	639.96	627.94	640.01	0.000041	1.86	418.53	30.00	0.08
Spwy	152	PF 1	1.00	624.00	624.59		624.64	0.001663	1.69	0.59	1.00	0.39
Spwy	152	PF 2	10.00	624.00	625.15	625.12	625.22	0.004604	2.10	4.76	25.00	0.85
Spwy	152	PF 3	20.00	624.00	625.24	625.23	625.37	0.004957	2.82	7.08	25.00	0.94
Spwy	152	PF 4	50.00	624.00	625.47	625.46	625.71	0.004456	3.92	12.75	25.00	0.97
Spwy	152	PF 5	100.00	624.00	625.76	625.74	626.16	0.003840	4.90	20.39	25.00	0.96
Spwy	152	PF 6	200.00	624.00	626.23	626.22	626.85	0.003684	6.31	31.68	25.00	0.99

HEC-RAS Plan: SPRC_BL River: Northeastern Reach: Spwy (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Spwy	152	PF 7	300.00	624.00	626.63	626.60	627.43	0.003411	7.18	41.81	25.00	0.98
Spwy	152	PF 8	400.00	624.00	626.96	626.94	627.95	0.003332	7.92	50.49	25.00	0.98
Spwy	152	PF 9	500.00	624.00	627.29	627.26	628.43	0.003299	8.57	58.36	25.00	0.99
Spwy	152	PF 10	600.00	624.00	632.99		633.13	0.000095	2.94	220.82	30.00	0.18
Spwy	152	PF 11	700.00	624.00	639.96		640.01	0.000020	1.82	429.76	30.00	0.08
Spwy	151	PF 1	1.00	624.00	624.59		624.63	0.001680	1.70	0.59	1.00	0.39
Spwy	151	PF 2	10.00	624.00	625.12	625.12	625.22	0.007571	2.44	4.10	25.00	1.06
Spwy	151	PF 3	20.00	624.00	625.23	625.23	625.37	0.006126	3.01	6.64	25.00	1.03
Spwy	151	PF 4	50.00	624.00	625.46	625.46	625.71	0.004890	4.03	12.40	25.00	1.01
Spwy	151	PF 5	100.00	624.00	625.74	625.74	626.15	0.004453	5.13	19.48	25.00	1.02
Spwy	151	PF 6	200.00	624.00	626.22	626.22	626.65	0.003789	6.37	31.41	25.00	1.00
Spwy	151	PF 7	300.00	624.00	626.59	626.59	627.43	0.003686	7.35	40.80	25.00	1.01
Spwy	151	PF 8	400.00	624.00	626.94	626.94	627.95	0.003540	8.08	49.53	25.00	1.01
Spwy	151	PF 9	500.00	624.00	627.26	627.26	628.43	0.003449	8.69	57.54	25.00	1.01
Spwy	151	PF 10	600.00	624.00	632.99		633.12	0.000117	2.99	200.65	25.00	0.19
Spwy	151	PF 11	700.00	624.00	639.95		640.01	0.000029	1.97	374.86	25.00	0.08
Spwy	114	PF 1	1.00	610.00	610.08		610.08	0.000854	0.52	1.92	25.00	0.33
Spwy	114	PF 2	10.00	610.00	610.22		610.27	0.002417	1.78	5.62	25.00	0.66
Spwy	114	PF 3	20.00	610.00	610.34		610.43	0.002505	2.36	8.46	25.00	0.72
Spwy	114	PF 4	50.00	610.00	610.59	610.49	610.77	0.002574	3.41	14.65	25.00	0.79
Spwy	114	PF 5	100.00	610.00	611.22		611.39	0.000952	3.28	30.49	25.00	0.52
Spwy	114	PF 6	200.00	610.00	613.17		613.27	0.000189	2.52	79.22	25.00	0.25
Spwy	114	PF 7	300.00	610.00	616.21		616.27	0.000057	1.93	155.31	25.00	0.14
Spwy	114	PF 8	400.00	610.00	620.63		620.67	0.000022	1.51	265.76	25.00	0.08
Spwy	114	PF 9	500.00	610.00	626.30		626.33	0.000011	1.23	407.61	25.00	0.05
Spwy	114	PF 10	600.00	610.00	633.07		633.09	0.000007	1.04	576.75	25.00	0.04
Spwy	114	PF 11	700.00	610.00	639.98		640.00	0.000005	0.93	749.56	25.00	0.03
Spwy	109	PF 1	1.00	610.00	610.07	610.03	610.08	0.001103	0.56	1.78	25.00	0.37
Spwy	109	PF 2	10.00	610.00	610.17	610.17	610.26	0.005799	2.32	4.32	25.00	0.98
Spwy	109	PF 3	20.00	610.00	610.27	610.27	610.41	0.005192	2.95	6.78	25.00	1.00
Spwy	109	PF 4	50.00	610.00	610.49	610.49	610.75	0.004480	4.04	12.37	25.00	1.01
Spwy	109	PF 5	100.00	610.00	611.21		611.38	0.000967	3.29	30.35	25.00	0.53
Spwy	109	PF 6	200.00	610.00	613.17		613.27	0.000189	2.53	79.19	25.00	0.25
Spwy	109	PF 7	300.00	610.00	616.21		616.27	0.000057	1.93	155.31	25.00	0.14
Spwy	109	PF 8	400.00	610.00	620.63		620.67	0.000022	1.51	265.76	25.00	0.08
Spwy	109	PF 9	500.00	610.00	626.30		626.33	0.000011	1.23	407.60	25.00	0.05
Spwy	109	PF 10	600.00	610.00	633.07		633.09	0.000007	1.04	576.75	25.00	0.04
Spwy	109	PF 11	700.00	610.00	639.98		640.00	0.000005	0.93	749.56	25.00	0.03
Spwy	100	PF 1	1.00	610.00	610.03	610.03	610.04	0.014233	1.03	0.97	38.00	1.13
Spwy	100	PF 2	10.00	610.00	610.13	610.13	610.19	0.006603	2.06	4.85	38.00	1.02
Spwy	100	PF 3	20.00	610.00	610.21	610.21	610.31	0.005602	2.56	7.80	38.00	1.00
Spwy	100	PF 4	50.00	610.00	610.38	610.38	610.57	0.004696	3.49	14.31	38.00	1.00
Spwy	100	PF 5	100.00	610.00	611.28	610.60	611.35	0.000330	2.05	48.89	39.41	0.32
Spwy	100	PF 6	200.00	610.00	613.21	610.95	613.25	0.000060	1.62	134.10	49.04	0.16
Spwy	100	PF 7	300.00	610.00	616.24	611.24	616.26	0.000014	1.21	293.06	53.00	0.09
Spwy	100	PF 8	400.00	610.00	620.65	611.51	620.66	0.000004	0.94	526.73	53.00	0.05
Spwy	100	PF 9	500.00	610.00	626.31	611.75	626.32	0.000002	0.77	827.16	53.00	0.03
Spwy	100	PF 10	600.00	610.00	633.06	611.98	633.06	0.000001	0.66	1165.60	53.00	0.02
Spwy	100	PF 11	700.00	610.00	639.99	612.19	639.99	0.000000	0.59	1551.88	53.00	0.02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River = Northeastern Reach = Spwy RS = 600
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Elevation (ft)
Station (ft)
Legend
WS PF 11
WS PF 10
WS PF 9
WS PF 8
WS PF 7
WS PF 6
WS PF 5
WS PF 4
WS PF 3
WS PF 2
WS PF 1
Ground
Bank Sta
SpwyRatingCurve Plan: SpwyRatingCurve-Blocked
River = Northeastern Reach = Spwy RS = 185
.05 .05 .05
SpwyRatingCurve Plan: SpwyRatingCurve-Blocked
River = Northeastern Reach = Spwy RS = 175
.05 .015 .05
SpwyRatingCurve Plan: SpwyRatingCurve-Blocked
River = Northeastern Reach = Spwy RS = 170
.05 .015
SpwyRatingCurve Plan: SpwyRatingCurve-Blocked
River = Northeastern Reach = Spwy RS = 166
.05 .015
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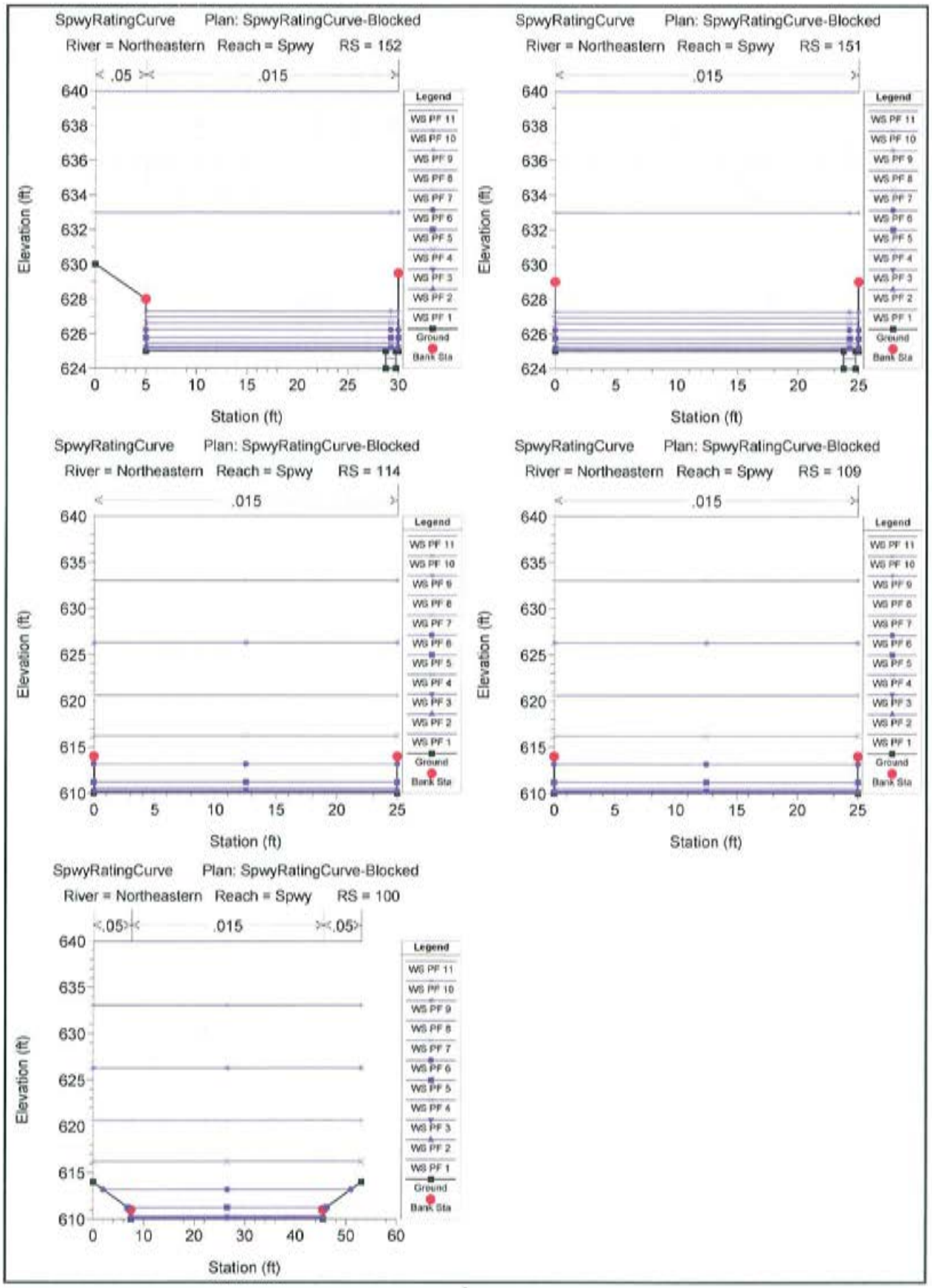
River = Northeastern Reach = Spwy RS = 154
.05 .015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River = Northeastern Reach = Spwy RS = 152
.05
.015
Elevation (ft)
Station (ft)
Legend
WS PF 11
WS PF 10
WS PF 9
WS PF 8
WS PF 7
WS PF 6
WS PF 5
WS PF 4
WS PF 3
WS PF 2
WS PF 1
Ground
Bank Sta
SpwyRatingCurve Plan: SpwyRatingCurve-Blocked
River = Northeastern Reach = Spwy RS = 151
.015
Elevation (ft)
Station (ft)
SpwyRatingCurve Plan: SpwyRatingCurve-Blocked
River = Northeastern Reach = Spwy RS = 114
.015
Elevation (ft)
Station (ft)
SpwyRatingCurve Plan: SpwyRatingCurve-Blocked
River = Northeastern Reach = Spwy RS = 109
.015
Elevation (ft)
Station (ft)
SpwyRatingCurve Plan: SpwyRatingCurve-Blocked
River = Northeastern Reach = Spwy RS = 100
.05
.015
.05
Elevation (ft)
Station (ft)

BASIN LAG TIME CALCULATION (Existing)

USING NRCS TR55 METHOD TO COMPUTE TIME OF CONCENTRATION

Existing Conditions

Project Data:		Comments:
PROJECT	Northeastern Station	
LOCATION	Oologah, OK	
DATE	Apr-11	
BASIN COND.		
BY:	JPM	
WSHED NAME	West	

SHEET FLOW: (100' MAX)

Land Use Undeveloped	n value	% Land use	Inc n
Conc.,gravel,asphalt,bare soil	0.015	0	0
Grass Short Prairie	0.15	0	0
Maintained Grass	0.03	0	0
Woods Light Underbrush	0.4	0	0
Woods Dense underbrush	0.8	0	0

based on information for imperviousness from Corps of Engineers

Land Use	% Conc	% Grass	n value	% Land Use	Inc n
Low D. Residential (1+ Acres)	25	75	0.21375	0	0
Med. D. Residential (1/3 Acres)	41	59	0.17135	0	0
High D. Residential (1/4 Acres)	47	53	0.15545	0	0
Multifamily	70	30	0.0945	0	0
Mobile Home Parks	20	80	0.227	0	0
C.B.D.	95	5	0.02825	0	0
Strip Commercial	90	10	0.0415	0	0
Shopping Center	95	5	0.02825	0	0
Instutional-Schools	40	60	0.174	0	0
Industrial	90	10	0.0415	100	0.0415
Highway ROW	35	65	0.18725	0	0
Public Utilities	60	40	0.121	0	0
Vacant urban land and	6	84	0.2361	0	0
Parks	0	0	0	0	
Other	0	0	0	0	0
		TOTAL		100	0.0415

LENGTH	100	FT.	MAX 100'	
2 YR. 24 HOUR PRECIP	4.02	IN.		
SLOPE	0.01	FT/FT		

$$T_1 = 0.007 \times \frac{(n \times L)^{0.8}}{R^{0.5} \times S^{0.4}}$$

SHALLOW CONCENTRATED FLOW

1=PAVED 2=UNPAVED	2	
LENGTH	1010.04	FT
SLOPE	0.0050	FT/FT
COMPUTED VELOCITY FROM FIGURE 3.1=	1.131	

$$T_2 = \frac{L}{60 \times V}$$

CHANNEL FLOW

			TOPWIDTH	40
XSECT AREA=	125.000	SQ FT	BOTTOM	10
			DEPTH	5
WETTED PERIMETER	41.623	FT		
SLOPE	0.0063	FT/FT		
MANNINGS N	0.04			
COMPUTED VELOCITY	6.159	FT/S		
LENGTH	2060.49	FT		

$$V = \frac{1.49 \times \left(\frac{a}{P_w}\right)^{\frac{2}{3}} \times s^{\frac{1}{2}}}{n}$$

$$T_6 = \frac{L}{60 \times V}$$

	Conditions	Adjusted	NRCS Method	Selected
WATERSHED NUMBER	West	Tc (Min)	Tc (Min)	Tc (Min)
SHEET FLOW	Max 30 Min	30.0	4.13	4.13
SHALLOW CONCENTRATED FLOW			14.88	14.88
CHANNEL FLOW			5.58	5.58
TOTAL			24.59	24.59
			Lag (Hrs) =	0.25

$$T_c = T_1 + T_2 + T_3 + T_4 + T_5 + T_6$$

Lag (min) = 14.75

BASIN LAG TIME CALCULATION (Existing)

USING NRCS TR55 METHOD TO COMPUTE TIME OF CONCENTRATION

Existing Conditions

Project Data:		Comments:
PROJECT	Northeastern Station	
LOCATION	Oologah, OK	
DATE	Apr-11	
BASIN COND.		
BY:	JPM	
WSHED NAME	East	

SHEET FLOW: (100' MAX)

Land Use Undeveloped	n value	% Land use	Inc n
Conc.,gravel,asphalt,bare soil	0.015	0	0
Grass Short Prairie	0.15	100	0.15
Maintained Grass	0.03	0	0
Woods Light Underbrush	0.4	0	0
Woods Dense underbrush	0.8	0	0

based on information for imperviousness from Corps of Engineers

Land Use	% Conc	% Grass	n value	% Land Use	Inc n
Low D. Residential (1+ Acres)	25	75	0.21375	0	0
Med. D. Residential (1/3 Acres)	41	59	0.17135	0	0
High D. Residential (1/4 Acres)	47	53	0.15545	0	0
Multifamily	70	30	0.0945	0	0
Mobile Home Parks	20	80	0.227	0	0
C.B.D.	95	5	0.02825	0	0
Strip Commercial	90	10	0.0415	0	0
Shopping Center	95	5	0.02825	0	0
Instutional-Schools	40	60	0.174	0	0
Industrial	90	10	0.0415	0	0
Highway ROW	35	65	0.18725	0	0
Public Utilities	60	40	0.121	0	0
Vacant urban land and	6	84	0.2361	0	0
Parks	0	0	0	0	
Other	0	0	0	0	0
		TOTAL		100	0.15

LENGTH	100	FT.	MAX 100'	
2 YR. 24 HOUR PRECIP	4.02	IN.		
SLOPE	0.2	FT/FT		

$$T_t = 0.007 \times \frac{(n \times L)^{0.8}}{R^{0.5} \times S^{0.4}}$$

CHANNEL FLOW -- 1

			TOPWIDTH	30
XSECT AREA=	60.000	SQ FT	BOTTOM	10
			DEPTH	3
WETTED PERIMETER	30.881	FT		
SLOPE	0.0018	FT/FT		
MANNINGS N	0.04			
COMPUTED VELOCITY	2.478	FT/S		
LENGTH	1643.35	FT		

$$V = \frac{1.49 \times \left(\frac{a}{p_w}\right)^{\frac{2}{3}} \times s^{\frac{1}{2}}}{n}$$

$$T_6 = \frac{60 \times L}{60 \times V}$$

CHANNEL FLOW -- 2

			TOPWIDTH	40
XSECT AREA=	137.500	SQ FT	BOTTOM	15
			DEPTH	5
WETTED PERIMETER	41.926	FT		
SLOPE	0.0052	FT/FT		
MANNINGS N	0.04			
COMPUTED VELOCITY	5.912	FT/S		
LENGTH	1934.24	FT		

$$V = \frac{1.49 \times \left(\frac{a}{p_w}\right)^{\frac{2}{3}} \times s^{\frac{1}{2}}}{n}$$

$$T_6 = \frac{L}{60 \times V}$$

	Conditions	Adjusted	NRCS Method	Selected
WATERSHED NUMBER	East	Tc (Min)	Tc (Min)	Tc (Min)
SHEET FLOW	Max 30 Min	30.0	3.48	3.48
CHANNEL FLOW -- 1			11.05	11.05
CHANNEL FLOW -- 2			5.45	5.45
TOTAL			19.98	19.98
			Lag (Hrs) =	0.20

$$T_c = T_1 + T_2 + T_3 + T_4 + T_5 + T_6$$

Lag (min) = 11.99

NE34P000222

Curve Number

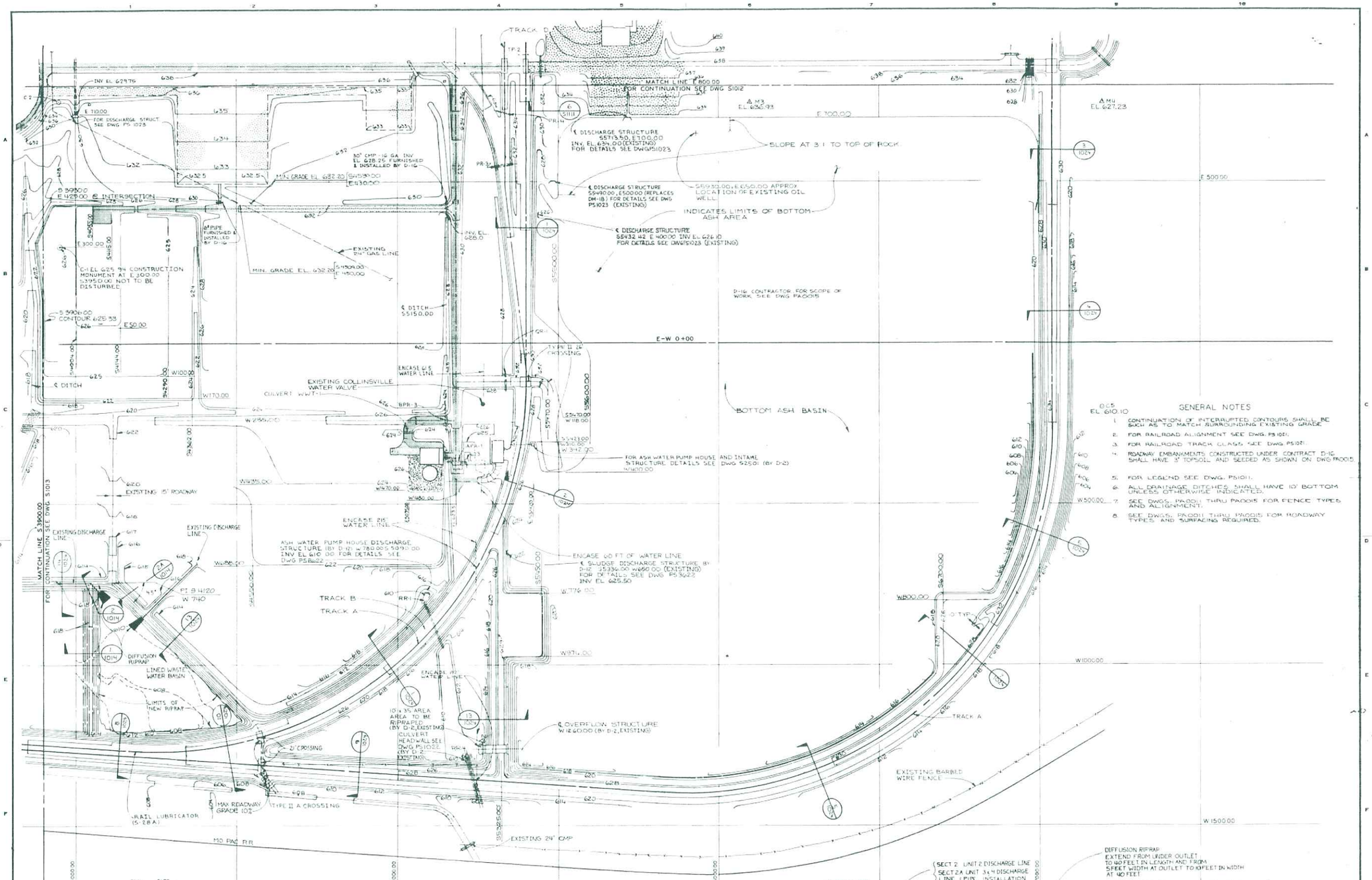
Basin	Land Use	CN	Area (ac)	Inc. CN	
West	Water	100	46.86	31.40	
West	Open Space - Poor	89	46.38	27.66	
West	Industrial	93	32.50	20.25	
West	Coal Pile	94	23.51	14.80	
					AMC III
		Total	**149.25**	**94.11**	**97.35**

Basin	Land Use	CN	Area (ac)	Inc. CN	
East	Open Space - Poor	89	12.68	22.63	
East	Coal Pile	94	37.19	70.10	
					AMC III
		Total	**49.87**	**92.73**	**96.70**

** All soils are Hydrologic Soil Group D*

Appendix C
Pertinent Drawings

NE34P000222



GENERAL NOTES

1. CONTINUATION OF INTERRUPTED CONTOURS SHALL BE SUCH AS TO MATCH SURROUNDING EXISTING GRADE.
2. FOR RAILROAD ALIGNMENT SEE DWG. PS1021.
3. FOR RAILROAD TRACK CLASS SEE DWG PS1021.
4. ROADWAY EMBANKMENTS CONSTRUCTED UNDER CONTRACT D-16 SHALL HAVE 3" TOPSOIL AND SEEDED AS SHOWN ON DWG PA0015.
5. FOR LEGEND SEE DWG. PS1011.
6. ALL DRAINAGE DITCHES SHALL HAVE 10' BOTTOM UNLESS OTHERWISE INDICATED.
7. SEE DWGS. PA0011 THRU PA0015 FOR FENCE TYPES AND ALIGNMENT.
8. SEE DWGS. PA0011 THRU PA0015 FOR ROADWAY TYPES AND SURFACING REQUIRED.

11-12-76	REVISED AS CIRCLED	13	UM	12						8-14-82	ISSUED FOR BIDS	17	TW	5-21	DC		
10-8-76	REVISED AS CIRCLED	12	UM	12						11-3-78	ADDED ROADWAY & CULVERT	16	JR	JG			
8-11-76	REVISED AS CIRCLED	11	ES	7-8						10-5-78	REVISED AS CIRCLED	15	JR	5-21			
5-14-76	REVISED AS CIRCLED	10	BM	5						9-22-78	ISSUED FOR BIDS, SPEC D-12	14	JR	5-21			
3-12-76	REVISED AS CIRCLED	9	LB	2-4													

NO.	BY	CK	APP
21	JR	JG	
20	SB	DC	
19	SB	DC	
18	SB	DC	

DATE	REVISIONS AND RECORD OF ISSUE
8-14-82	ISSUED FOR BIDS, SPEC D-12
5-21-82	ISSUED FOR ADDENDUM 1, SPEC D-12
5-6-82	ISSUED FOR BIDS, SPEC D-12

SCALE: 1:100 50 0 100 200'

DRAWN: CLM
CHECKED: MDJ

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF OKLAHOMA

DATE 5/29/75 REG. NO. 8892

BLACK & VEATCH
CONSULTING ENGINEERS
PROJECT 6571/6572

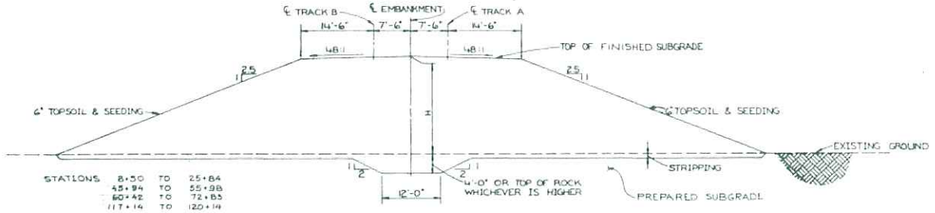
PUBLIC SERVICE COMPANY OF OKLAHOMA
NORTHEASTERN STATION - UNITS 3 & 4

SITE GRADING
PLANT SITE AREA IV

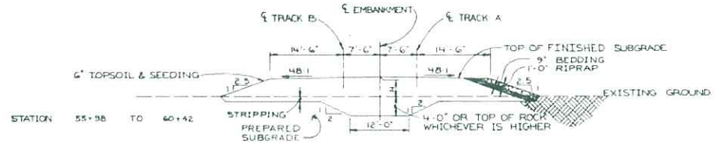
DWG. NO. PS1C14
REV. 21
PROJ. NO. 85127-E

CUT 1012

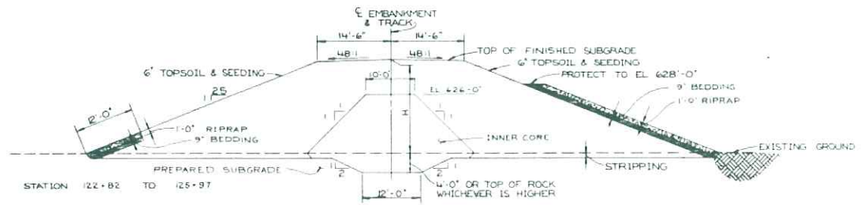
NE34P000222



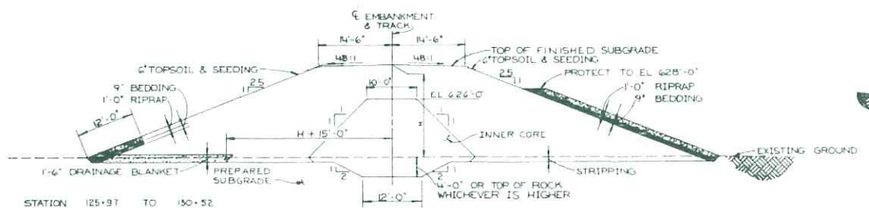
TYPICAL SECTION 1



TYPICAL SECTION 2



IMPERVIOUS ENBANKMENT SECTION 3



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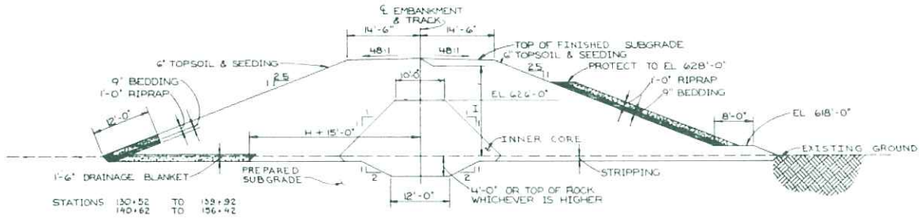

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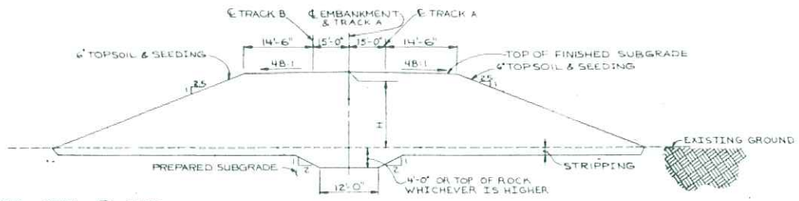
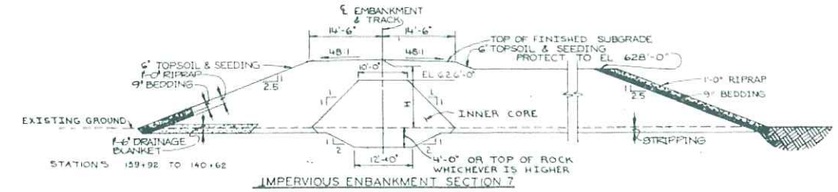
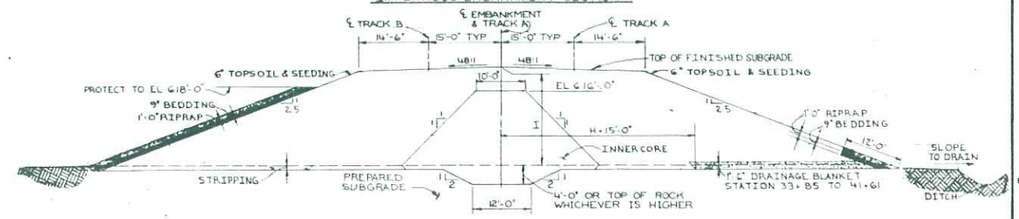


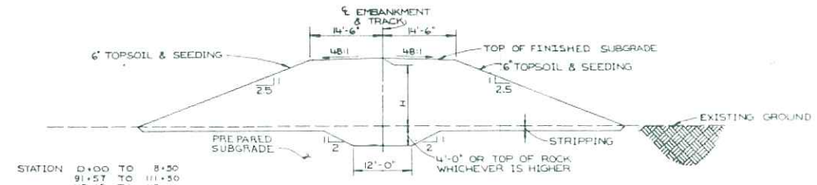
IMPERVIOUS EMBANKMENT SECTION 6



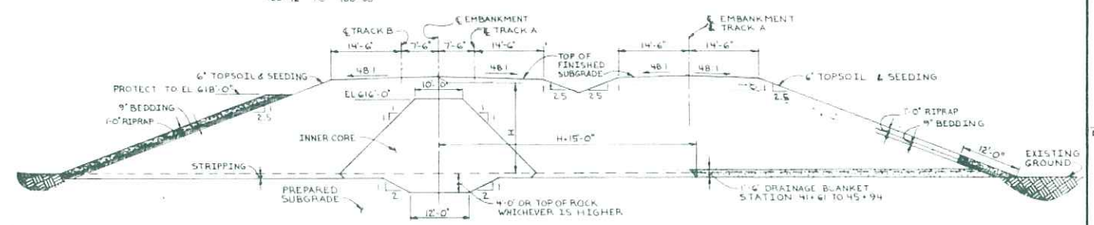
IMPERVIOUS ENBANKMENT SECTION 7



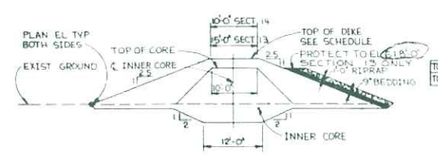
IMPERVIOUS ENBANKMENT SECTION 8



TYPICAL SECTION 9



IMPERVIOUS ENBANKMENT SECTION 10



IMPERVIOUS EMBANKMENT SECTION 13 & 14

SECTION 13 & 14 SCHEDULE	WASTE WATER POND	BOTTOM ASH POND
TOP DIKE	EL 618.0	EL 629.0
TOP CORE	EL 616.0	EL 626.0

GENERAL NOTES

1. EACH SECTION IS FACING TOWARD INCREASING STATION NUMBER
2. FINISHED AND PREPARED SUBGRADE SHALL BE CONSTRUCTED AS REQUIRED BY SPECIFICATION D-2.

				2-12-82	CONFORMED TO CONSTRUCTION RECORDS	8	JR				
				6-1-78	REVISED EMBANKMENT SECTION 7	7	PM				
				3-12-76	GENERAL REVISIONS	6	TD	TR			
				11-6-75	GENERAL REVISIONS	5	CB				
				9-29-75	GENERAL REVISIONS	4	JR				
				8-29-75	REV & ISSUED FOR CONTRACT & CONST. SPEC D-2	3	NH	TD			
				7-17-75	REVISED & ISSUED FOR ADDENDUM 1 - SPEC D-2	2		TD			
				6-13-75	REVISED & ISSUED FOR BIDS, SPEC D-2	1		TD			
				5-8-75	ISSUED FOR PSO REVIEW	0		TD			
				DATE	REVISIONS AND RECORD OF ISSUE	NO.	BY	CK	APP		

SCALE: 1" = 10'

I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF OKLAHOMA.

BLACK & VEATCH CONSULTING ENGINEERS
PROJECT 6571/6572

PUBLIC SERVICE COMPANY OF OKLAHOMA
NORTHEASTERN STATION - UNITS 3 & 4

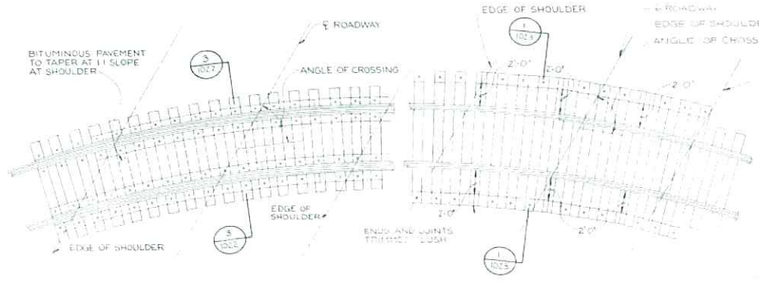
EMBANKMENT DETAILS

DWG. NO. PS1024

REV. 8

85127-E

NE34P000222

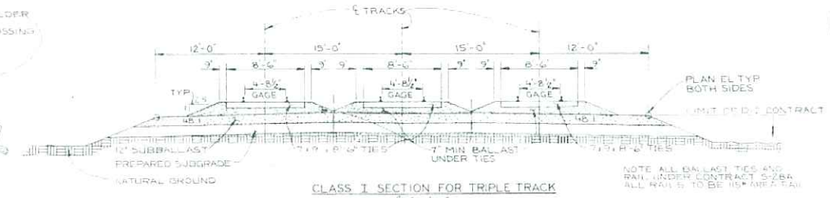


TYPE II A
CURVES 12°30' OR LESS

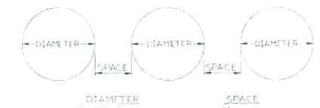
CURVED TRACK
NO SCALE

TYPE III
CURVES GREATER THAN 12°30'

TYPICAL RAILROAD CROSSINGS

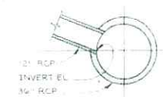


CLASS I SECTION FOR TRIPLE TRACK
SCALE 3/16" = 1'-0"

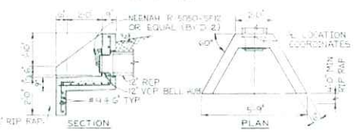


DIAMETER	SPACE
UP TO 24"	12"
30" TO 72"	½ DIA. OF PIPE
72" AND OVER	36"

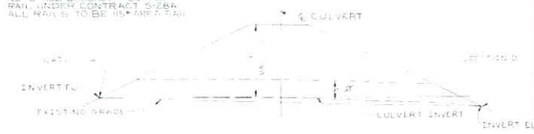
TYPICAL CULVERT SPACING
NO SCALE



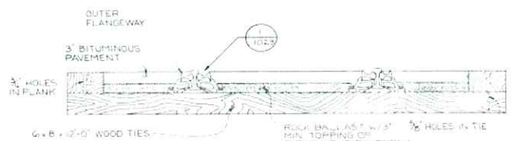
STORM SEWER "Y" CONNECTION
SCALE: 3/16" = 1'-0"



ASH WATER PUMPHOUSE DISCHARGE STRUCTURE
SCALE: 3/16" = 1'-0"
SEE DWG PS1011

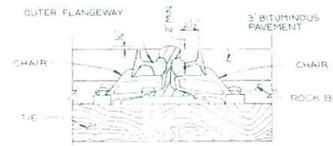


TYPICAL DRAINAGE CULVERT SECTION
NO SCALE

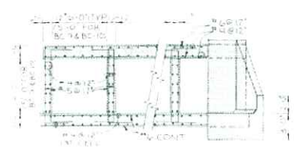


SECTION 1
NO SCALE
SEE TURN DWG

NOTES
1. 6"x8" WOOD PLANKS
2. ¾"x10" WASHER HEAD TIMBER DRIVE SPIKE
3. SEE RAILROAD CROSSING NOTES DWG PS1001

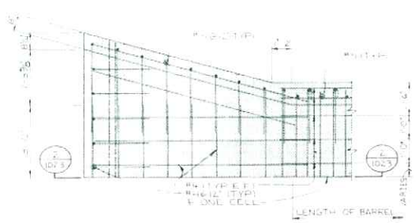


DETAIL 1
NO SCALE

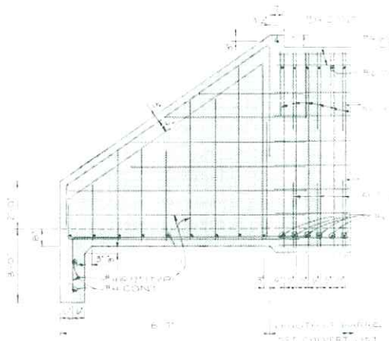


TYPICAL BOX CULVERT SECTION W/WINGWALL AND APRON
SCALE: 3/16" = 1'-0"

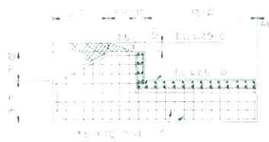
BOX CULVERT NOTES
FOR WINGWALL AND APRON DETAILS SEE THIS SHEET
CONCRETE SHALL HAVE MIN 28 DAY COMPRESSIVE STRENGTH OF 3000 PSI
STEEL REINFORCEMENT SHALL CONSIST OF DEFORMED BARS GRADE 60
CONSTRUCTION PLANE CONFORMS TO AREA NATURAL CHANNEL BED
BOTTOM HAVE A CROWN W/FLOAT FINISH



BOX CULVERT
WINGWALL & APRON PLAN
SCALE: 3/16" = 1'-0"

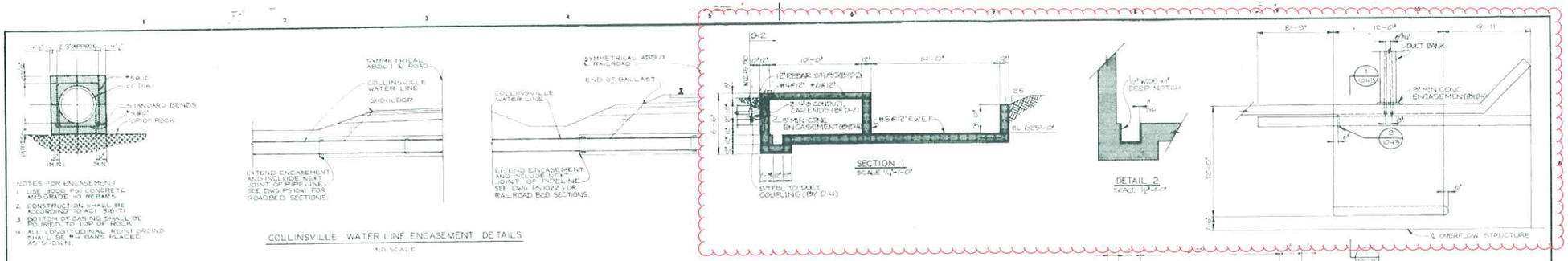


SECTION 2
SCALE: 3/16" = 1'-0"
SEE THIS DWG



HALF SECTION
ANTI-SEEP COLLAR

DRAINAGE CULVERT LIST																		
		CULVERT NO	CENTER LINE LOCATION SOUTH	CENTER LINE LOCATION E.W.	Ø DIAM	NO OF UNITS	NOTES	SIZE GAGE	SIZE CORR SUR	SIZE LGTH	END TYPE	INVERT ELEV LOCATION A	INVERT ELEV LOCATION B
D2	D2	EP-1	[illegible]	[illegible]	48	2		16	3x1	60	1	[illegible]	[illegible]
D2	D2	EP-2	[illegible]	[illegible]	24	1		16	3x1	48	1	[illegible]	[illegible]
D2	D2	EP-3	[illegible]	[illegible]	48	1		16	3x1	48	1	[illegible]	[illegible]
D2	D2	EP-4	[illegible]	[illegible]	24	1		16	3x1	48	1	[illegible]	[illegible]
D2	D2		[illegible]	[illegible]	48	1		16	3x1	50	1	[illegible]	[illegible]
D2	D2		3310.00	1107.00	48	1		16	3x1	50	1	693.80	693.00
D2	D2		3302.00	1160.00	48	1		16	3x1	50	1	692.80	692.00
D2	D2	EP-2	1093.00	934.00	18	1		16	[illegible]	24	1	[illegible]	[illegible]
D2	D2		4562.00	1177.00	24	1		16	[illegible]	36	1	[illegible]	[illegible]
D2	D2		[illegible]	[illegible]	24	1		16	[illegible]	36	1	[illegible]	[illegible]
D2	D2		1275.00	1 [illegible]	36	1	REBENDED	16	3x1	54	1	[illegible]	426.00
D2	D2		1300.00	[illegible]	48	1		16	3x1	54	1	[illegible]	428.00
D2	D2		1500.00	1 30.00	48	1		16	3x1	48	3	[illegible]	[illegible]
D2	D2		[illegible]	[illegible]	36	1		16	3x1	60	3	[illegible]	[illegible]
D2	D2		[illegible]	[illegible]	36	1	RELOCATED FROM EXIST	16	3x1	60	3	[illegible]	[illegible]
D2	D2		6160.00	[illegible]	36	1	RELOCATED FROM EXIST	16	3x1	60	3	[illegible]	[illegible]
D2	D2		5168.75	[illegible]	12	1		16	STD	36	3	[illegible]	653.00
D2	D2		[illegible]	[illegible]	24	1		16	STD	54	3	[illegible]	[illegible]
D2	D2		1200.00	1 [illegible]	24	1		16	STD	50	3	655.20	652.80
D2	D2		[illegible]	[illegible]	36	1		16	STD	50	3	[illegible]	[illegible]
D2	D2		[illegible]	[illegible]	18	1		16	3x1	50	3	1.00	.83
D2	D2		[illegible]	[illegible]	18	1		16	3x1	50	3	[illegible]	[illegible]
D2	D2		[illegible]	[illegible]	24	1		16	3x1	75	1	[illegible]	622.00
D2	D2	MP-3	1535.00	[illegible]	18	1		16	STD	48	1	[illegible]	[illegible]
D2	D2		[illegible]	[illegible]	18	1	ASR INVARS	16	STE	24	1	633.00	632.80
D2	D2		[illegible]	[illegible]	12	1		16	STD	36	1	[illegible]	[illegible]
D2	D2	WKT 2	[illegible]	[illegible]	30+31	1	METAL ARCH	12	3x1	44	3	622.20	622.00
D2	D2		[illegible]	[illegible]	[illegible]	1	FOR INTERLOCKING	16		50	1	[illegible]	[illegible]
D2	D2		[illegible]	[illegible]	[illegible]	1	DWG PS1013	16		75	1	633.44	633.22
D2	D2		[illegible]	[illegible]	[illegible]	1	FOR BI DETAIL	16		60	1	[illegible]	[illegible]
D2	D2		[illegible]	[illegible]	[illegible]	1

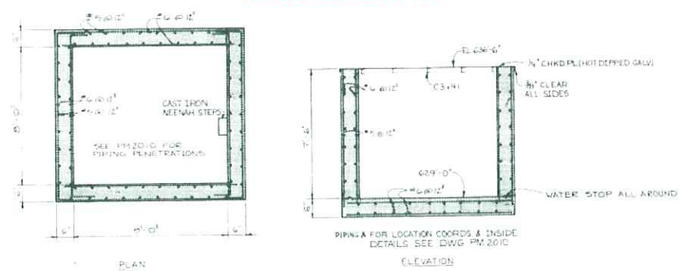


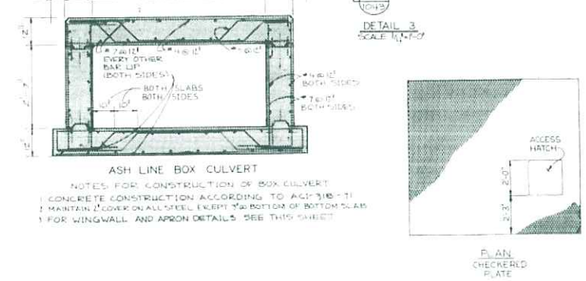
NOTES FOR ENCASEMENT
1. USE 3000 PSI CONCRETE AND GRADE 40 REBARS.
2. CONSTRUCTION SHALL BE ACCORDING TO ACI 318-71
3. BOTTOM OF CASING SHALL BE POURED TO TOP OF ROCK
4. ALL LONGITUDINAL REINFORCING SHALL BE #4 BARS PLACED AS SHOWN.

COLLINSVILLE WATER LINE ENCASEMENT DETAILS
NO SCALE

HOSE HOUSE LIST					
NO	CORNER LOCATION SOUTH	CORNER LOCATION E OR W	ELEVATION	DRAWING	TYPICAL
1					
2	3919.00	E 1066.00		D-4	D-4
3	3919.00	E 1488.00		D-4	D-4
4	4472.00	E 888.00		D-4	D-4
5	4504.00	E 1532.00		D-4	D-4
6	4805.00	E 1160.900		D-4	D-4
7	4805.00	E 1732.50		D-4	D-4
8	5530.00	E 1282.00		D-4	D-4
9	5200.00	E 1091.00		D-4	D-4
10	6143.00	E 1198.50		D-4	D-4
11	6598.00	E 1210.00		D-4	D-4
12	6973.00	E 1673.00		D-4	D-4
13	4650.00	E 2067.50		D-4	D-4
14	4650.00	E 2191.00		D-4	D-4

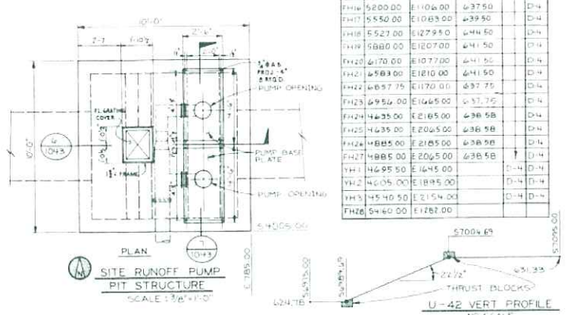
YARD & FIRE HYDRANT LIST					
NO	CENTERLINE LOCATION SOUTH	CENTERLINE LOCATION E OR W	ELEVATION	DRAWING	TYPICAL
FH 1	4542.00	E 1083.00	633.58		D-4
FH 2	4475.00	E 886.00	631.50		D-4
FH 3	NOT USED				
FH 4	4075.00	E 886.00	629.50		D-4
FH 5	3909.00	E 1066.00	637.58		D-4
FH 6	3969.00	E 1250.00	637.58		D-4
FH 7	3909.00	E 1660.00	637.58		D-4
FH 8	3980.00	E 1492.00	636.00		D-4
FH 9	4170.00	E 1463.50	637.50		D-4
FH 10	4420.00	E 1492.00	637.50		D-4
FH 11	4500.00	E 1262.50	636.50		D-4
FH 12	4790.00	E 1615.00	638.58		D-4
FH 13	4790.00	E 1735.00	639.58		D-4
FH 14	5040.00	E 1619.00	639.58		D-4
FH 15	5040.00	E 1735.00	639.58		D-4
FH 16	5200.00	E 1106.00	637.50		D-4
FH 17	5550.00	E 1083.00	639.50		D-4
FH 18	5527.00	E 1279.50	640.50		D-4
FH 19	5880.00	E 1207.00	641.50		D-4
FH 20	6170.00	E 1077.00	641.50		D-4
FH 21	6583.00	E 1210.00	641.50		D-4
FH 22	6857.75	E 1170.00	637.75		D-4
FH 23	6956.00	E 1665.00	637.75		D-4
FH 24	4635.00	E 2165.00	638.58		D-4
FH 25	4635.00	E 2065.00	638.58		D-4
FH 26	4885.00	E 2185.00	638.58		D-4
FH 27	4885.00	E 2065.00	638.58		D-4
FH 1	4695.50	E 1645.00		D-4	D-4
FH 2	4605.00	E 1885.00		D-4	D-4
FH 3	4540.50	E 2154.00		D-4	D-4
FH 28	5460.00	E 1282.00			





ASH LINE BOX CULVERT

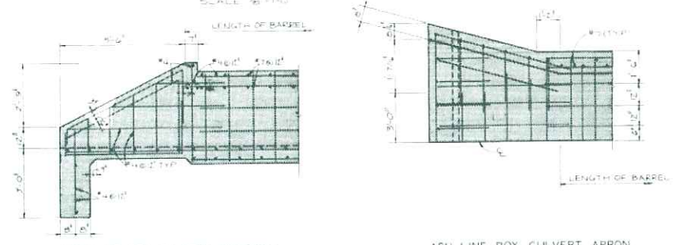
NOTES FOR CONSTRUCTION OF BOX CULVERT
1. CONCRETE CONSTRUCTION ACCORDING TO ACI 318-71
2. MAINTAIN ½" COVER ON ALL STEEL EXCEPT ⅜" BOTTOM OF BOTTOM SLAB
3. FOR WINGWALL AND APRON DETAILS SEE THIS SHEET



SITE RUNOFF PUMP PIT STRUCTURE
SCALE 3/8"=1'-0"

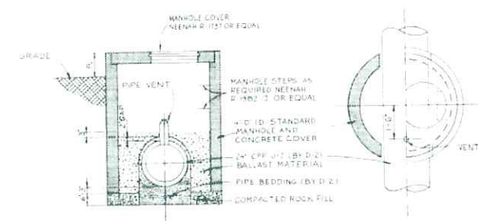
U-42 VERT PROFILE
NO SCALE

BOILER DRAIN VALVE PIT
SCALE ½"=1'-0"

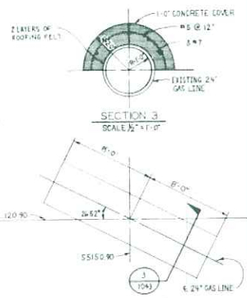


ASH LINE BOX CULVERT WINGWALL
SCALE 1/2"=1'-0"

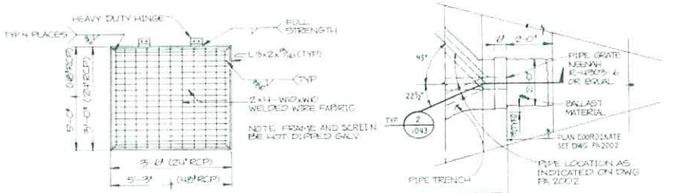
ASH LINE BOX CULVERT APRON
SCALE 1/2"=1'-0"



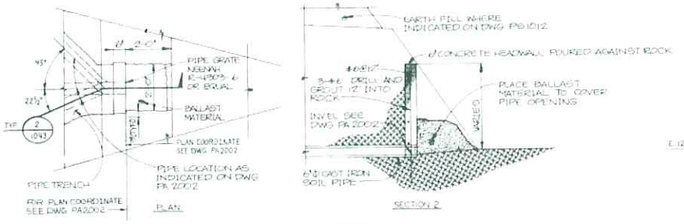
MAKE UP WATER MANHOLE
SCALE 1/2"=1'-0"



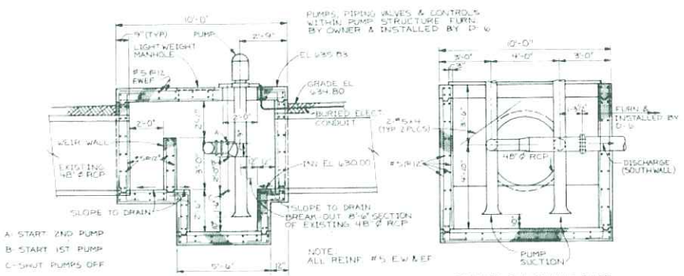
DRAINAGE CULVERT LIST (CONT FROM DWG PS1023)												
DRAWING	TYPICAL	CULVERT NO	CENTERLINE LOCATION SOUTH	CENTERLINE LOCATION E-W	Ø DIAM	NO OF UNIT	NOTES	SIZE GAGE	SIZE CORR SIZE	SIZE LGTH	END TYPE	INVERT ELEV LOCATION A	INVERT ELEV LOCATION B
D-4	D-4	CTR-2	4524.00	L 2028	24"	1		18	STD	70'	1	639.50	639.00
D-4	D-4	CTR-3	4775.00	E1772.00	12"	1		18	STD	55	1	641.50	641.00
D-4	D-4	CTR-4	4576.00	E1630.00	24	1		18	STD	65	1	638.00	637.50
D-4	D-4	BC-9	6920.00	E1545.00	5'x5'	2	FOR BC DETAILS DWG PS1023		SEE	35		629.60	629.50
D-4	D-4	BC-10	6905.00	E1772.00	5'x5'	2				25		629.80	629.70
D-4	D-4	TR-2	3459.00	E12.0.00	12"	1		16	STD	90	3	637.10	636.90
D-4	D-4	TR-5	4780.00	E1200.00	12"	1		16	STD	80	3	636.20	635.80
		PR6-6	5335.0	970	12	1						633.75	632.75
		PR7-7	5300.0	810	12	1						634.0	633.5

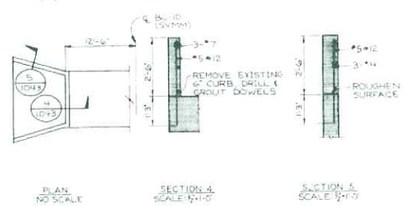


DETAIL OF FRAME AND SCREEN AT DISCHARGE STRUCTURE
SEE DWG PS1023
SCALE ¼"=1'-0"

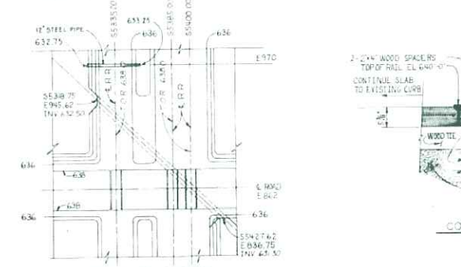


TRENCH DRAIN HEADWALL
SCALE 1/2"=1'-0"





BOX CULVERT 10 COAL RETENTION WALL


12" STEEL PIPE
E.R.R.
E.R.R.
E.W.D.
E.W.D.
E.R.R.
E.R.R.
E.W.D.
E.W.D.
E.R.R.
E.R.R.
E.W.D.
E.W.D.

APPENDIX B

Document 18

Coal Combustion Dam Inspection Checklist Form

Site Name:	**AEP - PSO of Oklahoma**	**Date:**	**February 16, 2011**
Unit Name:	**Northeastern 3 & 4**	**Operator's Name:**	**AEP - PSO of OK**
Unit I.D.:	**F01**	**Hazard Potential Classification:**	**High** ☐ **Significant** ☐ **Low** ☒
	Inspector's Name:	**Kyle Shepard and Andy Cueto**	

Check the appropriate box below. Provide comments when appropriate. If not applicable or not available, record "N/A". Any unusual conditions or construction practices that should be noted in the comments section. For large diked embankments, separate checklists may be used for different embankment areas. If separate forms are used, identify approximate area that the form applies to in comments.

	Yes	No		Yes	No
1. Frequency of Company's Dam Inspections?	X		18. Sloughing or bulging on slopes?		X
2. Pool elevation (operator records)?	X		19. Major erosion or slope deterioration?		X
3. Decant inlet elevation (operator records)?	X		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	X		Is water entering inlet, but not exiting outlet?		X
5. Lowest dam crest elevation (operator records)?	X		Is water exiting outlet, but not entering inlet?		X
6. If instrumentation is present, are readings recorded (operator records)?	X		Is water exiting outlet flowing clear?	X	
7. Is the embankment currently under construction?		X	21. Seepage (specify location, if seepage carries fines, and approximate seepage rate below):		
8. Foundation preparation (remove vegetation, stumps, topsoil in area where embankment fill will be placed)?	N/A	N/A	From underdrain?	X	
9. Trees growing on embankment? (If so, indicate largest diameter below)		X	At isolated points on embankment slopes?	X	
10. Cracks or scarps on crest?		X	At natural hillside in the embankment area?		X
11. Is there significant settlement along the crest?		X	Over widespread areas?		X
12. Are decant trashracks clear and in place?	N/A	N/A	From downstream foundation area?		X
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		X	"Boils" beneath stream or ponded water?		X
14. Clogged spillways, groin or diversion ditches?		X	Around the outside of the decant pipe?		X
15. Are spillway or ditch linings deteriorated?		X	22. Surface movements in valley bottom or on hillside?		X
16. Are outlets of decant or underdrains blocked?		X	23. Water against downstream toe?	X	
17. Cracks or scarps on slopes?		X	24. Were Photos taken during the dam inspection?	X	

Major adverse changes in these items could cause instability and should be reported for further evaluation. Adverse conditions noted in these items should normally be described (extent, location, volume, etc.) in the space below and on the back of this sheet.

Issue #	Comments
	Plans, reports, and other data to be provided on CD by end of February 2011.

Coal Combustion Waste (CCW)

Impoundment Inspection

Impoundment NPDES Permit OK0034380 **INSPECTOR** Edward Dihrberg

Date 1 Oct 1999
Impoundment Name Northeast Station (F01) Bottom Ash Basin

Impoundment Company AEP/PSO
EPA Region Region 6

State Agency (Field Office) Address Oklahoma Department of Environmental Quality

(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New ☐ **Update** ☒

	Yes	No
Is impoundment currently under construction?	☐	☒
Is water or ccw currently being pumped into the impoundment?	☒	☐

IMPOUNDMENT FUNCTION: STORAGE

Nearest Downstream Town Name: ELBA, OKLAHOMA

Distance from the impoundment: 2.2 MILES

Location:

Latitude	36	Degrees	25	Minutes	53.39	Seconds	**N**
Longitude	95	Degrees	42	Minutes	04.43	Seconds	**W**

State OKLAHOMA **County** ROGERS

	Yes	No
Does a state agency regulate this impoundment?	☐	☒

If So Which State Agency?

HAZARD POTENTIAL *(In the event the impoundment should fail, the following would occur):*

☐ **LESS THAN LOW HAZARD POTENTIAL:** Failure or misoperation of the dam results in no probable loss of human life or economic or environmental losses.

☒ **LOW HAZARD POTENTIAL:** Dams assigned the low hazard potential classification are those where failure or misoperation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

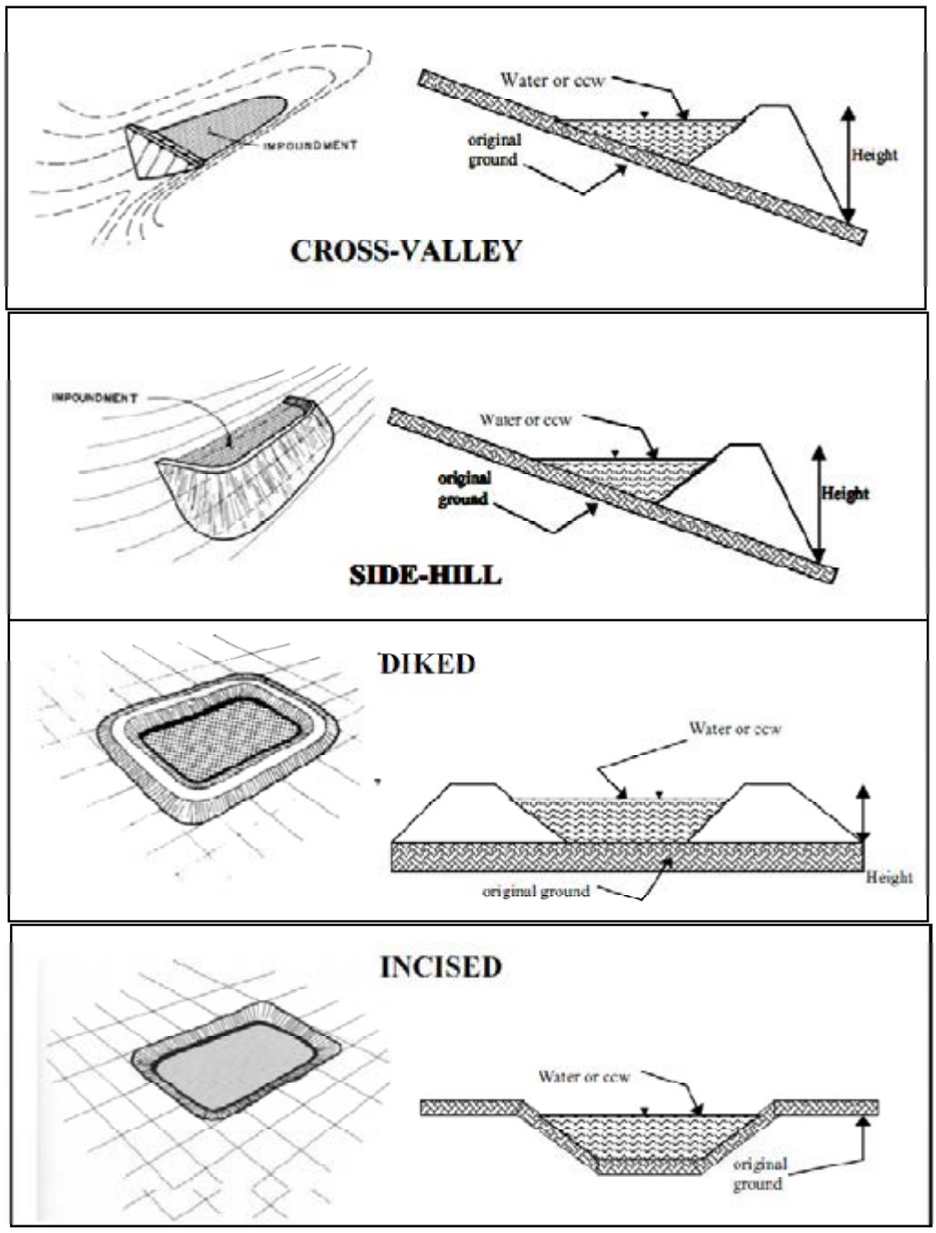
☐ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

☐ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

FROM VISUAL INSPECTION, NO IMPACT TO DOWNSTREAM AREAS WAS WARRANTED.

CONFIGURATION:



☐ Cross-Valley ☒ Side-Hill ☐ Diked

☐ Incised (form completion optional) ☐ Combination Incised/Diked

Embankment Height (ft)	± 25	**Embankment Material**	NATIVE SOIL
Pool Area (ac)	26	**Liner**	In situ
Current Freeboard (ft)	2	**Liner Permeability**	N/A

TYPE OF OUTLET (Mark all that apply)

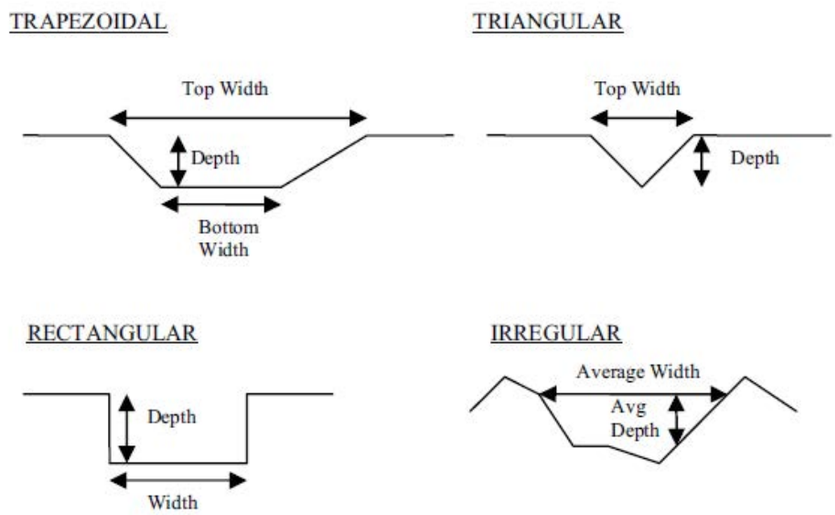
☒ **Open Channel Spillway**

- ☐ Trapezoidal
- ☐ Triangular
- ☒ Rectangular (24' W x 5' D)
- ☐ Irregular

depth (ft)

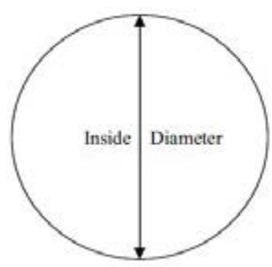
average bottom width (ft)

top width (ft)



☒ **Outlet**

36" inside diameter
(SDR 17 – smooth lined – 19.5" OD)



Material

- ☐ corrugated metal
- ☐ welded steel
- ☐ concrete
- ☐ plastic (hdpe, pvc, etc.)
- ☒ other (specify): DUCTILE IRON PIPE

	Yes	No
Is water flowing through the outlet?	☒	☐

☐ **No Outlet**

☐ **Other Type of Outlet**
(specify):

The Impoundment was Designed By **Black & Veatch Consulting Engineers**

	Yes	No
Has there ever been a failure at this site?	☐	☒

If So When?

If So Please Describe :

	Yes	No
Has there ever been significant seepages at this site?	☐	☒
If So When?		

If So Please Describe :

	Yes	No
Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site?	☐	☒

If so, which method (e.g., piezometers, gw pumping,...)?

If So Please Describe :

Two piezometers recently installed at SW embankment

ADDITIONAL INSPECTION QUESTIONS

Concerning the embankment foundation, was the embankment construction built over wet ash, slag, or other unsuitable materials? If there is no information just note that.

No. the foundation wasn't built over wet ash, slag, or other unsuitable materials

Did the dam assessor meet with, or have documentation from, the design Engineer-of-Record concerning the foundation preparation?

Yes. The designer was Black and Veatch

From the site visit or from photographic documentation, was there evidence of prior releases, failures, or patchwork on the dikes?

No evidence of any releases, failures or patchwork on the dikes.