The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 1

AECOM

Submitted to
Illinois Power Generating Company
134 Cips Lane
Coffeen, IL 62017

Submitted by
AECOM
1001 Highlands Plaza Drive West
Suite 300
St. Louis, MO 63110

October 2016

CCR Rule Report: Initial Safety Factor Assessment

For

Ash Pond No. 1

At Coffeen Power Station

1 Introduction

This Coal Combustion Residual (CCR) Rule Report documents that Ash Pond No. 1 at the Illinois Power Generating Company Coffeen Power Station meets the safety factor assessment requirements specified in 40 Code of Federal Regulations (CFR) §257.73(e). Ash Pond No. 1 is located near Coffeen, Illinois in Montgomery County, approximately 0.3 miles east of the Coffeen Power Station. Ash Pond No. 1 serves as the primary wet impoundment basin for bottom ash produced by the Coffeen Power Station.

Ash Pond No. 1 is an existing CCR surface impoundment as defined by 40 CFR §257.53. The CCR Rule requires that the initial safety factor assessment for an existing CCR surface impoundment be completed by October 17, 2016.

The owner or operator of the CCR unit must obtain a certification from a qualified professional engineer stating that the initial safety factor assessment meets the requirements of 40 CFR § 257.73(e). The owner or operator must prepare a safety factor assessment every five years.

2 Initial Safety Factor Assessment

40 CFR §257.73(e)(1)
The owner or operator must conduct initial and periodic safety factor assessments for each CCR unit and document whether the calculated factors of safety for each CCR unit achieve the minimum safety factors specified in (e)(1)(i) through (iv) of this section for the critical cross section of the embankment. The critical cross section is the cross section anticipated to be the most susceptible of all cross sections to structural failure based on appropriate engineering considerations, including loading conditions. The safety factor assessments must be supported by appropriate engineering calculations.

(i) The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.

(ii) The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.

(iii) The calculated seismic factor of safety must equal or exceed 1.00.

(iv) For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

A geotechnical investigation program and stability analyses were performed to evaluate the design, performance, and condition of the earthen dikes of Ash Pond No. 1. The exploration consisted of hollow-stem auger borings, cone penetration tests, piezometers, and laboratory program including strength, hydraulic conductivity, consolidation, and index testing. Data collected from the geotechnical investigation, available design drawings, construction records, inspection reports, previous engineering investigations, and other pertinent historic documents were utilized to perform the safety factor assessment and geotechnical analyses.

In general, the subsurface conditions at Ash Pond No. 1 consist of medium stiff to stiff lean clay embankment fill, overlying medium stiff to stiff weathered loess clay, overlying a thin zone of very soft clay, which in turn overlies very stiff to hard glacial till. The phreatic surface within the subsurface is typically at the ground surface at the toe of the embankment and near the embankment/foundation interface beneath the crest.

Five (5) representative cross sections were analyzed using limit equilibrium slope stability analysis software to evaluate stability of the perimeter dike system and foundations. The cross sections were located to represent critical surface geometry, subsurface stratigraphy, and phreatic conditions across the site. Each cross section was evaluated for each of the loading conditions stipulated in §257.73(e)(1).

The Soils Susceptible to Liquefaction loading condition, §257.73(e)(1)(iv), was not evaluated because a liquefaction susceptibly evaluation did not find soils susceptible to liquefaction within the Ash Pond No. 1 dikes. As a result, this loading condition is not applicable to Ash Pond No. 1.

Results of the Initial Safety Factor Assessments, for the critical cross-section for each loading condition, are listed in **Table 1** (i.e., the table identifies the lowest calculated factor of safety for any one of the five analyzed cross sections for each loading condition).

Table 1 – Summary of Initial Safety Factor Assessments

Loading Conditions	§257.73(e)(1) Subsection	Minimum Factor of Safety	Calculated Factor of Safety
Maximum Storage Pool Loading	(i)	1.50	1.50
Maximum Surcharge Pool Loading	(ii)	1.40	1.49
Seismic	(iii)	1.00	1.03
Soils Susceptible to Liquefaction	(iv)	1.20	Not Applicable

Based on this evaluation, Ash Pond No. 1 meets the requirements in §257.73(e)(1).

3 Certification Statement

CCR Unit: Illinois Power Generating Company; Coffeen Power Station; Ash Pond No. 1

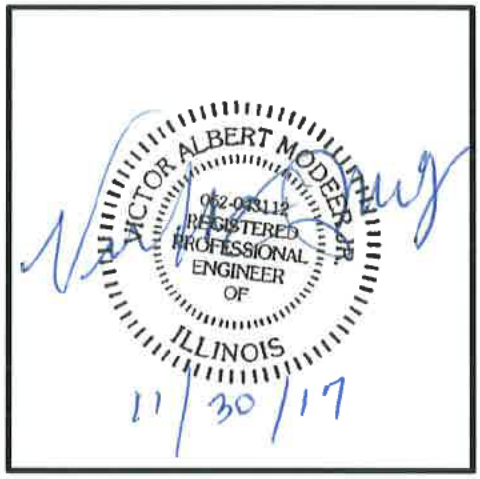
I, Victor A. Modeer, being a Registered Professional Engineer in good standing in the State of Illinois, do hereby certify, to the best of my knowledge, information, and belief that the information contained in this CCR Rule Report, and the underlying data in the operating record, has been prepared in accordance with the accepted practice of engineering. I certify, for the above-referenced CCR Unit, that the initial safety factor assessment dated October 13, 2016 meets the requirements of 40 CFR §257.73(e).

VICTOR A MODEER JR.

Printed Name

10/13/16

Date



About AECOM

AECOM (NYSE: ACM) is a global provider of professional technical and management support services to a broad range of markets, including transportation, facilities, environmental, energy, water and government. With nearly 100,000 employees around the world, AECOM is a leader in all of the key markets that it serves. AECOM provides a blend of global reach, local knowledge, innovation, and collaborative technical excellence in delivering solutions that enhance and sustain the world's built, natural, and social environments. A Fortune 500 company, AECOM serves clients in more than 100 countries and has annual revenue in excess of $19 billion.

More information on AECOM and its services can be found at www.aecom.com.

1001 Highlands Plaza Drive West
Suite 300
St. Louis, MO 63110
1-314-429-0100

The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 2

City Water, Light & Power
Ash Impoundments
Springfield, Sangamon County, Illinois

Initial Safety Factor Assessment for Coal Combustion Residuals Surface Impoundments

October 2016

Prepared for:
City Water, Light & Power
3100 Stevenson Drive
Springfield, Illinois 62703

Prepared by:

ANDREWS ENGINEERING INC
3300 Ginger Creek Drive
Springfield, IL 62711
Tel: (217) 787-2334; Fax: (217) 787-9495

TABLE OF CONTENTS

1. INTRODUCTION 1

2. BACKGROUND 1

3. GEOMETRY OF THE STRUCTURES 2

4. GEOTECHNICAL INFORMATION 2
   - 4.1 Lakeside Ash Pond Geotechnical Data 2
   - 4.2 Dallman Ash Pond Geotechnical Data 3
   - 4.3 Seismic Ground Motion 3

5. SLOPE STABILITY ANALYSIS 4
   - 5.1 Lakeside Ash Pond Slope Stability 4
     - 5.1.1 Long-Term Static Slope Stability Analysis 4
     - 5.1.2 Short-Term Static Slope Stability Analysis 4
     - 5.1.3 Seismic Slope Stability Analysis 5
   - 5.2 Dallman Ash Pond Slope Stability 5
     - 5.2.1 Long-Term Static Slope Stability Analysis 5
     - 5.2.2 Short-Term Static Slope Stability Analysis 5
     - 5.2.3 Seismic Slope Stability Analysis 5

6. SUMMARY 6

TABLES

TABLE 1: Lakeside Ash Pond 3

TABLE 2: Dallman Ash Pond 3

TABLE 3: Slope Stability Results 6

APPENDICES

APPENDIX A: Site Map

APPENDIX B: Lakeside Soils Logs and Cross Section

APPENDIX C: Fly Ash Technical Papers

APPENDIX D: Dallman Boring Log and Cross Section

APPENDIX E: USGS Earthquake Hazards Program Probabilistic Seismic Hazard Analysis

APPENDIX F: Lakeside Ash Pond Static Slope Stability Analysis

APPENDIX G: Dallman Ash Pond Slope Stability Analysis

1. INTRODUCTION

City Water, Light and Power (CWLP) Lakeside Ash Pond and Dallman Ash Pond are coal combustion residuals (CCR) surface impoundments. An Initial Safety Factor Assessment of the CCR surface impoundments was conducted as required by 40 CFR Part 257.73:

> *257.73(e): Periodic safety factor assessments. (1) The owner or operator must conduct an initial and periodic safety factor assessments for each CCR unit and document whether the calculated factors of safety for each CCR unit achieve the minimum safety factors specified in paragraphs (e)(1)(i) through (v) of this section for the critical cross section of the embankment. The critical cross section is the cross section anticipated to be the most susceptible of all cross sections to structural failure based on appropriate engineering considerations, including loading conditions. The safety factor assessments must be supported by appropriate engineering calculations.*
>
> *257.73(f): (1) Initial assessments. Except as provided by paragraph (f)(2) of this section, the owner or operator of the CCR unit must complete the initial assessments required by paragraphs (a)(2), (d), and (e) of this section no later than October 17, 2016. The owner or operator has completed an initial assessment when the owner or operator has placed the assessment required by paragraphs (a)(2), (d), and (e) of this section in the facility's operating record as required by § 257.105(f)(5), (10), and (12).*

Analysis is performed herein for the Initial Safety Factor Assessment of the existing ash ponds at Springfield City Water, Light and Power, Lakeside and Dallman Ash Ponds, Springfield, Illinois, as required per 40 CFR 257.73(e). Based upon historical geotechnical data and the existing conditions of the ash ponds, all factors of safety exceed the regulatory minimums as demonstrated within this report.

Information reviewed for this report includes the following documents:

- Coal Ash Impoundment Site Assessment Final Report (May 2011)
- Historical Aerial Photographs (April 1995 – March 2014)
- Engineering Report: Proposed Embankment Modification; CWLP Ash Disposal Area (July 1987).
- Construction Grading Plan for the Dallman Ash Pond (August 1976)

2. BACKGROUND

CWLP operates a series of ash and lime sludge clarification or settling ponds east of the power plant complex in Springfield, Illinois. The ponds are operated under National Pollutant Discharge Elimination System (NPDES) Permit Number IL0024767.

The Lakeside Ash Pond is primarily a diked embankment with some incising along the east perimeter and was placed into service prior to 1958. The original Lakeside Ash Pond was been divided into four separate ponds since it was expanded vertically in 1988: three lime softening ponds and the settling pond. The current Lakeside Ash Pond is approximately 27.6 acres and ceased receiving ash in 2009.

The second impoundment, the Dallman Ash Pond, which is a diked embankment, was placed into service in approximately 1976 and is approximately 34.5 acres. Fly ash and bottom ash are sluiced to the Dallman Ash Pond with raw lake water.

Settled water from both the Dallman Ash Pond and Lakeside Ash Pond flow into opposite sides of a Clarification Pond before being discharged, typically, to Sugar Creek at Outfall 004.

3. GEOMETRY OF THE STRUCTURES

According to personal interviews with CWLP staff, the most recent change made to the CCR surface impoundment was a vertical expansion to the Lakeside Ash Pond system in 1988. The vertical expansion consists of berms built on top and inside of the existing embankments in such a way that the toe of the outer slope of the expansion berms match up with the top of the inner slope of the existing embankments, typically identified as upstream construction. The vertical expansion berms are approximately ten feet in height.

A site map drawing containing an aerial photograph and approximate boundaries for all of the CWLP CCR Units, including the ash and lime softening ponds, is provided in Appendix A.

No changes to the geometry of the structures are applicable for this report. No changes are apparent due to structure movement or deformation.

4. GEOTECHNICAL INFORMATION

4.1 Lakeside Ash Pond Geotechnical Data

A review of the historical documents found a previous geotechnical investigation and stability analysis, which was conducted prior to the upstream construction of Lakeside Ash Pond. The results of that geotechnical investigation are utilized within this assessment of the safety factors. Additionally, a literature review of technical papers was conducted to determine the geotechnical parameters for the fly ash within the impoundments. Provided in Table 1 are highly conservative geotechnical parameters based upon the previous geotechnical investigation utilized in the static and seismic slope stability model.

Included in Appendix B are copies of the historical soils logs and cross sections that support the geotechnical parameters provided in Table 1. Technical papers supporting the ash geotechnical parameters are included in Appendix C.

TABLE 1

Lakeside Ash Pond

Soil Description	Density (pcf)	Total Strengths (Short Term)		Effective Strengths (Long Term)	
		ϕ (degrees)	c (psf)	ϕ' (degrees)	c (psf)
Ash	100	15	0	25	0
Embankment	120	0	1,400	32	145
Sandy Silty Clay w/Clayey Silt	120	0	1,800	32	190
Sandy Silty Clay	120	0	1,000	32	190
Shale	130	0	2,000	0	2,000

4.2 Dallman Ash Pond Geotechnical Data

A review of the historical documents revealed the original construction plans, with cross sections provided, was completed. More recent site investigations have been conducted in the area during the installation of piezometers, which provide the stratigraphic and in situ strengths of earthen materials that correlate well with the Lakeside Ash Ponds geotechnical data. The historical data have been used to develop conservative geotechnical parameters for slope stability analysis as provided below in Table 2.

Included in Appendix D are copies of the boring log and cross section that support the geotechnical parameters provided in Table 2.

TABLE 2

Dallman Ash Pond

Soil Description	Density (pcf)	Total Strengths (Short Term)		Effective Strengths (Long Term)	
		ϕ (degrees)	c (psf)	ϕ' (degrees)	c (psf)
Ash	100	15	0	25	0
Embankment	120	0	1,400	32	145
Rip-Rap	140	40	0	40	0
Silty Clay	120	0	1,800	32	190
Clayey Silt	120	0	1,400	32	190
Sandy Silty Clay	120	0	1,000	32	190
Sand w/Silt	120	34	0	34	0
Shale	130	0	2,000	0	2,000

4.3 Seismic Ground Motion

CWLP is susceptible to potential seismic activity as provided by the USGS Earthquake Hazards Program. Included in Appendix E of this geotechnical engineering report is the 2008 National Seismic Hazard Mapping Program's Probabilistic Seismic Hazard Analysis for the site (Latitude 39.762 North, Longitude 89.597 West). The Peak Horizontal Ground Acceleration is approximately 0.09965 g. The maximum acceleration of (aHmax = 0.10g) was selected for use in stability calculations.

5. SLOPE STABILITY ANALYSIS

The static and seismic slope stability model utilized for the following analysis was the Morgenstern and Price Circular Search Method within the Slope/W computer-based slope stability modeling software. Morgenstern and Price satisfies all conditions of equilibrium.

The periodic safety factor assessment requires that each CCR unit document whether the calculated factors of safety for each CCR unit achieve the minimum safety factors. The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50. The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40. The calculated seismic factor of safety must equal or exceed 1.00. For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

The Lakeside and Dallman Ash Ponds are not susceptible to liquefaction since the embankments are constructed of a sandy silty clay, thus analyses for each are not included below. Liquefaction occurs in fine grained non-cohesive soils. The embankments at CWLP are constructed of cohesive soils.

5.1 Lakeside Ash Pond Slope Stability

The slope stability analysis was performed on a critical cross section, previously identified as Section 2 in the Engineering Report: Proposed Embankment Modification; CWLP Ash Disposal Area (July 1987)., Based upon a review of this report and existing conditions, Section 2 appears to remain the critical cross section. Section 2 is located on the north side of the Lakeside Ash Pond next to the Clarification Pond. For a very conservative analysis, the slope was analyzed as if the Clarification Pond was drained and dredged back to the pre-existing grades of approximately 535 feet MSL.

The Lakeside Ash Pond is not susceptible to liquefaction since the embankment is constructed of a sandy silty clay; thus, analysis is not included below.

5.1.1 Long-Term Static Slope Stability Analysis

The long-term static slope stability analysis was performed on the Lakeside Ash Pond cross section using the geotechnical parameters as provided in Table 1. The long-term analysis utilizes the effective shear strength parameters, which are the drained condition. The long-term static slope stability analysis found that the factor of safety for the most critical failure surface was 1.532. The critical failure surface and stability report are included in Appendix F-1. This analysis verifies that Lakeside exceeds the factor of safety for the long-term, maximum storage pool loading condition and the maximum surcharge pool loading condition since the analysis was performed filled with ash and the pool elevation matching the top of the embankment.

5.1.2 Short-Term Static Slope Stability Analysis

The short-term static slope stability analysis was performed on the Lakeside Ash Pond cross section using the geotechnical parameters as provided in Table 1. The short-term analysis utilizes the total shear strength parameters, which are the undrained condition. The short-term static slope stability analysis found that the factor of safety for the most critical failure surface was 1.640. The critical failure surface and stability report are included in Appendix F-2.

5.1.3 Seismic Slope Stability Analysis

The seismic slope stability analysis was performed on the Lakeside Ash Pond cross section using the geotechnical parameters as provided in Table 1. The seismic analysis utilizes the total shear strength parameters, which are the undrained condition since a seismic event occurs in a short period of time. In addition, a horizontal acceleration of 0.10g was utilized within the modeling to represent the peak horizontal ground acceleration anticipated for CWLP. The seismic slope stability analysis found that the factor of safety for the most critical failure surface was 1.260. The critical failure surface and stability report are included in Appendix F-3. This analysis verifies that Lakeside exceeds the seismic factor of safety with maximum surcharge pool loading condition.

5.2 Dallman Ash Pond Slope Stability

The slope stability analysis was performed on a critical cross section based upon a review of the historical construction diagrams, cross sections and the available stratigraphic data. Section 10+00 is located on the north side of the Dallman Ash Pond near the relocated Sugar Creek. For a very conservative analysis, the slope was analyzed as if Sugar Creek had nearly zero flow at approximately 520 feet MSL.

5.2.1 Long-Term Static Slope Stability Analysis

The long-term static slope stability analysis was performed on the Dallman Ash Pond cross section using the geotechnical parameters as provided in Table 2. The long-term analysis utilizes the effective shear strength parameters, which are the drained condition. The long-term static slope stability analysis found that the factor of safety for the most critical failure surface was 2.245. The critical failure surface and stability report are included in Appendix G-1. This analysis verifies that Dallman exceeds the factor of safety for the long term, maximum storage pool loading condition and the maximum surcharge pool loading condition since the analysis was performed filled with ash and the pool elevation matching the top of the embankment.

5.2.2 Short-Term Static Slope Stability Analysis

The short-term static slope stability analysis was performed on the Dallman Ash Pond cross section using the geotechnical parameters as provided in Table 2. The short-term analysis utilizes the total shear strength parameters, which are the undrained condition. The short-term static slope stability analysis found that the factor of safety for the most critical failure surface was 2.897. The critical failure surface and stability report are included in Appendix G-2.

5.2.3 Seismic Slope Stability Analysis

The seismic slope stability analysis was performed on the Dallman Ash Pond cross section using the geotechnical parameters as provided in Table 2. The seismic analysis utilizes the total shear strength parameters, which are the undrained condition since a seismic event occurs in a short period of time. In addition, a horizontal acceleration of 0.10g was utilized within the modeling to represent the peak horizontal ground acceleration anticipated for CWLP. The seismic slope stability analysis found that the factor of safety for the most critical failure surface was 1.754. The critical failure surface and stability report are included in Appendix G-3. This analysis verifies that Dallman exceeds the seismic factor of safety with maximum surcharge pool loading condition.

6. SUMMARY

The analyses indicate that Lakeside and Dallman Ash Ponds provide factors of safety equal to or greater than minimum values as required by 40 CFR 257.73(e). This is predicated upon the assumption that cohesive and frictional shear strengths of materials meet or exceed those used in the analyses. Table 3 below provides a summary of the slope stability results.

TABLE 3

Slope Stability Results

Cross Section	Stability Model Results	40 CFR 257.73 Minimum F.S.
Lakeside Long Term Static	1.532	1.5
Dallman Long Term Static	2.245	
Lakeside Short Term Static	1.640	1.4
Dallman Short Term Static	2.897	
Lakeside Seismic	1.26	1.0
Dallman Seismic	1.754	

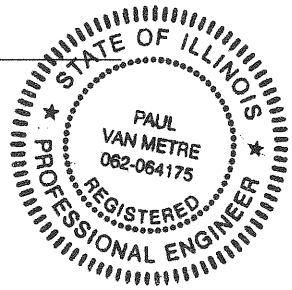
7. STATEMENT

This Initial Safety Factor Assessment for Coal Combustion Residuals Surface Impoundments was completed for CWLP by Andrews Engineering, Inc. in accordance with the requirements under 40 CFR Part 257.73(e) and 257.73(f).

Paul M. Van Metre, P.E.

10-13-2016

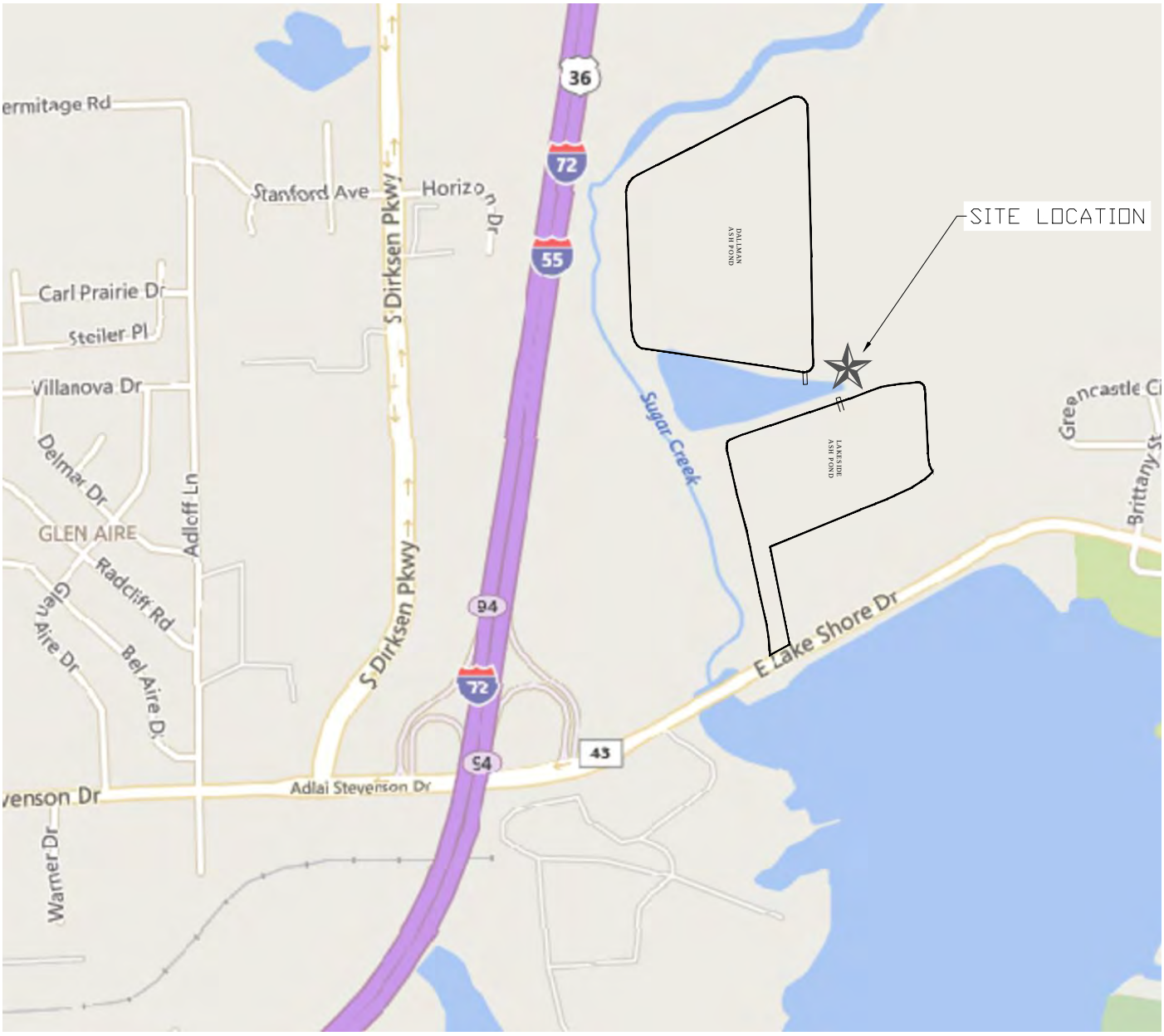
Date



APPENDIX A

Site Map

J:\S\Springfield CWLP\CWLP\dwg\SURFACE IMPOUNDMENTS.dwg Tab: FIGURE 1





SITE LOCATION

N

0 500 1000 2000

SCALE: IN FEET

NOTE:
BASE IMAGE DERIVED FROM BING

ANDREWS ENGINEERING, INC.
3300 Ginger Creek Drive, Springfield, IL 62711-7233
Tel (217) 787-2334 Fax (217) 787-9495
Pontiac, IL • Naperville, IL • Indianapolis, IN • Warrenton, MO
Professional Design Engineering and Land Surveying Firm #184-001541

APPROVED BY: PMV	DESIGNED BY: PMV	DRAWN BY: RMC

SITE LOCATION MAP

PLANS PREPARED FOR

CWLP

SPRINGFIELD, SANGAMON COUNTY, ILLINOIS

DATE: OCTOBER 2016

PROJECT ID: 150077/0011

SHEET NUMBER:

FIG. 1

© 2016 Andrews Engineering, Inc.



FIG. 2A

CWLP COAL COMBUSTION RESIDUALS SURFACE IMPOUNDMENTS

PLANS PREPARED FOR

CITY, WATER, LIGHT & POWER

SPRINGFIELD, SANGAMON COUNTY, ILLINOIS

DATE: OCTOBER 2016

PROJECT ID: 150077/0011

SHEET NUMBER:

ANDREWS
ENGINEERING, INC.
3300 GINGER CREEK DRIVE
SPRINGFIELD, ILLINOIS 62711-7233
PH (217) 787-2334 FAX (217) 787-9495
PONTIAC, IL • LOMBARD, IL • INDIANAPOLIS, IN • WARRENTON, MO
PROFESSIONAL DESIGN ENGINEERING AND LAND SURVEYING FIRM #184-001541

APPROVED BY: PMV | DESIGNED BY: PMV | DRAWN BY: MPN

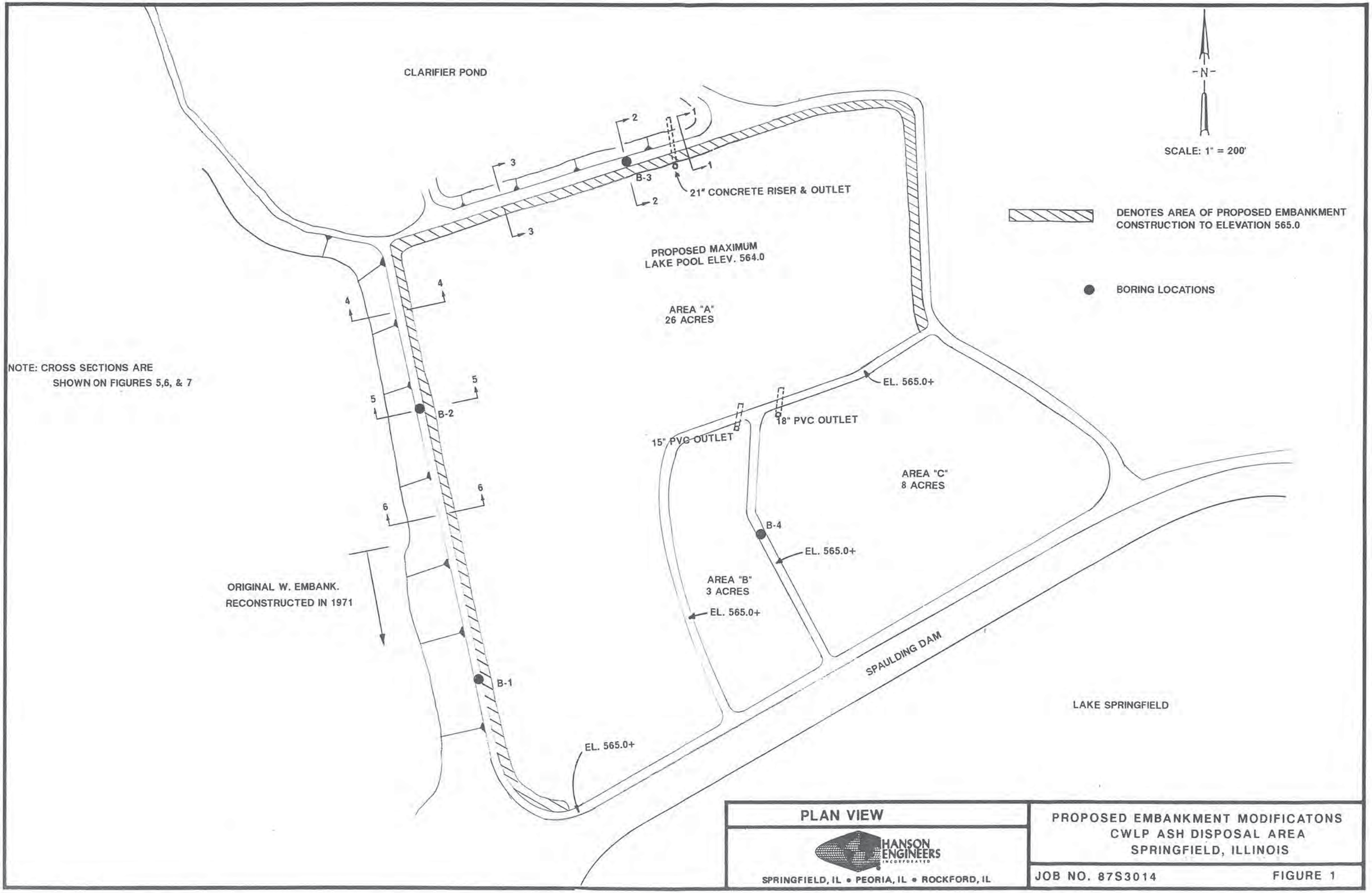
REVISIONS

NO.	DATE	DESCRIPTION	BY

© 2016 Andrews Engineering, Inc.

APPENDIX B

Lakeside Soils Logs and Cross Section



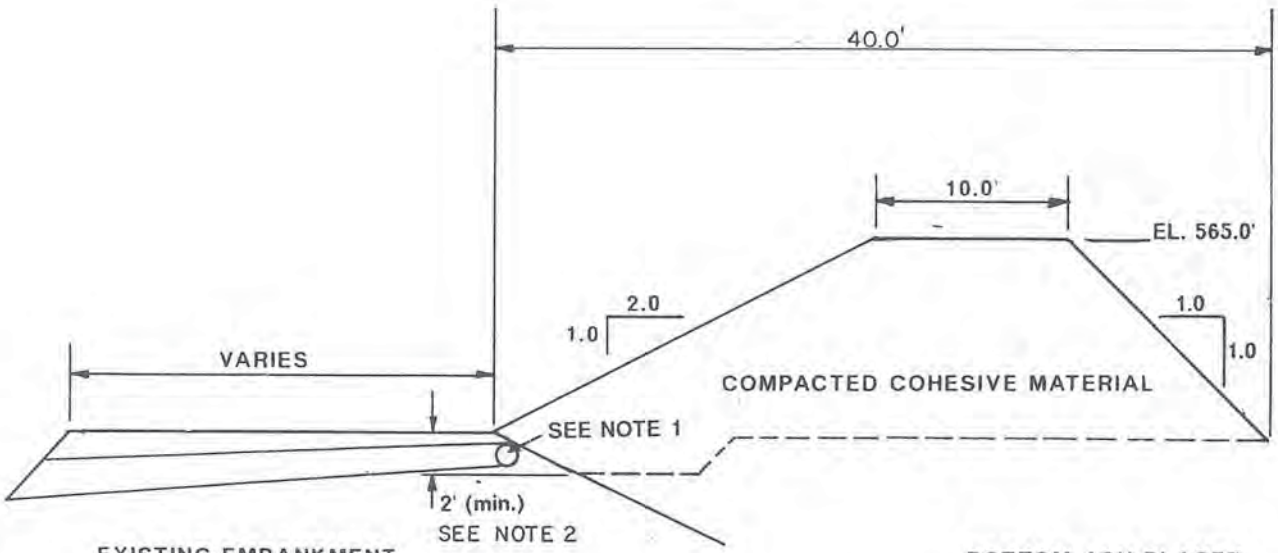
PLAN VIEW

HANSON ENGINEERS INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

PROPOSED EMBANKMENT MODIFICATONS
CWLP ASH DISPOSAL AREA
SPRINGFIELD, ILLINOIS

JOB NO. 87S3014 FIGURE 1



TYPICAL SECTION

NOTE: 1 - FILTER FABRIC WRAPPED PERFORATED CORRUGATED DRAINAGE PIPE WITH NON-PERFORATED OUTLETS INTO CLARIFIER POND. PIPE IS SURROUNDED WITH BED OF BOTTOM ASH

NOTE: 2 - COMPACTED COHESIVE MATERIAL "KEYED" INTO STABLE WORKING SURFACE A MINIMUM DEPTH OF 2 ft. FOR SEEPAGE CONTROL

EMBANKMENT CONFIGURATION	PROPOSED EMBANKMENT MODIFICATONS CWLP ASH DISPOSAL AREA SPRINGFIELD, ILLINOIS
HANSON ENGINEERS INCORPORATED SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL	JOB NO. 87S3014 FIGURE 2

OPERATOR CMP

DATE June-2-1987

JOB NO.

HANSON ENGINEERS INCORPORATED

LABORATORY SOIL TEST DATA

PROJECT NAME AND LOCATION

CWL&P
Ash Pond Study
Springfield, Illinois

BOR.	SAMP.	DEPTH	ELEV.	N	STRENGTH TESTS Qu	M	P	W	γ_w	γ_d	SPECIAL TESTS	SAMPLE DESCRIPTION
	Ground Surface Elev = 557.6											
1	1	2'-6"	555.1	14				6				Bottom Ash
	2	5'-0"	552.6	3				10				" "
	3	7'-6"	550.1	5				31				" " Dk. gray v.f. sandy silt
	4	10'-0"	547.6	1				79				Drk. gray v.f. sandy silt.
	5	12'-6"	545.1	4	0.92	B	0.8	33				Gray v.f. sandy silty clay.
	6	15'-0"	542.6	4			3.6	67				Gray silty f. sand. (fly ash).
	7	17'-6"	540.1	9				46				Fly ash.
	8	20'-0"	537.6	8				61				" "
	9	22'-6"	535.1	5	0.71	Sh	1.3	26				Yel. brn. & gray v.f. sandy silty clay / ox. spots.
	10	25'-0"	532.6	15	2.27	B	1.8/38	21				Mix colored v.f sandy silty clay (tr. f.-c. sand & f. gravel)
	11	27'-6"	530.1	9	1.86	B	2.4	27				Drk. gray v.f. sandy silty clay.
	12	30'-0"	527.6	8	0.50	B	0.6	33				" " " " " " " "
	Ground Surface Elev = 555.5											
2	1	2'-6"	553.0	21	5.89	BSp	4.5+	14				Brn. gray v.f. sandy silty clay / ox. spots.
	2	5'-0"	550.5	20	2.27	B	2.4	27				Yel. brn & gray v.f. sandy silty clay (tr. ox. spots.)
	3	7'-6"	548.0	10	1.86	B	2.2	29				Grn. & drk. brn v.f. sandy silty clay (tr. ox. spots.)
	4	10'-0"	545.5	12	2.68	BSh	2.4	25				Yel brn & gray v.f. sandy silty clay / ox. spots.
	5	12'-6"	543.0	13	2.68	B	2.9	27				Grn. gray clay (tr. silt & ox. spots.)
	6	15'-0"	540.5	12	2.33	B	2.4	28				Brn. gray v.f sandy silty clay / ox. spots.
	7	17'-6"	538.0	15	1.94	BSh	2.6	27				Yel. brn & gray v.f. sandy silty clay (tr. chard. pts.)
	8	20'-0"	535.5	14	2.27	B	2.5	28				" " & " " " " " " (" " ")
	9	22'-6"	533.0	15	2.68	B	2.8	28				" " & " " " " " " (" " ")
	10	25'-0"	530.5	9	1.16	B	1.1	26				" " & " " " " " " clayey silt / chard. pts.
	11	27'-6"	528.0	8	0.54	B	0.6	23				" " & " " " " " " silt (tr. chard pts.)
	12	30'-0"	525.5	6	0.89	B	0.7	24				" " & " " " " " " " / chard pts.
	13	35'-0"	520.5	5	0.78	B	0.8	23				" " & " " " " " " " & brn. f.-m. sand.
	14	40'-0"	515.5	19				14				Brn. gray f.-m. sand.
	14A	40'	515.5	19				29				Gray shaley clay.

Figure 8

OPERATOR CMP

DATE June-2-1987

JOB NO.

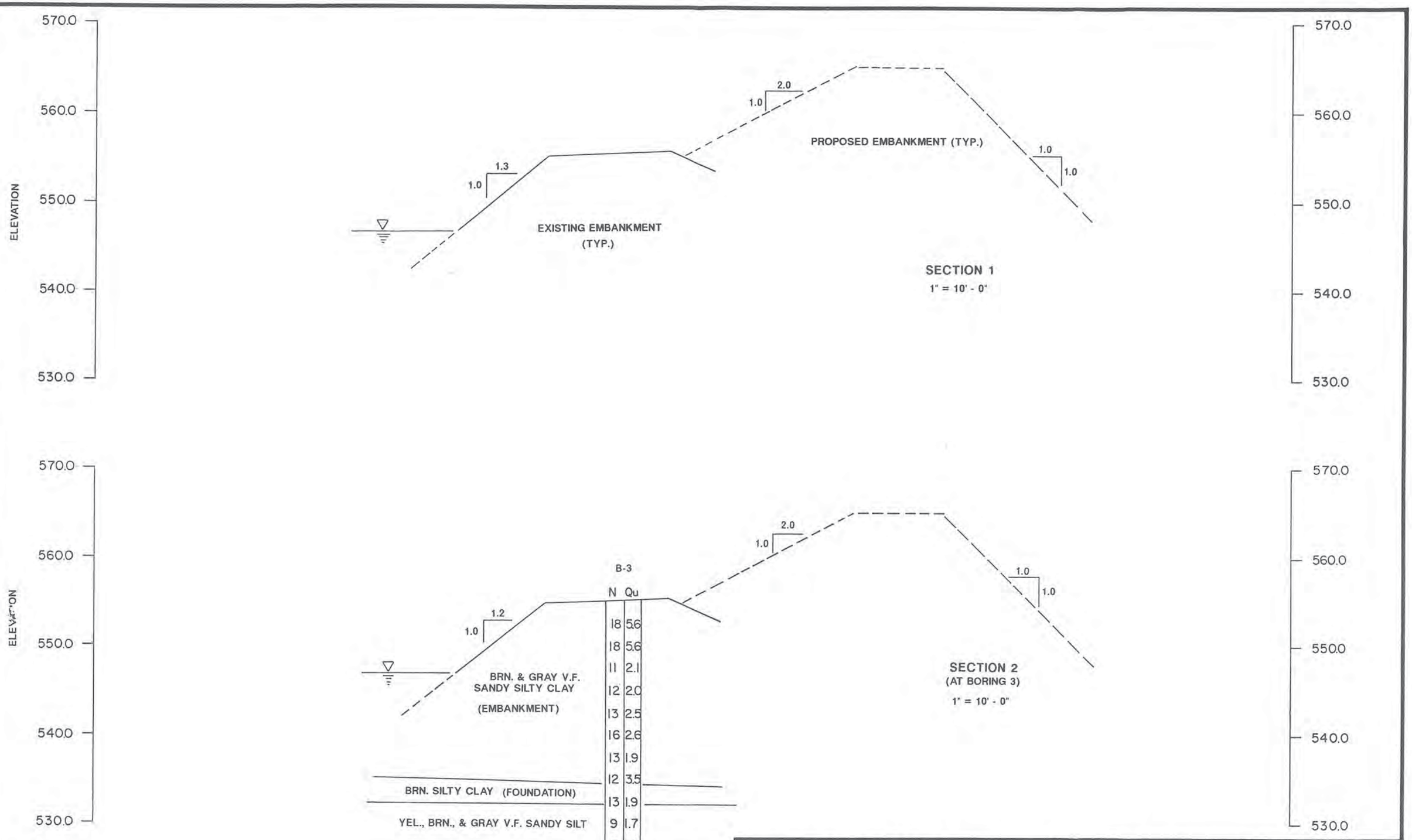
HANSON ENGINEERS INCORPORATED

LABORATORY SOIL TEST DATA

PROJECT NAME AND LOCATION
CWL&P
Ash Pond Study
Springfield, Illinois

BOR.	SAMP.	DEPTH	ELEV.	N	STRENGTH TESTS Qu	M	P	W	γ_W	γ_D	SPECIAL TESTS	SAMPLE DESCRIPTION
	Ground Surface Elev = 555.2											
3	1	2'6"	552.7	18	5.56	BSh	4.5+	21				Brn. & drk. brn. v.f. sandy silty clay (tr. chard. pts. & sm. roots)
	2	5'0"	550.2	13	5.62	BSp	4.5+	22				Drk. gray clay (tr. chard. pts. & sm. roots.)
	3	7'6"	547.7	11	2.13	BSh	2.4	26				Yel. brn. & gray. v.f. sandy silty clay (tr. chard pts.)
	4	10'0"	545.2	12	1.94	BSh	2.1	29				" " & drk. gray clay (tr. ox. spots.)
	5	12'6"	542.7	13	2.52	B	2.6	25				" " & gray v.f. sandy silty clay (tr. chard. pts.)
	6	15'0"	540.2	16	2.62	B	2.6	26				Drk. gray v.f. sandy silty clay.
	7	17'6"	537.7	13	1.86	B	1.6	28				Yel. brn. & gray v.f. sandy silty clay (tr. chard. pts.)
	8	20'0"	535.2	12	3.50	BSh	3.0/4.5+	21				Drk. gray v.f. sandy silty clay.
	9	22'6"	532.7	13	1.94	B	2.2	28				Yel brn & gray v.f. sandy silty clay & clayey silt/chard pts
	10	25'0"	530.2	9	1.71	B	1.7	26				" " & " " " " silt / chard. pts.
	11	27'6"	527.7	7	1.24	B	1.2	27				" " & " " " " " / " " .
	12	30'0"	525.2	21	3.49	B	3.6	26				Brn. gray clay.
	Ground Surface Elev = 566.2											
4	1	2'6"	563.7	5	3.05	Sh	2.8	20				Yel. brn. & gray v.f. sandy silt.
	2	5'0"	561.2	11	1.71	Sp	2.7	25				" " & " " " " " & fly ash.
	3	7'6"	558.7	7	1.65	BSh	2.2	13				" " & " v.f.-m. sandy silt (tr. c. sand.)
	4	10'0"	556.2	10	1.47	BSh	1.9	22				" " & " clay / brn. silty f. sand (tr. fly ash.)
	5	12'6"	553.7	8				18				Fly ash.
	6	15'0"	551.2	7				27				" " .
	7	17'6"	548.7	1				94				Drk. gray silty v.f. sand (fly ash)
	8	20'0"	546.2	2				108				" " " " " " " " (" ")
	9	25'0"	541.2	1				129				" " " " " " " " (" ")
	10	30'0"	536.2	16	2.68	B	2.3	31				" " v.f. sandy silty clay.

Figure 4



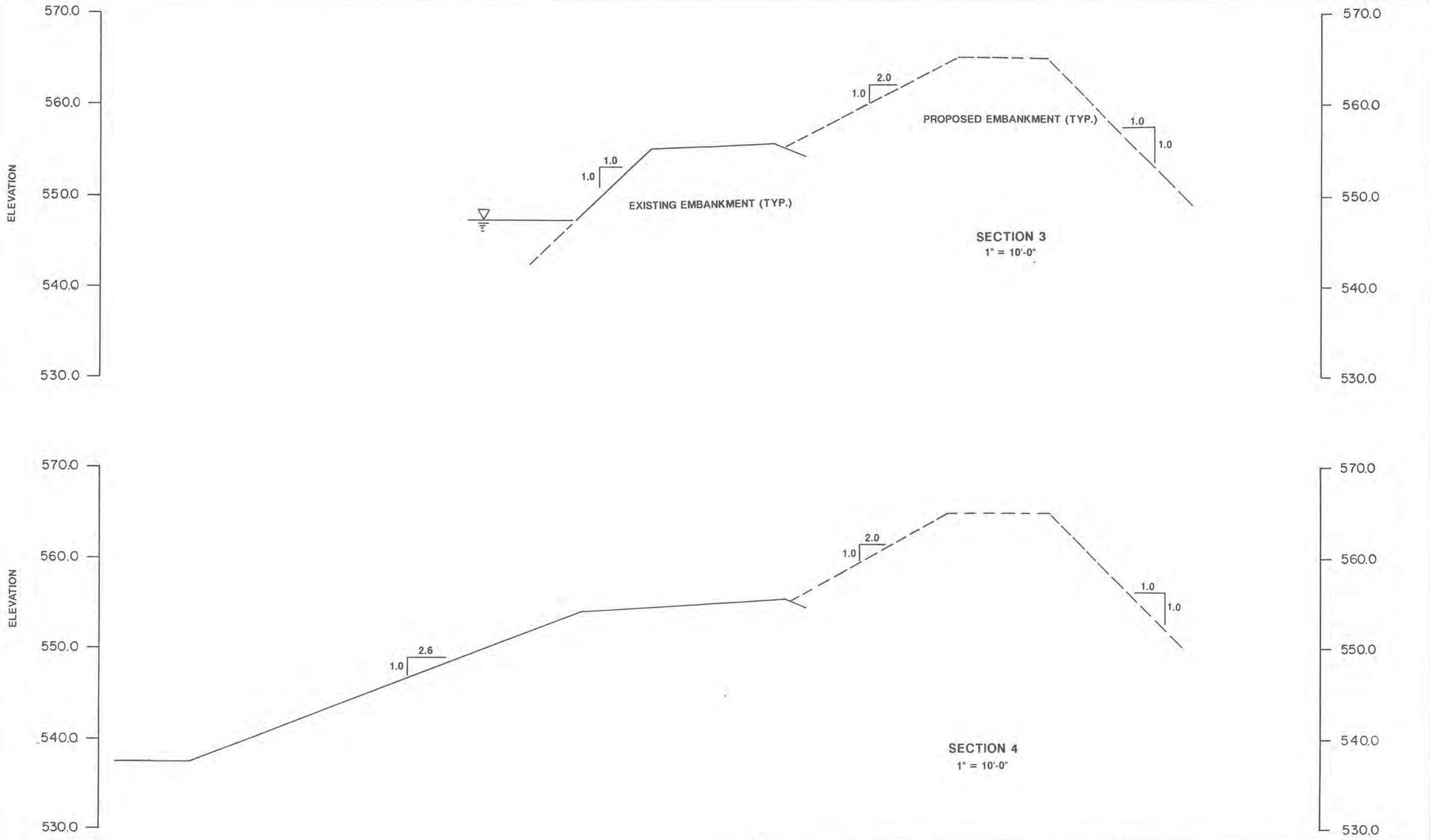
CROSS SECTIONS

HANSON ENGINEERS INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

PROPOSED EMBANKMENT MODIFICATONS
CWLP ASH DISPOSAL AREA
SPRINGFIELD, ILLINOIS

JOB NO. 87S3014 FIGURE 5



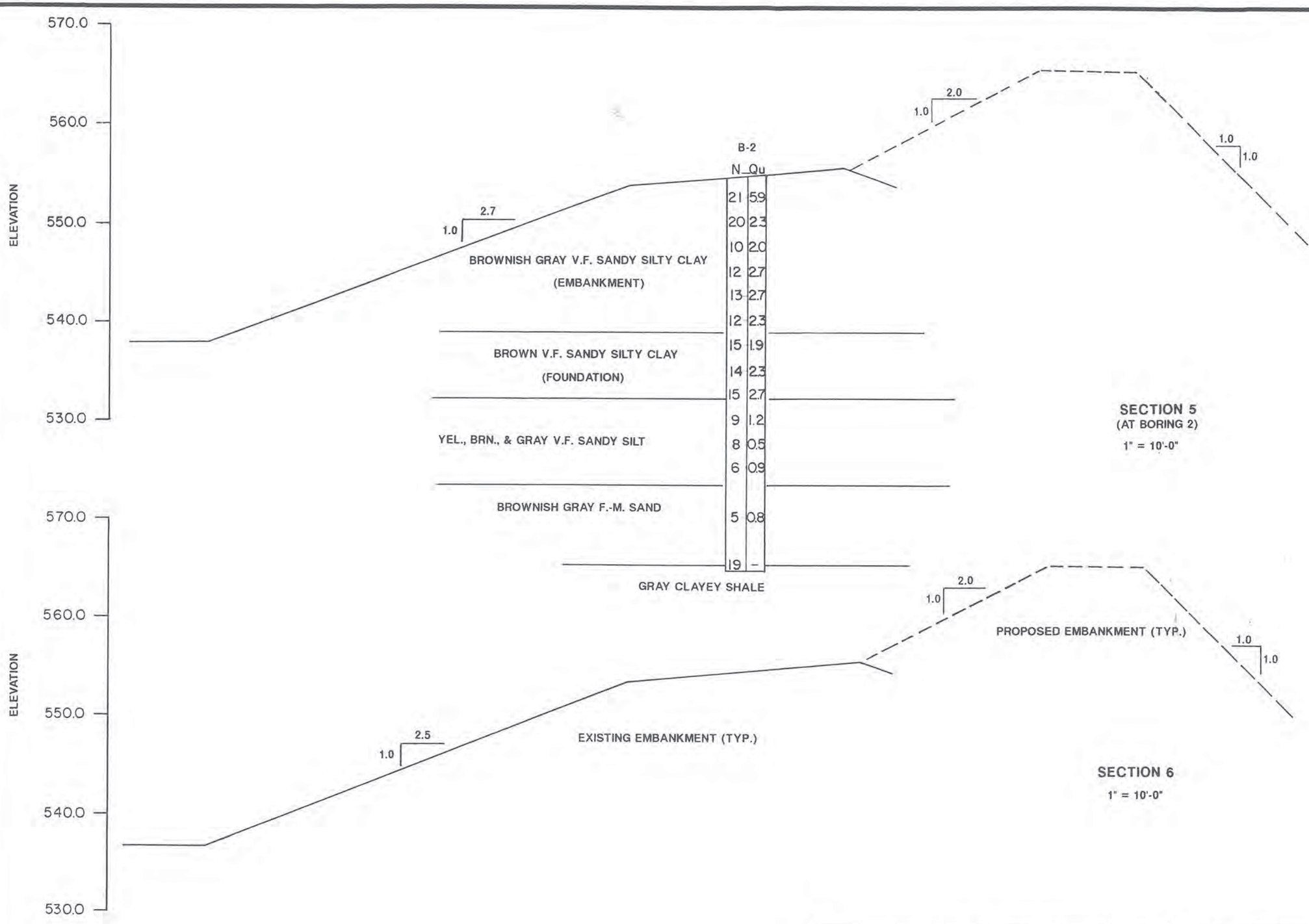
CROSS SECTIONS

HANSON ENGINEERS INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

PROPOSED EMBANKMENT MODIFICATONS
CWLP ASH DISPOSAL AREA
SPRINGFIELD, ILLINOIS

JOB NO. 87S3014 FIGURE 6



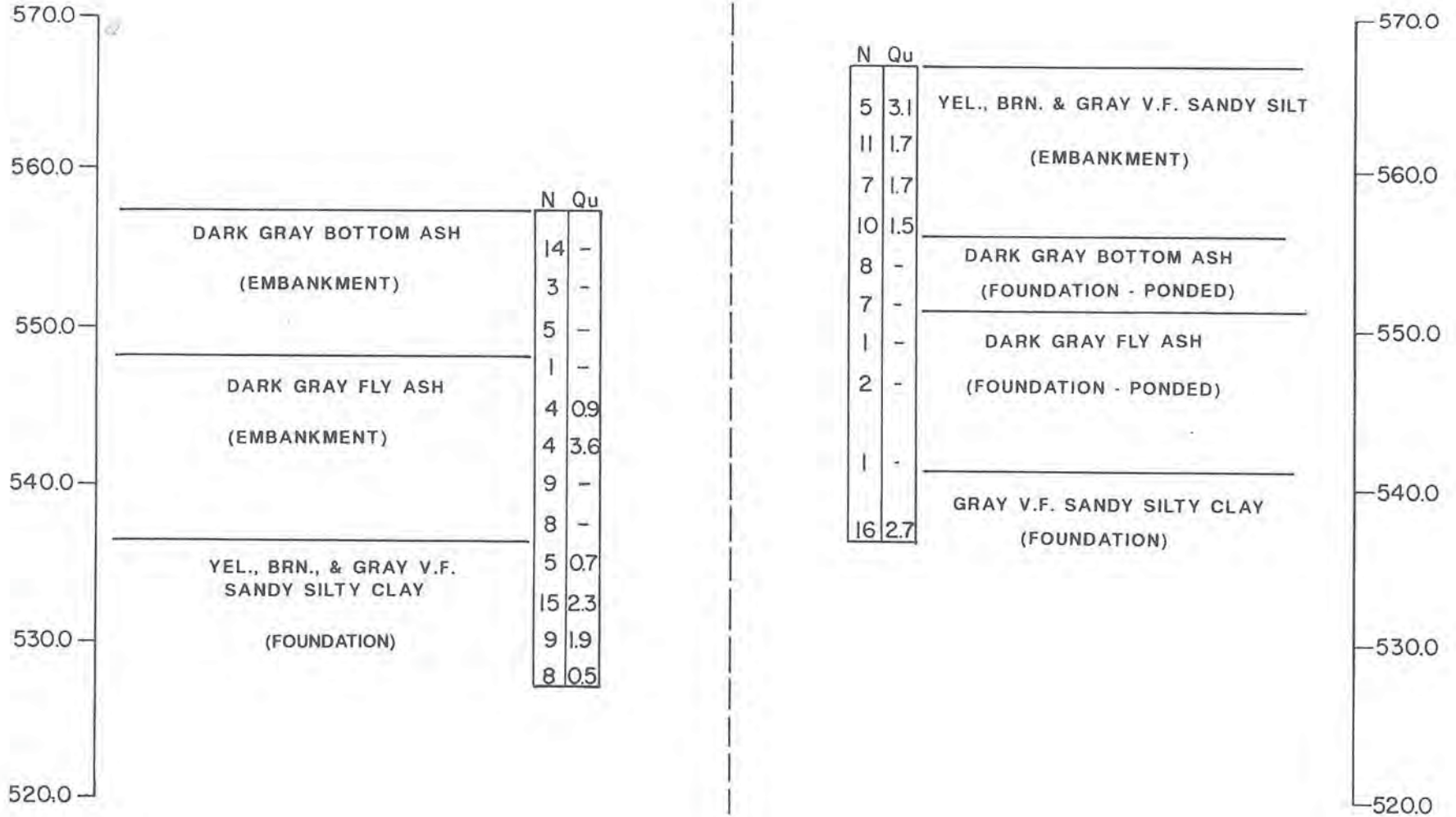
CROSS SECTIONS

HANSON ENGINEERS INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

PROPOSED EMBANKMENT MODIFICATONS
CWLP ASH DISPOSAL AREA
SPRINGFIELD, ILLINOIS

JOB NO. 87S3014 FIGURE 7



BORING PROFILES

HANSON ENGINEERS INCORPORATED

SPRINGFIELD, IL • PEORIA, IL • ROCKFORD, IL

PROPOSED EMBANKMENT MODIFICATONS
CWLP ASH DISPOSAL AREA
SPRINGFIELD, ILLINOIS

JOB NO. 87S3014 FIGURE 8

CENTRAL ILLINOIS DRILLING COMPANY
1909 OAKWOOD AVE.
BLOOMINGTON, ILLINOIS 61701
(309) 662-5968

LOG OF BORING

CONTRACTED WITH HANSON ENGINEERS — BORING NO. B-1
PROJECT NAME CWLP ASH POND — CONTRACT NO.
LOCATION PER PLAN
DATUM — HAMMER WT. 140# — HAMMER DROP 30" — HOLE DIA. 6"
SURFACE ELEV. — CORE DIA. — CASING
DATE STARTED 5-18-87 — COMPLETED 5-18-87 — DRILLING METHOD HSA

ELEV.	DESCRIPTION	STRATA DEPTH	DEPTH SCALE	SAMPLES BLOWS FT.	NO.	TYPE	RECOV.	QP	NOTES
		0.0	30						
	Blk. bot. ash, tr. f. gravel fill moist-wet		5	6-7-7	1	ss	14"	--	
				3-2-1	2	ss	8	--	
				3-2-3	3	ss	10	--	WATER 5-18-87 DD 5.0' 8:45am BAR 20.5' 10:15am AAR 4.6' 10:35am
		9.2							
	Blk. fly ash		10	2-1-0	4	ss	12	--	DWL 4.0' 6:35pm
				2-2-2	5	ss	15	0.8	
	wet		15	6-2-2	6	ss	14	0.9	
				4-4-5	7	ss	18	--	
			20	3-5-3	8	ss	18	--	

CENTRAL ILLINOIS DRILLING COMPANY
1909 OAKWOOD AVE.
BLOOMINGTON, ILLINOIS 61701
(309) 662-5968

LOG OF BORING

CONTRACTED WITH HANSON ENGINEERS BORING NO. B-1
PROJECT NAME CWLP ASH POND CONTRACT NO.
LOCATION PER PLAN
DATUM HAMMER WT. 140# HAMMER DROP 30" HOLE DIA. 6"
SURFACE ELEV. CORE DIA. CASING
DATE STARTED 5-18-87 COMPLETED 5-18-87 DRILLING METHOD HSA

ELEV.	DESCRIPTION	STRATA DEPTH	DEPTH SCALE	SAMPLES BLOWS FT.	NO.	TYPE	RECOV.	QP	NOTES
		0.0	30						
				3-2-3	9	ss	18"	1.2	
		23.1							
	Green gray silty clay, tr. f.m. sand, tr. f. gravel moist	25.7	25	6-8-7	10	ss	18	4.5+	
	Dk. gray silty clay moist			4-4-	11	ss	18	3.1	
		30.0	30	3-4-4	12	ss	18	2.0	
	END OF BORING 30.0'								

CENTRAL ILLINOIS DRILLING COMPANY
1909 OAKWOOD AVE.
BLOOMINGTON, ILLINOIS 61701
(309) 662-5968

LOG OF BORING

CONTRACTED WITH HANSON ENGINEERS BORING NO. B-2
PROJECT NAME CWLP ASH POND CONTRACT NO.
LOCATION
DATUM HAMMER WT. 140# HAMMER DROP 30" HOLE DIA. 6"
SURFACE ELEV. CORE DIA. CASING
DATE STARTED 5-18-87 COMPLETED 5-18-87 DRILLING METHOD HSA

ELEV.	DESCRIPTION	STRATA DEPTH	DEPTH SCALE	SAMPLES BLOWS FT.	NO.	TYPE	RECOV.	QP	NOTES
		0.0	30						
	10" white rock, brn. gray silty clay fill moist	3.3		8-10-11	1	ss	15"	4.5+	
	Light brn. silty clay fill moist	5.8	5	8-9-11	2	ss	16	3.0	
	Brn. green blk. silty clay fill moist			3-5-5	3	ss	15	2.1	WATER 5-18-87
				3-5-7	4	ss	16	2.4	DD 28.5' 12:00pm BAR 18.5' 1:55pm AAR WCI 15.0' 2:
			10						
				3-6-7	5	ss	13	2.0	Dwl 14.0' 6:30pm
				3-5-7	6	ss	18	1.7	
			15						
				5-6-9	7	ss	18	3.2	
				5-6-8	8	ss	18	3.2	
			20						

CENTRAL ILLINOIS DRILLING COMPANY
1909 OAKWOOD AVE.
BLOOMINGTON, ILLINOIS 61701
(309) 662-5968

LOG OF BORING

CONTRACTED WITH HANSON ENGINEERS BORING NO. B-2
PROJECT NAME CWLP ASH POND CONTRACT NO.
LOCATION PER PLAN
DATUM HAMMER WT. 140# HAMMER DROP 30" HOLE DIA. 6"
SURFACE ELEV. CORE DIA. CASING
DATE STARTED 5-18-87 COMPLETED 5-18-87 DRILLING METHOD HSA

ELEV.	DESCRIPTION	STRATA DEPTH	DEPTH SCALE	SAMPLES BLOWS FT.	NO.	TYPE	RECOV.	QP	NOTES
		0.0	30						
		22.7		4-6-9	9	ss	18"	3.5	
	Brn. gray silty clay, tr. f. sand moist	25.4	25	3-3-6	10	ss	18	1.8	
	Brn. gray clayey silt, some f. sand, occas. 1-3" f. sand seams a wet	31.5	30	3-4-4	11	ss	18	1.5	
				2-3-3	12	ss	18	0.5	
	Brn. f.m. sand wet		35	2-2-3	13	ss	18	1.2	
		39.8		11-11-12	14	ss	18	2.5	
	Brn. f.m. sand wet	40.0	40						
	END OF BORING 40.0'								

CENTRAL ILLINOIS DRILLING COMPANY
1909 OAKWOOD AVE.
BLOOMINGTON, ILLINOIS 61701
(309) 662-5968

LOG OF BORING

CONTRACTED WITH HANSON ENGINEERS BORING NO. B-3
PROJECT NAME CWLP ASH POND CONTRACT NO.
LOCATION PLAN
DATUM HAMMER WT. 140# HAMMER DROP 30" HOLE DIA. 6"
SURFACE ELEV. CORE DIA. CASING
DATE STARTED 5-18-87 COMPLETED 5-18-87 DRILLING METHOD HSA

ELEV.	DESCRIPTION	STRATA DEPTH	DEPTH SCALE	SAMPLES BLOWS FT.	NO.	TYPE	RECOV.	QP	NOTES
		0.0	30						
	5" white rock, brn. gray blk. silty clay fill moist	4.5		7-6-12	1	ss	14"	4.5+	
				6-9-9	2	ss	18	4.5+	
	Blk. silty clay fill moist		5						
		8.3		5-5-6	3	ss	16	1.7	WATER 5-18-87
	Brn. green blk. silty clay fill moist		10	3-4-8	4	ss	17	2.5	DD 24.0' 3:50pm BAR 12.4' 4:05pm AAR 10.0' 4:25pm DWL 9.5' 6:45pm
		17.9		3-6-7	5	ss	18	2.2	
	Blk. gray silty clay fill moist		15	3-6-8	6	ss	18	2.4	
				5-6-7	7	ss	18	2.3	
		20.6	20	3-4-8	8	ss	18	3.0	

CENTRAL ILLINOIS DRILLING COMPANY
1909 OAKWOOD AVE.
BLOOMINGTON, ILLINOIS 61701
(309) 662-5968

LOG OF BORING

CONTRACTED WITH HANSON ENGINEERS BORING NO. B-3
PROJECT NAME CWLP ASH POND CONTRACT NO.
LOCATION PER PLAN
DATUM HAMMER WT. 140# HAMMER DROP 30" HOLE DIA. 6"
SURFACE ELEV. CORE DIA. CASING
DATE STARTED 5-18-87 COMPLETED 5-18-87 DRILLING METHOD HSA

ELEV.	DESCRIPTION	STRATA DEPTH	DEPTH SCALE	SAMPLES BLOWS FT.	NO.	TYPE	RECOV.	QP	NOTES
		0.0	30						
				5-6-9	9	ss	18"	2.0	
	Brn. gray silty clay								
	moist-wet		25	3-4-5	10	ss	18	2.0	
				3-3-4	11	ss	18	1.6	
		28.2							
	Gray brn. clay, little silt moist	30.0		6-9-12	12	ss	18	3.8	
			30						
	END OF BORING 30.0'								

CENTRAL ILLINOIS DRILLING COMPANY
1909 OAKWOOD AVE.
BLOOMINGTON, ILLINOIS 61701
(309) 662-5968

LOG OF BORING

CONTRACTED WITH HANSON ENGINEERS BORING NO. B-4
PROJECT NAME CWLP ASH POND CONTRACT NO.
LOCATION PER PLAN
DATUM HAMMER WT. 140# HAMMER DROP 30" HOLE DIA. 6"
SURFACE ELEV. CORE DIA. CASING
DATE STARTED 5-18-87 COMPLETED 5-18-87 DRILLING METHOD HSA

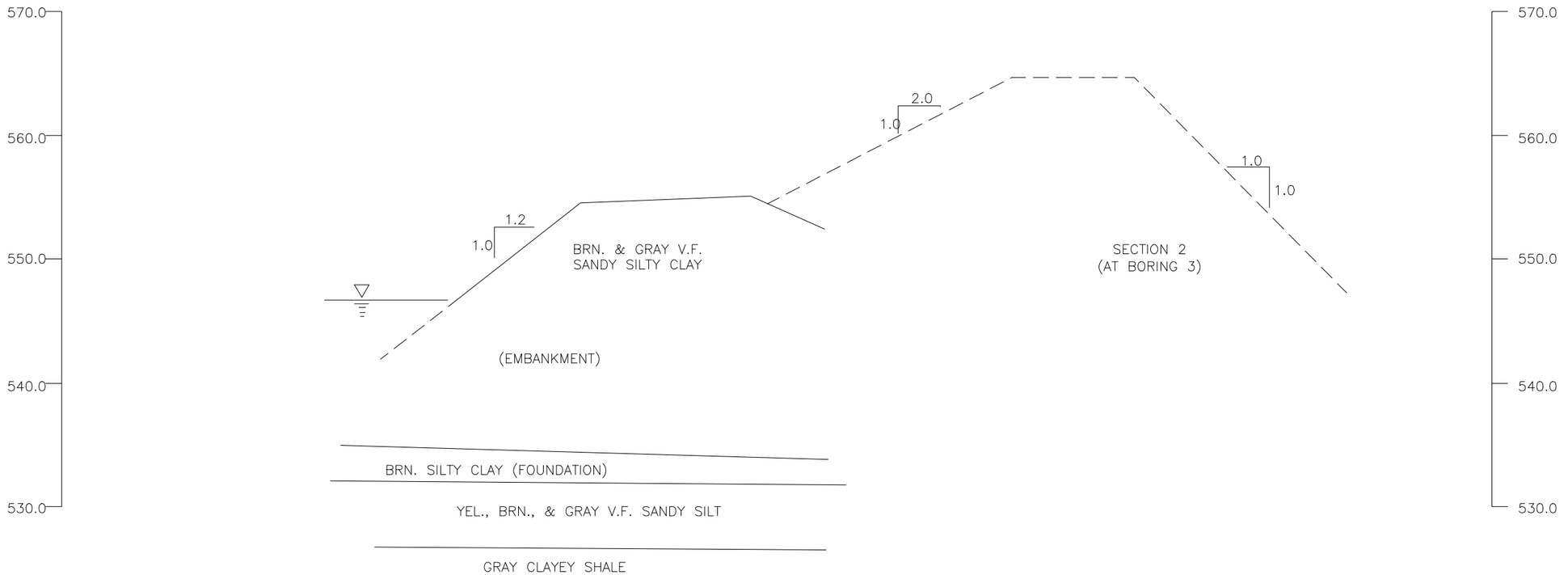
ELEV.	DESCRIPTION	STRATA DEPTH	DEPTH SCALE	SAMPLES BLOWS FT.	NO.	TYPE	RECOV.	QP	NOTES
		0.0	30						
	Brn. silty clay fill moist	4.0		3-3-2	1	ss	10"	3.5	
	Brn. gray blk. silty clay fill moist		5	4-5-6	2	ss	12	3.2	
				3-3-4	3	ss	10	2.5	WATER 5-18-87 DD 11.0' 5:15pm BAR 22.0' 6:00pm AAR 9.8' 6:30pm
		10.5	10	3-5-5	4	ss	13	2.5	DWL 9.5' 6:50pm
	Blk. bot. ash fill wet			5-4-4	5	ss	18	--	
		15.2	15	5-4-3	6	ss	16	--	
	Blk. fly ash fill wet			1-1-0	7	ss	18	0.2	
			20	0-0-2	8	ss	.8	0.2	

CENTRAL ILLINOIS DRILLING COMPANY
1909 OAKWOOD AVE.
BLOOMINGTON, ILLINOIS 61701
(309) 662-5968

LOG OF BORING

CONTRACTED WITH HANSON ENGINEERS BORING NO. B-4
PROJECT NAME CWLP ASH POND CONTRACT NO.
LOCATION PER PLAN
DATUM HAMMER WT. 140# HAMMER DROP 30" HOLE DIA. 6"
SURFACE ELEV. CORE DIA. CASING
DATE STARTED 5-18-87 COMPLETED 5-18-87 DRILLING METHOD HSA

ELEV.	DESCRIPTION	STRATA DEPTH	DEPTH SCALE	SAMPLES BLOWS FT.	NO.	TYPE	RECOV.	QP		NOTES
		0.0	30							
				1-0-1	9	ss	18"	0.5		
		25.5	25							
	Blk. gray clay, tr. silt moist									
		30.0		4-6-10	10	ss	18	3.3		
			30							
	END OF BORING 30.0'									



NOTES:
CROSS-SECTION BASED ON CONSTRUCTION PLAN DRAWINGS INCLUDED IN ENGINEERING REPORT PROPOSED EMBANKMENT MODIFICATIONS, HANSON ENGINEERS, INC., JULY 1987

REVISIONS

NO.	DATE	DESCRIPTION	BY

ANDREWS ENGINEERING, INC.
3300 GINGER CREEK DRIVE
SPRINGFIELD, ILLINOIS 62711-7233
PH (217) 787-2334 FAX (217) 787-9495
PONTIAC, IL • LOMBARD, IL • INDIANAPOLIS, IN • WARRENTON, MO
PROFESSIONAL DESIGN ENGINEERING AND LAND SURVEYING FIRM #184001541

APPROVED BY: PMV | DESIGNED BY: PMV | DRAWN BY: RMC

LAKESIDE ASH POND CROSS-SECTION 2

PLANS PREPARED FOR
CITY, WATER, LIGHT & POWER
SPRINGFIELD, SANGAMON COUNTY, ILLINOIS

DATE: OCTOBER 2016

PROJECT ID: 150077/0011

SHEET NUMBER:

X-SEC.

© 2016 Andrews Engineering, Inc.

J:\S\Springfield CWLP\CWLP\dwg\CROSS-SECTION 2.dwg Tab: Layout1 Last Saved: October 7, 2016, by Ryan Curtis Plotted: Friday, October 07, 2016 10:13:31 AM

APPENDIX C

Fly Ash Technical Papers

Engineering Characteristics of Coal Combustion Residuals and a Reconstitution Technique for Triaxial Samples

Nicholas A. Lacour

Thesis submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Master of Science
In
Civil Engineering

Adrián Rodriguez-Marek, Chair
Joseph Dove
James Martin

19 June, 2012
Blacksburg, Virginia

Keywords: coal combustion residuals, fly ash, bottom ash, surface impoundments

Copyright 2012, Nicholas A. Lacour

Engineering Characteristics of Coal Combustion Residuals and a Reconstitution Technique for Triaxial Samples

Nicholas Alexander Lacour

ABSTRACT

Traditionally, coal combustion residuals (CCRs) were disposed of with little engineering consideration. Initially, common practice was to use a wet-scrubbing system to cut down on emissions of fly ash from the combustion facilities, where the ash materials were sluiced to the disposal facility and allowed to sediment out, forming deep deposits of meta-stable ash. As the life of the disposal facility progressed, new phases of the impoundment were constructed, often using the upstream method. One such facility experienced a massive slope stability failure on December 22, 2008 in Kingston, Tennessee, releasing millions of cubic yards of impounded ash material into the Watts Bar reservoir and damaging surrounding property. This failure led to the call for new federal regulations on CCR disposal areas and led coal burning facilities to seek out geotechnical consultants to review and help in the future design of their disposal facilities. CCRs are not a natural soil, nor a material that many geotechnical engineers deal with on a regular basis, so this thesis focuses on compiling engineering characteristics of CCRs determined by different researchers, while also reviewing current engineering practice when dealing with CCR disposal facilities. Since the majority of coal-burning facilities used the sluicing method to dispose of CCRs at one point, many times it is desirable to construct new "dry-disposal" phases above the retired ash impoundments; since in-situ sampling of CCRs is difficult and likely produces highly disturbed samples, a sample reconstitution technique is also presented for use in triaxial testing of surface impounded CCRs.

Acknowledgments

I would like to thank Dr. Adrián Rodriguez-Marek, my advisor, for his guidance throughout my thesis work and throughout my academic career at Virginia Tech. I would also like to thank my parents for their encouragement and support throughout my entire academic career. Lastly, I would like to thank my grandmother for passing on my great-grandparents' rock collection that first sparked my interest in geology and undoubtedly led to my interest in geotechnical engineering.

Contents

1. Introduction and Background 1

1.1 Introduction 1

1.2 Kingston Fossil Plant Failure 5

1.3 Outline 6

2. Engineering Characterization of CCRs 8

2.1 Specific Gravity 9

2.2 Consolidation Properties and Volume Stability 11

2.3 Hydraulic Conductivity 21

2.4 Shear Strength 26

2.5 Compaction Characteristics 37

3. Dynamic Properties of CCRs 40

3.1 Cyclic Shear Strength Properties of CCRs 40

4. CCR Failure Modes and Monitoring Practices 45

4.1 Surface Impoundments 45

4.2 CCR Landfills 49

4.3 Failure Modes 50

5. Slope Stability of CCRs 52

5.1 Limit Equilibrium and Finite Element Analyses 52

6. Settlement Calculations for CCRs 59

6.1 Test Fill Results 59

6.2 Settlement Calculation by Consolidation Theory 60

6.3 Settlement Calculation by D'Appolonia Method 61

6.4 Other Observations 63

7. Reconstitution Technique for Surface Impounded CCRs 65

7.1 Moist Tamping 65

7.2 Air/Water Pluviation 66

7.3 Slurry Deposition Techniques 67

7.4 Slurry Deposition Technique Applied to SI CCRs 67

7.5 Analysis of Slurry Deposition Technique with SI CCRs 75

8. Conclusions 86

8.1 Engineering Characterization of CCRs 86

8.2 Dynamic Properties of CCRs 86

8.3 CCR Failure Modes and Monitoring Practices 87

8.4 Slope Stability of CCRs 87

8.5 Settlement Calculations for CCRs 88

8.6 Slurry Deposition Technique Applied to SI CCRs 88

8.7 Recommendations for Further Study 89

References 90

Appendix A 96

Sample Preparation and Fabric Analysis Spreadsheets 96

List of Figures

Figure 1: Aerial photographs comparing the Kingston Fossil Plant ash disposal area before and after the massive slope failure on December 22, 2008. 6

Figure 2: Variability plot for the specific gravities determined by studies performed in different countries. 13

Figure 3: Variability plot for the compression indices of studies done on fly ashes and surface impounded ashes. 15

Figure 4: Variability plot of the compression indices for studies done on bottom ashes. 16

Figure 5: Variability plot of the recompression indices for studies done on fly ashes, bottom ashes, and surface impounded ashes 17

Figure 6: Variability plot for the coefficient of consolidation of studies done on fly ash, bottom ash, and surface impounded ash. 18

Figure 7: Variability plot of the hydraulic conductivity of fly ashes from different countries, as determined by different researchers. 24

Figure 8: Variability plot of the hydraulic conductivity of surface impounded ashes and bottom ashes from different countries, as determined by different researchers. 25

Figure 9: Micrographs of bottom ash particles magnified 112 and 373 times (Jakka et al. 2010) 26

Figure 10: Micrographs of fly ash magnified 100 and 2,000 times (courtesy of Kevin Foster).. 27

Figure 11: Variability plot of effective stress friction angle of various CCRs as determined by different researchers using the direct shear test. 30

Figure 12: Variability plot of the effective stress friction angle of various CCRs as determined by different researchers using the consolidated drained triaxial test. 31

Figure 13: Variability plot of the effective stress friction angle of various CCRs as determined by different researchers using the consolidated undrained triaxial test. 32

Figure 14: Variability plot of the effective stress friction angle of fly ashes for all shear strength tests performed by various researchers. 33

Figure 15: Variability plot of the effective stress friction angle of surface impounded ashes for all shear strength tests performed by various researchers. 34

Figure 16: Variability plot of the effective stress friction angle of bottom ashes for all shear strength tests performed by various researchers. 35

Figure 17: Variability plot of the total stress friction angle of all CCRs as determined by consolidated undrained triaxial tests performed by various researchers. 36

Figure 18: Compaction curves for different Indian fly ashes compared to those for several natural soils (Sridharan et al. 2001) 38

Figure 19: Plot of excess pore pressure ratio versus number of loading cycles for compacted Indian surface impoundment ash at different cyclic stress ratios and 1 Hz loading frequency (Mohanty et al. 2010). 41

Figure 20: Plot of excess pore pressure ratio versus number of loading cycles for compacted Indian surface impoundment ash at a cyclic stress ratio of 0.10 and confining pressure of 2214 psf and 0.1 Hz loading frequency (Jakka et al. 2010) 42

Figure 21: Plot of CSR versus number of loading cycles to liquefaction for different surface impounded CCRs tested by different researchers at confining stresses close to 50 kPa. Jakka et al. loaded specimens at 0.1 Hz to 1 Hz and Dey and Gandhi loaded specimens at 1 Hz. For comparison, curves for sands tested at the same confining pressure are superimposed (Mulilis et al 1976). 42

Figure 22: Plot of CSR versus number of loading cycles to liquefaction for surface impounded CCRs tested by Jakka et al (2010) at a confining pressure of 100 kPa. For comparison,

curves for C778 sand at the same confining pressure are superimposed (Carraro et al 2003). 43

Figure 23: Plot of CSR versus number of loading cycles to liquefaction for different surface impounded CCRs tested by different researchers at 200 kPa confining stress. Jakka et al. loaded specimens at 0.1 Hz to 1 Hz and Mohanty et al. loaded specimens at 1 Hz. 43

Figure 24: Example of how to determine the energy dissipated by a soil throughout a single loading cycle (Yoshimoto et al. 2006). 44

Figure 25: Flow chart illustrating risk management utilizing the observational method (after Davies and Martin 2000) 47

Figure 26: Comparison of failure modes of upstream mine tailings dams as compared to other types of mine tailings dams (modified from Davies and Martin 2000) 47

Figure 27: Sample surveillance plan schedule for a mine tailings impoundment (after Davies and Martin 2000) 48

Figure 28: Subsurface profile of a slope stability example for an SI CCR embankment. 54

Figure 29: Analyses for the in-situ condition, first with the in-situ measured water table (above) and then with a hypothetical higher water table (below). Slip surfaces are shown for factors of safety below 1.7 for the above case and between 1.0 and 1.2 for the below case. 55

Figure 30: Analyses for an added upstream dry-disposed cell over the surface impoundment, for the in-situ water table (above) and for a hypothetical higher groundwater table (below). Slip surfaces with factors of safety between 1.5 and 1.6 are shown in the above case and between 1.2 and 1.3 for the below case. 56

Figure 31: Analyses for an added upstream dry-disposed cell above the surface-impoundment for the in-situ groundwater table (above) and for a hypothetical higher groundwater table (below). Slip surfaces with factors of safety between 1.5 and 1.7 are shown for the above case and between 1.2 and 1.4 for the below case. 57

Figure 32: Plots published by D'Appolonia et al. (1970) to determine the values of the geometry factors to be used in footing settlement analyses. 62

Figure 33: Acrylic mixing tube with a rubber stopper on one end and rubber gasket seal glued to the opposite end. 68

Figure 34: Thin metal disk approximately the same diameter of the bottom porous disk. 69

Figure 35: Water bath large enough to completely submerge the mixing tube and allow for easy placement of the porous disk and metal plate. The rubber membrane can also be seen rolled down around the mixing tube. 69

Figure 36: Water bath large enough to accommodate the bottom of the triaxial cell and submerge the bottom platen. 70

Figure 37: A custom-made split-collar to accommodate the additional volume of soil when the slurry is first placed in the specimen split-mold. This collar was machined out of nylon to fit the dimensions of the split-mold being used and the flexible collar used to accommodate the extra water volume when the slurry was placed. 70

Figure 38: Placement of the porous disk and transferring of the fines lost in the water bath to a container to be oven-dried and weighed. 71

Figure 39: Securing of the porous disk with the thin rubber membrane and placement of the thin metal disk over the opening in the membrane. 72

Figure 40: Rolling up the membrane around the mixing tube and placement of the specimen split-mold, the slurry extension collar, and the water extension collar after removal of the triaxial cell base from the water bath. 73

Figure 41: Setup used to densify SI CCR slurry-deposition samples. Notice that the short-circuit between the top and bottom drainage is being used to drain the sample as it is densified with the top platen applied. The top platen fits snugly enough into the extension collar to keep a water-proof seal. The white piece on the top of the triaxial base is simply a part to keep the

piston plumb as the slight pressure is applied to the top of the sample during densification. 74

Figure 42: Ice bath placed around the compacted specimen for a period of four hours to set the gelatin. 76

Figure 43: Specimen removed from the split mold and membrane following gelatin curing period. 77

Figure 44: Each specimen slice volume was determined using water displacement. A 500 mL capacity beaker and a ruler incremented at 1/100" were used to do this. The vertical distance between a 100 mL addition of water to the beaker and the equation for the volume of a cylinder was used to calculate the diameter of the beaker; with the diameter known, it was determined that volumes could be measured accurately to ± 1.4 cm^3. 79

Figure 45: Plot comparing grain-size distributions across the height of specimen one. 81

Figure 46: Plot comparing grain-size distribution across the height of specimen two. 82

Figure 47: Plot comparing grain-size distribution across the height of specimen three. 83

Figure 48: Plot comparing grain-size distributions of the top slices of all three specimens..... 83

Figure 49: Plot comparing grain-size distribution of the middle slices of all three specimens. .. 84

Figure 50: Plot comparing grain-size distribution for the bottom slices of all three specimens.. 84

Figure 51: Comparison of all gradations for all three samples. 85

List of Tables

Table 1: Reported specific gravities of CCRs from different countries..... 9

Table 2: Percentages by weight of major oxide constituents of CCRs from different countries (after Yudbhir and Honjo 1991)..... 11

Table 3: Compression and recompression indices and coefficients of consolidation for CCRs reported by different researchers..... 14

Table 4: Classification of Soils based on FSR (adapted from Sridharan and Prakash 2000) 19

Table 5: Values of hydraulic conductivity for different CCRs for different countries as determined by different researchers (adapted from Prakash Sridharan 2009)..... 23

Table 6: Shear strength parameters determined by different researchers using the direct shear test. 28

Table 7: Shear strength parameters determined by different researchers using the consolidated drained triaxial test. 29

Table 8: Shear strength parameters determined by different researchers using the consolidated undrained triaxial test. 29

Table 9: Summary of shear strength and hydraulic parameters used in CCR surface impoundment slope stability example. 53

Table 10: Consolidation settlements calculated for test fill placed over a CCR surface impoundment. 60

Table 11: Specimen relative density and density summary. The bottom two rows summarize relative density and density data for the entire specimen. 80

Chapter 1

Introduction and Background

Ever since the promulgation of the Resource Conservation and Recovery Act in 1976, there has been debate on the proper waste classification of coal combustion by-products. They have traditionally been disposed of in a fashion similar to that of mine tailings wastes. However, the failure of the Kingston Fossil Plant's main disposal cell on December 22, 2008 has once again led to discussions on how to properly regulate the disposal of these materials. From an engineering standpoint, geotechnical engineers have very little experience with coal combustion wastes, which have some unique engineering properties that set them apart from naturally occurring soils. A comprehensive literature review and compilation of engineering properties of coal combustion residual materials is consolidated and compared between researchers from different nations. Additionally, a triaxial sample reconstitution technique is proposed for surface impounded coal combustion residuals (different types of coal combustion residuals are addressed in section 1.1) which minimizes particle segregation and ensures constant density across the height of the sample. This chapter presents an introduction to the thesis and presents a brief summary of the December 22, 2008 slope stability failure at the Tennessee Valley Authority's (TVA's) Kingston power plant, which served as an inspiration for this thesis.

1.1 Introduction

Coal is the most commonly used fuel in generating electrical energy in the United States. In 2009, coal-powered steam turbines produced 45% of the almost 4 trillion kilowatt-hours of

consumed energy in the US (Energy Information Administration 2010). With the burning of such large quantities of coal, there is naturally also a large amount of ash and other byproducts. The four main types of byproducts of burnt coal as described by the Environmental Protection Agency (EPA 2011) are:

Fly Ash: mostly spherical silt to clay-sized particles composed mostly of silica removed from plant exhaust gases through the use of electrostatic precipitators or bag-houses with secondary scrubber systems.

Bottom Ash: coarse, porous, angular fine sand to fine gravel-sized particles of agglomerated ash formed in pulverized ash furnaces.

Boiler Slag: molten bottom ash collected at the base of slag tap and cyclone type furnaces that is quenched with water, causing it to fracture, crystallize, and form pellets. It is composed of hard, black, angular particles that have a smooth, glassy appearance.

Flue Gas Desulfurization (FGD) Material: product of a process used for reducing SO_2 emissions from the gas system of a coal-fired boiler. Depending on the scrubbing process, the material is either predominantly calcium sulfite ($CaSO_3$), calcium sulfate ($CaSO_4$), or a mixture of the two. It consists of small, fine, particles. Calcium Sulfate FGD material can be used in place of gypsum ($CaSO_4 \cdot 2H_2O$) in wallboard manufacturing or in cement production, while calcium sulfite can be used as embankment and road base material.

There are beneficial reuses for each of these byproducts, though generation almost always outweighs demand. In order to avoid confusion, when referring to these byproducts, the definitions outlined by EPA (*Federal Register* 2010) will be used. When referring to burnt-coal byproducts being beneficially used, the term Coal Combustion Products (CCPs) will be used, while Coal Combustion Residuals (CCRs) will be used when referring to byproducts that are destined for disposal.

Use of CCPs are unique to the application in which they are being utilized. Therefore, the focus of this thesis is on the geotechnical engineering properties and design and monitoring considerations for CCR landfills and surface impoundments.

Depending on the type of system used to remove fly ash from and/or to desulfurize the exhaust gases of boilers used in electricity generation, CCRs have traditionally been disposed of using either a dry (or, more accurately, a moisture conditioned) placement method or a hydraulic sluicing method . Again referring to EPA definitions (*Federal Register* 2010), any disposal area where CCRs are disposed of using a dry method will be referred to as a CCR landfill, while any area that CCRs are disposed of hydraulically will be referred to as a CCR surface impoundment. A CCR surface impoundment is a disposal area much akin to a mine tailings dam disposal area, or to a dredge spoil area. While CCR landfill wastes are placed using backhoes or other heavy equipment and compacted in a moist condition, CCR surface impoundment wastes are simply the result of a wet-scrubbing removal system for fly ashes; the effluent from these wet-scrubbing processes is then often mixed with bottom ashes and hydraulically placed in a disposal area contained by some sort of dike system.

As a result of the Kingston Fossil Plant failure, EPA found it necessary to reexamine regulatory policies regarding the disposal of CCRs:

With the promulgation of 42 U.S.C. §6901 (1976), commonly known as the Resource Conservation and Recovery Act (RCRA), CCRs were not initially specified as hazardous (subtitle C) or solid wastes (subtitle D). In 1980, the Solid Waste Disposal Act amendments to RCRA were enacted, one of which was the “Bevill Amendment”, 42 U.S.C. §6921 (b)(3)(A)(i). This amendment temporarily exempted CCRs from subtitle C regulation, classifying them as subtitle D, which is subject to state regulation. In 1988, EPA released a report entitled *Wastes from the Combustion of Coal by Electric Utility Power Plants* in which they concluded that the four above-mentioned CCRs did not exhibit hazardous characteristics according to RCRA regulations and would therefore not be regulated under Subtitle C. However, it was not until August 9, 1993 that EPA issued the final regulatory determination applicable to these CCRs (*Federal Register* 1993), stating that regulation of them as hazardous wastes was unwarranted (Dockter and Jagiella 2005).

Most recently, on June 21, 2010, EPA announced their intent to regulate CCRs generated from the combustion of coal at electric utilities under the RCRA. The EPA announcement introduced two options:

- EPA would reverse the 1993 and 2000 exemptions of CCRs under the Bevill Amendment and list them as special wastes subject to regulation under subtitle C of RCRA when they are destined for disposal in landfills or surface impoundments.
- EPA would leave the Bevill determination in place while regulating the disposal of CCRs under subtitle D of RCRA by issuing national minimum criteria.

Regardless of the chosen alternative, EPA is also proposing to establish dam safety requirements in order to address the stability of CCR surface impoundments to prevent catastrophic releases like that at the TVA Kingston plant. EPA has suggested the adoption of the Hazard Potential Classification System for Dams, developed by the U.S. Army Corps of Engineers, since it would be relatively straightforward in its application to surface impoundments.

The main purpose of this thesis is to consolidate current published material on the properties of CCRs and to quantify the variability within the engineering properties of CCRs between countries, individual power plants, and CCR types. Furthermore, CCR impoundment areas are plentiful across the U.S. and power generating companies would prefer to begin dry disposal of CCRs directly over retired CCR surface impoundments. In order to do this, a geotechnical site investigation must be performed, in which the static and dynamic shear strengths of the surface impounded materials are analyzed. Since CCRs tend to be non-plastic in nature, undisturbed sampling is often difficult, time consuming, costly, and anything but "undisturbed." Therefore, a second objective of this thesis is to analyze a slurry deposition specimen reconstitution technique that is easier and less costly than undisturbed sampling, in order to determine if this specimen reconstitution technique forms samples of uniform relative density without particle segregation.

1.2 Kingston Fossil Plant Failure

The Kingston Fossil Plant is a coal-fired electrical power plant constructed and operated by the Tennessee Valley Authority (TVA). Construction on the facility began in 1951 and the first coal-fired electrical unit began in 1954. Ash slurries were initially released into a slack water area created by a two dikes with a gap in-between to allow water from the Watts Bar Reservoir to enter. The ash slurries and the waters of the reservoir were then allowed to commingle until the two dikes were connected in 1958, separating the reservoir and the ash disposal area. This slack water area collected silt and clay sediments from the period of 1942 to 1954; after 1954, disposed ash was added to the silts and clays being deposited and with the construction of the closure dike, additional clay runoff sediment was deposited along with the runoff silts, reservoir clays, and disposed ash. This formed a slick, weak layer found by AECOM to be a major contribution to the ash disposal area's failure in December of 2008 (Walter and Butler 2009).

The AECOM Root Cause Analysis report attributed the failure as most likely due to creep in the aforementioned weak layer due to active loading in a dredge cell contained within the disposal area. This creep caused an initial failure of various disposal phase dikes founded on older disposed ash deposits, which, in turn, caused progressive failure of upstream ashes, leading to undrained loading and subsequent failure of the downstream ash material and disposal area perimeter dike. The upstream progressive failure stopped upon reaching a former divider dike within the disposal area. The estimated ash released in the failure was 5.4 million cubic yards. Figure 1 provides an aerial photograph of the disposal area before and after the slope failure.



Figure 1: Aerial photographs comparing the Kingston Fossil Plant ash disposal area before and after the massive slope failure on December 22, 2008.

While this failure may have occurred because of a very unique site condition, AECOM did note in their Root Cause Analysis report that "extensive void ratio data in un-failed areas of the Dredge Cells showed a lack of significant consolidation of the wet ash with depth," which would indicate that strength would not increase significantly with depth in the disposed ash material. This property also raises the question of stability of these sort of disposal areas under dynamic loading. If surface-impounded coal ashes do not tend to increase in density with depth, this could leave a very deep, potentially liquefiable layer of CCRs at a given site, rather than just a single liquefaction-prone layer (which is usually the case in naturally-deposited soils).

The entire Root Cause Analysis report and other investigatory data for the Kingston Fossil Plant failure can be accessed on the TVA website at http://www.tva.gov/kingston/rca/.

1.3 Outline

This thesis is composed of eight chapters. The first chapter introduces the background as well as inspiration for the thesis topic. Chapters two and three provide consolidated research results on the static and dynamic engineering properties of CCRs, respectively. Chapter four discusses

similarities between mine tailings disposal areas and CCR disposal areas and provides some guidance on how monitoring techniques developed for mine tailings disposal areas can be directly applied or slightly modified so that they can be applied to CCR disposal areas. Chapters five and six address how slope stability and settlement analyses can differ for CCR materials as opposed to naturally occurring soils. Chapter seven provides a review of common triaxial reconstitution techniques used on granular materials, while also analyzing a reconstitution technique to determine if it produces homogenous samples in terms of grain size distribution and relative density with height. Finally, chapter eight provides some final observations for each chapter, as well as a summary of topics that require further research in the future.

Chapter 2

Engineering Characterization of CCRs

Index and mechanical properties of soils provide the basic information required to design earth retaining structures, foundations, and earthen embankments and to perform slope stability analyses; determining the index properties and running field and laboratory tests to determine these properties is the first step in any geotechnical engineering application. In any given region, there is a large body of literature from past projects describing the local soils that engineers can use as a resource to accelerate this initial process. CCRs, however, are not a natural soil and have characteristics that make their behavior in certain situations markedly different than natural soils of similar grain size; additionally, coal ashes can vary considerably from one site to another based on differences in the coal source, coal preparation methods, type of power plant unit, and combustion temperatures (Yudbhir and Honjo 1991). This chapter outlines some of the major differences in the properties of CCRs as compared to other soils and compiles some CCR characteristics obtained from published technical literature. Additionally, test data from engineering reports for five specific coal combustion plants in the U.S. are included; however, information identifying the specific plants has been omitted at the request of the plant operators. These five plants are referred to as Site 1 through Site 5 consistently throughout this thesis.

2.1 Specific Gravity

Perhaps one of the most unusual characteristics of CCRs is their wide range of specific gravities. While some CCRs may have specific gravities of around 2.7 or even 2.8, some have been reported to have specific gravities as low as 1.47. Table 1 provides some values of specific gravity (G_s) determined for CCRs by researchers in different countries.

Table 1: Reported specific gravities of CCRs from different countries

Reference	Type of CCR	Country	G_s
Martin et al. (1990)	Fly Ash	USA	2.03-2.49
Tu et al. (2007)		USA	2.10-2.40
Kim and Prezzi (2008)		USA	2.30-2.81
Site 3		USA	2.42-2.71
Site 4		USA	2.21-2.73
Sridharan et al. (1998)		India	1.95-2.31
Pandian and Balasubramonian (1999)		India	1.97-2.55
Prashanth et al. (1999)		India	2.03-2.67
Sridharan et al. (2001)		India	2.07-2.55
Trivedi and Sud (2004)		India	1.72-2.03
Pandian (2004)		India	1.95-2.55
Das and Yudhbir (2005)		India	2.14-2.62
Prakash and Sridharan (2006)		India	1.95-2.55
Prakash and Sridharan (2009)		India	1.66-2.55
Jakka et al. (2010)		India	2.18-2.27
Raymond (1961)		UK	2.05-2.26
Sherwood (1975)		UK	1.90-2.37
Indraratna and Nutalaya (1991)		Canada	1.90-2.90
		Thailand	2.27-2.45
Kolay and Kismoor (2009)		Malaysia	2.11-2.31
Muhardi et al. (2010)		Malaysia	2.50-2.70
Site 1	Surface Imp.	USA	2.13-2.30
Site 2		USA	2.16-2.26
Site 3		USA	2.55-2.62
Site 4		USA	2.20-2.47
Site 5		USA	2.29-2.61

Reference	Type of CCR	Country	G_s
Sridharan et al. (1998)		India	1.91-2.15
Sridharan et al. (2001)		India	1.96-2.66
Trivedi and Sud (2002)		India	1.60-2.10
Trivedi and Sud (2004)		India	1.98-2.00
Pandian (2004)		India	1.91-2.50
Prakash and Sridharan (2006)		India	1.91-2.50
Bera et al. (2007)		India	2.16-2.23
Prakash and Sridharan (2009)		India	1.64-2.66
Skarzynska et al. (1989)		UK	2.10-2.24
		Poland	1.90-2.31
Seals et al. (1972)	Bottom Ash	USA	2.28-2.78
Sridharan et al. (1998)		India	1.82-2.15
Sridharan et al. (2001)		India	1.98-2.19
Pandian (2004)		India	1.82-2.15
Prakash and Sridharan (2006)		India	1.66-2.17
Prakash and Sridharan (2009)		India	1.47-2.19
Jakka et al. (2010)		India	2.50-2.59
Kolay and Kismoor (2009)		Malaysia	2.09-2.32

Despite the wide range of specific gravities observed for CCRs, most researchers recognize that they usually have a specific gravity lower than that of natural soils (Prakash and Sridharan 2009, Trivedi and Singh 2004b, Tu et al. 2007). It logically follows that since the unit weight of CCRs is less than that of natural soils, horizontal earth pressures in CCRs will be less than that of natural soils as well. Prakash and Sridharan (2009) cite this as a property that makes them ideal for use as backfill material for retaining structures or as a lightweight fill in other construction applications.

Many factors contribute to variability in the specific gravity of coal ashes, such as the parent coal and the combustion and cooling processes. Figure 1 compares variability of the specific gravity of different coal ashes from different countries. Additionally, some of the research studies done on ash from several different plants have a much higher variability than studies done on specific sites, indicating that variability in the specific gravity of CCRs within a given plant is lower than the specific gravity of CCRs within the country where that plant is in. Examining Figure 2, it is interesting to note the clear difference in the mean values of specific gravity between US coal ashes and Indian coal ashes; this may be due to higher iron contents in

US coals. Table 2 provides percentages of major constituent oxides in CCRs from different countries by weight, which shows how much the mineralogy of CCRs can vary between countries, another factor that can account for high variability in the specific gravity of CCRs from different countries (Yudbhir and Honjo 1991). Loss on ignition (LOI) for the CCRs is also reported in Table 2, that is, the loss in mass of the samples upon strong heating.

Table 2: Percentages by weight of major oxide constituents of CCRs from different countries (after Yudbhir and Honjo 1991).

Constituents	USA	UK	Canada	India	Thailand	Japan	Hong Kong	China	Australia	S. Africa	Poland	Germany
SiO_2	28-59	37-54	37-59	13-64	27-34	50-62	38-77	44-55	44-73	40-53	43-52	48
Al_2O_3	7-38	17-33	12-24	14-31	19-28	22-30	14-46	20-32	16-33	24-35	19-34	25
Fe_2O_2	4-42	6-22	3-39	3-24	20-24	4-7	1-18	1-17	3-6	5-11	1-13	7
CaO	0-13	1-27	1-13	1-34	11-16	3-7	0-16	5-9	0-9	5-10	2-9	3
LOI	0-48	0-27	0-10	0-16	0-2	1-6	4-8	3-9	1-9	2-11	2-10	-
Glass Content	54-87	54-87	54-95	-	-	56-58	-	29-40	49-60	29-43	-	-

Note: LOI = loss on ignition

2.2 Consolidation Properties and Volume Stability

CCRs have historically been disposed of in two major ways: collected from boilers hydraulically and diverted to a surface impoundment or collected through electrostatic precipitators or flue gas desulfurization systems and dry-placed into CCR landfills. In either of these disposal alternatives, there is traditionally no defined level of compactive effort used and depending on future uses of the disposal sites, the consolidation characteristics of CCRs can be of interest to geotechnical engineers. Again, since CCRs are not naturally occurring soils, there has been little testing on their consolidation properties and volume stability. Table 3 provides compression and recompression indices and coefficients of consolidation determined by different researchers.

Few researchers report a value for the recompression index; in a disposal area, there would not necessarily be an unloading-reloading process during normal operations. Whenever recompression indices are reported, it is usually in reference to reuse of CCRs in construction applications. Furthermore, the recompression indices reported are extraordinarily low. The reported values of coefficient of consolidation, c_v, are highly variable, as might be expected for materials that have non-typical stress histories. Furthermore, it is important to note that values of

c_v cannot be determined using the traditional Taylor or Casagrande methods, since the majority of deformation for laboratory consolidation tests is complete within one minute; therefore, it is necessary to take deformation readings at very small time intervals (Yudbhir & Honjo 1991). It is also important to note that reported values of c_v mean little independent of the vertical effective stress at which that value was recorded, since the coefficient of consolidation is dependent on both the compressibility of the material and the permeability of the material, based on Terzaghi's original one-dimensional consolidation equation:

$$c_v = \frac{1}{\gamma_w}\frac{k_v}{m_v} \tag{1}$$

where c_v = coefficient of consolidation
γ_w = unit weight of water
k_v = vertical coefficient of permeability
m_v = coefficient of compressibility

Since both k_v and m_v generally decrease with increasing overburden stress, but not necessarily at the same rate, it is hard to relate the coefficient of consolidation to the compression and recompression indices in a general manner. Consequently, the values of c_v reported in Table 3 should not be taken as "typical" values, because of how c_v is mathematically defined.

Some of the variability of compression and recompression indices and coefficient of consolidation of CCRs can be attributed to the type of CCR. For example, it is logical to assume that bottom ash would have a higher coefficient of consolidation, since it has a higher hydraulic conductivity and a lower compressibility than fly ash. For this reason, variability plots for fly ash and surface impounded ash have been presented separately from those for bottom ash. Figures 3 through 5 present variability plots for the compression and recompression indices for different types of CCRs. Since the recompression index of bottom ash is rarely determined by researchers, the variability plot for recompression index includes fly ash, surface impounded ash, and bottom ash. Figure 6 presents a variability plot for the coefficient of consolidation for CCRs at different placement conditions.

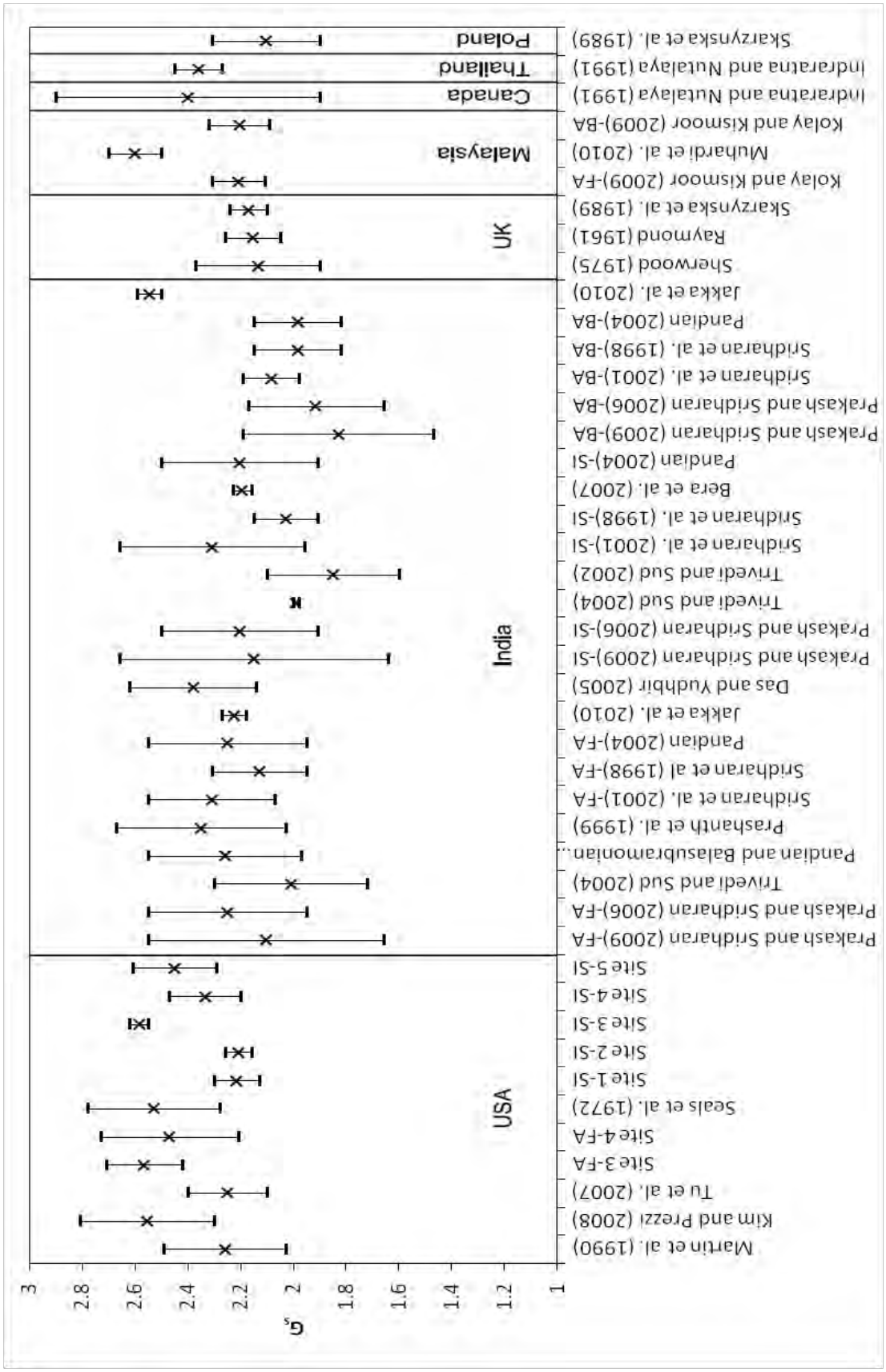


Figure 2: Variability plot for the specific gravities determined by studies performed in different countries.

Table 3: Compression and recompression indices and coefficients of consolidation for CCRs reported by different researchers.

Reference	Type of CCR	Country	C_c	C_r	C_v (cm^2/s)	Vertical Stress (psi)
Tu et al. (2007)	FA Resed.	USA	0.0390-0.0640	0.0035-0.0072	2.00-70.0	0.203-150
Site 1	SI	USA	0.080-0.710	0.0100-0.0300	-	0.694-111
Pandian and Balasubramonian (1999)	FA	India	-	-	0.00200-0.0802	0.73-116
Trivedi and Sud (2002)	SI/MH	India	0.00600-0.0100	0.000300-0.00300	-	3.34-116
Kaniraj and Gayathri (2004)	FA Comp.	India	0.0410-0.0840	0.00800	0.080-2.00	1.42-182
Pandian (2004)	FA	India	0.0490-0.284	-	1.16×10^{-5}-1.27×10^{-4}	7.12-113
	SI	India	0.0520-0.300	-	2.93×10^{-7}-8.17×10^{-4}	0.00-56.9
	BA	India	0.0570-0.484	-	7.57×10^{-7}-3.35×10^{-5}	0.00-56.9
Madhyannapu et al. (2008)	FA Resed.	India	0.100-0.167	0.00400-0.00800	-	
Prakash and Sridharan (2009)	FA Comp.	India	-	-	0.140-3.25	-
	SI Comp.	India	-	-	0.960-10.0	-
	BA Comp.	India	-	-	1.43-10.15	-
Jakka et al. (2010)	FA Comp.	India	0.079-0.246	0.018-0.023	-	7.26-29.0
	BA Comp.	India	0.051-0.059	0.013-0.024	-	7.26-29.0
Kolay and Kismoor (2009)	FA Comp.	Malaysia	0.0490-0.0510	-	-	319-2467
	SI Comp.	Malaysia	0.0780	-	-	319-2468
	BA Comp.	Malaysia	0.103-0.113	-	-	319-2469
Muhardi et al. (2010)	FA Comp.	Malaysia	0.150	-	3.00×10^{-5}-1.53×10^{-4}	-
	BA Comp.	Malaysia	1.54	-	-	-
Yudhbir and Honjo (1991)	FA Comp.	-	0.0300-0.375	-	-	-
	FA SI	-	0.0650-0.610	-	-	-
	FA SID	-	0.610-0.885	-	-	-
CAPCO (1990)	FA Comp.	Hong Kong	-	-	9.51×10^{-3}-1.90^{-2}	-
Haws et al. (1985)	FA Comp.	UK	-	-	9.51×10^{-4}-6.34×10^{-3}	-
Koo (1991)	FA Comp.	Thailand	-	-	3.17×10^{-4}-7.61×10^{-3}	-

FA = fly ash
BA = bottom ash
SI = surface impoundment ash
SID = surface impoundment/loose dry dump ash
MH = mixed hopper ash
Comp. = compacted
Resed. = resedimented

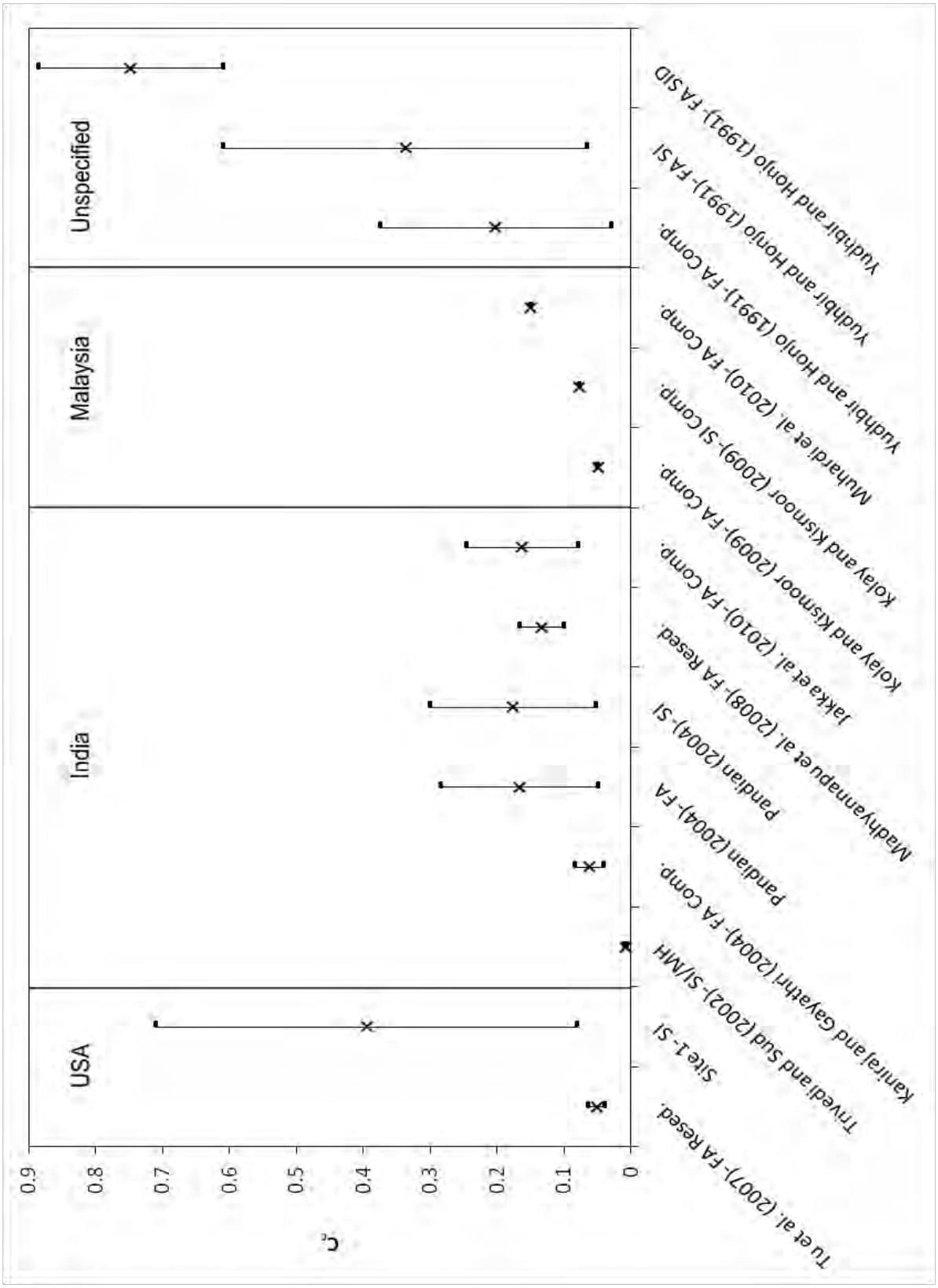


Figure 3: Variability plot for the compression indices of studies done on fly ashes and surface impounded ashes.

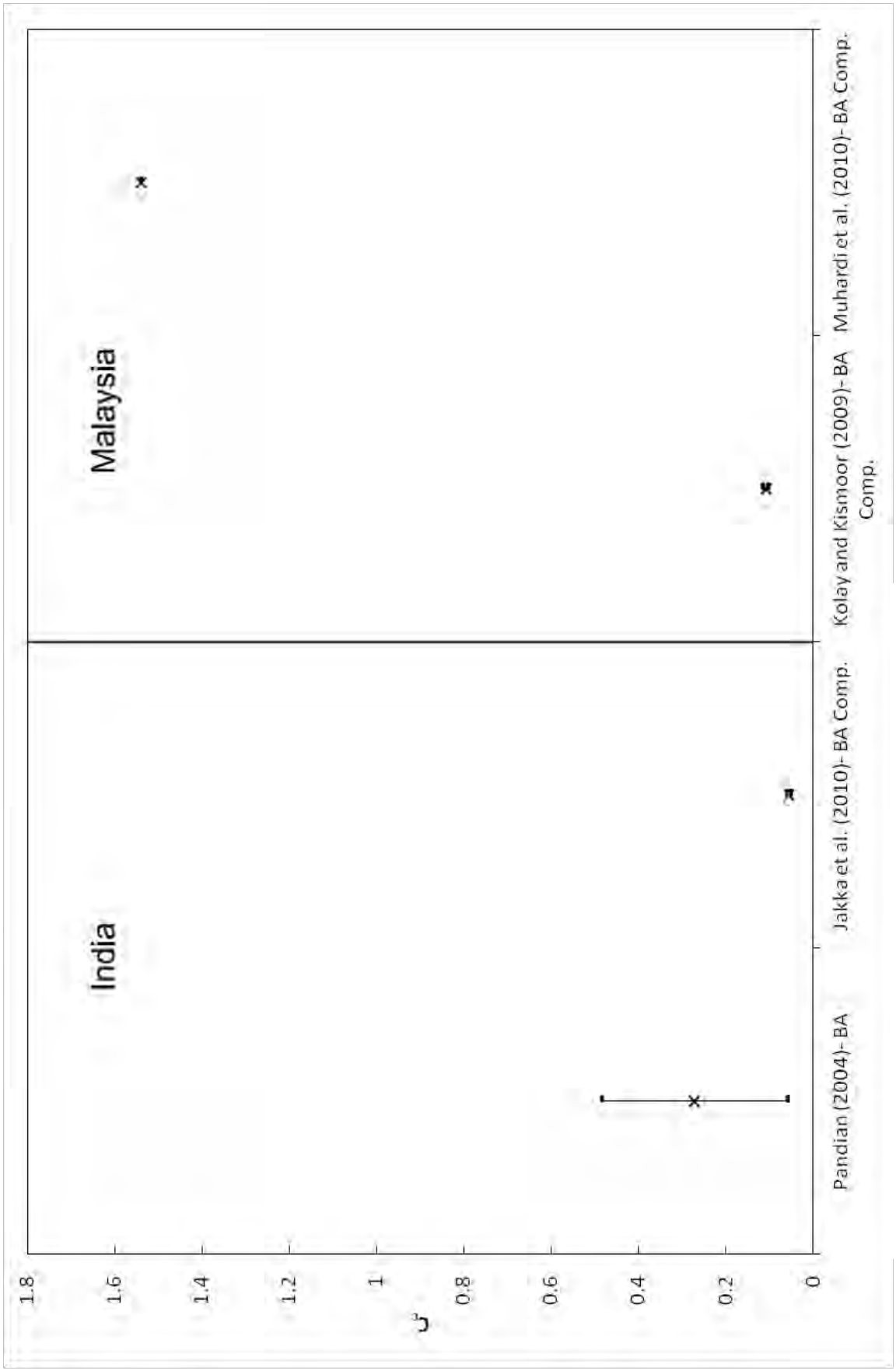


Figure 4: Variability plot of the compression indices for studies done on bottom ashes.

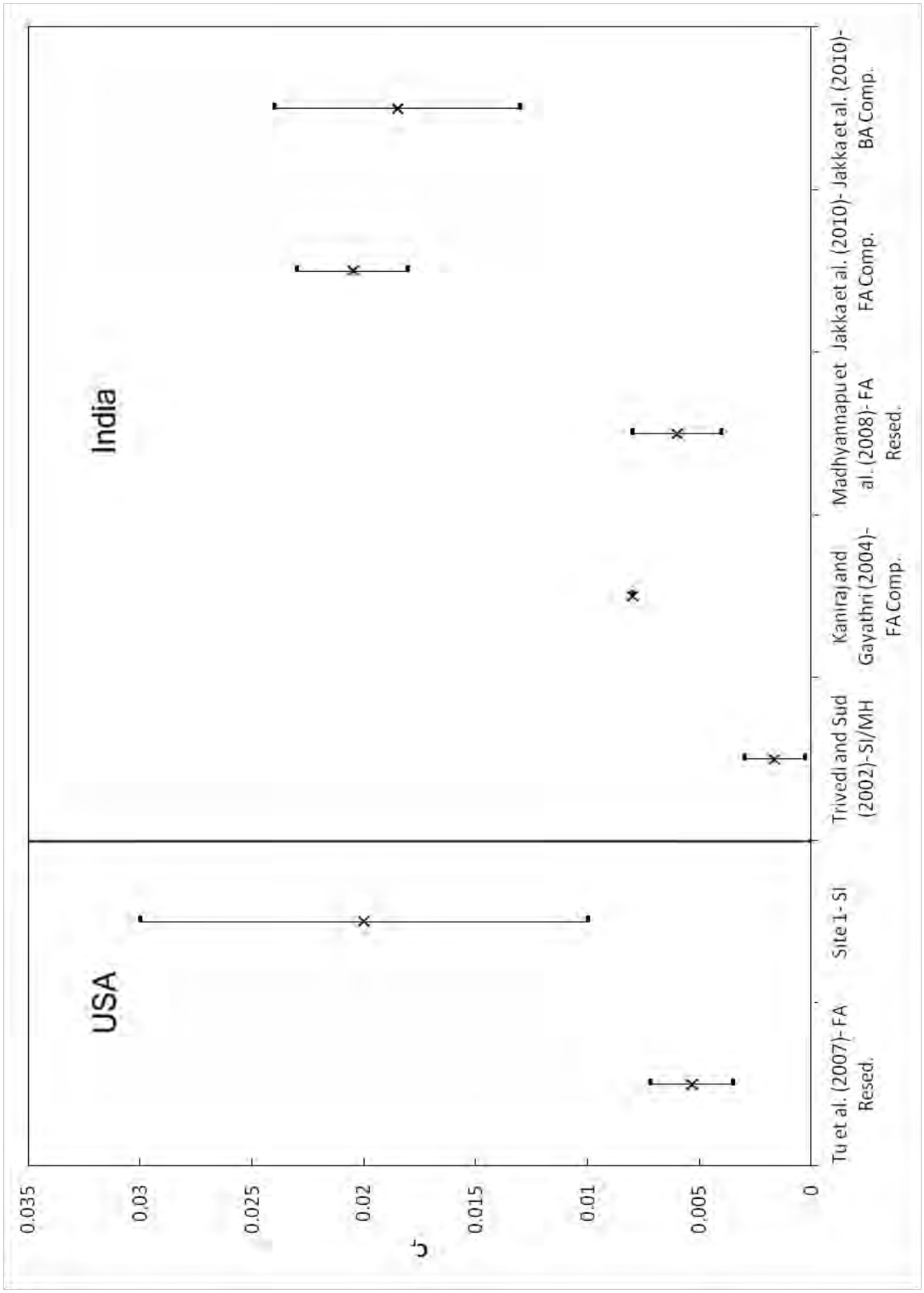


Figure 5: Variability plot of the recompression indices for studies done on fly ashes, bottom ashes, and surface impounded ashes

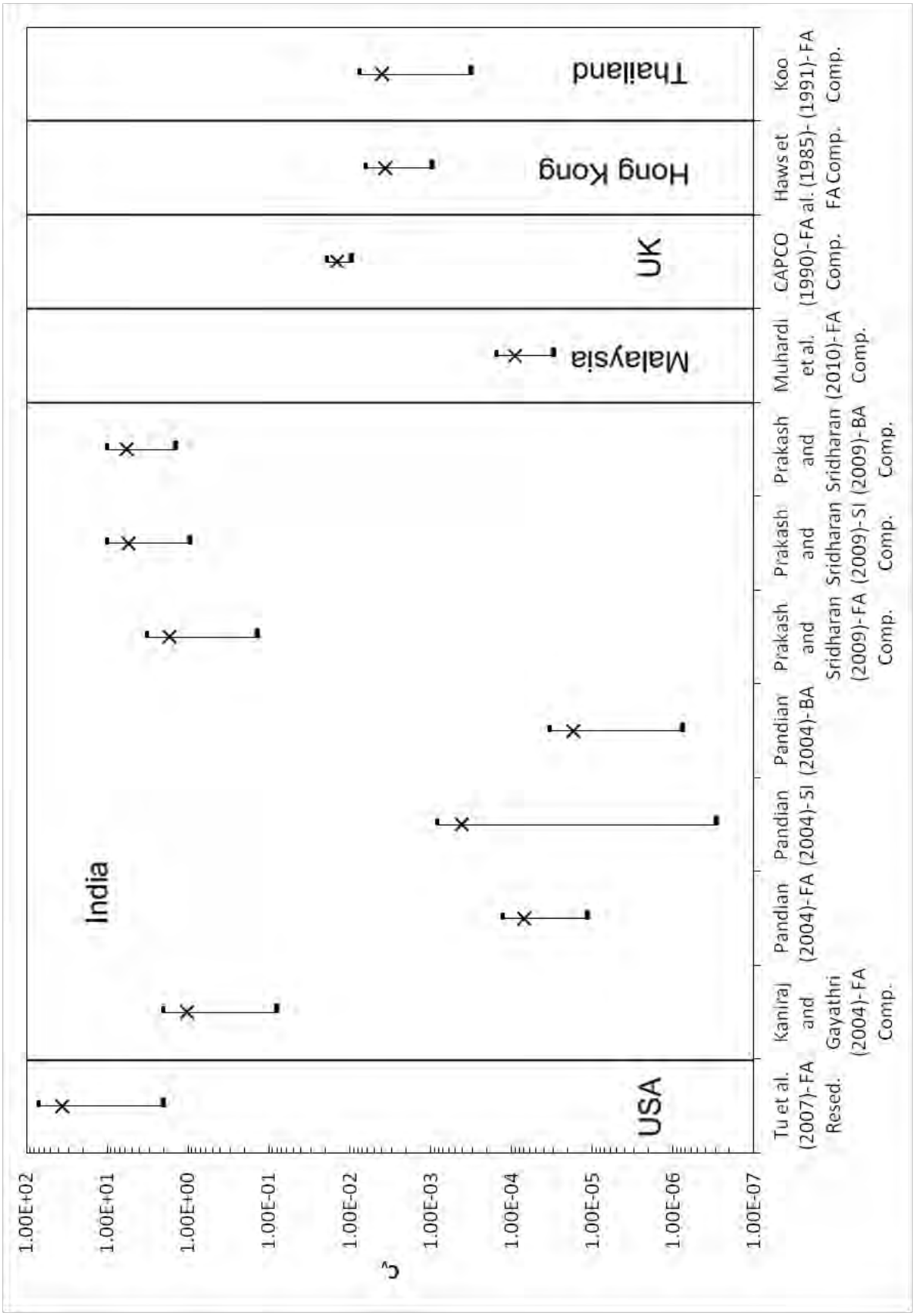


Figure 6: Variability plot for the coefficient of consolidation of studies done on fly ash, bottom ash, and surface impounded ash.

If structures are to be built on former CCR disposal areas or dry-disposed ashes are to be placed on hydraulically-placed deposits, volume stability of CCRs can also be of engineering concern. Swell, shrink, and collapse potentials are the three main types of volume instability examined for soils.

According to Sridharan and Prakash (2009), the swell potential of a soil can be examined through the use of the free swell ratio (FSR) which is defined as

$$FSR = \frac{V_d}{V_k} \tag{2}$$

where V_d = sediment volume of 10 g of oven-dried soil that passes a 425 μm sieve placed in a 100 ml jar which is then filled with de-aired water.

V_k = a sample identical to V_d except the solute is carbon tetrachloride or kerosene.

Note: a fume hood is required if there are any hazardous materials associated with the samples being tested

The swell potential can be determined based on the ranges of FSR as outlined in Table 4:

Table 4: Classification of Soils based on FSR (adapted from Sridharan and Prakash 2000)

FSR	Soil Type	Swell Potential
≤1.0	Nonswelling	Negligible
1.0-1.5	Mixture of swelling and nonswelling	Low
1.5-2.0	Swelling	Moderate
2.0-4.0	Swelling	High
>4.0	Swelling	Very High

Additionally, ASTM D4829 (2003), "Standard Test Method for Expansion Index of Soils," provides a standardized method of determining the swell potential of soils based on the expansion index (EI_{50}). In order to determine the EI_{50} of a soil, a dried soil sample must first be mixed with distilled water to the approximate optimum moisture content and allowed to sit in an air-tight container for at least 16 hours. Then, the conditioned soil is compacted in a 4.01 inch diameter mold in two two-inch lifts using 15 well-distributed blows of a 5.5 lb, 2.00 inch diameter rammer dropped from a height of 12 inches. Once the sample degree of saturation (S) is measured to be within 40% to 60%, the sample is loaded into a consolidometer and consolidated

for 10 minutes under a load of 1.0 psi before the initial reading on the dial indicator is taken. The specimen is then inundated with distilled water while periodic readings of the dial indicator are made in accordance with test D2435 (2003) for 24 hours or until the rate of expansion becomes less than 0.0002 inches per hour. The EI of a soil is then defined as

$$EI_{50} = EI_{meas} - (50 - S_{meas}) \cdot \frac{65 + EI_{meas}}{220 - S_{meas}} \tag{3}$$

where S_{meas} = the degree of saturation measured in the test

and

$$EI_{meas} = \frac{\Delta H}{H_1} \cdot 1000 \tag{4}$$

where ΔH = the change in height ($D_2 - D_1$) of the sample, mm
H_1 = initial height, mm
D_1 = initial dial reading, mm
D_2 = final dial reading, mm

The shrink potential of soils is usually assessed based on that soil's shrinkage limit, which is outlined in ASTM D4943 (2002) and calculated according to equation 5:

$$SL = w - \left[\frac{(V - V_d) \cdot \rho_w}{m_s}\right] \cdot 100 \tag{5}$$

where w = moisture content of the soil at the time it was placed in the dish (%)
V = the volume of the wet soil pat = volume of the dish
V_d = volume of the dry soil pat
ρ_w = density of water
m_s = mass of the dry soil pat

However, CCRs are generally non-plastic and ASTM D4943 is only applicable when the soil is cohesive in nature. Based on the fact that CCRs generally have a uniform gradation it can be assumed that they would have a high shrinkage limit (Prakash and Sridharan, 2009).

The collapse potential of a soil is the percent change in volume of a specimen after inundation. It is usually determined using oedometer tests and, as a result, can either be expressed mathematically in terms of height or void ratio, according to equation 6.

$$C_p = \frac{\Delta h}{h_0} = \frac{\Delta e}{(1 + e_0)} \tag{6}$$

where Δh = change in height of the specimen upon inundation
h_0 = the height of the specimen prior to inundation
Δe = change in void ratio of the specimen upon inundation
e_0 = void ratio of the specimen prior to inundation

Since collapse potential can change given different applied stress levels and overconsolidation states, there are any number of typical collapse potential values for a given soil, depending on the in-situ stress and the preconsolidation pressure of the soil. Generally, if the collapse potential is below 1%, there is no danger of collapse of soil structure (Mudhyannapu et al. 2008, Trivedi and Sud 2004).

It is important to note that collapse potential increases dramatically for some dry-disposed coal ashes when tested in a moist condition as opposed to a dry condition; even soils that classify as non-collapsible in a dry condition can become collapsible in a moist condition. This is due to the presence of soluble substances not present in the coal ashes disposed of using wet disposal methods (Trivedi and Sud 2004).

2.3 Hydraulic Conductivity

An important soil property for seepage calculations for earthen embankments is hydraulic conductivity. This is an especially important property for CCR surface impoundments, since they tend to be deposited in a meta-stable structure. In addition, the CCRs are often used to construct embankments as the surface impoundments are raised. Hydraulic conductivity of CCRs deposited in surface impoundments can display anisotropy as a result of its cyclic, lacustrine-style deposition. For engineering purposes, the hydraulic conductivity of both the compacted embankment material and the disposed CCR material will be of interest, as these values are used in erosion analyses. Table 5

presents hydraulic conductivities of different types of CCRs from different countries as determined by various researchers. Due to the fact that there are different disposal methods for CCRs and different types of CCRs that are often co-disposed of, there is a wide variety of placement conditions, each of which can potentially create a different soil fabric and therefore a different range of hydraulic conductivities.

The CCRs were divided into two groups in order to assess variability in hydraulic conductivity: fly ash and surface impounded ash/bottom ash. This was done because oftentimes surface impounded ash is made up of both fly ash and bottom ash; this fact, coupled with its loose placement condition ensures hydraulic conductivity will be at the material's naturally highest value. Figures 7 and 8 are variability plots hydraulic conductivity of fly ashes and surface impounded ash/bottom ash from different countries, as determined by different researchers. It is important to note that not all researchers specified whether it fly ash tested was class c or class f (class c exhibits self-cementing properties); this fact could be a further contributor to the variability in values of hydraulic conductivity of fly ashes.

Table 5: Values of hydraulic conductivity for different CCRs for different countries as determined by different researchers (adapted from Prakash Sridharan 2009)

Reference	Country	CCR Type	Testing Condition	k (cm/s)
Seals et al. (1972)	USA	BA	Relative density = 50%	5.0×10^{-3} to 0.094
McLaren and DiGioia (1987)		Class F FA	$\gamma_{d\,max_SP}$, $\gamma_{d\,max_MP}$	1.3×10^{-5}
		Class F FA	SI or poorly compacted	1.8×10^{-5}
		Class C FA	$\gamma_{d\,max_SP}$, $\gamma_{d\,max_MP}$	1.1×10^{-5}
Martin et al. (1990)		FA	$\gamma_{d\,max_SP}$	1.8×10^{-5} to 1.2×10^{-4}
		BA	$\gamma_{d\,max_SP}$	1.2×10^{-3}
Yudbhir and Honjo (1991)		Class C FA	$\gamma_{d\,max}$	1.0×10^{-7} to 2.0×10^{-7}
		Class F FA	$\gamma_{d\,max}$	2.0×10^{-6} to 6.0×10^{-5}
Glogowski et al. (1992)		Eastern US FA	-	1.9×10^{-5}
		Western US FA	-	3.1×10^{-5}
Site 1		SI	Undisturbed	1.1×10^{-3} to 1.7×10^{-2}
Site 3		FA-SI	Undisturbed	7.0×10^{-7} to 6.5×10^{-7}
		BA	Bulk Recompacted	2.3×10^{-6}
Site 4		FA-Comp.	Undisturbed	1.3×10^{-7} to 8.2×10^{-5}
		SI	Undisturbed	1.6×10^{-5} to 6.3×10^{-5}
Site 5		FA-Comp.	Undisturbed	1.5×10^{-5} to 8.0×10^{-4}
		SI	Undisturbed	4.8×10^{-6} to 4.0×10^{-4}
Pandian and Balasubramonian (1999)	India	FA	Compacted to 0.95 $\gamma_{d\,max}$ and saturated	1.4×10^{-5} to 4.2×10^{-4}
Kaniraj and Gayathri (2004)		FA	$\gamma_{d\,max}$	4.7×10^{-6} to 6.0×10^{-6}
Prakash and Sridharan (2009)		FA	Compacted at $\gamma_{d\,max}$ and saturated	8.0×10^{-6} to 1.9×10^{-4}
		SI	-	5.0×10^{-5} to 9.6×10^{-4}
		BA	-	9.9×10^{-5} to 7.1×10^{-4}
Jakka et al. (2010)		FA	loose	7.0×10^{-7} to 2.1×10^{-6}
		FA	dense	3.5×10^{-7} to 9.4×10^{-7}
		BA	loose	6.0×10^{-6} to 1.3×10^{-5}
		BA	dense	1.4×10^{-6} to 3.7×10^{-6}
Indraratna et al. (1991)	Thailand	Class C FA	$\gamma_{d\,max_SP}$	4.0×10^{-7} to 7.0×10^{-7}
		Class C FA	$\gamma_{d\,max_SP}$, 2 weeks curing	$<10^{-7}$
Gray and Lin (1972)	UK	FA	$\gamma_{d\,max}$	5.0×10^{-7} to 8.0×10^{-5}
Porbaha et al. (2000)	Japan	FA	Slurry (e_i = 0.85 to 1.02)	10^{-5} to 10^{-4}
Skarzynska et al. (1989)	Poland	SI	-	1.5×10^{-5} to 5×10^{-5}
Chan et al. (1986)	Canada	FA	in situ	10^{-7} to 10^{-4}
		BA	-	4.8×10^{-4} to 3.4×10^{-3}
Gitari et al. (2009)	South Africa	FA	Air flush core samples, constant head	4.6×10^{-5} to 6.9×10^{-5}
		BA	Air flush core samples, constant head	8.1×10^{-5} to 4.9×10^{-4}
		FA/BA Dry Dump	Field Slug Tests	2.3×10^{-5} to 9.6×10^{-3}

Note: FA = fly ash; SI = surface impoundment ash; BA = bottom ash; OMC = optimum moisture content; e_i = initial void ratio; FA-SI = surface impounded fly ash; FA-DS = dry-stacked fly ash; FA Comp. = field-compacted fly ash

Figure 7: Variability plot of the hydraulic conductivity of fly ashes from different countries, as determined by different researchers.

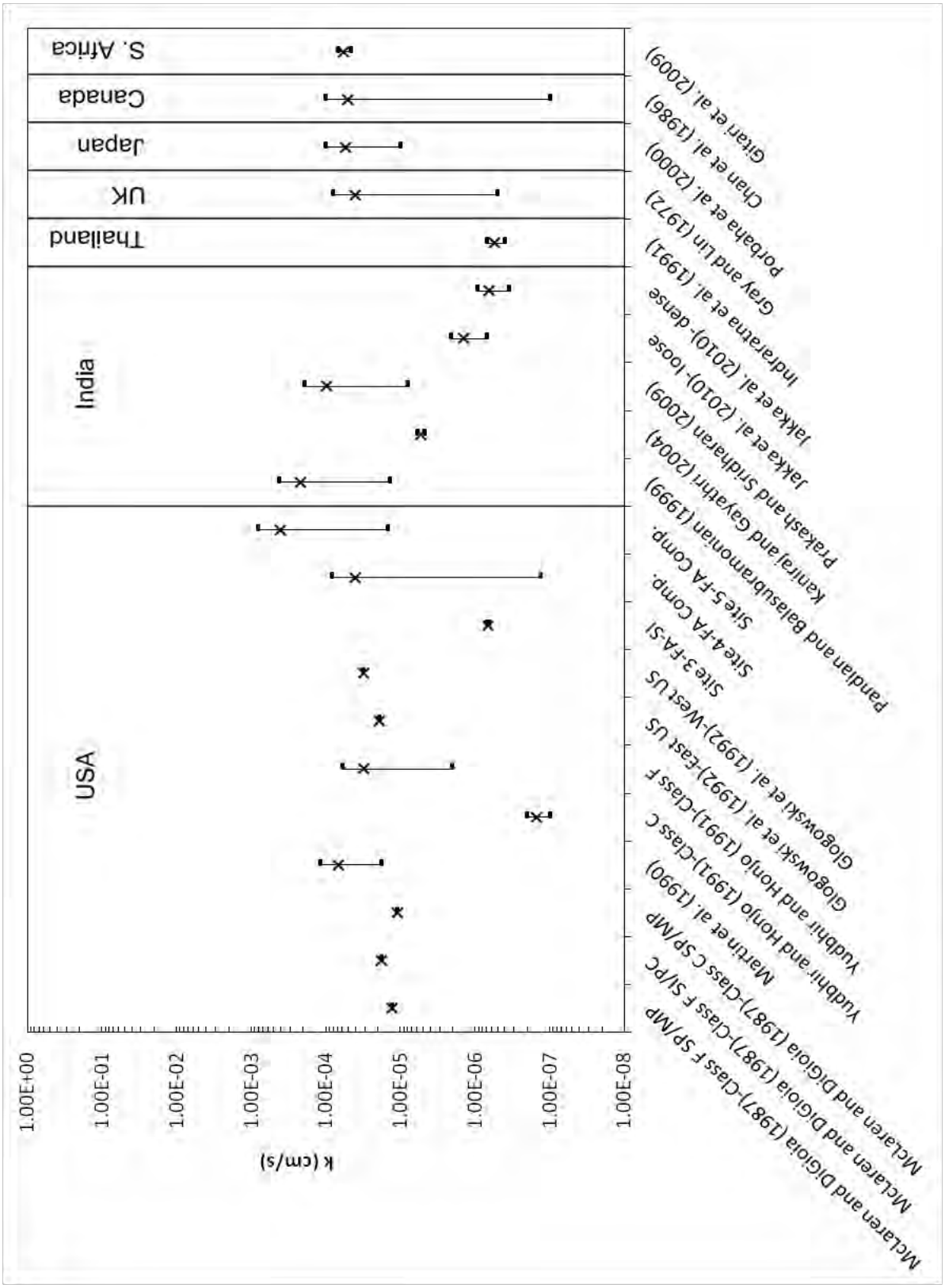


Figure 7: Variability plot of the hydraulic conductivity of fly ashes from different countries, as determined by different researchers.

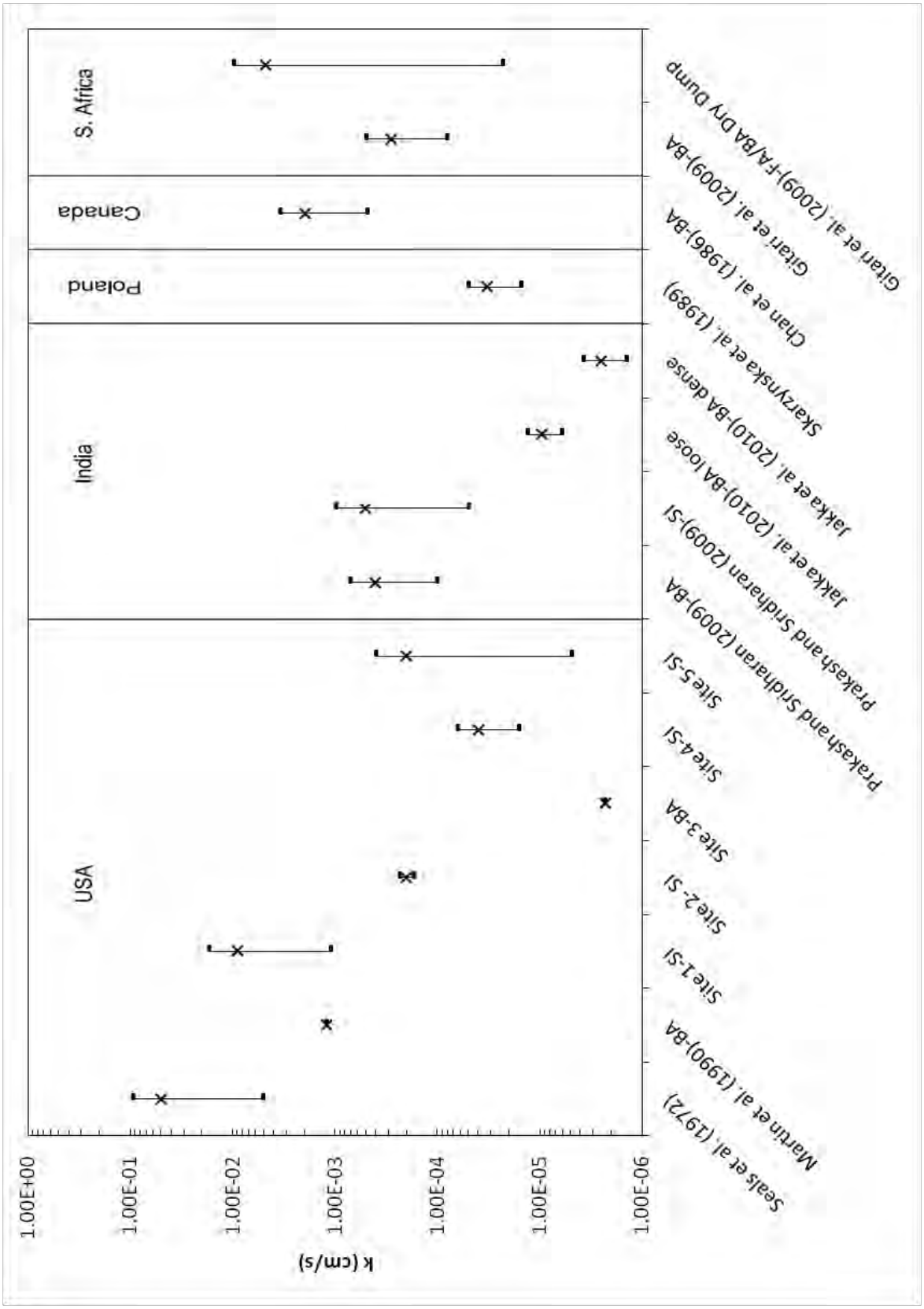


Figure 8: Variability plot of the hydraulic conductivity of surface impounded ashes and bottom ashes from different countries, as determined by different researchers.

2.4 Shear Strength

X-ray diffraction studies indicate that CCRs do not contain any of the clay minerals responsible for the cohesive portion of shear strength in soils (Trivedi and Singh 2004a, Trivedi and Singh 2004b, Ward and French 2005), which means that CCRs must derive their strength entirely from the frictional interaction between ash particles. Through the use of a scanning electron microscope (SEM), it is possible to study the morphological characteristics of coal ash particles and get an idea of their angularity, which would in turn offer clues as to the source of their frictional strength. As shown in Figures 9 and 10, bottom ash is much more angular than fly ash. In general, this can be associated with higher friction angles than fly ash at low confining stresses, which is usually the case. At high confining stresses, the higher angularity could lead to more particle breakage for bottom ash, and consequently to a larger degradation of their frictional resistance.

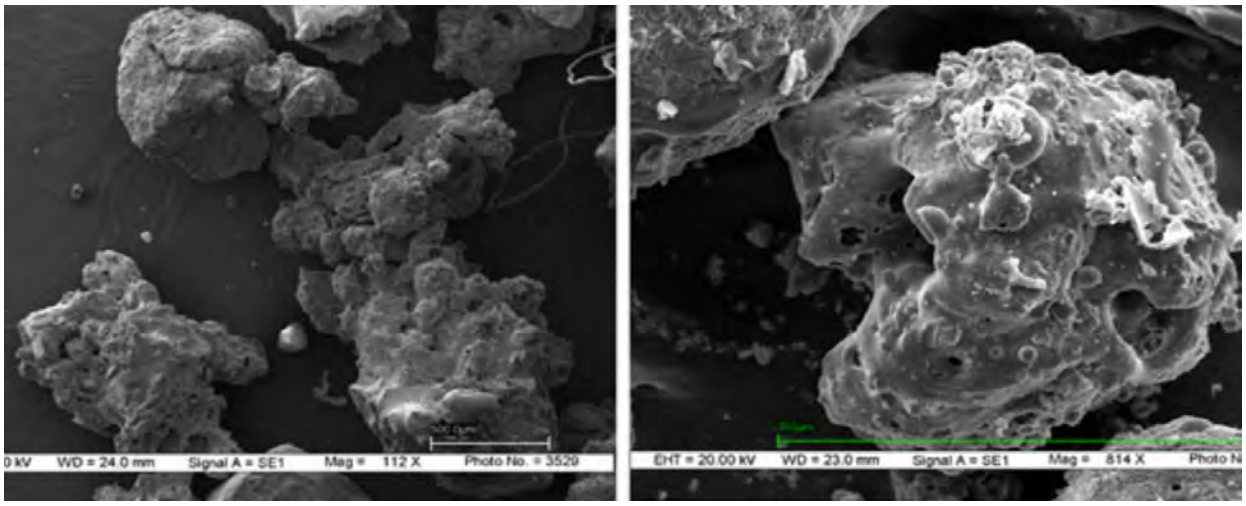


Figure 9: Micrographs of bottom ash particles magnified 112 and 373 times (Jakka et al. 2010)

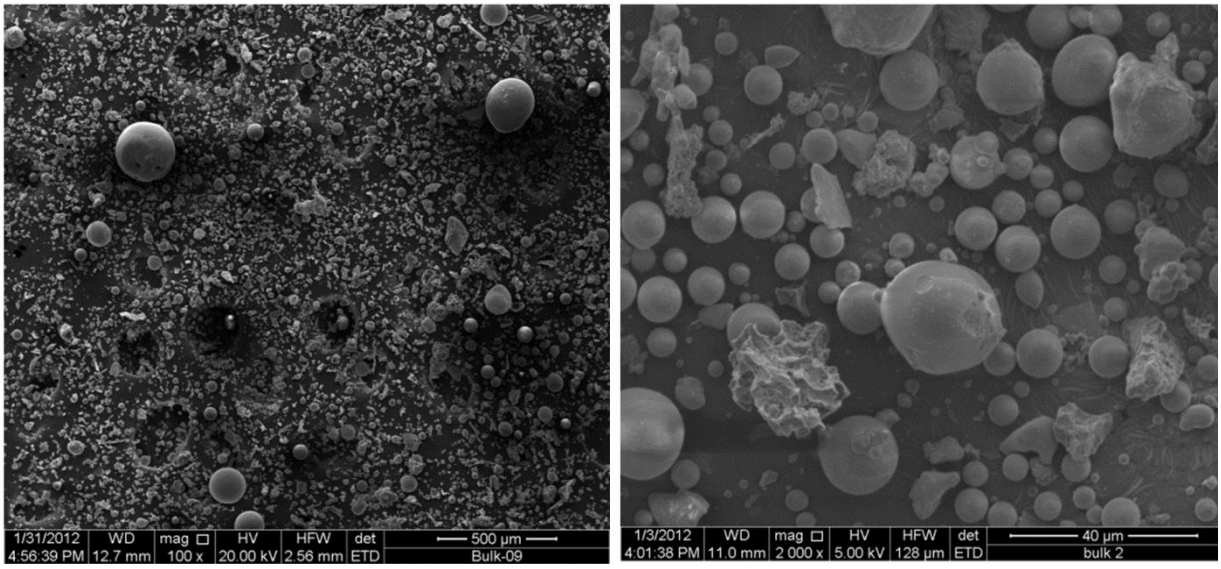


Figure 10: Micrographs of fly ash magnified 100 and 2,000 times (courtesy of Kevin Foster).

Shear strength parameters can be determined using several different laboratory test procedures. For CCRs, the most commonly performed tests are the direct shear test, consolidated drained triaxial test, and the consolidated undrained triaxial test. While the consolidated undrained triaxial test provides both effective and total stess strength parameters, most researchers only report effective strength parameters. This is undoubtedly because the rate of loading because of disposal is usually small enough that pore pressure dissipations are able to complete prior to the next disposal cycle; additionally, total strength parameters from CU tests can be misleading because of their dependence on the value of backpressure at which the specimen is sheared. Tables 6 through 8 report shear strength parameters of different CCRs from direct shear, consolidated drained, and consolidated undrained tests, respectively, reported in different studies. Figures 11 through 13 provide variability plots for the effective stress friction angles determined by various studies, compared on the basis of test type. Figures 14 through 16 provide variability plots on the basis of CCR type, while Figure 17 is a variability plot for the total stress parameters for all types of CCRs, since these parameters are not always reported. Variability plots were not made for values of cohesion since CCRs are usually reported to be non-plastic and the cohesions reported were either apparent cohesions of compacted, unsaturated samples or of samples that may have had self-cementing properties that would not be common to

all disposed CCR materials. All acronymns used with the variability plots are consistent with those used in the Tables; for the Figures 14 through 16, DS, CD, and CU designate "direct shear test," "consolidated drained triaxial test," and "consolidated undrained triaxial test," respectively.

Table 6: Shear strength parameters determined by different researchers using the direct shear test.

Reference	Country	CCR Type	Condition	ϕ'_p (°)	c'_p (psf)
Kim & Prezzi (2008)	USA	FA	Comp. DoO	32.9-35.8	100-403
		FA	Comp. WoO	31.7-34.4	104-380
		FA	Comp. Sat.	30.2-34.5	58-276
Site 5		SI	Comp. Sat.	26.8-42.2	0
		SI	Undisturbed	23.4-35.4	0
Pandian (2004)	India	FA	Loose Dry	29.0-36.0	-
		SI	Loose Dry	29.0-34.0	-
		BA	Loose Dry	32.0-34.0	-
		FA	Loose Sat.	27.0-37.0	-
		SI	Loose Sat.	25.0-40.0	-
		BA	Loose Sat.	30.0-37.0	-
		FA	Comp.	28.0-42.0	205-819
		SI	Comp.	29.0-38.0	328-1024
		BA	Comp.	30.0-37.0	205-410
		FA	Comp. Sat.	28.0-41.0	-
		SI	Comp. Sat.	29.0-36.0	-
		BA	Comp. Sat.	30.0-37.0	-
Prakash &Sridharan (2009)		FA	Loose	29.0-33.0	-
		SI	Loose	30.0-33.0	-
		BA	Loose	31.0-34.0	-
		FA	Comp.	32.0-37.0	334-543
		SI	Comp.	30.0-33.0	272-334
		BA	Comp.	31.0-34.0	209-397
		FA	Comp. Sat.	32.0-35.0	0
		SI	Comp. Sat.	29.0-32.0	0
		BA	Comp. Sat.	30.0-33.0	0
Kolay & Kismoor (2009)	Malaysia	FA	Comp. Sat.	30.6-34.9	162-168
		SI	Comp. Sat.	26.2	70
		BA	Comp. Sat.	26.6	3.0-14
Muhardi et al. (2010)		FA	Comp.	23.0	251
		FA	Comp. Sat.	26.0	63
		BA	Comp.	32.0	79
		BA	Comp. Sat.	31.0	0

Note: ϕ'_p = peak effective friction angle; c'_p = peak effective cohesion; Comp. = compacted; Sat. = saturated; DoO = Dry of Optimum; WoO = Wet of Optimum

Table 7: Shear strength parameters determined by different researchers using the consolidated drained triaxial test.

Reference	Country	CCR Type	Condition	RC (%)	ϕ' (°)	c' (psf)
Kim & Prezzi (2008)	USA	FA	Reconst.	95	33.5-47.1	0
		FA	Reconst.	90	27.9-37.9	0
Site 5		SI	Reconst.	-	27.1-31.0	0
Pandian (2004)	India	FA	Reconst.	100	33.0-37.0	418-1942
		FA	Reconst.	100	33.0-43.0	0
Prakash &Sridharan (2009)		FA	Reconst.	95	33.0-43.0	0
Jakka et al. (2010)		FA	Reconst.	-	32.9-37.0	0
		BA	Reconst.	-	33.7-41.7	0
Muhardi et al. (2010)	Malaysia	FA	Reconst.	-	41.0	522
		BA	Reconst.	-	46.0	0
Indraratna et al. (1991)	Thailand	FA	Reconst.	-	26.0	731
		FA	Reconst. Pozz.	-	36.0	37594

Note: Reconst. = reconstituted; Pozz. = pozzolanic curing allowed to occur

Table 8: Shear strength parameters determined by different researchers using the consolidated undrained triaxial test.

Reference	Country	CCR Type	Condition	RC (%)	ϕ (°)	c (psf)	ϕ' (°)	c' (psf)
Site 1	USA	SI	Undist.	-	11.1-19.5	0-950	25.2-33.0	90-190
Site 2		SI	Undist.	-	12.0-45.5	640-2580	31.8-32.1	0-140
Site 3		FA	Reconst.		-	-	36.0	14.3
		SI	Undist.	-	-	-	39.6	0
		BA	Reconst.		-	-	41.0-44.0	0-261
Site 4		FA	DS, Undist.	-	3.4-37.7	200-1900	28.7-36.7	0-400
		SI	Undist.	-	18.3-27.4	400-1600	29.5-38.6	0-740
Prakash &Sridharan (2009)	India	FA	Reconst.	95	20.0-41.0	0	26.0-39.0	334-2005
		SI	Reconst.	95	25.0-34.0	0-1170	28.0-36.0	585-2109
		BA	Reconst.	95	24.0-35.0	0-564	24.0-35.0	585-1149
Jakka et al. (2010)		FA	Reconst.	-	-	-	22.3-38.5	0
		BA	Reconst.	-	-	-	32.2-42.6	0
Muhardi et al. (2010)	Malaysia	FA	Reconst.	-	41.0	710	-	-
		BA	Reconst.	-	44.0	0	-	-
Indraratna et al. (1991)	Thailand	FA	Reconst.	-	20.0	0	26.0	0

Note: Undist. = undisturbed; Reconst. = reconstituted; DS = dry-stacked in field

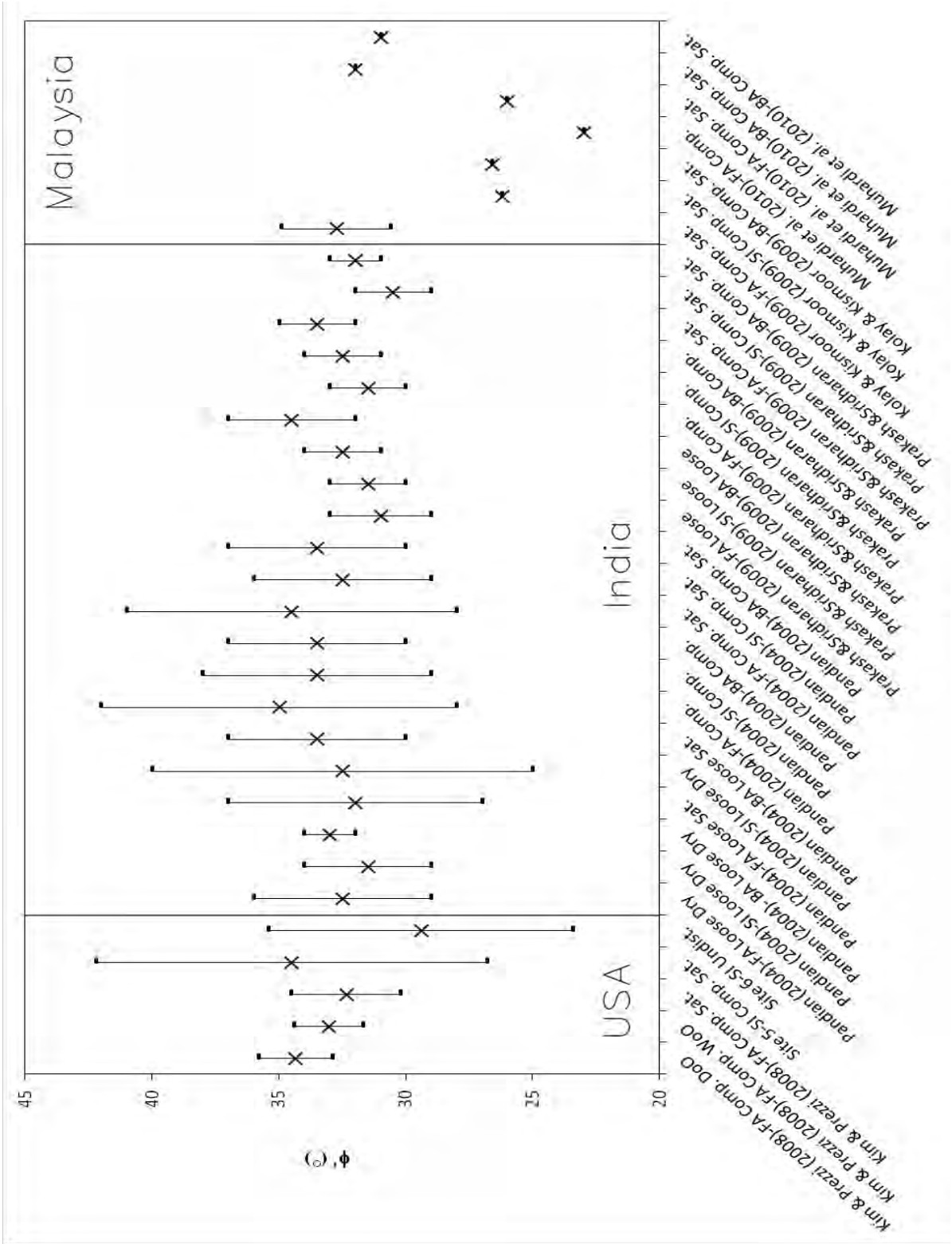


Figure 11: Variability plot of effective stress friction angle of various CCRs as determined by different researchers using the direct shear test.

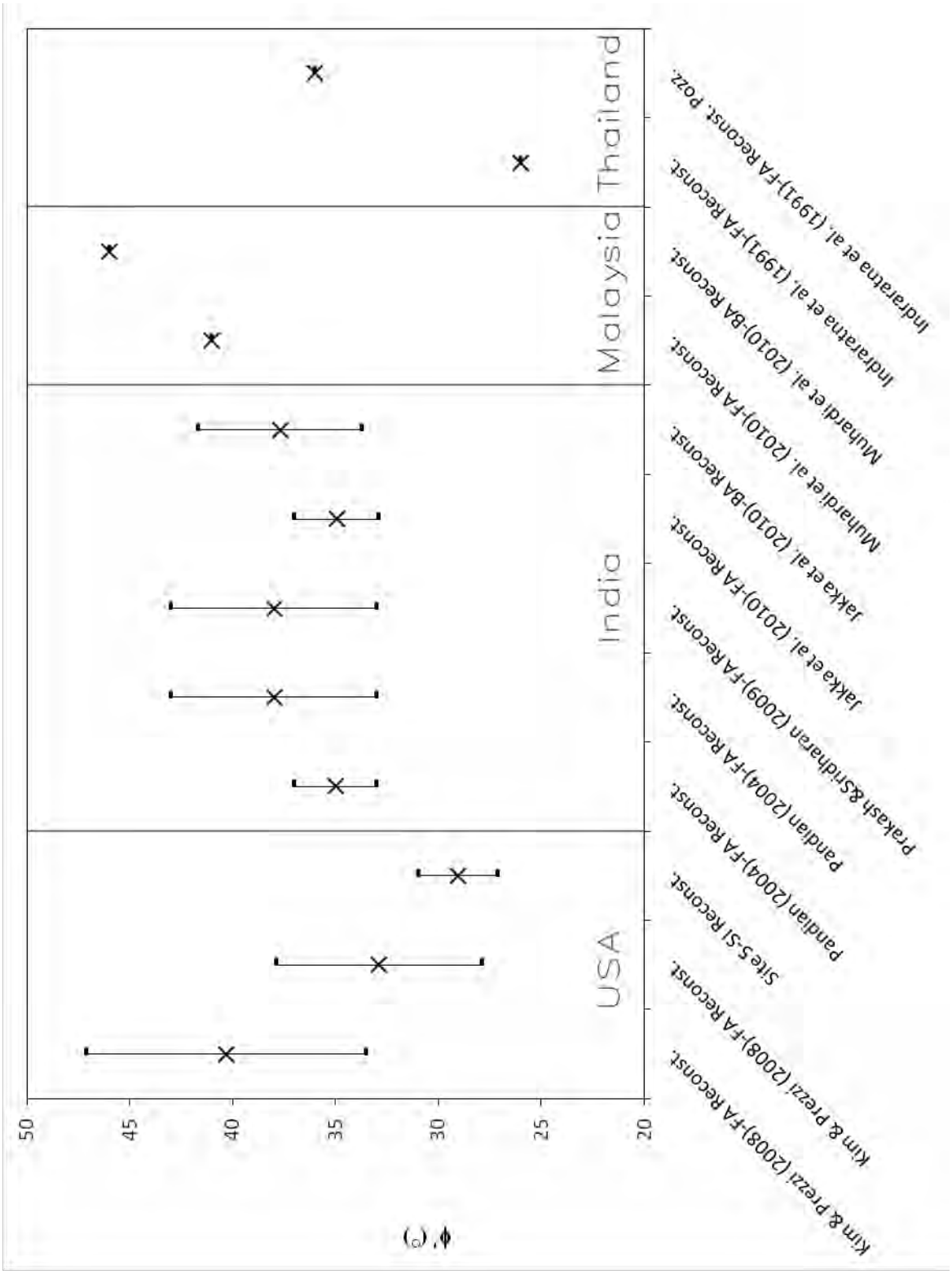


Figure 12: Variability plot of the effective stress friction angle of various CCRs as determined by different researchers using the consolidated drained triaxial test.

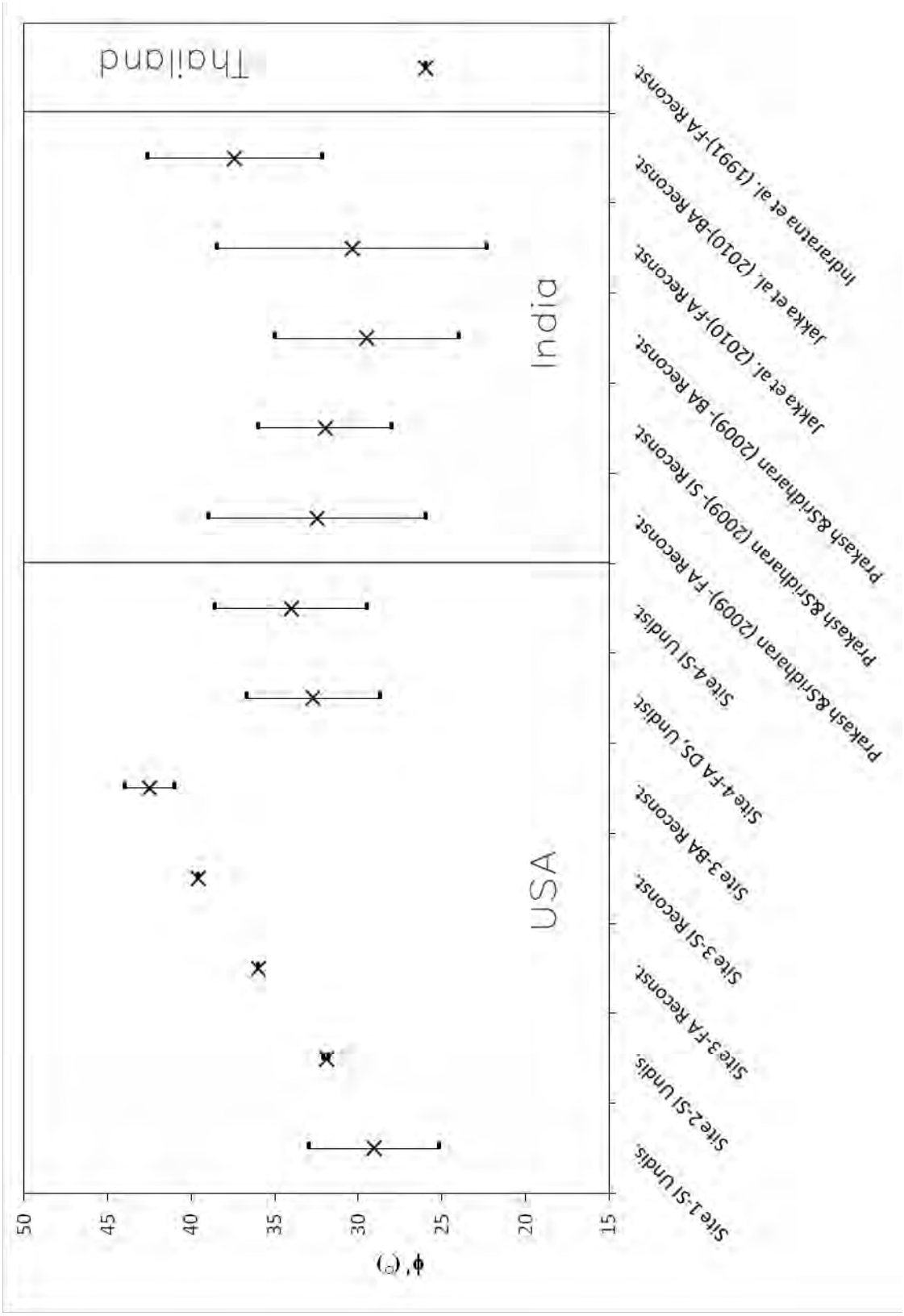


Figure 13: Variability plot of the effective stress friction angle of various CCRs as determined by different researchers using the consolidated undrained triaxial test.

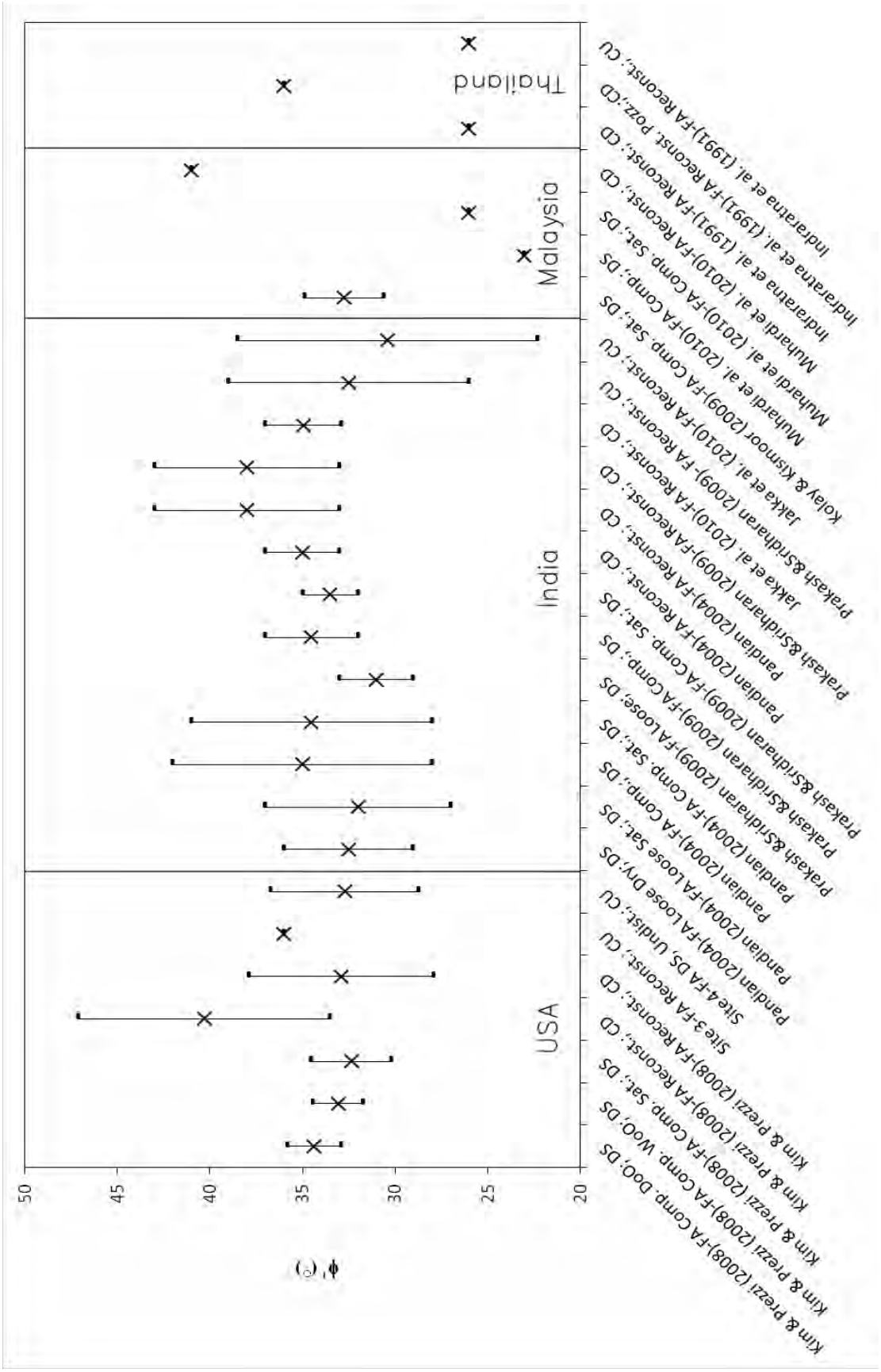


Figure 14: Variability plot of the effective stress friction angle of fly ashes for all shear strength tests performed by various researchers.

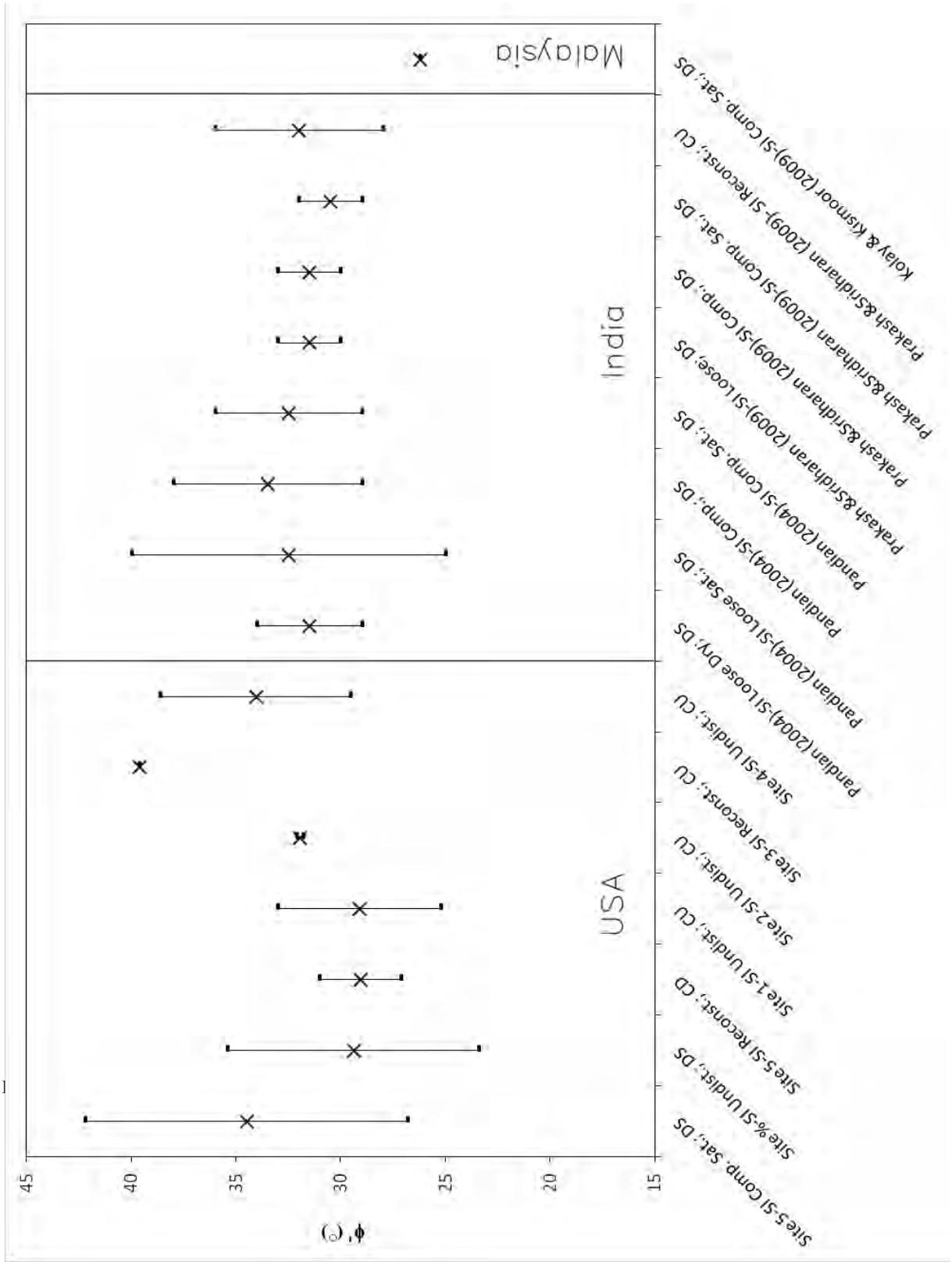


Figure 15: Variability plot of the effective stress friction angle of surface impounded ashes for all shear strength tests performed by various researchers.

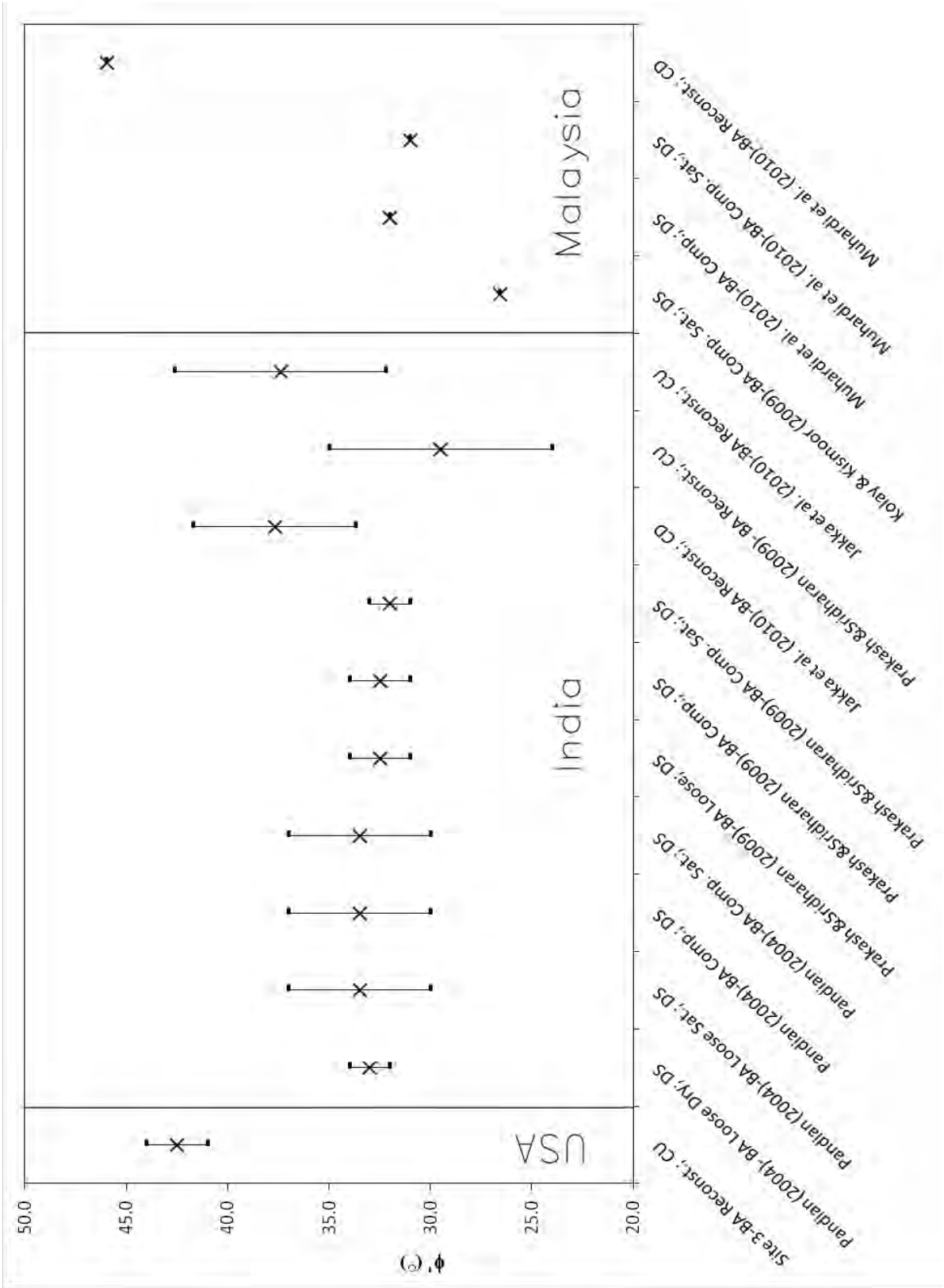


Figure 16: Variability plot of the effective stress friction angle of bottom ashes for all shear strength tests performed by various researchers.

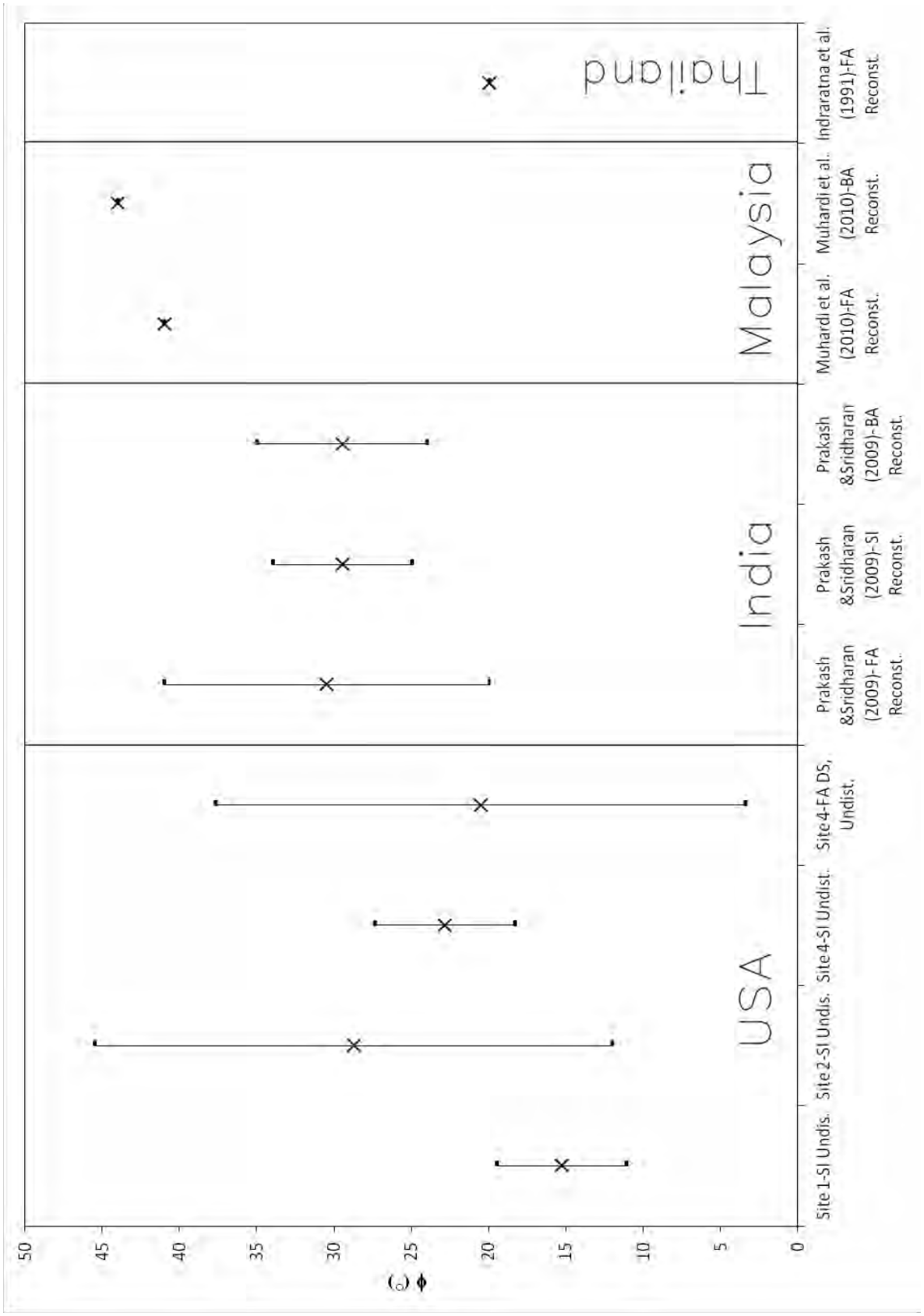


Figure 17: Variability plot of the total stress friction angle of all CCRs as determined by consolidated undrained triaxial tests performed by various researchers.

2.5 Compaction Characteristics

Since CCRs are often used in the construction of embankments for CCR disposal areas, an understanding of their compaction characteristics is necessary to control stability and seepage of the CCR disposal areas. A unique consideration when studying the compaction characteristics of CCRs is their generally low specific gravity. Since CCRs tend to have lower specific gravities and higher air voids than natural soils, their maximum dry density tends to be lower and their optimum moisture content higher than most natural soils (Bera et al. 2007, Prashanth et al. 1999, Trivedi and Singh 2004a). Trivedi and Singh (2004a) associate the high optimum water content of CCRs with the porous nature of the particles; most of the water is absorbed by the particles at lower water contents such that the particles are not workable until higher moisture contents. The lower dry density and higher corresponding water contents of CCRs results in a compaction curve that appears "flatter" than those of most natural fine-grained soils, as shown in Figure 18. The "A-Z soils" included in the plots for comparison are for natural soils from Ohio, as published by J. G. Joslin in the proceedings of the 1958 ASTM Symposium on Soil Testing in Highway Design and Construction.

Bera et al. (2007) also developed empirical models to predict the maximum dry density and optimum moisture content of a specific surface impounded ash, as long as both of these values are known for the standard proctor test:

$$MDD_E = 1.60783 \cdot MDD_{proc} + 1.85727\left(\frac{E}{E_{proc}}\right) - 6.89047 \quad (7)$$

$$OMC_E = 1.73090 \cdot OMC_{proc} - 9.01750\left(\frac{E}{E_{proc}}\right) - 25.33520 \quad (8)$$

where MDD_E = maximum dry density at a given applied energy
MDD_E = maximum dry density for a proctor test
E = amount of energy input for given condition
E_{proc} = amount of energy input for a proctor test
OMC_E = optimum moisture content for a given applied energy
OMC_{proc} = optimum moisture content for a proctor test

It should be noted, however, that these relationships were developed using test data from Indian CCRs. Therefore, before using these relationships, it should be verified that they apply to the specific CCRs in question.

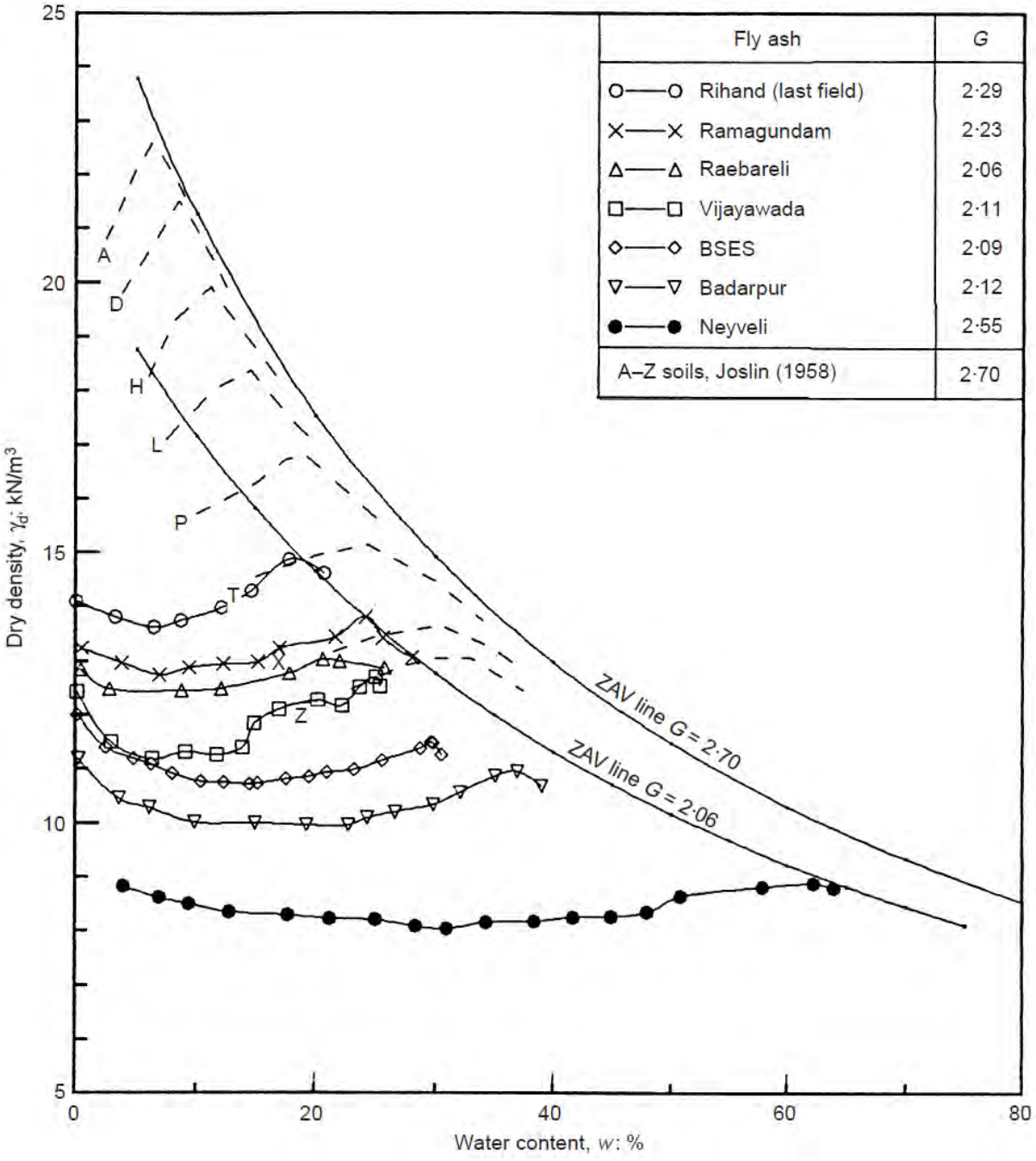


Figure 18(a): Compaction curves for different Indian fly ashes compared to those for several natural soils (Sridharan et al. 2001)

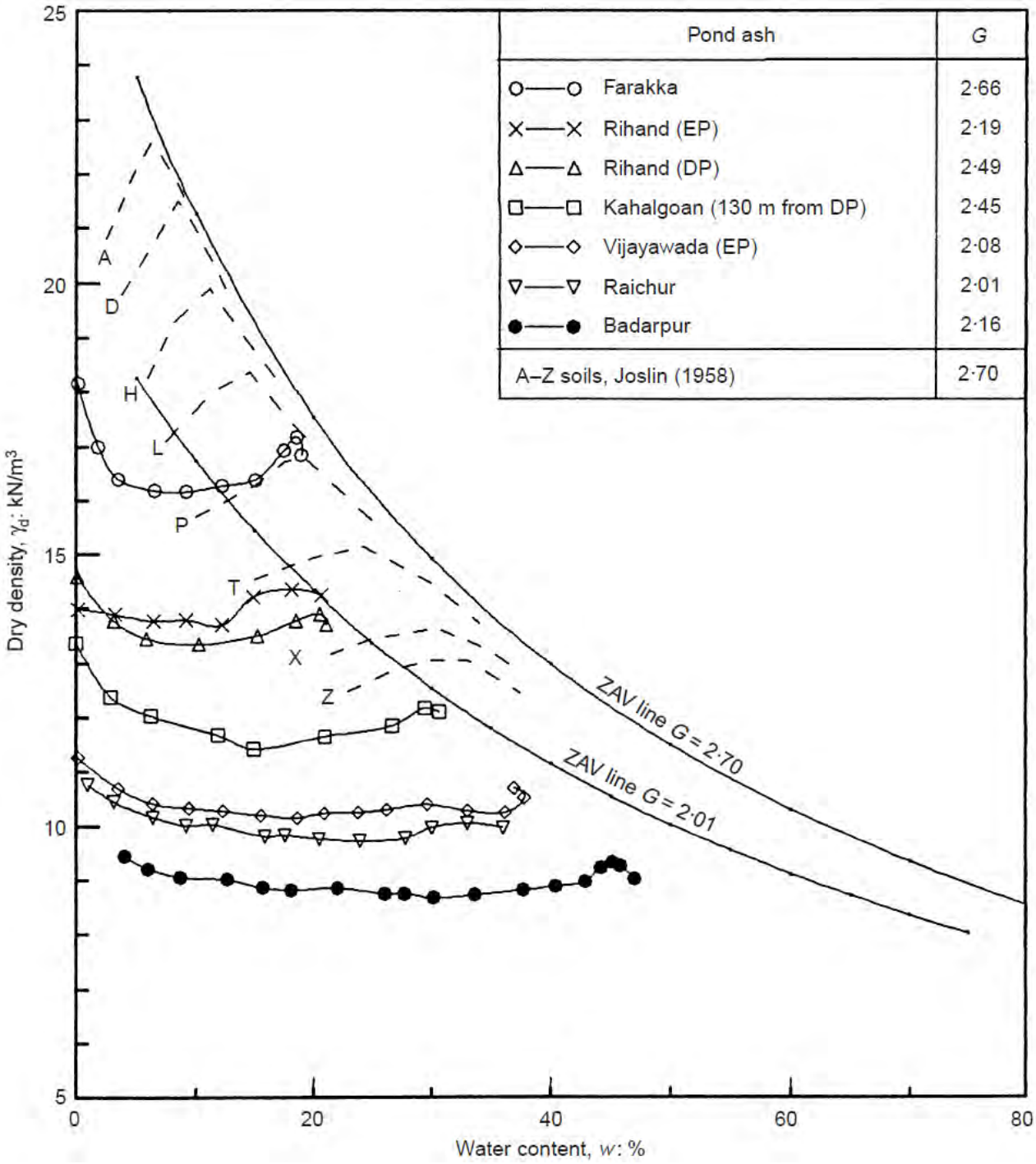


Figure 18(b): Compaction curves for different Indian surface impoundment ashes compared to those for several natural soils (Sridharan et al. 2001)

In Figures 17(a) and 17(b), the CCRs sometimes have a higher dry density at a dry condition (w = 0%). This is not a practical condition to use in construction or disposal situations, however, as there would be considerable dust pollution during placement (Sridharan et al. 2001).

Chapter 3

Dynamic Properties of CCRs

Regardless of the fact that CCRs are often composed of mostly fine-grained particles, they are still granular, non-plastic particles that exhibit no cohesion other than apparent cohesion in the moist state (Kaniraj and Gayathri 2004, Prakash and Sridharan 2009). Based on their grain-size, many CCRs could be classified as fine-grained soils, (which are commonly considered to have a lower liquefaction potential), but since these CCRs are also generally non-plastic, they have the potential of being liquefaction-prone. Liquefaction potential of CCRs is higher in the case of impounded CCRs, since these tend to exist at a saturated or nearly saturated state in-situ (and saturation is a necessary condition for liquefaction). In addition, the high moisture contents imply that impounded CCRs will have no negative pore pressures to help stabilize the soil mass under dynamic loading. Furthermore, the generally metastable structure of impounded CCRs makes their dynamic properties of great importance, even at low intensities of shaking. There have been a limited number of publications on the dynamic properties of CCRs; while this section presents and discusses currently published information on the dynamic properties of CCRs, there is still a need for further research in this area.

3.1 Cyclic Shear Strength Properties of CCRs

The most common laboratory test used to assess the dynamic properties of soils is the cyclic triaxial shear test. Cyclic triaxial testing apparatuses are expensive and provide very specific results, so very few commercial consultant firms own or even have access to them. Therefore,

cyclic triaxial testing has traditionally been done at the academic level and has seen little use in commercial consulting. Given the specialized nature of the cyclic triaxial test, there is limited research published on the cyclic triaxial properties of CCRs. Since the cyclic shear strength properties of CCRs is a very specific topic, the research available on this topic is from academics of varied nationalities, all of whom have slightly different methods of analyzing the raw data; as a result, comparing results can be difficult.

Despite differences in how to analyze and present cyclic triaxial test results between researchers, it is useful to compare results using fundamental parameters of cyclic response, such as plots of excess pore pressure (usually excess pore pressure ratio) versus number of loading cycles, or plots of the cyclic stress ratio (CSR=$\sigma_d/2\sigma_{3c}$') versus number of loading cycles, which represents a measure of how the shear strength of the material in question degrades with cyclic loading. Figures 19 and 20 present some typical plots comparing excess pore pressures to the number of cycles to initial liquefaction, and Figures 21 through 23 present plots of CSR versus number of loading cycles to liquefaction (generally defined as 5% double-amplitude axial strain) for different surface impounded CCRs at different confining stresses and relative densities.

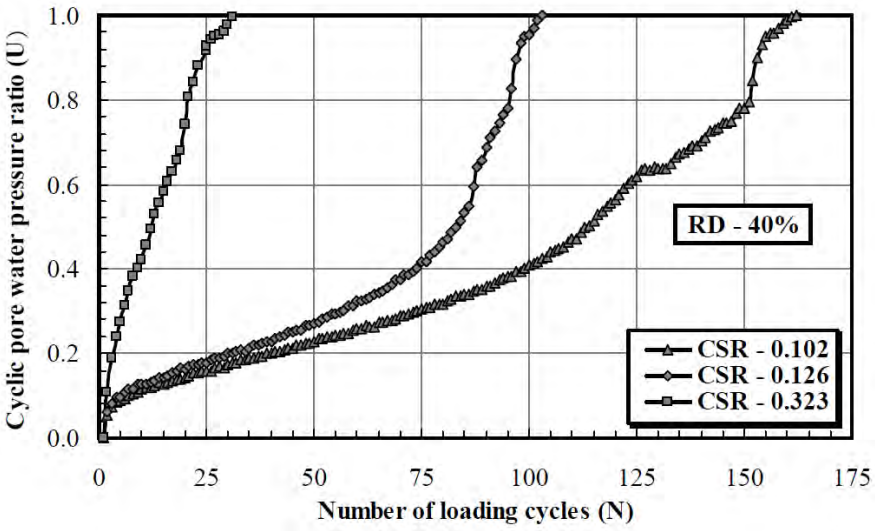


Figure 19: Plot of excess pore pressure ratio versus number of loading cycles for compacted Indian surface impoundment ash at different cyclic stress ratios and 1 Hz loading frequency (Mohanty et al. 2010).

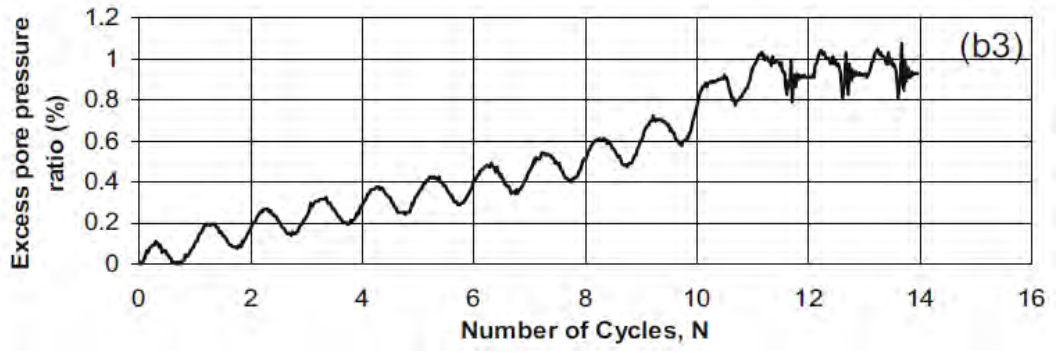


Figure 20: Plot of excess pore pressure ratio versus number of loading cycles for compacted Indian surface impoundment ash at a cyclic stress ratio of 0.10 and confining pressure of 2214 psf and 0.1 Hz loading frequency (Jakka et al. 2010)

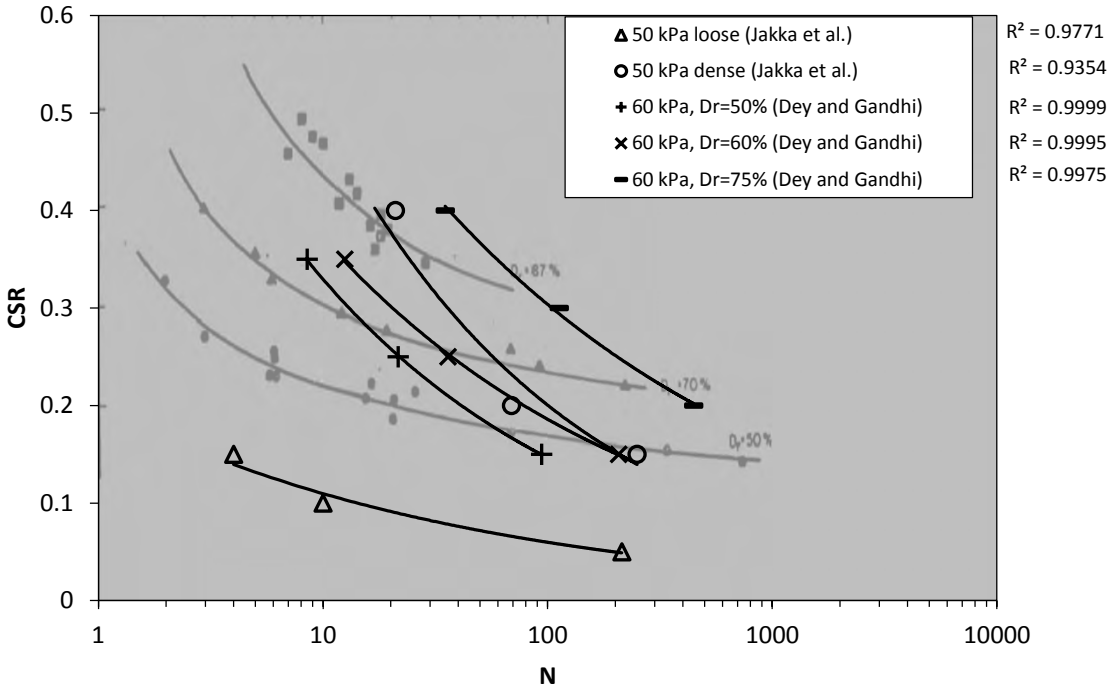


Figure 21: Plot of CSR versus number of loading cycles to liquefaction for different surface impounded CCRs tested by different researchers at confining stresses close to 50 kPa. Jakka et al. loaded specimens at 0.1 Hz to 1 Hz and Dey and Gandhi loaded specimens at 1 Hz. For comparison, curves for sands tested at the same confining pressure are superimposed (Mulilis et al 1976).

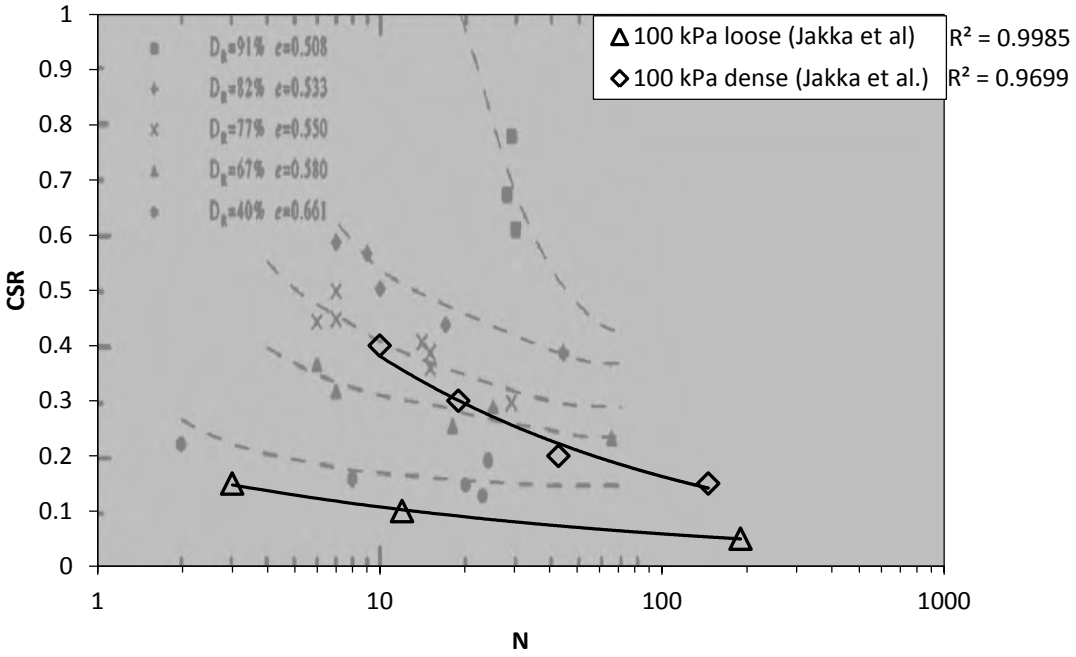


Figure 22: Plot of CSR versus number of loading cycles to liquefaction for surface impounded CCRs tested by Jakka et al (2010) at a confining pressure of 100 kPa. For comparison, curves for C778 sand at the same confining pressure are superimposed (Carraro et al 2003).

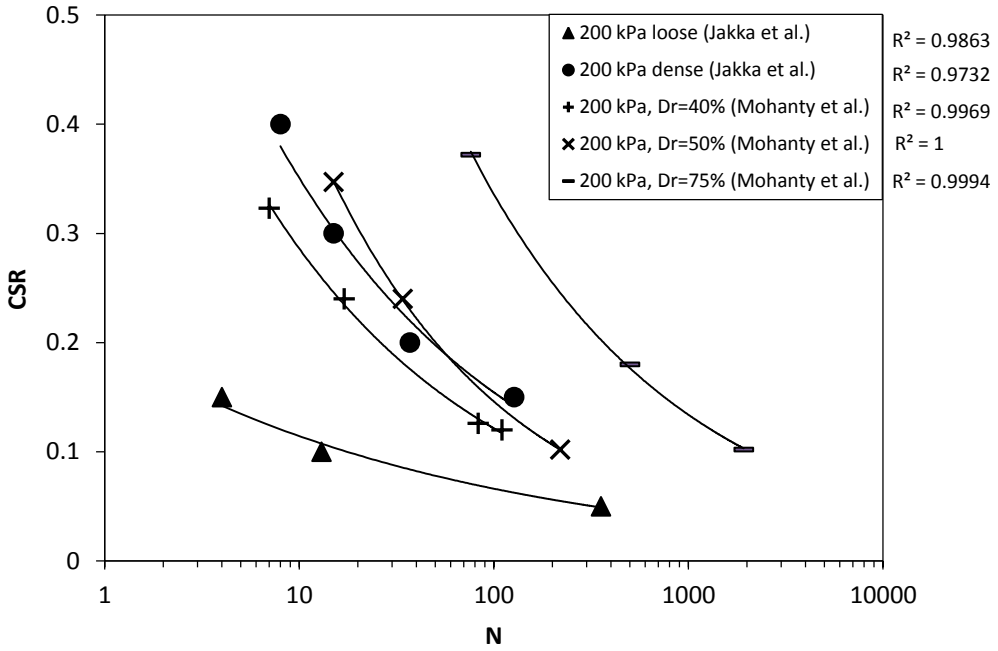


Figure 23: Plot of CSR versus number of loading cycles to liquefaction for different surface impounded CCRs tested by different researchers at 200 kPa confining stress. Jakka et al. loaded specimens at 0.1 Hz to 1 Hz and Mohanty et al. loaded specimens at 1 Hz.

For the two plots of CSR versus number of cycles to initial liquefaction where results for surface impounded CCRs are compared to tests done on sands, it is apparent that the CCRs tested tend to be more resistant to liquefaction than natural sands at higher CSRs, but less resistant to liquefaction at lower CSRs. As more cyclic triaxial tests are run on surface impounded CCRs, it will be more apparent as to whether this is an actual trend, or just an apparent trend in these three studies.

Lastly, many researchers include a plot of the hysteresis loops for a cyclically-tested triaxial sample. This is simply a plot of the deviator stress versus the axial strain through a single load cycle, at which point the plot begins again, creating a nearly-symmetrical shape about the origin of the plot. The area contained within all of these loops represents the cumulative energy dissipated by the soil being tested (Yoshimoto et al. 2006). The cumulative dissipated energy method was used by Towhata and Ishihara (1985) in order to analyze cyclic shear behavior and liquefaction strength of soils. Figure 24 shows a diagram illustrating the dissipation energy contained within a hysteresis loop.

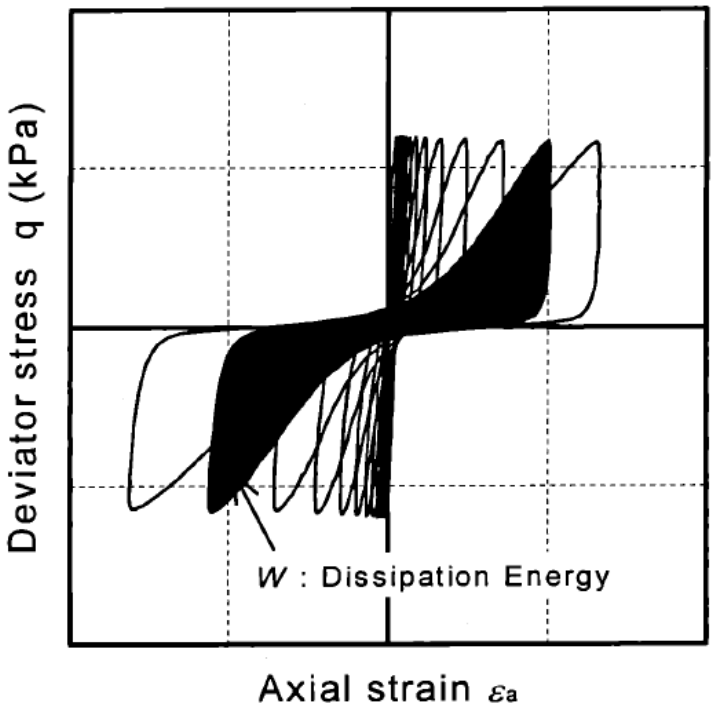


Figure 24: Example of how to determine the energy dissipated by a soil throughout a single loading cycle (Yoshimoto et al. 2006).

Chapter 4

CCR Failure Modes and Monitoring Practices

The critical failure mode for a CCR impoundment is not necessarily the same as for a CCR landfill, since differences in placement techniques for each have a significant effect on the fabric and shear strength properties of the CCRs. Determining the failure modes and developing monitoring practices for CCR impoundments can be done using the same methods as for mine tailings dams because of their similar structure. CCR landfills can be monitored much like any other earthen embankment (with material properties being the major difference), except that unlike most embankments, there is no end of construction until the landfill is retired.

4.1 Surface Impoundments

The observational method is a method of risk management outlined by Dr. Ralph Peck as the process of making design adjustments based on observed behavior in a given structure. The design can be adjusted to be either more or less conservative in order to optimize design (Martin and Davies 2000). This method of risk management is ideal for use with tailings dams since tailings dams are continuously constructed until they are retired; the same is true of CCR surface impoundments, which indicates that such methods could easily be applied to CCR surface impoundment monitoring programs. Figure 25 is a flow chart illustrating the risk management process utilizing the observational method, as applied to tailings dam design; however, the

process is general enough that the same or a slightly modified flow chart could be used for surface impounding ash structures.

Another important consideration when developing a monitoring plan for surface impoundments is whether the dikes were constructed using the upstream or downstream methods, since use of the upstream method can lead to weaker dike foundations and an increased probability of sudden or catastrophic failure (Martin and Davies 2000). The upstream construction method consists of constructing the dike of a new phase of a disposal area partly on the top of the previous phase dike and partly on the upstream disposed material; contrarily, the downstream construction method consists of constructing the new phase dike partially on the previous phase dike and partially on land downstream of the disposal area. Figure 26 illustrates that the weaker foundations of mine tailings constructed using the upstream method is evident based on the prevalence of certain failure modes for upstream tailings dams as compared to other types of tailings dams (slope failure and earthquake failure constitute 59% of failure modes for upstream tailings dams, compared to 24% for other types of tailings dams).

Taking all of these factors into consideration, a sample surveillance plan schedule for a mine tailings impoundment is provided in Figure 27. As with the risk management chart presented in Figure 25, this flowchart is general enough that it could be used in its current form, or slightly modified in developing a surveillance plan for CCR surface impoundments.

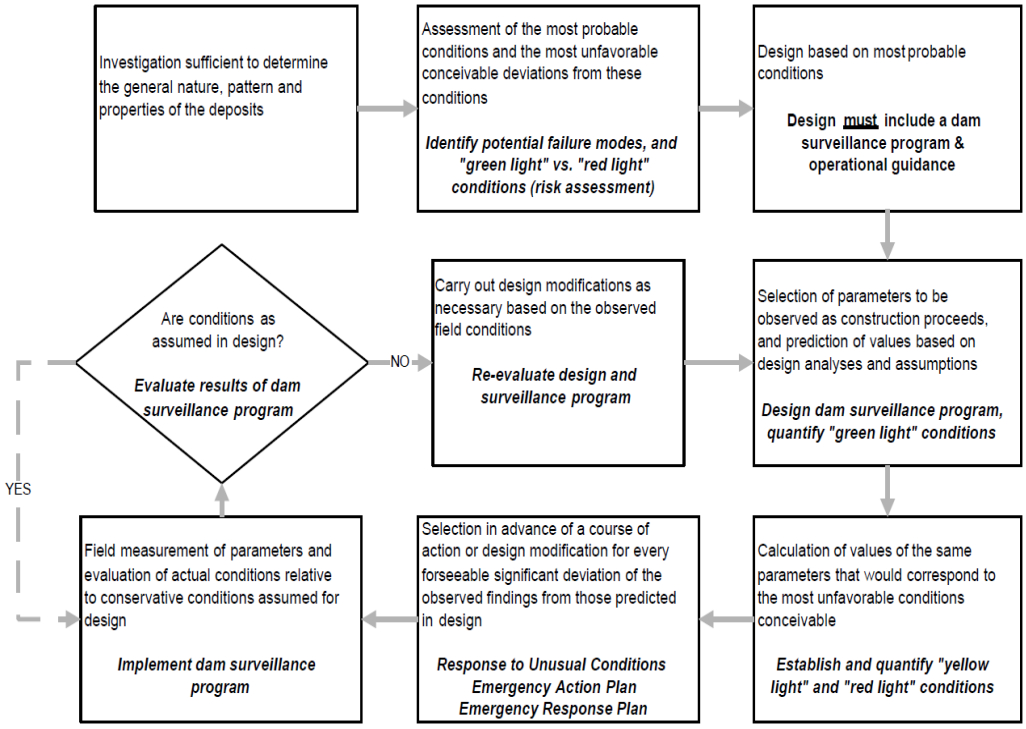


Figure 25: Flow chart illustrating risk management utilizing the observational method (after Martin and Davies 2000)

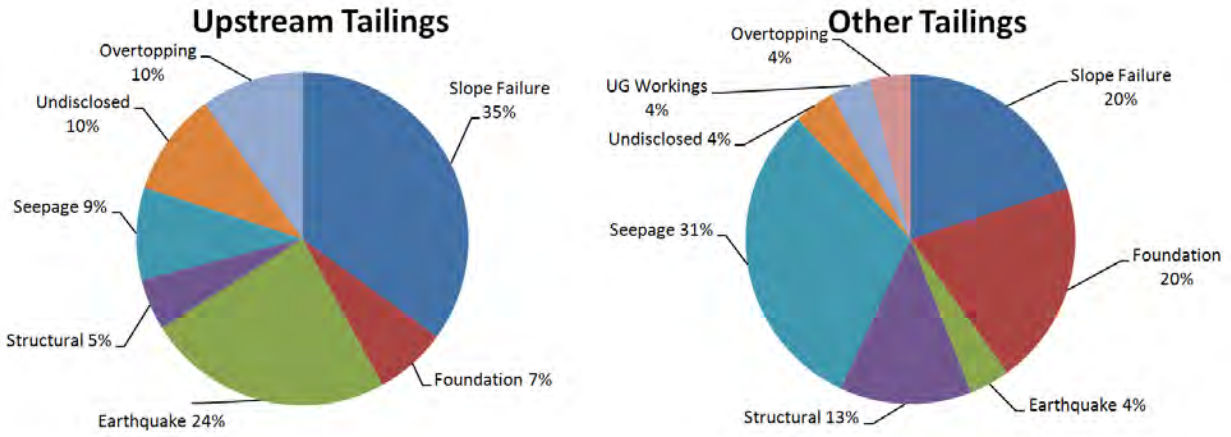


Figure 26: Comparison of failure modes of upstream mine tailings dams as compared to other types of mine tailings dams (modified from Martin and Davies 2000)

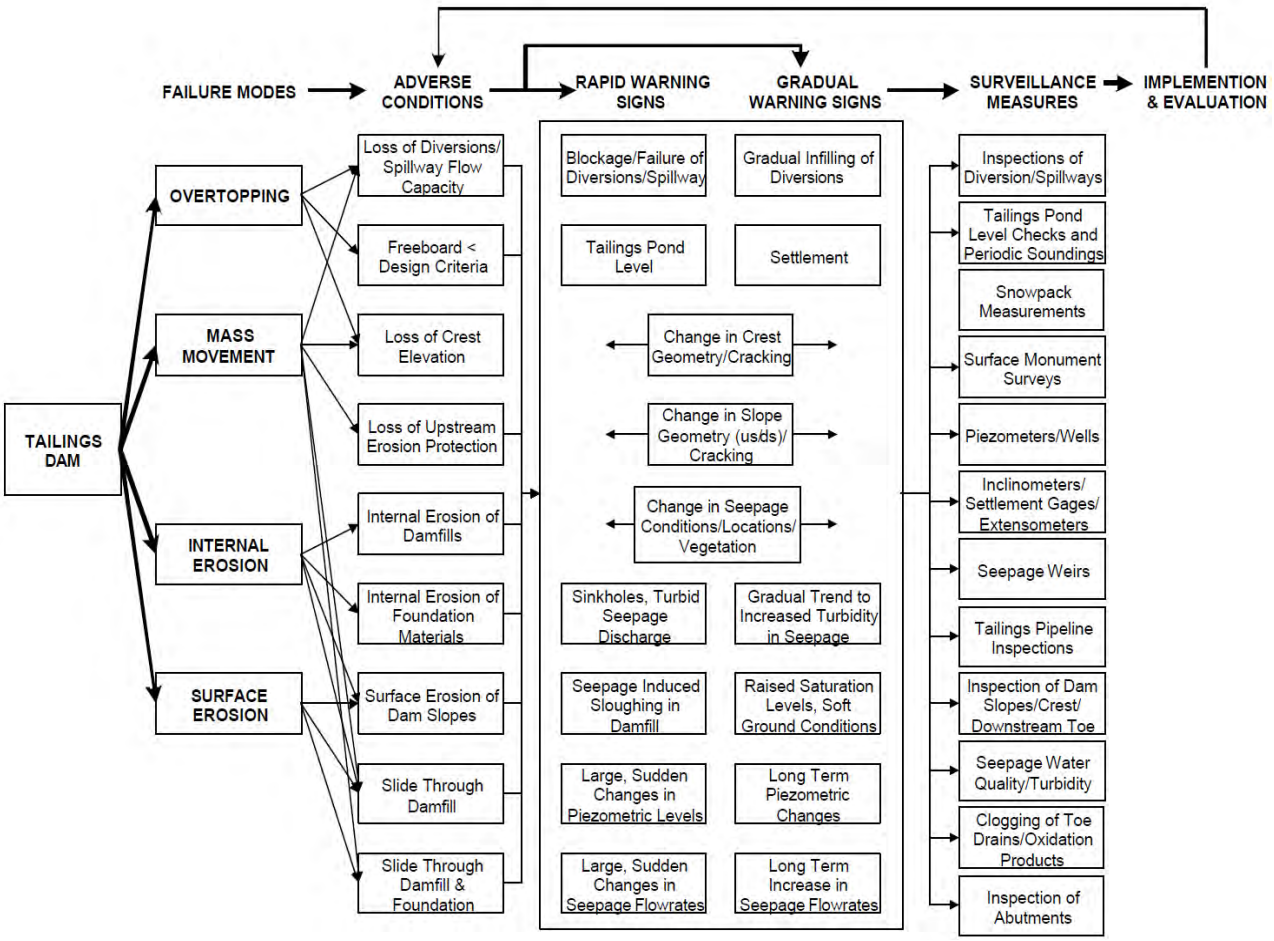


Figure 27: Sample surveillance plan schedule for a mine tailings impoundment (after Martin and Davies 2000)

Since CCR surface impoundments can have containment dikes constructed out of CCR material, natural soils, or a combination of both and these landfills have the potential to collect precipitation. An analysis procedure that can be used alongside the observational method is to treat them as earthen dams according to recommendations of the Bureau of Reclamation and the Army Corps of Engineers.

The Bureau of Reclamation's *Dam Safety Risk Analysis Best Practices Training Manual* (Scott et al. 2010) provides an overview in Chapter 1 of their recommended method for determining potential failure modes of dams for use in conducting risk analyses of dams. In Chapter 1, the authors identify determination of potential failure modes of dams as the basis for risk evaluations, making it one of the most important steps in risk analysis of a dam. They recommend a comprehensive and thorough review of all relevant background information such

as, but not limited to, geology, design, analysis and construction documentation, flood and seismic loadings, operations, dam safety evaluations, and performance and monitoring documentation. Additionally, they recommend a site examination, including questioning of the operations personnel as to how unusual events are handled and what they consider to be the vulnerabilities of the structure. The data review process should include several qualified professionals from different disciplines to ensure a thorough investigation. Lastly, the authors outline three major parts in describing a potential failure mode:

- **The initiator**, or what causes the initiation or onset of the failure mode
- **Failure progression**, a step-by-step outline of mechanisms that lead to failure
- **The resulting impacts**, a description of the expected method and magnitude of a failure if it were to occur

For more in-depth guidance on determining failure modes and developing a risk analysis program for a specific structure, the U.S. Bureau of Reclamation's *Dam Safety Risk Analysis Best Practices Training Manual* can be accessed online at http://www.usbr.gov/ssle/damsafety/Risk/methodology.html, entitled "Complete Best Practices Document."

4.2 CCR Landfills

CCR landfills are generally placed at a moist state and compacted to some degree, being constructed in a similar manner to regular earthen embankments. As a result, they can be analyzed like any other earthen embankment, with special attention paid to the engineering properties and placement conditions of the CCR materials used in the embankment. The placement method for CCR materials in CCR landfills results in less uncertainty in their fabric and relative density, generally resulting in an overall more stable structure than with surface impoundments.

Ideally these compacted CCR embankments would remain well-drained, but depending on the geology of the site and variability in the hydraulic conductivity of the CCR materials, monitoring

the groundwater table within these areas and how it is affected by rainfall patterns is good practice, unless it is clearly apparent that such monitoring is unnecessary. An additional consideration with CCR landfills is the need to continually condition the landfill surface with water in order to cut down on dust pollution and surface erosion. Ideally, slopes of CCR landfills should be seeded as soon as is feasible, in order to manage surface erosion and eliminate the need to continually condition the moisture of the slopes.

One unique case would be for sites where a CCR landfill is constructed over a retired surface impoundment. This is an appealing option to most CCR disposers, since land area can be reused, negating or delaying the need to purchase new land to construct a disposal area. Since the foundation material cannot be as well-characterized as the material being placed, a more rigorous design and monitoring procedure would be necessary, perhaps the same as or similar to those discussed in section 4.1.

4.3 Failure Modes

Failure modes for CCR surface impoundments and landfills include all of the usual failure modes for a dam or embankment. However, since disposal operations continue for years or decades, the need to continually monitor disposal areas for signs indicating the initiation of a particular failure mode is very important. Since surface impounded CCRs generally have a less stable structure than CCR landfills, they will generally tend to require more vigorous monitoring. Because of the differences in disposal methods between CCR surface impoundments and CCR landfills, the most likely failure modes will not be the same for each structure.

The most common failure modes for earthen dams and embankments include internal erosion or piping (of embankment or foundation materials), surface erosion leading to global instability, excessive seepage leading to an embankment breach, overtopping during a storm event, loss of freeboard due to excessive embankment settlements or subsidence, lateral movement of the embankment, and failure as a result of a seismic event (MSHA 2009; Martin and Davies 2000). Many of these failure modes are included in Figure 27, with common warning signs indicating the initiation of these failure modes.

The majority of these failure modes can be recognized with good monitoring practices, with the exception of failures due to seismic events, for obvious reasons. There is little data on the performance of CCR disposal areas during seismic events and also very little data on the dynamic properties of CCR materials. As a result, dynamic properties of CCRs is an area where further research and laboratory testing is required.

The overall uncertainty in the engineering properties of CCR materials make it necessary to be more vigilant with monitoring practices in order to recognize when different failure modes are initiated so that remedial actions can be taken to prevent costly failures, both on an economic and life scale. Since surface impoundments often most closely resemble tailings dams in their design, a good reference for monitoring practices and identifying failure modes for surface impoundments is the MSHA 2009 "Engineering and Design Manual: Coal Refuse Facilities," which can be accessed at:

http://www.msha.gov/Impoundments/DesignManual/ImpoundmentDesignManual.asp.

Chapter 5

Slope Stability of CCRs

The basic principles of slope stability and methods of assessing slope stability of CCR surface impoundments and landfills are the same as for naturally occurring soils; however, the results of these analyses can be very different based on the unique properties of CCR materials. For example, while an ash might have a high percentage of clay-sized particles, they rarely have any cohesion at all and may be very prone to erosion; many naturally occurring soils with clay-sized particles have a cohesive component of strength and are usually considered erosion resistant. In most instances, CCR disposal areas will not be loaded enough to incur excess pore pressures that will not be fully dissipated by the next loading cycle (the next workday). For this reason, it is generally only necessary to perform effective-stress steady-state shear strength slope stability analyses for CCR disposal areas. Special analyses, such as rapid draw-down analyses may be necessary as dictated by site geometry and design rainfall events.

5.1 Limit Equilibrium and Finite Element Analyses

The majority of slope stability analyses today are performed using commercial software programs that utilize limiting equilibrium analyses and/or finite element analyses of slope stability and seepage through slopes. It is good practice and the recommendation of the United

States Army Corps of Engineers (USACE) that some sort of check be done on the results of these software programs. In their Slope Stability Manual (EM 1110-2-1902), the USACE states that, "verification should be commensurate with the level of risk associated with the structure," and that one or more of the following methods should be used in verification of the initial analyses:

- Graphical (force polygon) method
- Spreadsheet calculations
- A second slope stability program
- Slope stability charts

The following example is of a slope stability analysis of a CCR surface impoundment using a limit equilibrium-based software program that also has a built-in finite element groundwater seepage option. The premise of this example is that a client wants to construct a dry-stacked CCR landfill on top of a retired surface impoundment. A thin layer with increased cohesion was included at the surface of all slopes in order to eliminate infinite slope failures that are solved with vegetation; this layer is not included in the table of strata properties, presented in Table 9.

Table 9: Summary of shear strength and hydraulic parameters used in CCR surface impoundment slope stability example.

Strata	γ (pcf)	N	σ_0' (tsf)	ϕ' (°)	c' (psf)	k (ft/s)	Sources
SI CCRs	92.0	N/A	N/A	25.2	0	2.55×10^{-6}	LT
Compacted CCRs	103.5	N/A	N/A	33.0	0	3.61×10^{-7}	Tables 6-8, Table 5
Embankment Fill	112.7	N/A	N/A	33.8	0	1.79×10^{-8}	LT
RR Embankment Fill	122.0	4.0	0.34	33.7	0	3.00×10^{-8}	Kulhawy and Mayne (1990)/LT
Alluvium	110.0	11.0	0.88	40.6	100	3.28×10^{-8}	Kulhawy and Mayne (1990)/LT
Saprolite	110.0	35.0	1.2	29.6	420	9.35×10^{-7}	LT
Partially Weathered Rock	120.0	N/A	N/A	30.0	500	3.28×10^{-9}	Assumed based on parent material
Bedrock	170.0	N/A	N/A	30.0	1.4×10^{5}	3.28×10^{-10}	Barton and Choubey (1977)

Note: LT = laboratory testing

Analyses were performed for six different conditions: three geometries, each with an in-situ water table and a hypothetical high water table. Figure 28 shows the in-situ subsurface conditions, while Figures 29 through 31 provide the output results with slip surfaces below specified factors of safety shown for the six geometries considered. All slip surfaces shown with a factor of safety value are the lowest factor of safety for that slope geometry.

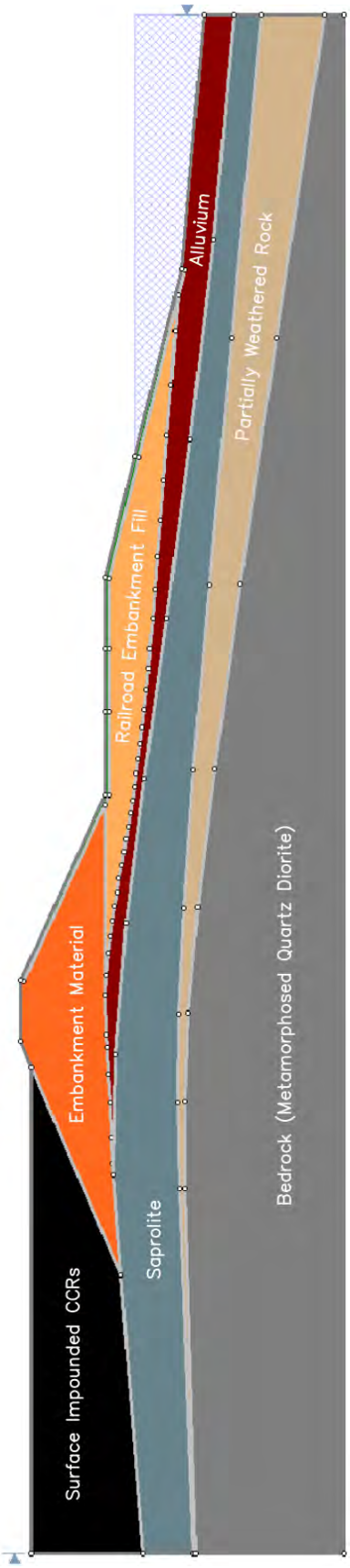


Figure 28: Subsurface profile of a slope stability example for an SI CCR embankment.

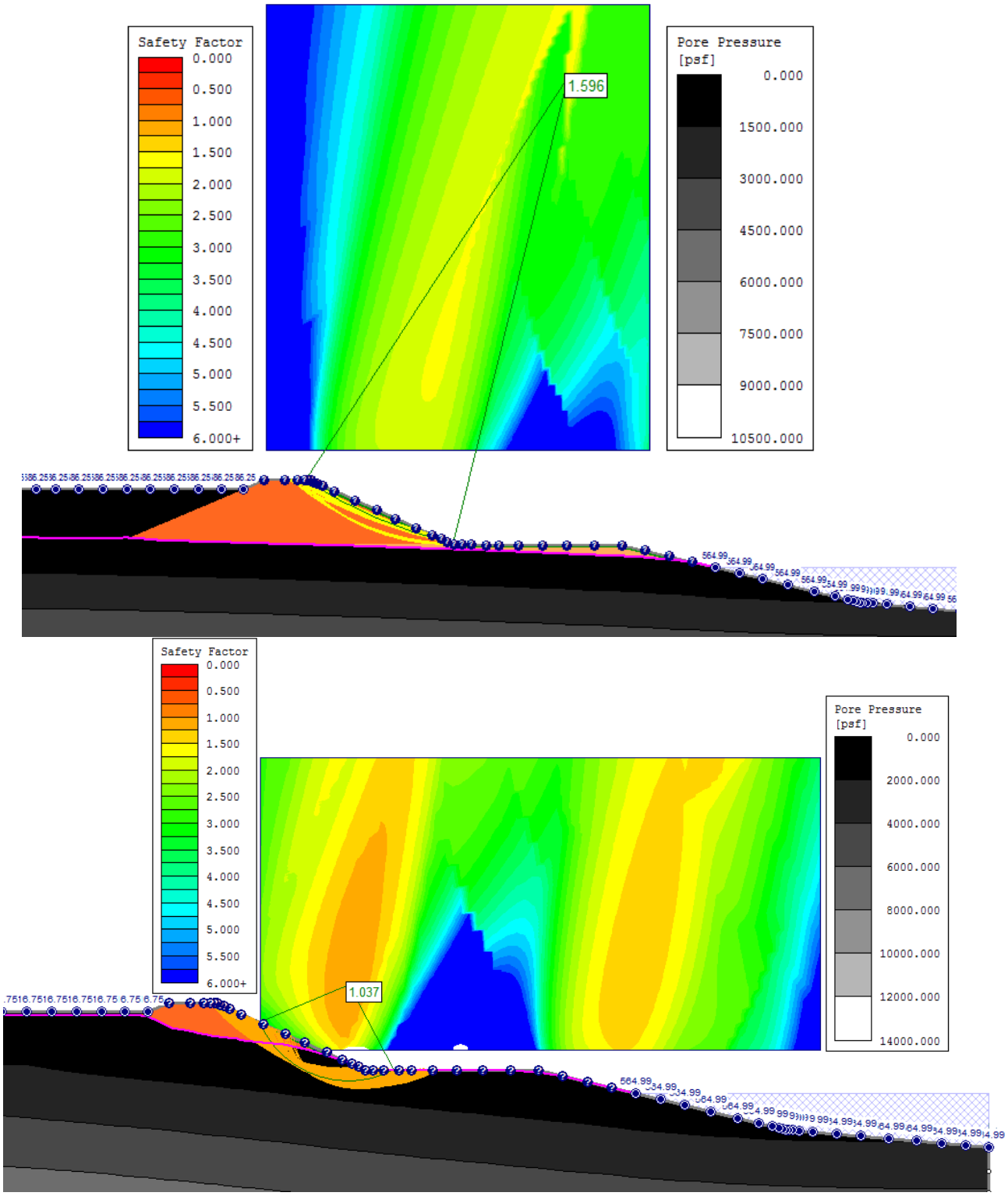


Figure 29: Analyses for the in-situ condition, first with the in-situ measured water table (above) and then with a hypothetical higher water table (below). Slip surfaces are shown for factors of safety below 1.7 for the above case and between 1.0 and 1.2 for the below case.

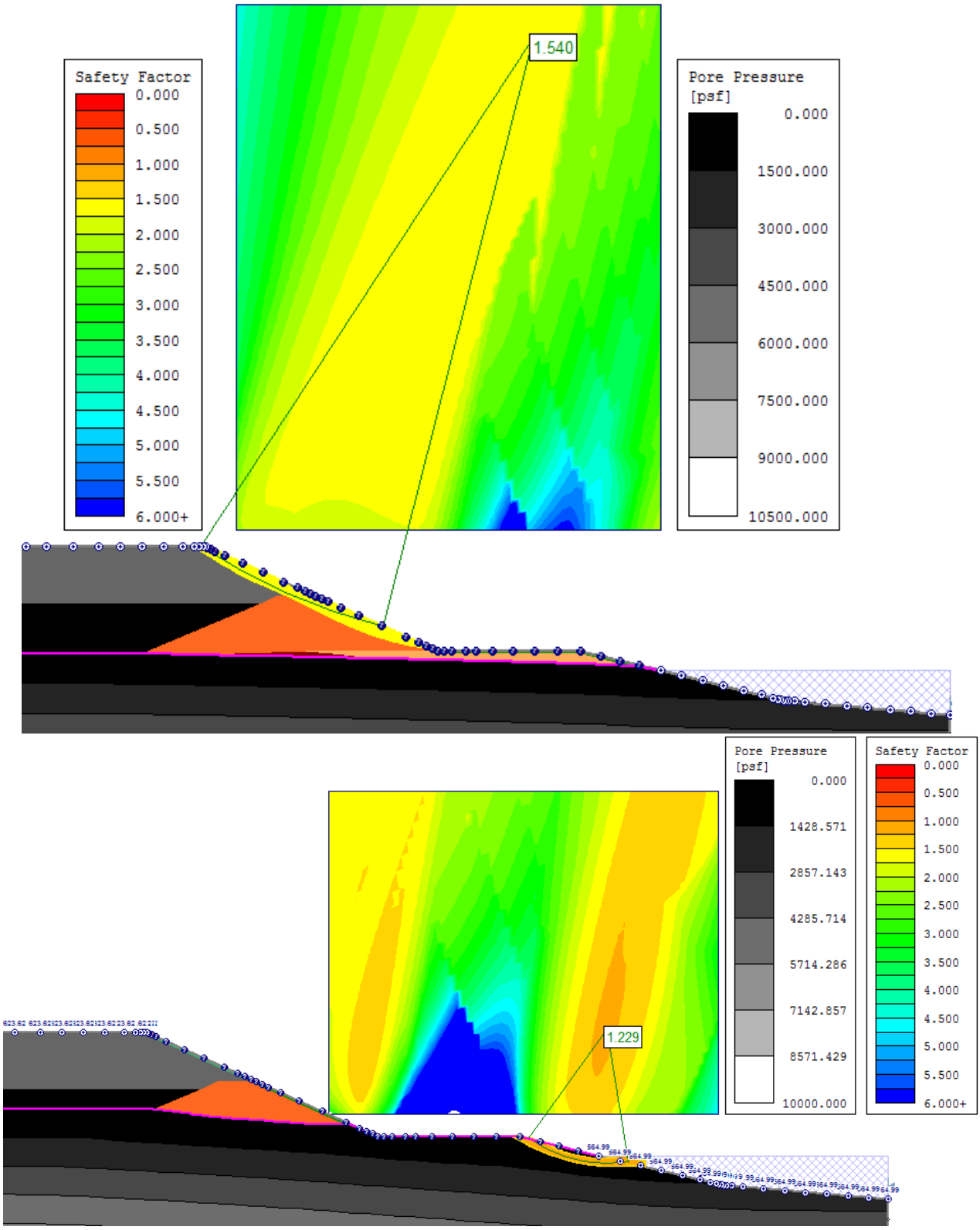


Figure 30: Analyses for an added upstream dry-disposed cell over the surface impoundment, for the in-situ water table (above) and for a hypothetical higher groundwater table (below). Slip surfaces with factors of safety between 1.5 and 1.6 are shown in the above case and between 1.2 and 1.3 for the below case.

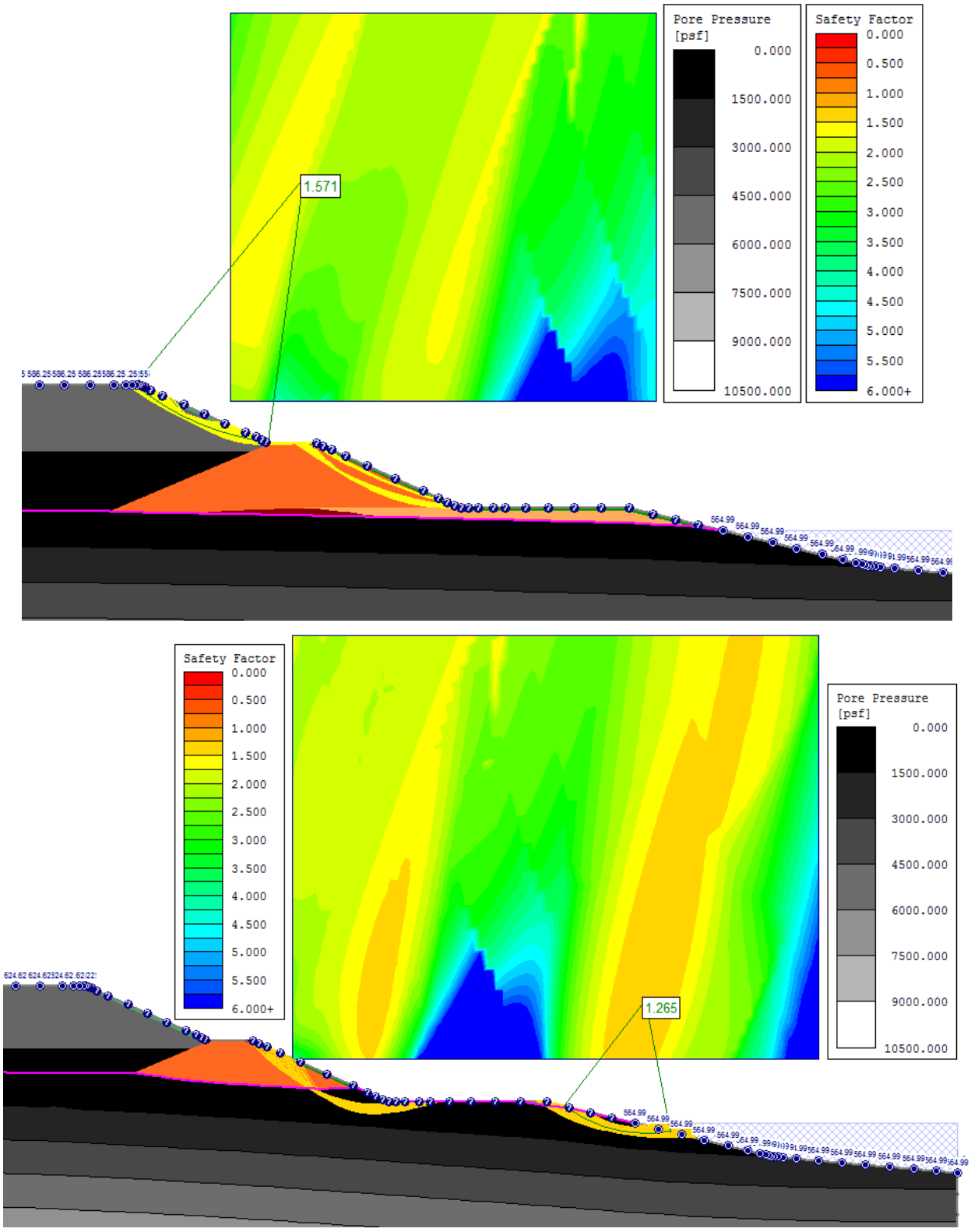


Figure 31: Analyses for an added upstream dry-disposed cell above the surface-impoundment for the in-situ groundwater table (above) and for a hypothetical higher groundwater table (below). Slip surfaces with factors of safety between 1.5 and 1.7 are shown for the above case and between 1.2 and 1.4 for the below case.

In all of the geometries considered in these analyses, a thin layer with a low cohesion was included in order to eliminate infinite slope failures that are easily remediated by keeping the slopes moist or vegetated. In addition, all of the geometries analyzed for the in-situ phreatic surface resulted in acceptable factors of safety, since the in-situ water table is so low compared to the site geometry. However, with a slight rise in the water level (perhaps as the result of a 100-year storm event), the factors of safety drop dramatically. This is the result of the fact that the embankment is constructed out of nonplastic soils that completely derive their strength from the frictional component of shear strength. As the water table rises, buoyancy effects decrease the effective overburden pressures in the geometry, thereby decreasing the slope shear strength and decreasing the factors of safety of all surfaces considered. Furthermore, the very low permeability of the embankment material makes this water table condition a real possibility, if no form of drainage through the slope is provided.

Chapter 6

Settlement Calculations for CCRs

It is common to see consolidation data reported for CCRs in research publications. However, given that CCRs often tend to be fairly free-draining, it would seem odd to use these values to determine settlement of CCRs, given that a structure or embankment were constructed over previously disposed CCRs. However, any methods developed to calculate settlements in sands are not necessarily applicable to CCRs or to silt-sized materials either. In this chapter, a comparison of common methods of calculating settlements will be made for CCRs at a specific site where a test fill was performed and actual CCR settlements monitored.

6.1 Test Fill Results

The results of a test fill of compacted, dry-placed fly ash performed over an approximately uniform 50 ft deep deposit of surface impounded ash was provided by S&ME. The test fill was 20 ft high and had lateral dimensions of 250 ft by 250 ft. The side-slopes all-around were 3H to 1V, making the entire footprint of the fill about 370 ft by 370 ft, or 136,900 ft^2. For the purposes of these analyses and the sake of simplicity this load will be characterized as a constant 20 ft load over the 250 ft square footprint of the test fill. The recorded settlements at the center of the test fill area were between 18.0 and 19.5 inches.

6.2 Settlement Calculation by Consolidation Theory

For increased accuracy, the surface impounded layer is divided into sub-layers and the settlements calculated for each layer and added together for the overall settlement. It is assumed that since the CCR material has not been loaded in the past that it is in the normally consolidated condition and that they unit weights of the surface impounded CCRs and dry-placed CCRs are 95 pcf and 100 pcf, respectively. Four sets of consolidation tests were performed on the impounded CCR material that made up the foundation for the test fill; the compression ratio for the test closest to the depth of the layer being considered is used in calculating the settlement in that layer. The water table is located 8 ft below the ground surface:

Table 10: Consolidation settlements calculated for test fill placed over a CCR surface impoundment.

Layer	T_L (ft)	D_{CL} (ft)	P_0 (psf)	ΔP (psf)	P_f (psf)	c_{ec}	S_i (in)
1	5	2.5	237.5	2000	2237.5	0.20225	11.82
2	10	10	587.7	2000	2587.7	0.20225	15.62
3	15	22.5	832.2	2000	2832.2	0.07299	6.99
4	20	40	1158.2	2000	3158.2	0.07299	7.63
						Σ	42.07

Note: T_L = layer thickness, D_{CL} = depth to center of layer, P_0 = initial stress condition, D_P = change in stress, P_f = final stress condition, and S_i = settlement for a specific layer

As displayed in Table 10, the settlements estimated using consolidation theory are just over twice the amount observed in the test fill. This is not really surprising since CCR materials do not tend to behave like soils where consolidation theory is used to calculate settlements; generally, plots of volumetric strain vs. normal stress from consolidation tests performed on CCRs do not have clearly log-linear portions corresponding to a recompression and compression ratio. As a result, depending on what values are assumed for $c_{\varepsilon c}$ and $c_{\varepsilon c}$, the settlement could either be greatly overestimated or underestimated, depending on different individuals' interpretations of the plot.

6.3 Settlement Calculation by D'Appolonia Method

The D'Appolonia (D'Appolonia et al. 1970) method of calculating settlements in sand is based on elasticity theory and can be applied to this sort of example with some moderate assumptions. Equation 8 is the equation developed by D'Appalonia et al. (1970):

$$\rho = \mu_0 \mu_1 \frac{qB}{M} \tag{9}$$

where ρ = settlement
μ_0, μ_1 = geometry factors from Figure 36
q = applied bearing pressure
B = footing width
M = 1-dimensional compression modulus

Figure 32 provides plots used to determine the geometry factors, while the applied bearing pressure and footing width are the same as determined in section 6.2. From logs of CPT tests performed at the test fill location, the average M measured over the depth of the CCR deposit was about 45 tsf (based on CPT correlations).

Given the dimensions of the test fill given in section 6.1 and Figure 32, μ_0 is estimated as 1.0 (since the fill is at the ground surface) and μ_1 would likely be around 0.14. The settlement can now be calculated as:

$$\rho = 1.0 \cdot 0.14 \cdot \frac{1 \text{ tsf} \cdot 250 \text{ ft}}{45 \text{ tsf}} = 0.777 \text{ ft} = 9.33 \text{ in}$$

The most obvious problems with applying this method to placement of a fill is that it was developed for shallow foundations, which are a rigid structure and it was developed for sands, while CCRs are usually classified as silts according to the USCS. Tan and Duncan (1991) cite that this method tends to underestimate settlements around 50% of the time, as it certainly does in this case.

Since this method underestimates the settlements observed at this site by about 50 percent, it may be useful to determine what value of compressibility modulus actually give an accurate settlement:

$$M = \mu_0 \mu_1 \frac{qB}{\rho} = 1.0 \cdot 0.14 \cdot \frac{1\ \text{tsf} \cdot 250\ \text{ft}}{1.5833\ \text{ft}} = 22.1\ \text{tsf}$$

This value for the compressibility modulus is equivalent to an average modulus calibrated to the observed settlements. While one data point is not sufficient to develop a correlation, if enough settlement tests were conducted for CCR materials, it would be possible to develop a CPT-*M* correlation that better predicts settlements than the one used in this investigation.

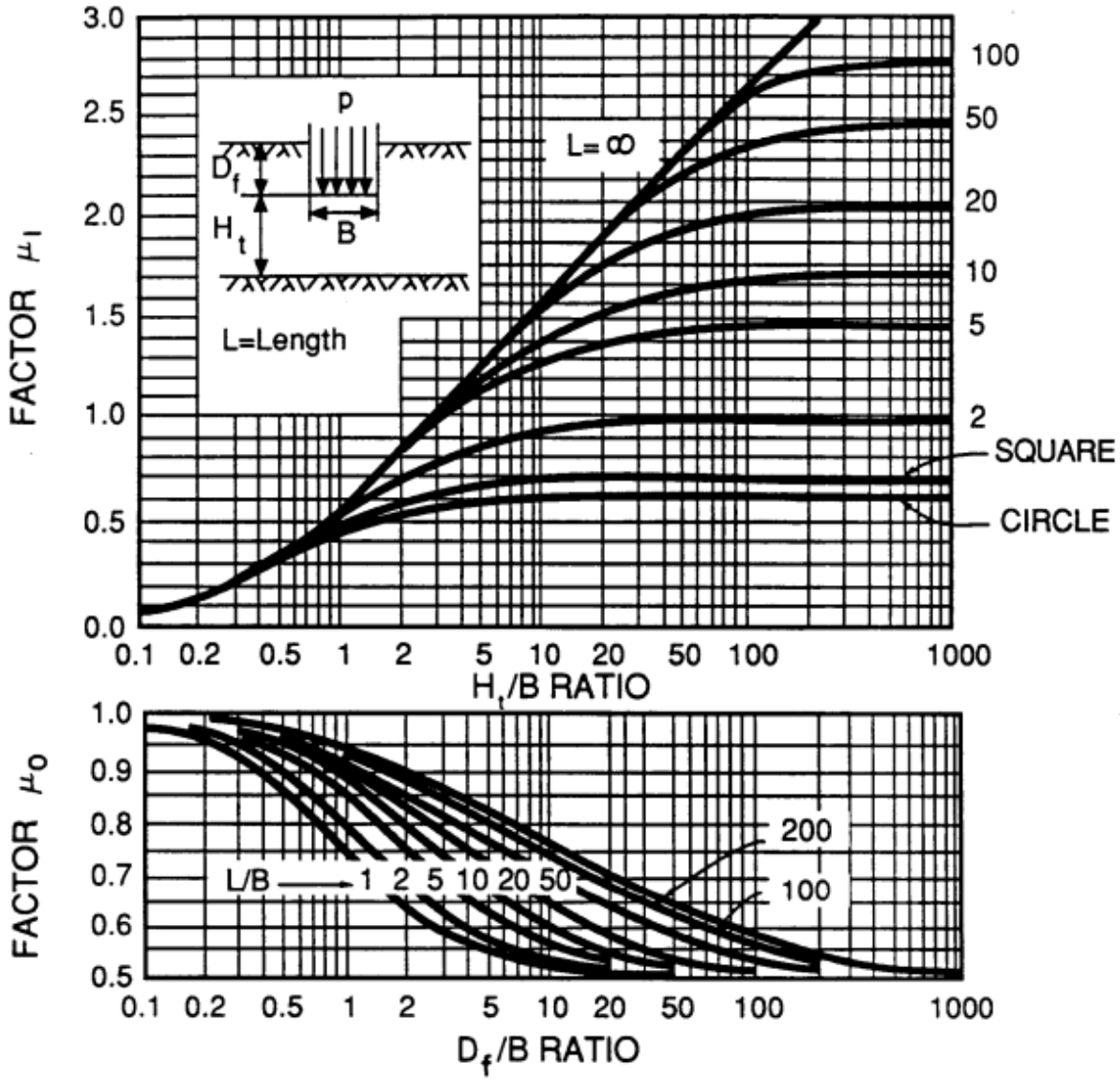


Figure 32: Plots published by D'Appolonia et al. (1970) to determine the values of the geometry factors to be used in footing settlement analyses.

6.4 Other Observations

As an alternative to specific methods of settlement calculations, if it is assumed that the fill is of large lateral extent, a basic calculation of settlement can be made using *M*, the pressure applied by the fill, and the depth of the soil strata being filled:

$$S = \frac{PZ}{M} \tag{10}$$

where P = the pressure applied as a result of the fill
Z = the depth of the soil where settlements are being considered

Again using a value of M = 45 tsf, the settlement is calculated as 13.33 inches. This is still an under-estimate of settlement for this test fill, but given that a CPT correlation for *M* in CCR materials was developed, it may be possible to calculate more precise estimates of settlement. Reduction factors could then be applied to equation 10 in order to attain an acceptable level of reliability.

A comparison of Young's modulus of soil (E_s) can also be made using Hooke's Law and the observed settlement:

$$E_s = \frac{PZ}{S} \tag{10}$$

where P = the pressure applied as a result of the fill
Z = the depth of the soil where settlements are being considered
S = the observed settlements after fill placement

versus the correlation of CPT tip resistance (q_t) to E_s used in Schmertmann's CPT settlement calculation method:

$$E_s \approx 2.5 \cdot q_t \tag{11}$$

Using Hooke's Law with a settlement of 19 inches and an applied fill pressure of 1 tsf, the E_s calculated is 31.6 tsf. Using the CPT correlation given in equation 11, the average CPT tip resistance over the depth of the CCR deposit below the test fill was about 17 tsf, which would return an E_s value of 42.5 tsf.

The accuracy of these values of E_s are questionable, however, Hooke's law assumes a linear-elastic stress-strain condition and the CPT correlation was developed for use with sandy soils. Ideally, CPT correlations should be developed specifically for CCR materials and E_s, which would require a large volume of CPT tests and data analysis.

Chapter 7

Reconstitution Technique for Surface Impounded CCRs

Sample reconstitution techniques try to balance process simplicity with matching the in-situ fabric of the soil as closely as possible. Some reconstitution techniques commonly used on sand and non-plastic silt materials include moist tamping methods, air and water-pluviated methods, and slurry deposited methods. In this chapter, a brief overview of these various methods is given and a technique not yet applied to coal ash materials is analyzed when used with surface impounded CCR materials (will be referred to as SI CCRs throughout this chapter).

7.1 Moist Tamping

The first moist tamping method was proposed by Ladd (1978) in a paper entitled "Preparing Test Specimens Using Undercompaction." In this method, specimens are formed by hand-tamping of moist soil (w% = 20% to 70%) in equal lifts within a triaxial sample split mold, while increasing the dry mass of soil in each subsequent lift. The soil samples should be mixed with water at least 16 hours prior to use and the lift thickness should not exceed 1 inch for specimens with a diameter of less than 4 inches. Ladd provided an equation to calculate the percent under-compaction for each layer placed:

$$U_n = U_{ni} - \left[\frac{(U_{ni} - U_{nt})}{n_t - 1} \times (n - 1)\right] \tag{11}$$

where U_{ni} = percent under-compaction selected for first layer
U_{nt} = percent under-compaction selected for final layer (normally zero)
n = number of layer being considered
n_i = first (initial) layer
n_t = total number of layers (final layer)

The U_{ni} of the first layer is usually between 0% for very dense specimens and 15% for very loose specimens. In order to determine the correct U_{ni}, a series of cyclic triaxial tests must be run with the same effective consolidation stresses and CSR, but with different values of U_{ni}. The specimen then observed during testing and the following observations indicate an inappropriate value of U_{ni}:

- Excessive necking or bulging in any part of the specimen during cyclic loading.
- Non-uniform vertical strains during unconsolidated-undrained loading.
- A honeycomb soil fabric structure at either end of the specimen.
- A non-uniform dry unit weight along the height of the specimen.

Other moist tamping techniques modify this method slightly, usually by either changing the method in which under-compaction is addressed or by defining a specific compaction energy to be used in compacting the sample. This method can be laborious if the correct value of U_{ni} must be determined, since a whole test regime must be completed. Additionally, with regards to hydraulically-placed soils, the fabric of the sample does not match in-situ conditions well.

7.2 Air/Water Pluviation

"Pluviation" or "raining" of soil is a technique first published by Kolbuszweski in 1948. In this technique, the soil is pluviated from a separate apparatus into the soil mold, either in a dry state, or in water. These apparatuses vary in complexity and have various opening sizes and diffuser designs. By controlling the flow rate of the soil through the diffuser and the fall height of the sand, it is possible to place the soil at varying relative densities (Rad and Tumay 1987).

While air-pluviated samples can provide relatively uniform specimens and is a good technique for modeling Aeolian deposits of poorly graded sands and silts, well-graded sands or sands with

high fines content have a tendency to segregate. Furthermore, the fabric of the sample can be disturbed during the saturation phase of triaxial testing due to fines washing out of their original placement (Keurbis and Vaid 1988). Air-pluviation would not likely model the fabric of surface-impounded CCRs well, since these CCRs are deposited in a hydraulic environment. Furthermore, the high content of non-plastic fines in CCRs would make loss of soil due to dust very high.

Similarly, water-pluviated specimens form uniform samples of poorly graded soils, though usually at lower relative densities than air-pluviated specimens, since soils fall at a slower velocity through water than through air. However, with well-graded soils, or soils with high fines contents, particle segregation can be a problem with this technique (Keurbis and Vaid 1988). Particle segregation would also be an issue with surface impounded CCRs, since these tend to be a mixture of bottom ash and fly ash.

7.3 Slurry Deposition Techniques

Like the previous two methods, there are several different slurry deposition methods. The first slurry deposition method was first developed by Keurbis and Vaid (1988), which is the technique that is being assessed for use on surface impounded CCRs in this thesis, with some slight modifications. For the sake of avoiding any redundancy, the procedure for this technique will be outlined with specific reference to its use on SI CCRs, with departures from the original procedure of Keurbis and Vaid noted.

7.4 Slurry Deposition Technique Applied to SI CCRs

The basic premise of the slurry deposition technique is to form a lean (just enough water to allow for effective soil mixing), saturated slurry of soil that can then be deposited directly from a mixing tube into a triaxial split-mold, with minimal disturbance to the mixture. The slurry should be lean enough to avoid the development of sedimentation currents during the transfer from the mixing tube to the split-mold, but not so lean that mixing becomes difficult. In addition, the procedure ensures that the sample will be fully or very close to fully saturated upon completion. The samples are deposited very loosely initially and can be densified to higher relative densities

by vibration. In their original slurry deposition method, Keurbis and Vaid recommend de-airing the soil-water mixture and then pluviating it into the mixing tube in order to better ensure saturation. However, CCRs can be fine enough that a considerable amount of the sample (of a specific grain-size) can be lost in the pluviation process. Therefore, the CCR samples prepared using this method are simply added to de-aired water directly into the mixing tube in order to minimize sample loss during the preparation process; if saturation ratios using this method are unacceptable, a soil-water mixture can de-aired under a vacuum or by boiling and then transferred directly to the mixing tube. The apparatus required for the CCR slurry deposition technique are as follows:

- Acrylic mixing tube, with an outer diameter slightly smaller than the target diameter of the sample being formed and a plug to seal off one end. The end opposite of the mixing tube will have rubber gasket seal glued around the rim. The other dimensions of this tube will be discussed later.



Figure 33: Acrylic mixing tube with a rubber stopper on one end and rubber gasket seal glued to the opposite end.

- A thin metal disk approximately the same diameter as the bottom porous disk used in testing.

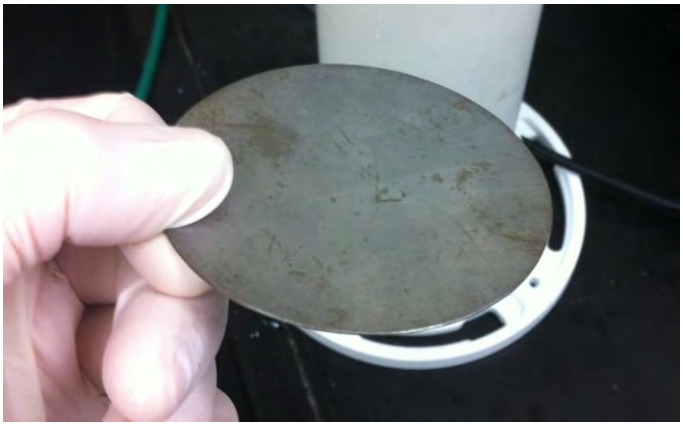


Figure 34: Thin metal disk approximately the same diameter of the bottom porous disk.

- A rubber or latex membrane with a smaller diameter than the mixing tube. Standard store-bought balloons can be cut to fit and are a cheap, readily available alternative.
- Water bath container for the acrylic mixing tube, large enough to completely submerge the mixing tube.

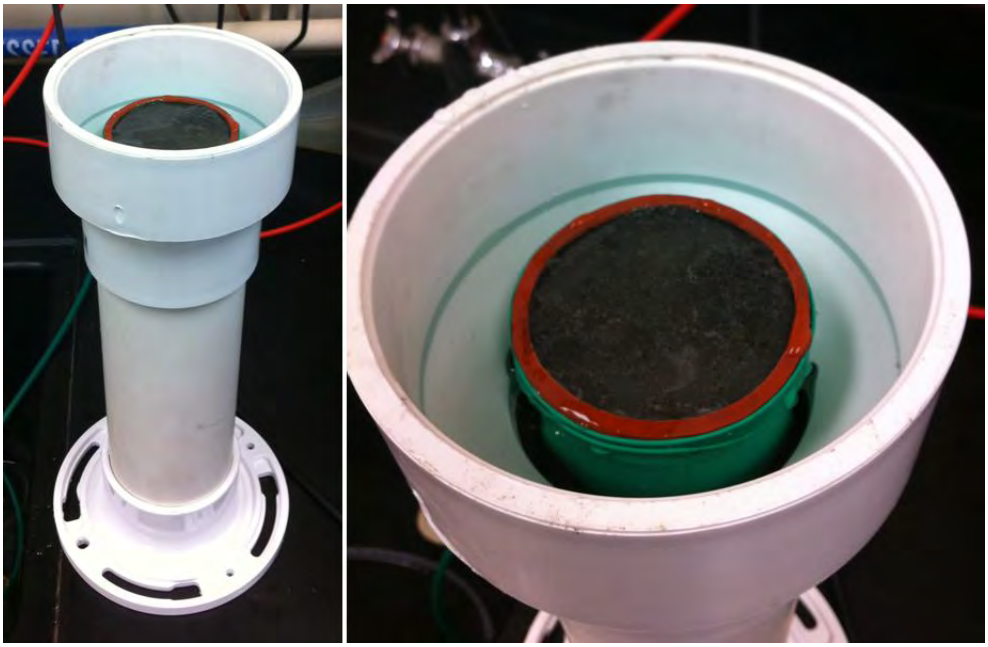


Figure 35: Water bath large enough to completely submerge the mixing tube and allow for easy placement of the porous disk and metal plate. The rubber membrane can also be seen rolled down around the mixing tube.

- Water bath container for the triaxial cell base-platen that can at least submerge the bottom drainage line and the porous disk when the mixing tube is placed on it.

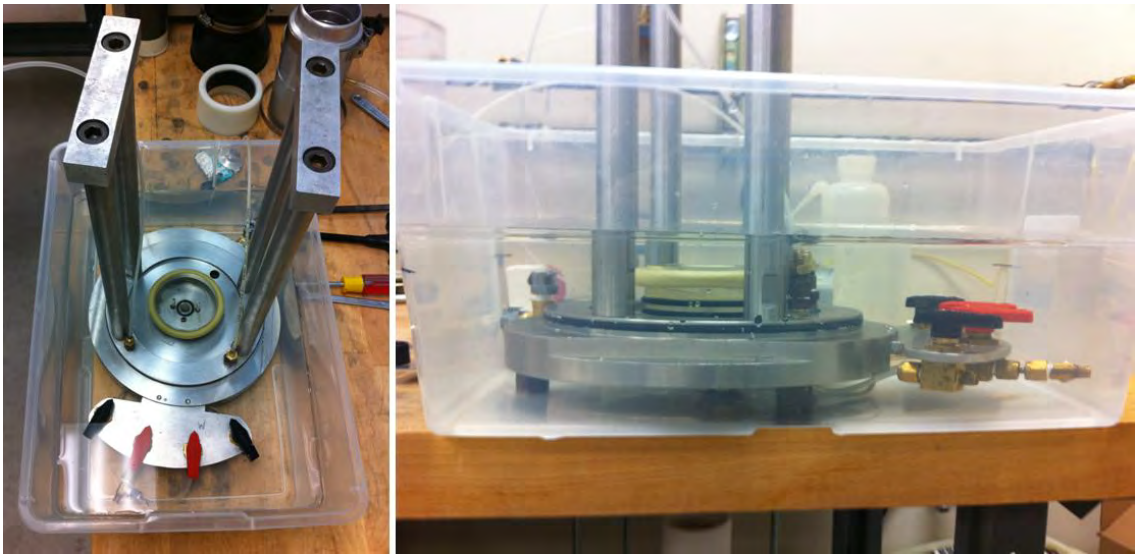


Figure 36: Water bath large enough to accommodate the bottom of the triaxial cell and submerge the bottom platen.

- A split-mold triaxial sample former.
- A collar that fits over the split-mold to accommodate the temporary increased volume of the sample when it is first placed.

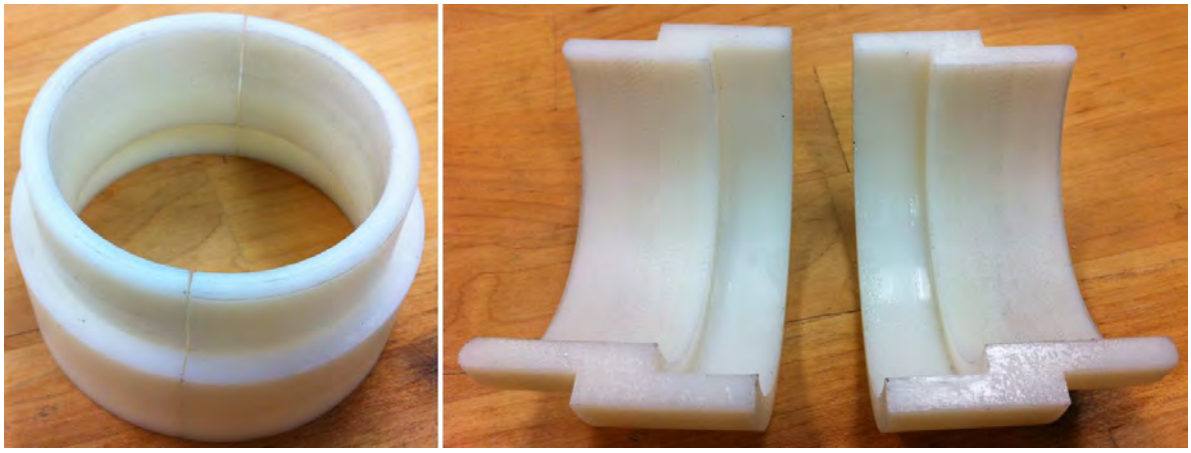


Figure 37: A custom-made split-collar to accommodate the additional volume of soil when the slurry is first placed in the specimen split-mold. This collar was machined out of nylon to fit the dimensions of the split-mold being used and the flexible collar used to accommodate the extra water volume when the slurry was placed.

- A small mechanical shaker or mallet to densify the sample once it is placed. If a mallet is used, a heavier mallet is best, as it transfers more energy than a standard rubber mallet.

In their original slurry-deposition method, Keurbis and Vaid made their soil-water mixtures using dried soil; for SI CCRs, this would be impractical because of the dust that would be lost in handling it in a dry state. Thus, it is recommended that the SI CCRs be mixed at a target water content in order to make it more workable. Once the soil is well-mixed, several small samples should be oven-dried to verify that the moisture content of the soil is homogenous.

The mixing tube should have the thin rubber membrane rolled down over the end with the rubber gasket seal and the other end plugged with the stopper. The moist CCR specimen is placed in the mixing tube, which should then be filled with de-aired water (some water can be in the tube prior to adding the moist soil in order to help collapse the structure of the moist CCRs and decrease their volume during placement in the tube). The mixing tube is now placed into the de-aired-water bath. Once the mixing tube is in the water-bath, a saturated, de-aired porous disk with a filter paper attached is placed on the open end, such that it is completely submerged in the water bath; some fines will escape the mixing tube while it is submerged and before the porous disk is placed over the opening (see Figure 38), so these fines should be put into a container to be oven-dried and weighed in order to adjust the dry mass of the sample.

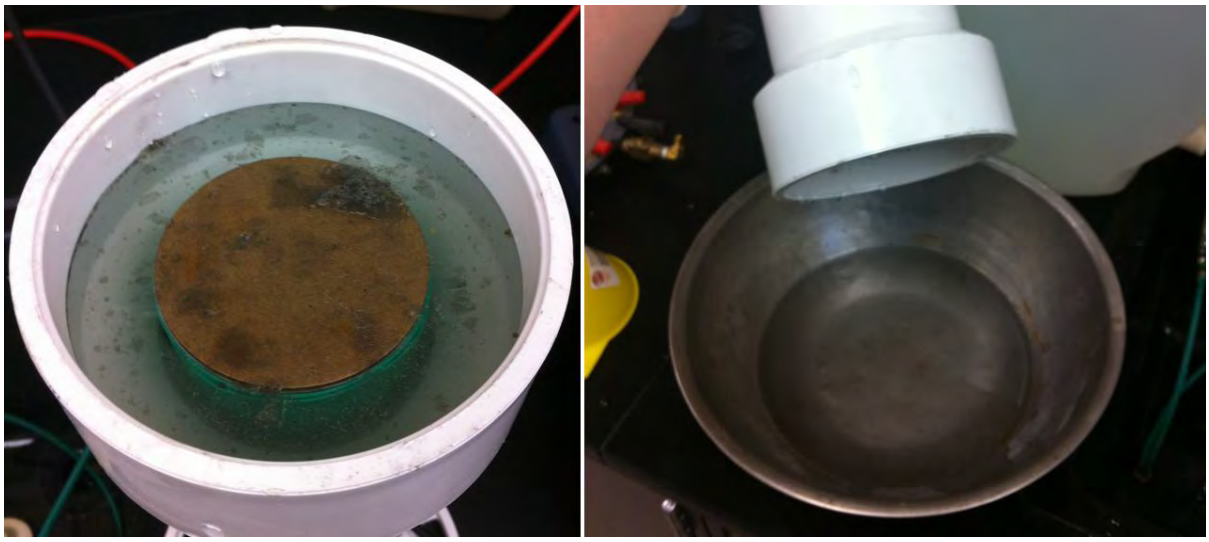


Figure 38: Placement of the porous disk and transferring of the fines lost in the water bath to a container to be oven-dried and weighed.

At this point, the thin rubber membrane is rolled over the porous disk, such that a small portion of the center of the disk is exposed. The thin, metal disk is now placed over the porous disk and membrane and the mixing tube is withdrawn from the water bath, while keeping firm pressure on the metal disk. The securing of the porous disk with the thin rubber membrane and placement of the metal disk are shown in Figure 39.

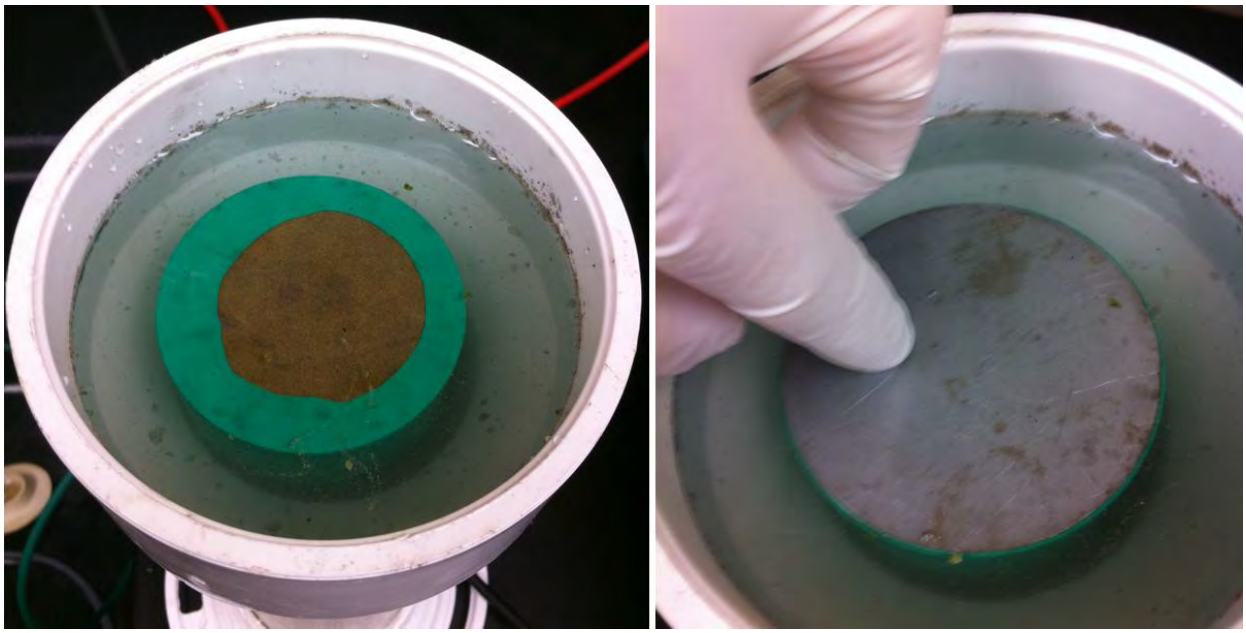


Figure 39: Securing of the porous disk with the thin rubber membrane and placement of the thin metal disk over the opening in the membrane.

Now the mixing tube is removed from the water bath while maintaining firm pressure on the thin metal disk and the soil slurry mixed vigorously, end-over-end for the next twenty minutes, to ensure homogeneity of the slurry. After twenty minutes has passed, the mixing tube is placed disk-end down and the mixture is allowed to settle to its loosest stable state. When the mixture has stabilized, the metal disk is removed (it should be held in place by suction when the mixing tube is lifted), the membrane rolled back to the edges of the porous stone, and the entire apparatus placed porous-disk-down onto the base platen, which is submerged in another de-aired water-bath. The rubber membrane around the mixing tube is now rolled up and off of the mixing tube. The sample membrane has been rolled down around and attached to the bottom platen with two o-rings prior to submerging the base platen in the de-aired water-bath and it is now rolled up and over the outside of the mixing tube. The entire bottom platen can now be removed from the water bath and the split mold formed around the mixing tube and sample membrane. Rolling of

the membrane over the mixing tube and placement of the split mold and collars after removal of the triaxial cell base from the water bath is illustrated in Figure 40.

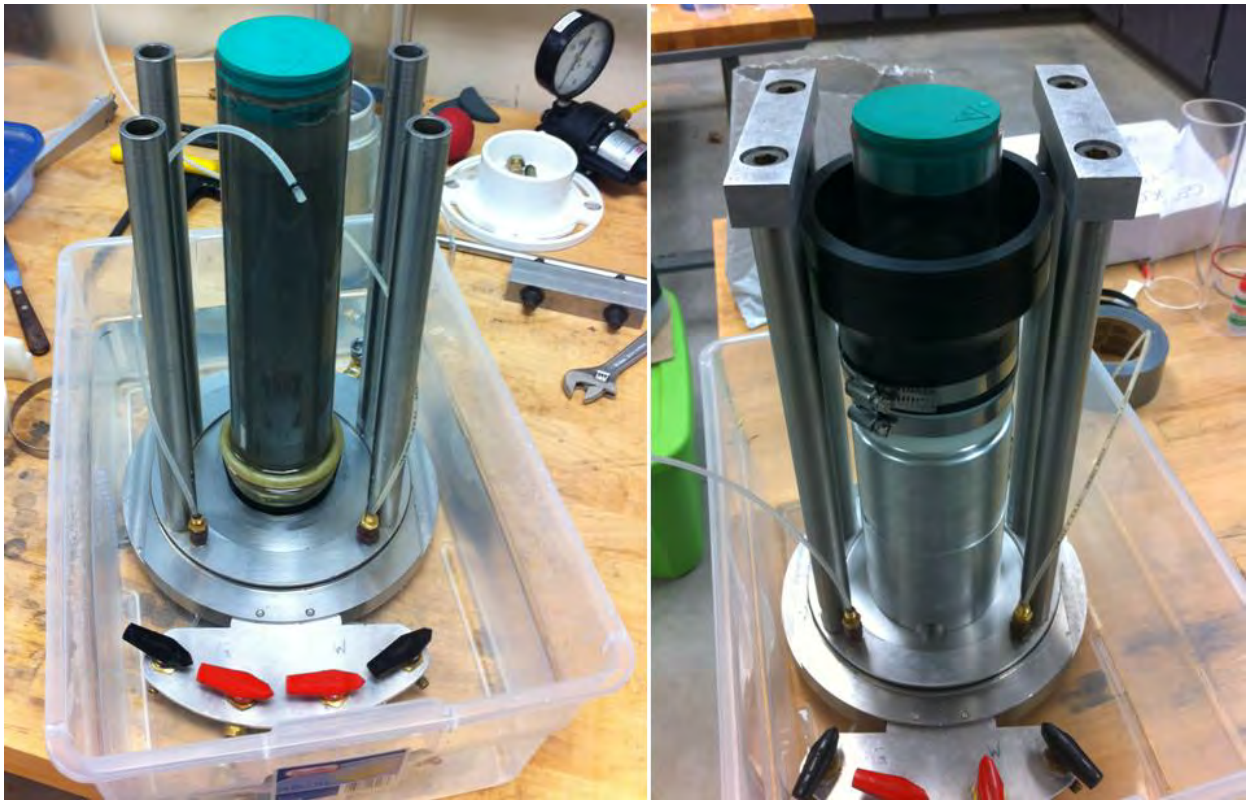


Figure 40: Rolling up the membrane around the mixing tube and placement of the specimen split-mold, the slurry extension collar, and the water extension collar after removal of the triaxial cell base from the water bath.

Once the extension collars for the split-mold is attached, a vacuum is applied between the split mold and the membrane; then, if additional volume is required to accommodate water volume, either a larger membrane can be secured using a hose clamp, or a flexible rubber PVC connection can be used (the flexible PVC connection was used in this experiment, as shown in the right-hand photograph in Figure 40). The last step before transferring the slurry to the split mold is to add a de-aired water bath to the split mold, outside of the mixing tube; this ensures minimal disturbance of the CCR material as it is transferred from the mixing tube to the split-mold. The rubber plug on the mixing tube can now be removed and the mixing tube slowly extruded, such that disturbance to the slurry is minimized as it is deposited in the split-mold. When the mixing tube has been fully extruded, the water level can be adjusted by allowing drainage through the drainage lines on the bottom platen (alternatively, some of the water and fines mixture at the top can be basted off and put into the same container as the fines from the

mixing tube water bath and oven-dried and later weighed to save time). Once the water level has dropped enough to allow removal of the extra membrane or flexible PVC connection, the slurry can be densified by attaching the top platen (which also has a filter-paper applied), applying a small pressure, and vibrating the sample if necessary, while allowing excess pore pressures to dissipate through top and bottom drainage lines, as shown in Figure 41. This should be done such that the piezometric pressure is the same across the sample, which was postulated to form specimens of sand at uniform densities with height by Vaid and Negussey (1988).

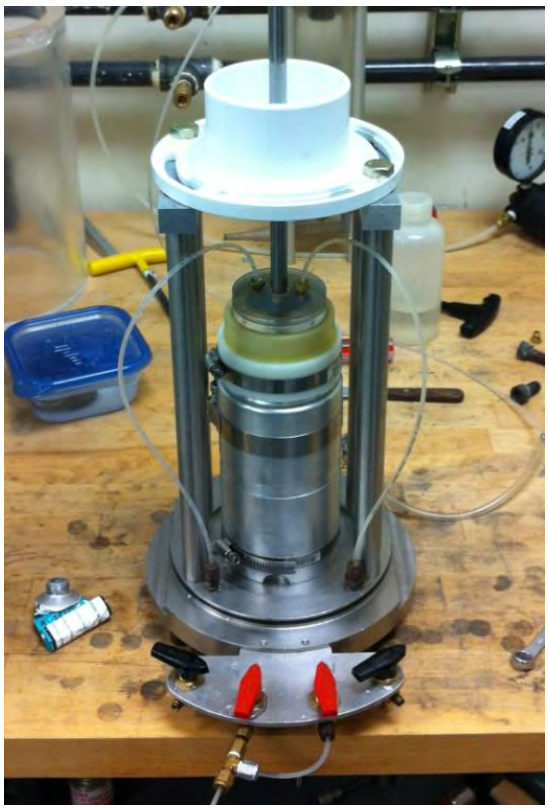


Figure 41: Setup used to densify SI CCR slurry-deposition samples. Notice that the short-circuit between the top and bottom drainage is being used to drain the sample as it is densified with the top platen applied. The top platen fits snugly enough into the extension collar to keep a water-proof seal. The white piece on the top of the triaxial base is simply a part to keep the piston plumb as the slight pressure is applied to the top of the sample during densification.

This vibrating can be accomplished with either a mechanical shaker or by tapping the side of the split mold gently with a mallet. However compaction of specimens to high relative densities can take quite a long time using a mallet, so a mechanical shaker would be preferable for SI CCR specimens. Once the target sample height is reached (and thereby the target sample volume reached), the extension collar is removed, the membrane is secured to the top platen with two o-

rings, and a small vacuum pressure is applied to the sample to allow removal of the split mold. The dimensions of the sample are then measured and the sample is placed into the triaxial testing apparatus.

The dimensions of the acrylic mixing tube are determined based on the minimum density of the largest volume of soil that will be used in making a sample. That is, the length of the tube is determined based on the amount of soil required in forming the densest sample to be tested, placed at a zero percent relative density. Keurbis and Vaid found that this volume, increased by five to ten percent is sufficient to allow for adequate slurry mixing, while avoiding large particle sedimentation distances. A sample calculation determining the appropriate length for a mixing tube is included in the appendix.

7.5 Analysis of Slurry Deposition Technique with SI CCRs

In order to assess the slurry deposition technique as applied to SI CCRs, relative density and gradation were determined for the top, middle, and bottom portions of the sample. Since CCRs tend to be non-plastic and negative pore water pressures in a moist sample are not high enough to ensure no disturbance of fabric during the verification process, a gelatin solidification technique developed by Emery et al. (1973) for use with sand specimens was modified for use in this experiment. Gelatin was chosen as the solidifying agent because it is easily dissolved using heat after the volume of each individual slice of the specimen is determined. Then, by adding bromelain, a proteolytic enzyme, the gelatin is broken down, leaving a brittle crystal that can then be avoided when selecting a sample to run a hydrometer test on, and that can be washed out when the gradation is analyzed above the #200 sieve.

SI CCRs have a wide range of hydraulic conductivities (a result of how they are generated and placed), sometimes being similar to sands and other times being more similar to silts. For this reason, the time required to permeate these samples with a gelatin solution is much longer than for clean sand samples. As a result, it was determined that a lower concentration should be used than recommended by Emery et al., such that the solution remains a liquid at room temperature, but is solidified by surrounding the sample in the split mold with an ice-bath; this is explained in more detail in the following paragraphs.

Once the compaction of the slurry deposited sample was complete, height measurements were made at four locations (front, back, right, and left sides of the top platen) using the frame of the triaxial cell and a Mitutoyo micrometer. The height of the sample was determined by subtracting the thicknesses of all the component parts that are not soil from the heights measured from the bottom platen to the triaxial cell frame at four points (front, back, right, and left sides). This was done as a quality-control measure to ensure that the overall relative density across the sample was close to the target relative density. A 0.75% by-mass gelatin solution is then permeated through the specimen by applying an elevation head between the gelatin reservoir and bottom drainage lines of the specimen and allowing drainage through the top drainage lines (not more than 18 inches). About two specimen pore volumes were permeated through the specimen to ensure complete replacement of the pore fluid. After the gelatin flushing of the specimen was complete, the drainage lines were all closed and an ice-bath was packed around the specimen, as shown in Figure 42. For this experiment, the ice bath was maintained over the height of the sample for a period of four hours, which was found to be adequate to solidify the specimen.

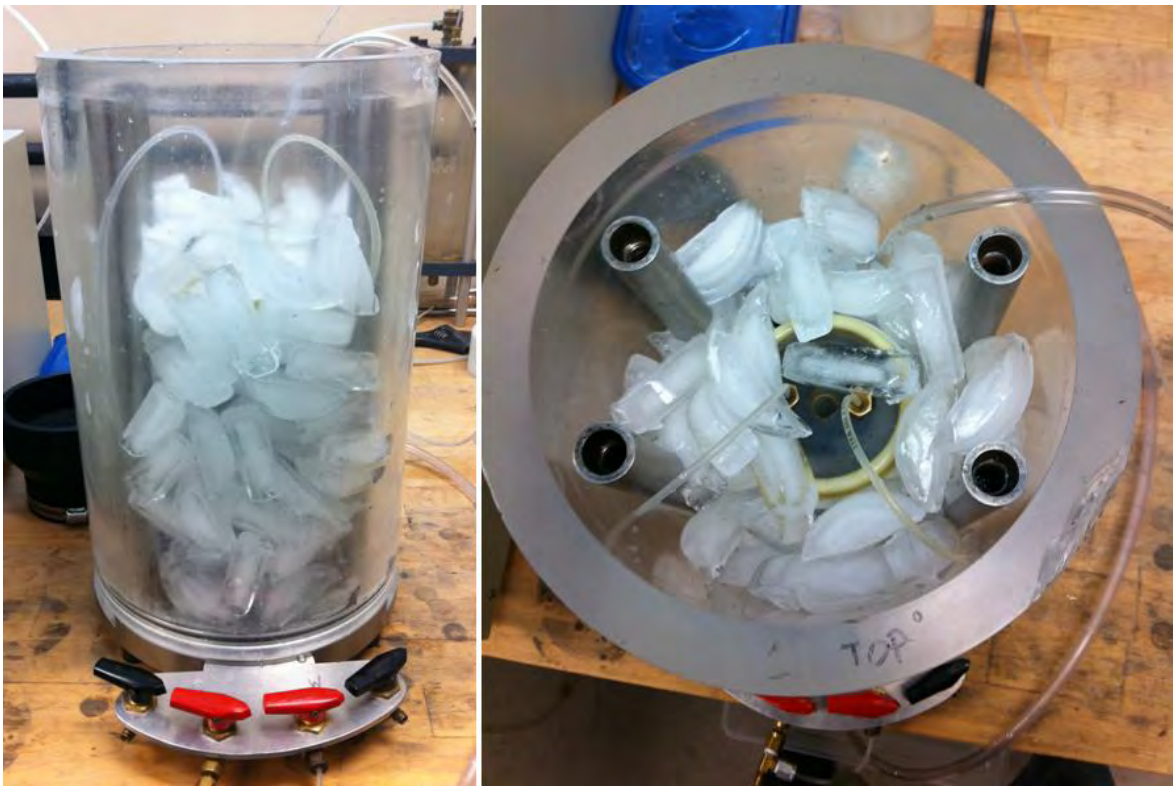


Figure 42: Ice bath placed around the compacted specimen for a period of four hours to set the gelatin.

After the four hours, the ice bath was removed and the specimen was removed from the split mold and taken out of the membrane, as shown in Figure 43, and cut into three approximately even-sized portions.

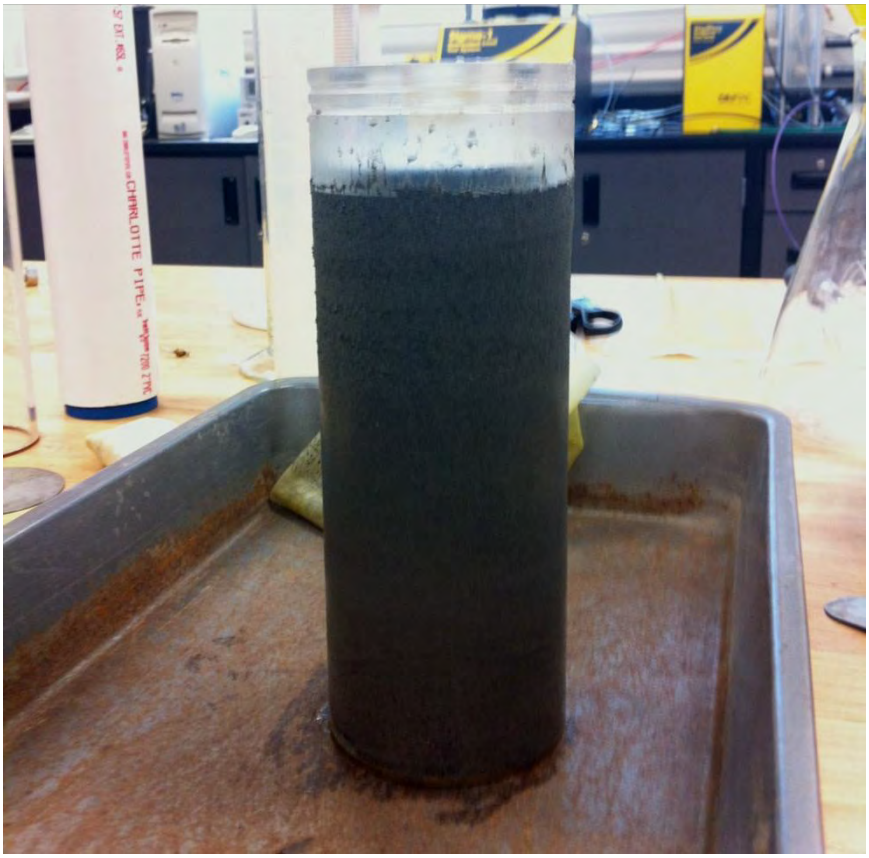


Figure 43: Specimen removed from the split mold and membrane following gelatin curing period.

The mass of these portions was taken and the volume determined using water displacement, as shown in Figure 44. These two measurements allow for the calculation of the density of each slice. It can be assumed that each of the slices is composed only of a mixture of gelatin and CCR material for the purposes of determining the relative density of each slice. The specific gravity of the gelatin solution was determined by permeating a portion of the solution through a piece of filter paper into a graduated cylinder and also placing this in an ice-bath for four hours, after which the mass and volume of the gelatin were measured and used to calculate the specific gravity at that temperature (ranged from 1.000 to 1.008). The specific gravity of the CCR material was determined according to ASTM D854, courtesy of Kevin Foster. Since the overall

density of each slice is known, and the density of both component materials is known, it is possible to calculate the volume of each component according to equations 12 and 13.

$$V_{s_slice} = \frac{\rho_{slice} \cdot V_{Slice} \frac{G_G M_{slice}}{\rho_{slice}}}{G_S - G_G} \tag{12}$$

where V_{s_slice} = volume of solids of the specimen slice
ρ_{slice} = density of the specimen slice
V_{slice} = volume of the specimen slice
G_G = specific gravity of the gelatin solution after ice-bath
M_{slice} = mass of the specimen slice
G_S = specific gravity of the CCR material

$$V_{g_slice} = \frac{M_{slice}}{\rho_{slice}} - V_{s_slice} \tag{13}$$

where V_{g_slice} = volume of gelatin of the specimen slice

Since it is assumed that the gelatin completely permeated the pore space of the sample, the volume of the gelatin is equal to the volume of voids in the slice and the void ratio can be calculated, which can then be used to calculate the relative density.

Once the densities of the slices has been determined, each slice is placed in its own container and allowed to dissolve (which will occur at room temperature), after which the Bromelain is added (a mass ratio of 1:10 of Bromelain to gelatin was found to be sufficient) and allowed to sit for two hours before placing it in an oven maintained at 110° C until it dried completely. ASTM D422-63 was followed in the particle-size analyses performed on each of the three slices for each sample, except for a few changes based on the properties of the CCR materials:

- The soil was not separated at the #10 sieve, since the material retained on the #10 sieve represented such a small portion of the sample. Additionally, in separating the samples at this sieve, there was the potential to lose specific particle sizes due to dust losses. Each of the hydrometer tests were separated on the #10 sieve following the test and the mass was adjusted accordingly for the hydrometer analysis calculations. This also

eliminates the need to perform the calculation given in section 16 of the ASTM specification.

- A dry sample was used in each hydrometer test, since there would have been considerable time delays waiting for the specimen to dry at room-temperature (especially considering the presence of gelatin and bromelain in the specimens.

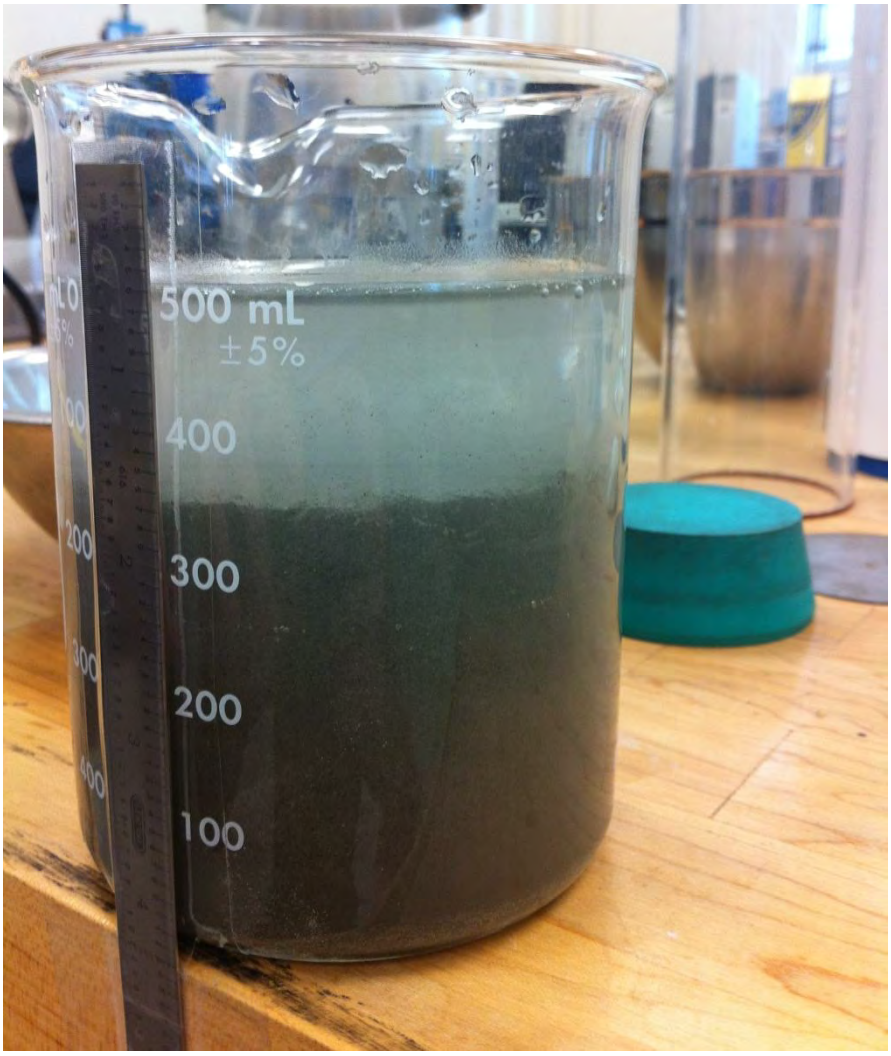


Figure 44: Each specimen slice volume was determined using water displacement. A 500 mL capacity beaker and a ruler incremented at 1/100" were used to do this. The vertical distance between a 100 mL addition of water to the beaker and the equation for the volume of a cylinder was used to calculate the diameter of the beaker; with the diameter known, it was determined that volumes could be measured accurately to ± 1.4 cm^3.

A dry sample of each of the slices could then be chosen to use in a hydrometer test (Bromelain-gelatin crystals were avoided in order to ensure they did not affect the results) to determine the

grain size distribution for soil passing the #200 sieve. This soil was then added back to the rest of the dried specimen slice and washed on a #200 sieve to be included in a grain-size analysis for the particles with diameters greater than 75 μm.

Three different specimens were prepared, all at a target relative density of 70%. The first two specimens were deposited without a water bath within the split mold, while the last one was deposited with a water bath within the split mold. Table 11 makes a comparison of overall specimen slice densities and relative densities for the three specimens showing that, with or without a water bath inside the split mold, all three specimens had an increase in relative density down the height of the specimen. The top slice on the last specimen had not fully cured and as a result deformed some during the mass and volume measurements, undoubtedly resulting in the negative value of relative density. However, the bottom two slices of all three specimens are very consistent and the overall increase in relative density down the height of the specimen indicates that the densification technique that Vaid and Negussey (1988) cite as producing specimens of uniform density does not apply to SI CCR materials. Additionally, the very high values of relative density for all of the bottom slices indicate that the maximum and minimum void ratios determined for the material do not necessarily reflect the actual minimum and maximum void ratios; this could be the result of an inaccurate calculation of the specific gravity of the material, since that is a direct parameter for determining void ratio or an indication that the standards ASTM D4253 and D4254 are not appropriate methods for determining the minimum and maximum densities of CCR materials.

Table 11: Specimen relative density and density summary. The bottom two rows summarize relative density and density data for the entire specimen.

	Specimen 1		Specimen 2		Specimen 3	
	D_r	ρ (g/cm^3)	D_r	ρ (g/cm^3)	D_r	ρ (g/cm^3)
Top Slice	45%	1.63	27%	1.60	-13%	1.54
Middle Slice	93%	1.72	79%	1.69	76%	1.69
Bottom Slice	117%	1.78	113%	1.77	112%	1.77
Average	85%	1.71	73%	1.69	58%	1.67
From Dimensions	73%	-	70%	-	70%	-

The gradation curves presented for each specimen in Figures 45 through 47 show little segregation of particle size, with the most notable trend being that the bottom slice did tend to

have a higher percentage of coarser particles within it; whether this phenomenon is solely the result of the placement method or the densification technique or whether both factors contribute is unclear and would require further study to determine. A comparison of the different slice gradations across specimens, presented in Figures 48 through 50, shows a very consistent gradation across the height of the sample between trials, indicating that this slight gradation difference is caused by a either the placement technique or the densification technique, though which of the one responsible cannot be stated with any certainty at this time. However, the effect of the placement technique and densification technique could be investigated easily through further testing. It is also interesting to note for specimen three, where a water-bath was used in the split-mold during slurry placement, that the gradations vary slightly more than for the two specimens, where a water-bath was not included. This may indicate that a water-bath allows sedimentation currents to form, while direct transfer without a water-bath minimizes the development of such currents. More reconstitutions would need to be made in order to perform meaningful statistical analyses on variation in gradation between samples made with and without water-baths to verify this claim. Lastly, Figure 51 plots all gradations on a single plot to make the extent of variation in the grain size distributions of the three specimens clear.

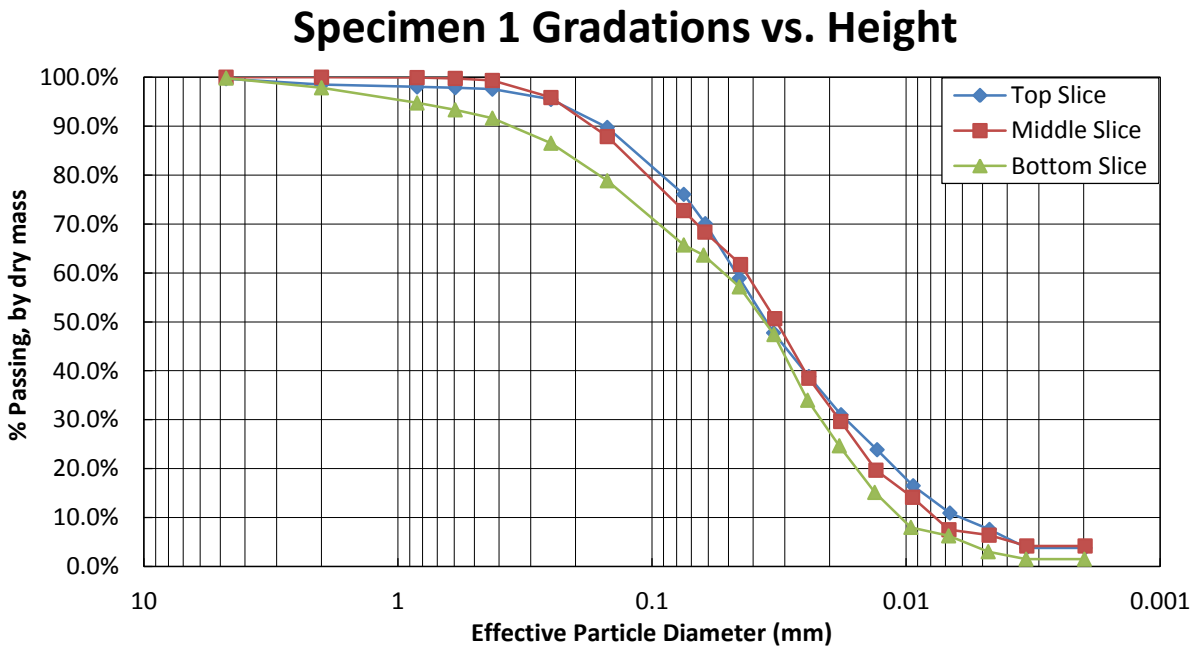


Figure 45: Plot comparing grain-size distributions across the height of specimen one.

While the results of the three reconstitutions performed for this thesis provide some insight, a statement cannot be made about the suitability of the slurry deposition method for use with SI CCRs at this time. However, it can be said that the densification technique used in this investigation is unsuitable for SI CCR materials; if an alternative densification method could be developed, a simple investigation could be undertaken to determine if the slight particle segregation observed in this investigation was due to the vibratory compaction technique used, or if it was the result of the slurry deposition technique itself.

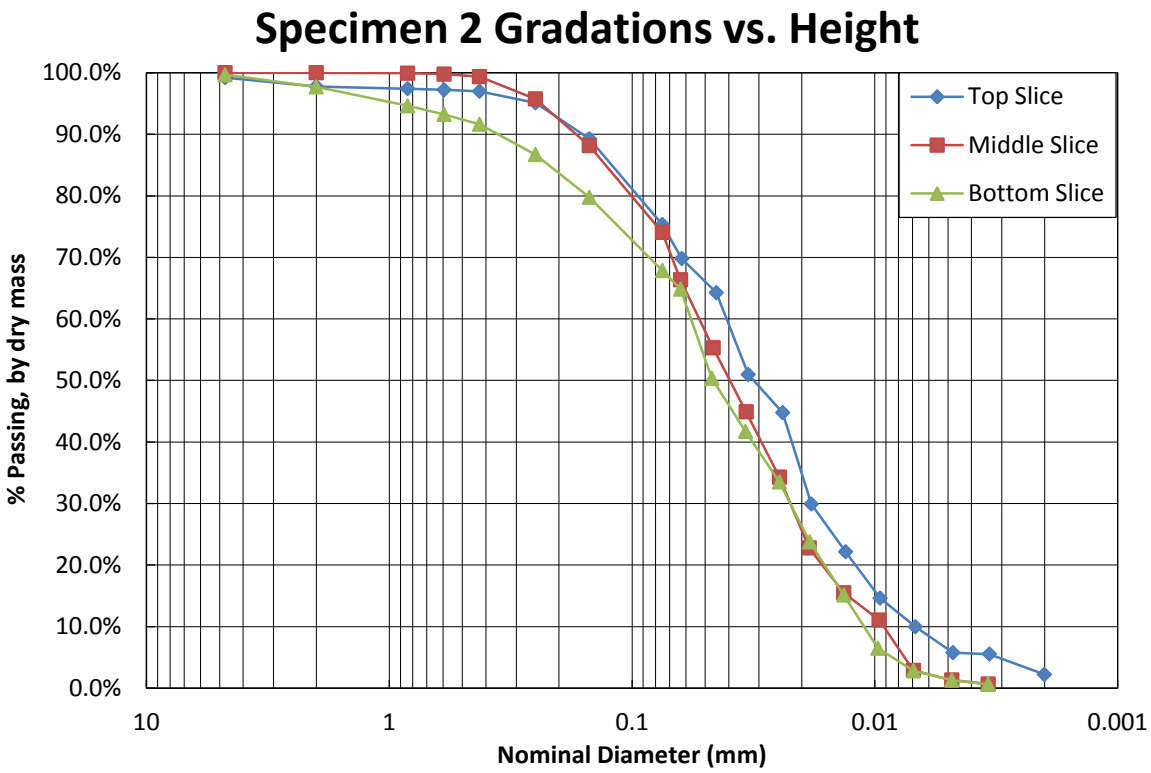


Figure 46: Plot comparing grain-size distribution across the height of specimen two.

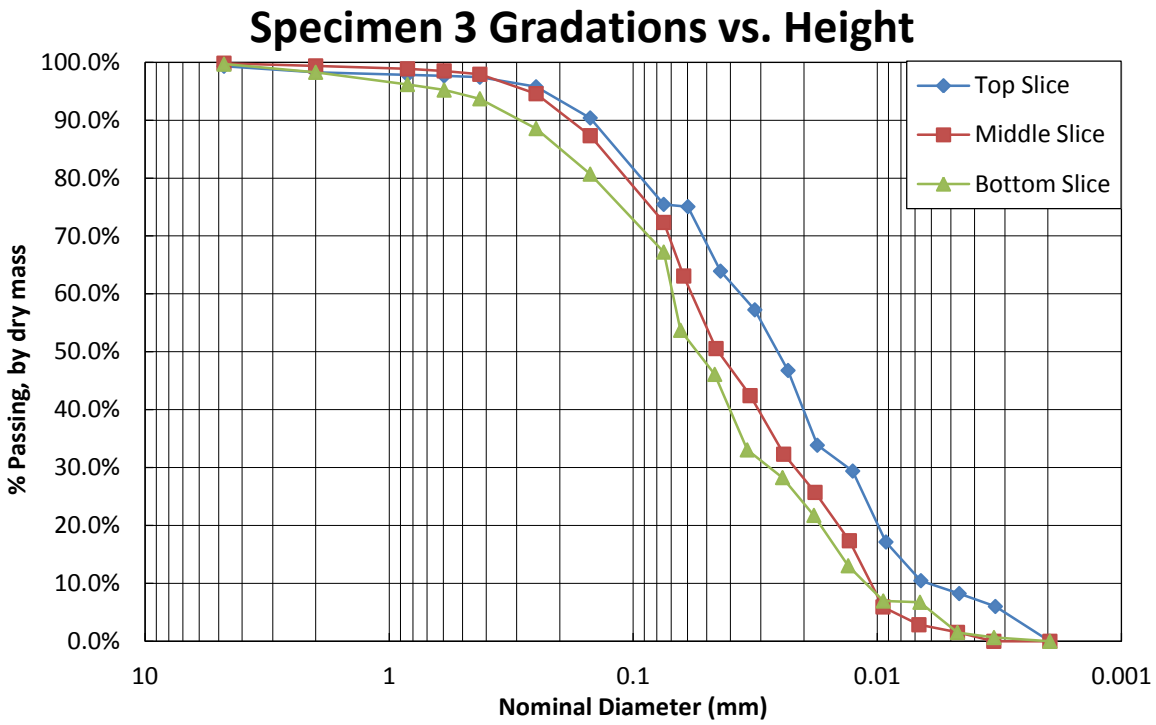


Figure 47: Plot comparing grain-size distribution across the height of specimen three.

.

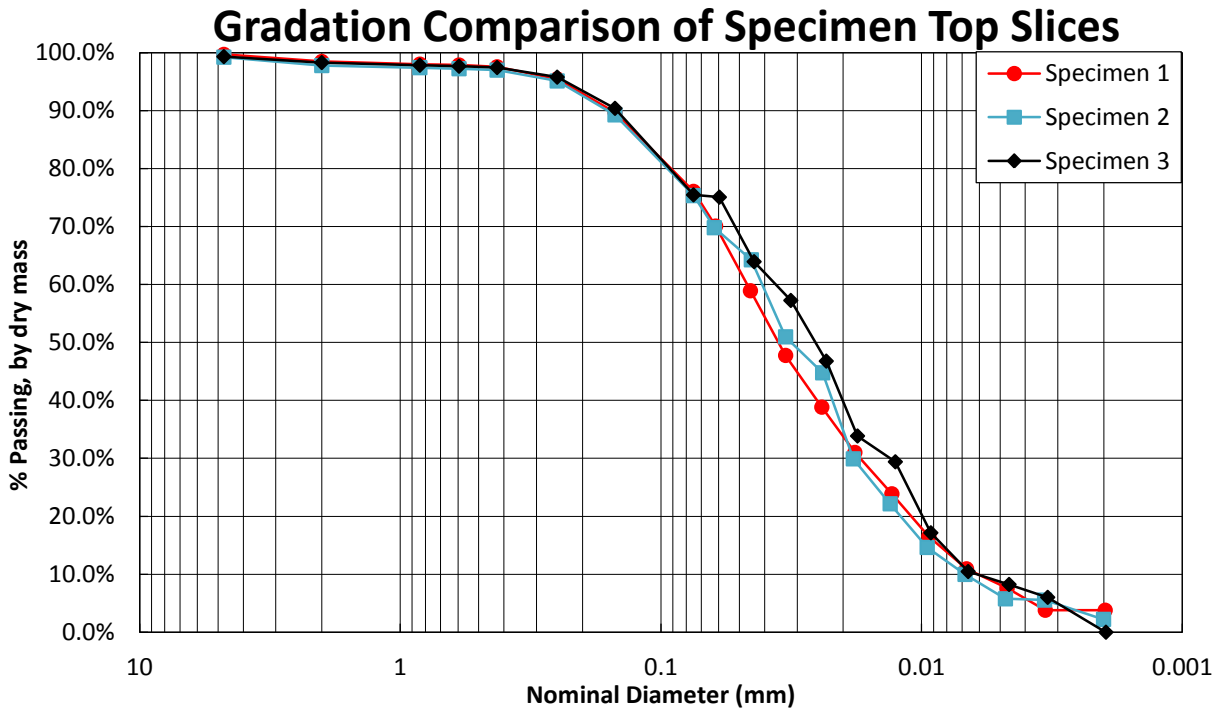


Figure 48: Plot comparing grain-size distributions of the top slices of all three specimens.

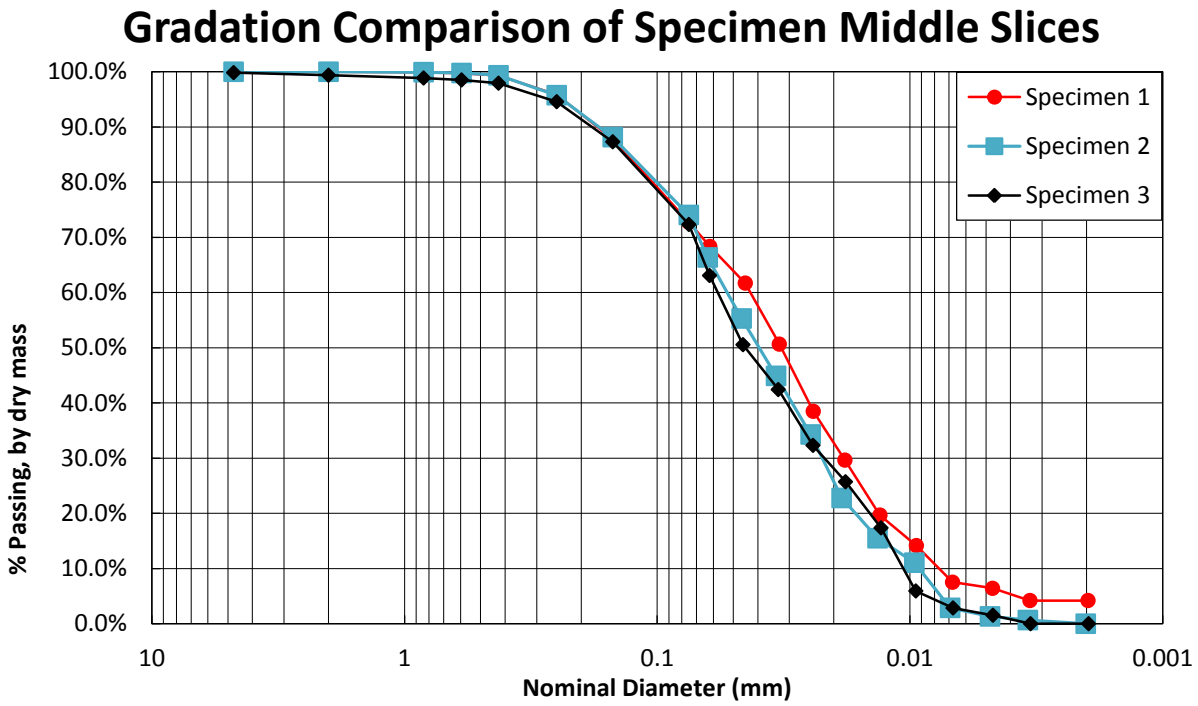


Figure 49: Plot comparing grain-size distribution of the middle slices of all three specimens.

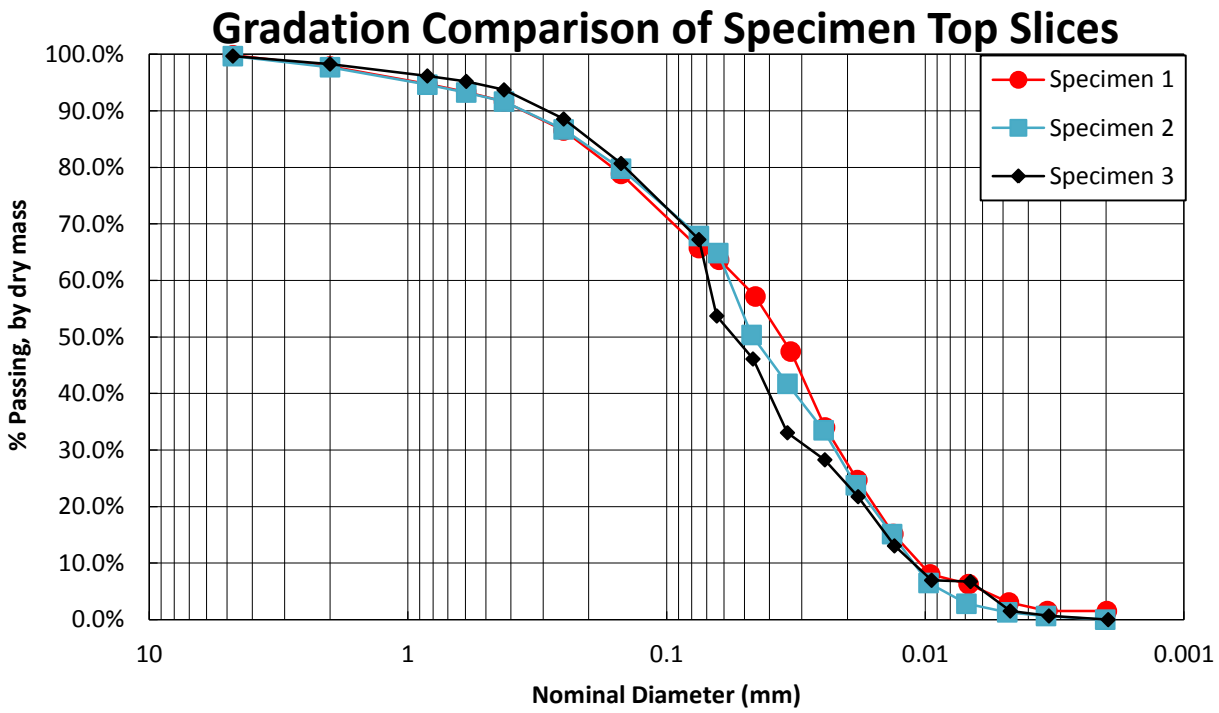


Figure 50: Plot comparing grain-size distribution for the bottom slices of all three specimens.

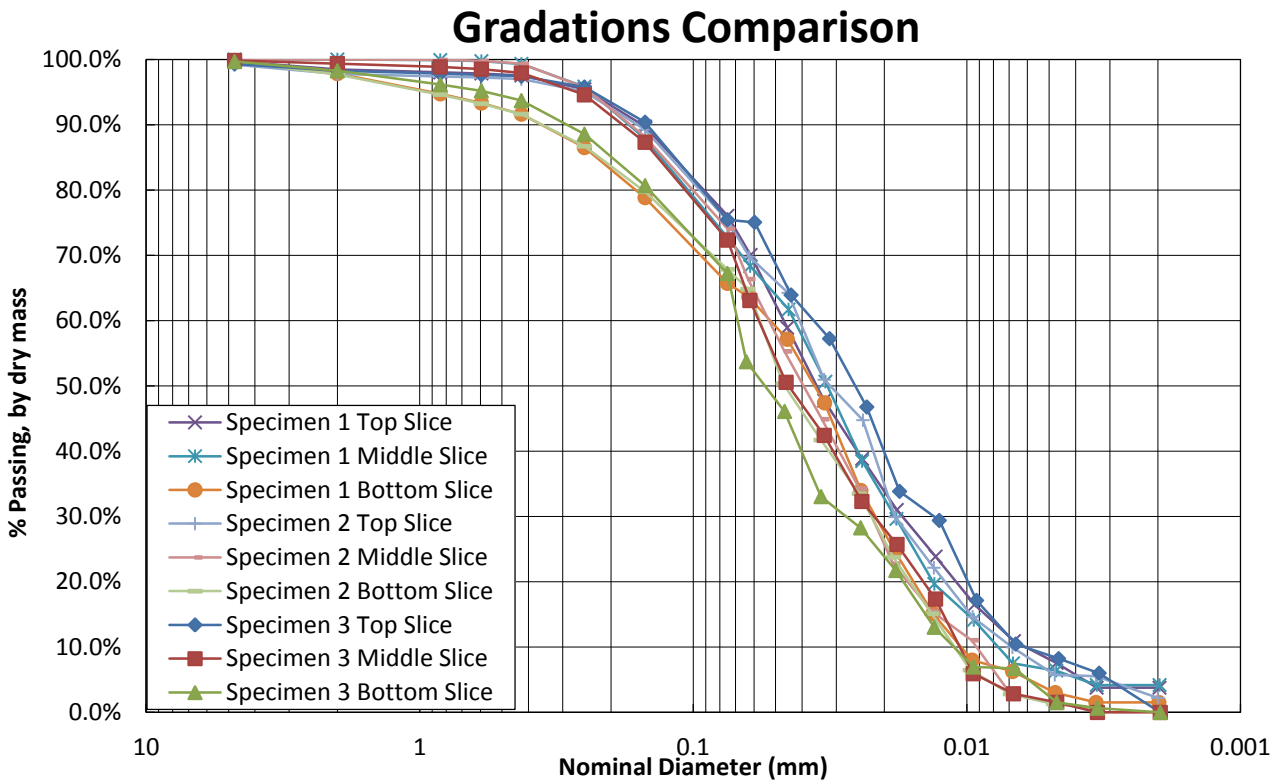


Figure 51: Comparison of all gradations for all three samples.

Examining Figure 51, it is obvious that a considerable amount of variability entered into gradation data with the portion of the graph that was determined using the hydrometer test. This may be the result of slight variations in temperature over the course of the test, regardless of the fact that the room temperature was thermostat-regulated. If temperature readings of the soil suspension had been take at each reading and used in calculating the values derived from Stokes' Law, this variability may have been reduced considerably. The maximum variability in the sieve analysis data for a given nominal diameter was about 10% by mass, while the maximum variability in the hydrometer analysis data for a given nominal diameter was about 25%.

Chapter 8

Conclusions

8.1 Engineering Characterization of CCRs

Geotechnical designs and analyses when working with CCRs are similar to those for natural soils in many respects. The physical and engineering properties of CCRs are what differentiate them from natural soils of similar grain size. Consequently, the single most important aspect of working with CCRs is determining their physical and engineering characteristics. As a result of current and past CCR disposal methods, determining variability in their properties across a given site is also important. As evidenced by the variability plots of the different engineering properties of CCRs, variability can vary greatly to very little within a specific site. However, since the coal source for a given site will inevitable vary, so will the engineering properties of the resulting ash. Because of the differences in properties of CCRs between given sites and from that of natural soils of similar grain size, a more thorough site investigation and laboratory testing schedule will almost always be necessary than for natural soils.

8.2 Dynamic Properties of CCRs

Being a mostly granular and non-plastic material, the characterization of the dynamic properties of CCRs is important to ensure that current and future CCR disposal areas are designed in order to withstand seismic events. Currently there is very little data on the dynamic

properties of CCRs and the data that is available is usually from different countries, whose CCRs may not be similar enough in makeup to merit comparison with CCRs in the U. S.; more dynamic laboratory testing is required before such a conclusion can be made.

8.3 CCR Failure Modes and Monitoring Practices

The two main types of CCR disposal areas, surface impoundments and landfills, are very different in their construction and therefore are prone to different failure modes. As a result, monitoring practices should be tailored to the type of disposal area it applies to. Despite the fact that there is a lack of literature and precedence regarding monitoring of CCR disposal areas, their design tends to be similar enough to mine tailings dams that monitoring practices for tailings dams could easily be adapted and applied to CCR disposal areas. The flowcharts developed by Martin and Davies (2000) provide an excellent template that could be adapted to develop a site monitoring program for CCR disposal areas, especially for surface impoundments.

8.4 Slope Stability of CCRs

Slope stability analyses with CCRs are basically the same as for natural soils, except that there is usually an inherently higher degree of uncertainty in the CCR material. For that reason, analyses involving CCRs should have a degree of conservatism built into every step, unless there is evidence to indicate that such a measure is unnecessary. If the dikes containing surface impounded CCRs are built CCR materials, or other non-plastic soils that have the potential to have low hydraulic conductivity, then a sudden rise in the water table has a deleterious effect on the impoundment's performance. For this reason, if such conditions do exist, it is good practice to install drainage (if not already installed) to ensure a steady-state water table can be maintained.

8.5 Settlement Calculations for CCRs

Many researchers report compression and recompression indices for CCR materials. However, since CCRs generally do not have clearly log-linear values of compression and recompression indices, calculating settlements using consolidation theory can yield variable settlements, depending on different individuals' interpretation of standard consolidation tests.

The two methods for settlement of foundations in sand provide very similar results, underestimating settlement considerably. This is possibly the result of scale effects and differences in the mechanics of the materials (silt-sized particles that are the result of an industrial process rather than natural sands). In order to accurately say that none of these settlement calculation methods works well in CCR surface impounded materials, however, more test fills would need to be performed and analyzed in a similar fashion.

8.6 Slurry Deposition Technique Applied to SI CCRs

While it was not verified that the slurry deposition technique can be applied to SI CCR materials, the method shows promise based on the low variability of grain-size distribution across specimen height for the three specimens tested. However, a major drawback to this method is that the original densification method suggested by Keurbis and Vaid (1988), which was for sands and silty sands, does not appear to work for SI CCR material. Furthermore, more investigations would be required to determine whether the gradation differences observed in these three samples are due to particle migration during vibratory densification or to the actual deposition technique; if it is due to the former, a different densification method may make the slurry deposition method a very attractive reconstitution technique because it is relatively easy and has excellent repeatability, as evidenced in the results presented in Chapter 7. All spreadsheets used in specimen preparation and specimen analysis are provided in the appendix.

8.7 Recommendations for Further Study

As discussed in Chapter two, since CCR materials are the result of an industrial process and not a naturally occurring soil, there is a variety of factors that can affect their engineering properties. Not being a naturally occurring soil, there is a comparatively small body of literature available that reports engineering properties of CCRs. Furthermore, these properties will not necessarily be comparable between different regions. It is therefore necessary to continue research in CCRs, especially with regards to the following:

- Effects of placement condition on the engineering properties of CCRs (i.e. surface impounded vs. moist-compacted).
- Variability in engineering properties of CCRs between disposal sites and within disposal sites (and how to best quantify variability for different properties).
- Dynamic properties of CCRs, to ensure that seismic design of CCR disposal areas is adequate and determine if some disposal areas are higher risk in the event of an earthquake.
- CPT correlations to determine engineering characteristics of CCR materials in-situ.
- The effect of time on the engineering properties of CCRs.
- Determining the most appropriate method to determine c_v of CCR materials, in order to determine if disposal loading rates may be cause for engineering concern.
- "Smarter" technologies that can be adapted to aid in monitoring CCR disposal areas that would better identify gradual changes that may not be readily apparent to daily inspectors.
- Further testing on slurry deposition reconstituted SI CCR samples to analyze soil fabric (a large enough body of tests to analyze statistically). The same method as used in this thesis could be used or methods to determine shear wave velocity across the height of the sample could be used.

References

ASTM. (2003). “Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading.” *D2435-03*, West Conshohocken, Pa.

ASTM. (2003). “Standard Test Method for Expansion Index of Soils.” *D4829-03*, West Conshohocken, Pa.

ASTM. (2003). “Standard Test Method for Shrinkage Factors of Soils by the Wax Method.” *D4943-03*, West Conshohocken, Pa.

ASTM. (1963). “Standard Test Method for Particle-Size Analysis of Soils.” *D422-63*, West Conshohocken, Pa.

Barton, N. and Choubey, V. (1977). “The Shear Strength of Rock Joints in Theory and Practice.” *Rock Mechanics*, 10(1-2), 1-54.

Carraro, J. A. H., Bandini, P., and Salgado, R. (2003). "Liquefaction Resistance of Clean and Nonplastic Silty Sands Based on Cone Penetration Resistance." *Journal of Geotechnical and Geoenvironmental Engineering*, 129(11), 965-976.

Bera, A. K., Ghosh, Ambarish, and Ghosh, Amalendu. (2007). “Compaction Characteristics of Pond Ash.” *J. Mater. Civil Eng.*, 19(4), 349-357.

D’Appolonia, D. J., D’Appolonia, E., and Brisette, R. F. (1970). “Settlement of Spread footings on Sand.” *Proceedings, Journal of Soil Mechanics and Foundation Division*, ASCE, Vol. 96, No. SM2, 754-761.

Das, S. K., Yudhbir (2005). “Geotechnical Characterization of Some Indian Fly Ashes.” *J. Mater. Civil Eng.*, 17(5), 544-552.

Dockter, B. A. and Jagiella, D. M. "Engineering and Environmental Specifications of State Agencies for Utilization and Disposal of Coal Combustion Products: Volume 2 – Environmental Regulations

Emery, J. J., Liam Finn, W. D., and Lee, K. W. (1973). "Uniformity of Saturated Sand Specimens." *Evaluation of Relative Density and Its Role in Geotechnical Projects Involving Cohesionless Soils, ASTM STP 523*, American Society for Testing and Materials, 182-194.

Energy Information Administration (2010). "Electricity Explained: Electricity in the United States," <http://www.eia.gov/energyexplained> (May 26, 2011).

Environmental Protection Agency (2011). "Coal Combustion Products," <http://www.epa.gov/wastes/conserve/rrr/imr/ccps/> (May 26, 2011).

Federal Register. (1993). 58(No. 151: Aug. 9), 42466-42482.

Federal Register. (2010). 75(No. 118: June 21), 35128-35264.

Gitari, M. W., Fatoba, O. O., Nyamihingura, A., Petrik L. F., Vadapalli, V. R. K., October, A., Dlamini, L., Gerike, G., and Mahlaba, J. S. (2009). "Chemical Weathering In A Dry Ash Dump: An Insight From Physiochemical and Mineralogical Analysis of Drilled Cores." *Proc. World of Coal Ash*, ACAA, Lexington, KY

Indraratna, B., Nutalaya, P., Koo, K. S., and Kuganenthira, N. (1991). "Engineering behavior of a low carbon, pozzolanic fly ash and its potential as a construction fill." *Can. Geotech. J.*, 28(4), 542-555.

Jakka, R. S., Ramana, G. V., and Datta, M. (2010a). "Shear Behaviour of Loose and Compacted Pond Ash." *Geotech. Geol. Eng.*, 28(6), 763-778.

Jakka, R. S., Datta, M., Ramana, G. V. (2010b). "Liquefaction behavior of loose and compacted pond ash." *Soil Dynamics and Earthquake Engineering*, 30(7), 580-590.

Joslin, J. G. (1958). "Ohio's Typical Moisture-Density Curves." *Proceedings, Symposium on Application of Soil Testing in Highway Design and Construction*, ASTM STP 239, 111-118.

Kaniraj, S. R. and Gayathri, V. (2004). “Permeability and Consolidation Characteristics of Compacted Fly Ash.” *J. Energy Eng.*, 130(1), 18-43.

Keurbis, R. and Vaid, Y. P. (1988). "Sand Sample Preparation —The Slurry Deposition Method." *Soils and Foundations*, 28(4), 107-118.

Kim, B. and Prezzi, M. (2008). “Evaluation of the mechanical properties of class-F fly ash.” *Waste Management*, 28(3), 649-659.

Kolay, P. K. and Kismoor, T. (2009). “Geotechnical Characterization of Coal Ashes from Sarawak for Bulk Utilization.” *J. of Solid Waste Technology and Management*, 35(2), 78-87.

Kulhawy, F.H. and Mayne, P. W. (1990). *Manual on Estimating Soil Properties for Foundation Design*. Final Report (EL-6800) submitted to Electric Power Research Institute (EPRI), Palo Alto, CA.

Ladd, R. S. (1978). "Preparing Test Specimens Using Undercompaction." *Geotechnical Testing Journal*, 1(1), 16-23.

Madhyannapu, R. S., Madhav, M. R., Puppala, A. J., and Ghosh, A. “Compressibility and Collapsibility Characteristics of Sedimented Fly Ash Beds.” *J. Mater. Civil Eng.*, 20(6), 401-409.

Martin, J. P., Collins, R. A., Browning, J. S., and Biehl, F. J. (1990). “Properties and Use of Fly Ashes for Embankments.” *Journal of Energy Engineering*, 116(2), 71-86.

Martin, T.E. and M. P. Davies (2000). “Development and Review of Surveillance Programs for Tailings Dams,” *Proceedings, Tailings Dams 2000*, Las Vegas, Association of State Dam Safety Officials (ASDSO), Lexington, KY, pp. 367-380.

McLaren, R. J. and DiGioia, A. M. (1987). “The typical engineering properties of fly ash.” *Geotechnical practice for waste disposal*, GSP 13, ASCE, 683-697.

Mohanty, B., Patra, N. R., and Chandra, S. (2010). “Cyclic Triaxial Behavior of Pond Ash.” *Proc. GeoFlorida, 2010*, Palm Beach, FL.

Muhardi, Marto, A., Kassim, K. A., Makhtar, A. M., Wei, L. F., and Lim, Y. S. (2010). "Engineering Charactertistics of *Tanjung Bin* Coal Ash." *Electronic J. of Geotechnical Eng.*, 15(K), 1117-1129.

Pandian, N. S. (2004). "Fly ash characterization with reference to geotechnical applications." *J. Indian Inst. Sci.* 84(6), 189-216.

Prakash, K. and Sridharan, A. (2009). "Beneficial Properties of Coal Ashes and Effective Solid Waste Management." *Practice Periodical of Hazardous, Toxic, and Radioactive Waste Management*, 13(4), 239-248.

Prashanth, J. P., Sivapullaiah, P. V., and Sridharan, A. (1999). "Compaction behaviour of fly ashes." *Ground Improvement*, 3(2), 77-88.

Rad, N. S. and Tumay M. T. (1987). "Factors Affecting Sand Specimen Preparation by Raining." *Geotechnical Testing Journal*, 10(1), 31-37.

Raymond, S. (1962). "Pulverized fuel ash as embankment material." *ICE Proceedings*, 19(4), 515-536.

Schmertmann, J. H. (1970). "Static cone to compute static settlement over sand." *Journal of Soil Mechanics and Foundations Division*, 96(3), 1011-1043.

Schmertmann, J. H., Hartmann, J. P., and Brown, P. R. (1978). Improved strain influence factor diagrams." *Journal of the Geotechnical Engineering Division*, 104(GT8), 1131-1135.

Scott, G. A., Engemoen, W. O., Gillette, D. R., L. W. Anderson, Liu, P., Feidler, W. R., Nuss, L. K., Trojanowski, J., England, J., Dise, K. M., and Schultz, R. W. (2010). *Dam Safety Risk Analysis Best Practices Training Manual*, Version 2.1, U.S. Department of the Interior Bureau of Reclamation, Denver, CO.

Sherwood, P. T. (1995). "Power Station Wastes (pulverized fuel ash and furnace bottom ash)." *Alternative materials in road construction*, 1st ed., (5), 52-63.

Singh, H. P., Maheshwari, B. K., Saran, S., and Paul, D. K. (2008). "Evaluation of Liquefaction Potential of Pond Ash." *Proc. World Conference on Earthquake Engineering*, Beijing, China.

Sridharan, A., Pandian, N. S., and Srinivas, S. (2001). "Compaction behaviour of Indian coal ashes." *Ground Improvement*, 5(1), 13-22.

Sridharan, A., Pandian, N. S., and Rao, P. S. (1998). "Shear strength characteristics of some Indian fly ashes." *Ground Improvement*, 2(3), 141-146.

Tan, C.K. and Duncan, J. M. (1991). "Settlement of Footings on Sands-Accuracy and Reliability." *Proceedings, Geotechnical Engineering Congress,* ASCE, GSP 27, Vol. 2, 446-455.

Trivedi, A. and Singh, S. (2004a). "Geotechnical and Geoenvironmental Properties of Power Plant Ash." *J. Inst. Eng.*, 85(), 93-99.

Trivedi, A. and Singh, S. (2004b). "Cone Resistance of Compacted Ash Fill." *J. Test. Eval.*, 32(6), 1-9.

Trivedi, A. and Sud, V. K. (2002). "Grain characteristics and engineering properties of coal ash." *Granular Matter*, 4(3), 93-101.

Trivedi, A. and Sud, V. K. (2004). "Collapse Behavior of Coal Ash." *J. Geot. Geoenv. Eng.*, 130(4), 403-415.

Tu, W., Zand, B., Ajlouni, M. A., Butalia, T. S., and Wolfe, W. E. (2007). "The Consolidation Characteristics of Impounded Class F Fly Ash—A Case History." *Proc. World of Coal Ash*, ACAA, Covington, KY.

United States Army Corps of Engineers (2003). *Slope Stability Engineer Manual*, EM 1110-2-1902.

Vaid, Y. P. and Negussey, D. (1988). "Preparation of reconstituted sand specimens." *Advanced Triaxial Testing of Soil and Rock, ASTM STP 977*, American Society for Testing and Materials, 405-417.

Walton, W. H. and Butler, W. (2009). *Root Cause Analysis of TVA Kingston Dredge Pond Failure on December 22, 2008*. Engineering Report by AECOM.

Ward, C. R. and French, D. (2005). "Relation between Coal and Fly Ash Mineralogy, Based on Quantitative X-Ray Diffraction Methods." *Proc., World of Coal Ash*, ACAA, Lexington, KY.

Yoshimoto, N., Hyodo, M., Nakata, Y., Orense, R. P., and Murata, H. (2006). "Cyclic Shear Strength Characteristics of Granulated Coal Ash." *Proc., GeoShanghai 2006*, Shanghai, China.

Yudbhir and Honjo, Y. (1991). "Applications of Geotechnical Engineering to Environmental Control." *Proc., Ninth Asian Regional Conference on Soil Mechanics and Foundation Engineering*, Bangkok, Thailand.

Appendix A

Sample Preparation and Fabric Analysis Spreadsheets

Sample Dimensions:

Note: Sample mold has bevelled top portion, so volume is calculated as two separate cylinders added together

H_{TC} =	0.72	inches	D_{TC} =	2.851	inches
H_{BC} =	5.465	inches	D_{BC} =	2.826	inches
T_{BS} =	0.112	inches	T_M =	0.012	inches
T_{TP} =	1.229	inches	T_{FP} =	0.007	inches

Where
- H_{TC} = height of top cylinder
- H_{BC} = height of bottom cylinder
- D_{TC} = diameter of top cylinder
- D_{BC} = diameter of bottom cylinder
- T_M = latex membrane thickness
- T_{BS} = thickness of bottom porous stone
- T_{TP} = thickness of top platen
- T_{FP} = thickness of filter paper

Measurements of Sample Height (Datum: cell frame):

Reading Loc.	Bottom Platen (in)	Top of Top Platen (in)	Sample Height (in)
Front	**12.247**	4.724	6.182
Back	**12.253**	4.724	6.188
Right	**12.249**	4.724	6.184
Left	**12.251**	4.724	6.186
		AVG:	6.185

So target volume, V_{TAR}, is:

V_{TAR} =	38.13	in^3
	624.9	cm^3

Minimum and maximum void ratios and specific gravity of solids are:

e_{min} =	0.65
e_{max} =	1.2
G_S =	2.22

Mixing Tube Dimensions Calculation Sheet:

D_r =	100%		Where	% V_T Voids =	percent of sample volume occupied by void space
e =	0.65			% V_T Solids =	percent of sample volume occupied by solids
% V_T Voids =	39%			$V_{S_100\%Dr}$ =	Volume of solids to prepare a sample at 100% relative density
% V_T Solids =	61%			$V_{V_0\%Dr}$ =	Volume of voids at a placement relative density of 0%
Mass solids =	840.72	g		V_{TOT} =	Volume of soil to prepare a sample with a target relative density of 100% at an initial relative density of 0%
$V_{S_100\%Dr}$ =	378.70	cm^3			
$V_{V_0\%Dr}$ =	454.44	cm^3			
V_{TOT} =	833.14	cm^3		V_{TUBE} =	Volume of specimen mixing tube
				D_{TUBE} =	Inner diameter of mixing tube
V_{TUBE} =	874.80	cm^3		H_{TUBE_req} =	Height of mixing tube of specified diameter
	53.384	in^3			
D_{TUBE} =	2.5	inches			
H_{TUBE_req} =	10.88	inches			

Specimen 1 Preparation Sheet:

D_{rTAR} =	70%	
M_{ash} =	764.3	g
w (%) =	29.2%	
M_{moist} =	987.9	g

Location	Target H_{TP} (in)	H_{BP} (in)	H_S (in)
Front	4.724	**12.247**	6.168
Back	4.724	**12.253**	6.174
Right	4.724	**12.249**	6.170
Left	4.724	**12.251**	6.172

Location	Initial H_{TP} (in)	Final H_{TP} (in)	H_{BP} (in)	H_{SI} (in)	H_{SF} (in)
Front	N/A	4.732	**12.247**	N/A	6.160
Back	N/A	4.7265	**12.253**	N/A	6.171
Right	N/A	4.728	**12.249**	N/A	6.166
Left	N/A	4.728	**12.251**	N/A	6.168

Fines Lost:		
Tare Name:	Cindy	
Tare:	475.0	g
Gross:	477.24	g
Net:	2.2	g
% Loss:	0.23%	

$G_{gelatin}$:		
Concentration :	0.75 % by mass	
Tare:	126.8	g
Gross:	224.5	g
Net:	97.7	g
Volume:	97.7	cm^3
$G_{gelatin}$:	1.000	

Approximate Placement D_r:		
D_{COLLAR} =	2.822	in
H_{SI_AVG} =	N/A	in
V_{CYL1} =	33.32	in^3
V_{CYL2} =	4.47	in^3
V_{CYL3} =	N/A	in^3
V_{TOT} =	N/A	in^3
V_{SOLIDS} =	N/A	in^3
V_{VOIDS} =	N/A	in^3
e =	N/A	
D_r =	N/A	

Approximate Densified D_r:		
V_{CYL2} =	4.315	in^3
V_{TOT} =	37.64	in^3
	616.74	cm^3
V_{SOLIDS} =	20.95	in^3
	343.29	cm^3
V_{VOIDS} =	16.69	in^3
	273.45	cm^3
e =	0.80	
D_r =	73.35%	

Note: Filter paper used between split-mold and membrane to see if vacuum was evenly distributed

Specimen 1 Fabric Testing Sheet:

Volume Calculation Information:

D_{beaker} =	3.33162	in
$V_{1/100''}$ =	0.0872	in^3
	1.43	cm^3

Top Slice

Mass =	278.67	g
Weight =	0.614	lb
Volume =	10.46	in^3
	171.43	cm^3
Density =	0.059	lb/in^3
	1.63	g/cm^3
$Mass_{Ovendry}$ =	195.87	g
$Mass_{Ovenwash}$ =	46.9	g
$\%Pass_{\#200}$ =	76%	

Sieve Analysis

Tare Name:	Tare 1
Tare Mass (g):	329.2
Tare + Dry Soil Mass (g):	525.1
Tare + Dry Soil Mass After Washing (g):	360.3

Subtract this from $Mass_{Ovenwash}$ =>

Sieve No.	Nominal diameter, mm	wt. retained (g)	% retained	% passing
#4	4.75	0.6	0.3%	99.7%
#10	2	2.4	1.5%	98.5%
#20	0.841	0.9	2.0%	98.0%
#30	0.595	0.3	2.1%	97.9%
#40	0.425	0.6	2.5%	97.5%
#60	0.25	4.1	4.5%	95.5%
#100	0.15	11.2	10.3%	89.7%
#200	0.075	26.8	23.9%	76.1%
Pan		1.9	100.0%	0.0%
	% lost:	0.00%		

Hydrometer Analysis

Time readings begin:	6/14/2012 8:23
Hydrometer Type:	152H
Composite Correction:	5.6
Dry mass of soil tested (g):	50.0
$M_{retained\ on\ \#10\ seive}$ (g):	1.2
Dry mass of soil past #10 (g):	48.8
W (dry mass of soil represented) (g):	49.6
Temperature (° F):	69
G_s correction factor (ASTM D 422, Table 1); Interpolated!:	1.11
K (ASTM eq. 4, based on temp and G_s):	0.0193
% Passing #10 Sieve:	98.5%

Elapsed time (min)	Reading	Comp. Reading	L (cm) (ASTM table 2)	P (ASTM eqn. 2)	D (mm) (ASTM eqn. 4)
1	37	31.4	10.2	70%	0.0617
2	32	26.4	11.0	59%	0.0453
4	27	21.4	11.9	48%	0.0332
8	23	17.4	12.5	39%	0.0241
15	19.5	13.9	13.1	31%	0.0180
30	16.3	10.7	13.6	24%	0.0130
60	13	7.4	14.2	17%	0.0094
120	10.5	4.9	14.6	11%	0.0067
250	9	3.4	14.8	8%	0.0047
500	7.3	1.7	15.1	4%	0.0034
1440	7.3	1.7	15.1	4%	0.0020

Middle Slice											
						Sieve No.	Nominal diameter, mm	wt. retained (g)	% retained	% passing	
Mass =	327.5	g	Sieve Analysis			#4	4.75	0	0.0%	100.0%	
Weight =	0.722	lb				#10	2	0	0.0%	100.0%	
Volume =	11.59	in^3	Tare Name:	Tare 2		#20	0.841	0.2	0.1%	99.9%	
	190.00	cm^3	Tare Mass (g):	332.6		#30	0.595	0.4	0.3%	99.7%	
Density =	0.062	lb/in^3	Tare + Dry Soil Mass (g):	570.7		#40	0.425	1	0.7%	99.3%	
	1.72	g/cm^3	Tare + Dry Soil Mass After Washing (g):	386.6		#60	0.25	8.3	4.2%	95.8%	
						#100	0.15	19	12.1%	87.9%	
$Mass_{Ovendry}$ =	238.12	g				#200	0.075	36	27.3%	72.7%	
$Mass_{Ovenwash}$ =	64.9	g		Subtract this from $Mass_{Ovenwash}$ =>		Pan		2.5	100.0%	0.0%	
$\%Pass_{\#200}$ =	73%										
							% lost:	0.00%			

						Elapsed time (min)	Reading	Comp. Reading	L (cm) (ASTM table 2)	P (ASTM eqn. 2)	D (mm) (ASTM eqn. 4)
			Hydrometer Analysis			1	36.5	30.9	10.3	68%	0.0619
			Time readings begin:	152H		2	33.5	27.9	10.8	62%	0.0448
			Hydrometer Type:	6/14/2012 10:05		4	28.5	22.9	11.6	51%	0.0329
			Composite Correction:	5.6		8	23	17.4	12.5	38%	0.0241
			Dry mass of soil tested (g):	50		15	19	13.4	13.2	30%	0.0181
			$M_{retained\ on\ \#10\ seive}$ (g):	0		30	14.5	8.9	13.9	20%	0.0131
			Dry mass of soil past #10 (g):	50		60	12	6.4	14.3	14%	0.0094
			W (dry mass of soil represented) (g):	50		120	9	3.4	14.8	8%	0.0068
			Temperature (° F):	69		250	8.5	2.9	14.9	6%	0.0047
			G_s correction factor (ASTM D 422, Table 1); Interpolated!:	1.11		500	7.5	1.9	15.1	4%	0.0033
			K (ASTM eq. 4, based on temp and G_s):	0.0193		1440	7.5	1.9	15.1	4%	0.0020
			% Passing #10 Sieve:	100.0%							

Bottom Slice

						Sieve No.	Nominal diameter, mm	wt. retained (g)	% retained	% passing	
			Sieve Analysis			#4	4.75	0.6	0.2%	99.8%	
Mass =	428.1	g				#10	2	6.5	2.2%	97.8%	
Weight =	0.944	lb	Tare Name:	Tare 3		#20	0.841	10.2	5.3%	94.7%	
Volume =	14.65	in^3	Tare Mass (g):	333.7		#30	0.595	4.6	6.7%	93.3%	
	240.00	cm^3	Tare + Dry Soil Mass (g):	662.1		#40	0.425	5.6	8.4%	91.6%	
Density =	0.064	lb/in^3	Tare + Dry Soil Mass After Washing (g):	436.2		#60	0.25	16.8	13.5%	86.5%	
	1.78	g/cm^3				#100	0.15	25.2	21.2%	78.8%	
						#200	0.075	43.1	34.3%	65.7%	
$Mass_{Ovendry}$ =	328.44	g		Subtract this from $Mass_{Ovenwash}$ =>		Pan		4.5	35.7%	64.3%	
$Mass_{Ovenwash}$ =	113.6	g									
$\%Pass_{\#200}$ =	65%						% lost:	0.30%			

						Elapsed time (min)	Reading	Comp. Reading	L (cm) (ASTM table 2)	P (ASTM eqn. 2)	D (mm) (ASTM eqn. 4)
			Hydrometer Analysis			1	35	29.4	10.6	64%	0.0627
			Time readings begin:	152H		2	32	26.4	11.0	57%	0.0453
			Hydrometer Type:	6/14/2012 11:43		4	27.5	21.9	11.8	47%	0.0331
			Composite Correction:	5.6		8	21.3	15.7	12.8	34%	0.0244
			Dry mass of soil tested (g):	50		15	17	11.4	13.5	25%	0.0183
			$M_{retained\ on\ \#10\ seive}$ (g):	0.02		30	12.6	7	14.2	15%	0.0133
			Dry mass of soil past #10 (g):	49.98		60	9.3	3.7	14.8	8%	0.0096
			W (dry mass of soil represented) (g):	51.1		120	8.5	2.9	14.9	6%	0.0068
			Temperature (° F):	69		250	7	1.4	15.1	3%	0.0047
			G_s correction factor (ASTM D 422, Table 1); Interpolated!:	1.11		500	6.3	0.7	15.3	2%	0.0034
			K (ASTM eq. 4, based on temp and G_s):	0.0193		1440	6.3	0.7	15.3	2%	0.0020
			% Passing #10 Sieve:	97.8%							

Summary											
$\Sigma Mass_{Ovendry}$ =	762.43	g									
				Checks on Relative Density of Individual Slices:							
Mass =	1034.3	g									
Weight =	2.280	lb		Knowns:							
Volume =	36.70	in^3		V_{s1} =	171.43	cm^3	Slice 1:				
	601.43	cm^3		V_{s2} =	190.00	cm^3	V_{S_S1} =	87.90	cm^3	e_{S1} =	0.95
Density =	0.062	lb/in^3		V_{s3} =	240.00	cm^3	V_{G_S1} =	83.53	cm^3	D_{rS1} =	45%
	1.72	g/cm^3		m_{s1} =	278.7	g					
				m_{s2} =	327.5	g	Slice 2:				
M_{DRIED_FINES} =	2.24	g		m_{s3} =	428.1	g	V_{S_S2} =	112.71	cm^3	e_{S2} =	0.69
M_{DRY_SAMPLE} =	762.1	g		ρ_{S1} =	1.63	g/cm^3	V_{G_S2} =	77.29	cm^3	D_{rS2} =	93%
V_{SOLIDS} =	343.29	cm^3		ρ_{S2} =	1.72	g/cm^3					
	20.95	in^3		ρ_{S3} =	1.78	g/cm^3	Slice 3:				
V_{VOIDS} =	258.14	cm^3		G_s =	2.22		V_{S_S3} =	154.17	cm^3	e_{S3} =	0.56
	15.75	in^3		G_{gel} =	1.000		V_{G_S3} =	85.83	cm^3	D_{rS3} =	117%
e =	0.75									e_{avg} =	0.73
				M_{DRY_SAMPLE} =	787.6017474		V_{TOT} =	601.43	cm^3	D_{r_avg} =	85%
D_r =	81.5%										

Specimen 2 Preparation Sheet:

D_{rTAR} =	70%	
M_{ash} =	764.3	g
w (%) =	29.2%	
M_{moist} =	987.8	g

Location	Target H_{TP} (in)	H_{BP} (in)	H_S (in)
Front	4.724	**12.247**	6.168
Back	4.724	**12.253**	6.174
Right	4.724	**12.249**	6.170
Left	4.724	**12.251**	6.172

Location	Initial H_{TP} (in)	Final H_{TP} (in)	H_{BP} (in)	H_{SI} (in)	H_{SF} (in)
Front	4.245	4.729	**12.247**	6.648	6.163
Back	4.245	4.728	**12.253**	6.653	6.170
Right	4.245	4.731	**12.249**	6.649	6.163
Left	4.246	4.725	**12.251**	6.650	6.171

Fines Lost:		
Tare Name:	Cindy	
Tare:	475.0	g
Gross:	476.3	g
Net:	1.3	g
% Loss:	0.13%	

$G_{gelatin}$:		
Concentration :	0.75 % by mass	
Tare:	126.8	g
Gross:	224.8	g
Net:	98	g
Volume:	98	cm^3
$G_{gelatin}$:	1.000	

Approximate Placement D_r:		
D_{COLLAR} =	2.825	
H_{IS_AVG} =	0.465	
V_{CYL1} =	33.66	in^3
V_{CYL2} =	4.52	in^3
V_{CYL3} =	2.86	in^3
V_{TOT} =	41.04	in^3
V_{SOLIDS} =	20.97	in^3
V_{VOIDS} =	20.07	in^3
e =	0.96	
D_r =	44%	

Approximate Densified D_r:		
V_{CYL2} =	4.36	in^3
V_{TOT} =	38.02	in^3
	622.98	cm^3
V_{SOLIDS} =	20.97	in^3
	343.69	cm^3
V_{VOIDS} =	17.04	in^3
	279.29	cm^3
e =	0.81	
D_r =	70.43%	

Specimen 2 Fabric Testing Sheet:

Volume Calculation Information:

D_{beaker} =	3.33162	in
$V_{1/100"}$ =	0.087	in^3
	1.43	cm^3

Top Slice

Mass =	237	g
Weight =	0.522	lb
Volume =	9.07	in^3
	148.57	cm^3
Density =	0.058	lb/in^3
	1.60	g/cm^3
$Mass_{Ovendry}$ =	165.8	g
$Mass_{Ovenwash}$ =	41.1	g
$\%Pass_{\#200}$ =	75%	

Sieve Analysis

Tare Name:	Tare 4
Tare Mass (g):	329.8
Tare + Dry Soil Mass (g):	495.6
Tare + Dry Soil Mass After Washing (g):	371.9

Subtract this from $Mass_{Ovenwash}$ =>

Sieve No.	Nominal diameter, mm	wt. retained (g)	% retained	% passing
#4	4.75	1.3	0.8%	99.2%
#10	2	2.4	2.2%	97.8%
#20	0.841	0.6	2.6%	97.4%
#30	0.595	0.3	2.8%	97.2%
#40	0.425	0.4	3.0%	97.0%
#60	0.25	3.1	4.9%	95.1%
#100	0.15	9.7	10.7%	89.3%
#200	0.075	23.1	24.7%	75.3%
Pan		1	100.0%	0.0%
	% lost:	0.12%		

Hydrometer Analysis

Time readings begin:	6/15/2012 17:13
Hydrometer Type:	152H
Composite Correction:	5
Dry mass of soil tested (g):	50.0
$M_{retained\ on\ \#10\ seive}$ (g):	1.2
Dry mass of soil past #10 (g):	48.8
W (dry mass of soil represented) (g):	49.9
Temperature (° F):	68
G_s correction factor (ASTM D 422, Table 1); Interpolated!:	1.11
K (ASTM eq. 4, based on temp and G_s):	0.0194
% Passing #10 Sieve:	97.8%

Elapsed time (min)	Reading	Comp. Reading	L (cm) (ASTM table	P (ASTM eqn. 2)	D (mm) (ASTM eqn. 4)
1	36.5	31.5	10.3	70%	0.0624
2	34	29	10.7	64%	0.0450
4	28	23	11.7	51%	0.0332
8	25.2	20.2	12.2	45%	0.0240
15	18.5	13.5	13.3	30%	0.0183
30	15	10	13.8	22%	0.0132
60	11.6	6.6	14.4	15%	0.0095
120	9.5	4.5	14.7	10%	0.0068
250	7.6	2.6	15.0	6%	0.0048
500	7.5	2.5	15.1	6%	0.0034
1440	6	1	15.3	2%	0.0020

Middle Slice											
						Sieve No.	Nominal diameter, mm	wt. retained (g)	% retained	% passing	
Mass =	367.1	g	Sieve Analysis			#4	4.75	0	0.0%	100.0%	
Weight =	0.809	lb				#10	2	0	0.0%	100.0%	
Volume =	13.25	in^3	Tare Name:	Tare 6		#20	0.841	0.2	0.1%	99.9%	
	217.14	cm^3	Tare Mass (g):	329.8		#30	0.595	0.4	0.2%	99.8%	
Density =	0.061	lb/in^3	Tare + Dry Soil Mass (g):	595.8		#40	0.425	1.1	0.6%	99.4%	
	1.69	g/cm^3	Tare + Dry Soil Mass After Washing (g):	400.0		#60	0.25	9.6	4.2%	95.8%	
						#100	0.15	20.2	11.8%	88.2%	
$Mass_{Ovendry}$ =	265.97	g				#200	0.075	37.5	25.9%	74.1%	
$Mass_{Ovenwash}$ =	69	g		Subtract this from $Mass_{Ovenwash}$ =>		Pan		1.7	100.0%	0.0%	
$\%Pass_{\#200}$ =	74%										
							% lost:	0.00%			

						Elapsed time (min)	Reading	Comp. Reading	L (cm) (ASTM table	P (ASTM eqn. 2)	D (mm) (ASTM eqn. 4)
			Hydrometer Analysis			1	35	30	10.6	66%	0.0631
			Time readings begin:	152H		2	30	25	11.4	55%	0.0463
			Hydrometer Type:	6/15/2012 14:54		4	25.3	20.3	12.1	45%	0.0339
			Composite Correction:	5		8	20.5	15.5	12.9	34%	0.0247
			Dry mass of soil tested (g):	50		15	15.3	10.3	13.8	23%	0.0186
			$M_{retained\ on\ \#10\ seive}$ (g):	0		30	12	7	14.3	15%	0.0134
			Dry mass of soil past #10 (g):	50		60	10	5	14.7	11%	0.0096
			W (dry mass of soil represented) (g):	50		120	6.3	1.3	15.3	3%	0.0069
			Temperature (° F):	68		250	5.6	0.6	15.4	1%	0.0048
			G_s correction factor (ASTM D 422, Table 1); Interpolated!:	1.11		500	5.3	0.3	15.4	1%	0.0034
			K (ASTM eq. 4, based on temp and G_s):	0.0194		1440	5	0	15.5	0%	0.0020
			% Passing #10 Sieve:	100.0%							

Bottom Slice

						Sieve No.	Nominal diameter, mm	wt. retained (g)	% retained	% passing	
Mass =	435.44	g	Sieve Analysis			#4	4.75	1.1	0.3%	99.7%	
Weight =	0.960	lb				#10	2	6.5	2.3%	97.7%	
Volume =	14.99	in^3	Tare Name:	Tare 5		#20	0.841	10.2	5.4%	94.6%	
	245.71	cm^3	Tare Mass (g):	335.8		#30	0.595	4.6	6.8%	93.2%	
Density =	0.064	lb/in^3	Tare + Dry Soil Mass (g):	666.8		#40	0.425	5.3	8.4%	91.6%	
	1.77	g/cm^3	Tare + Dry Soil Mass After Washing (g):	444.1		#60	0.25	16.3	13.3%	86.7%	
						#100	0.15	23	20.2%	79.8%	
$Mass_{Ovendry}$ =	331	g				#200	0.075	39.4	32.1%	67.9%	
$Mass_{Ovenwash}$ =	106.2	g		Subtract this from $Mass_{Ovenwash}$ =>		Pan		2.7	100.0%	0.0%	
$\%Pass_{\#200}$ =	68%										
							% lost:	-0.06%			

						Elapsed time (min)	Reading	Comp. Reading	L (cm) (ASTM table	P (ASTM eqn. 2)	D (mm) (ASTM eqn. 4)
			Hydrometer Analysis			1	35	30	10.6	65%	0.0631
			Time readings begin:	152H		2	28.3	23.3	11.7	50%	0.0469
			Hydrometer Type:	6/15/2012 15:19		4	24.3	19.3	12.3	42%	0.0341
			Composite Correction:	5		8	20.5	15.5	12.9	33%	0.0247
			Dry mass of soil tested (g):	50		15	16	11	13.7	24%	0.0186
			$M_{retained\ on\ \#10\ seive}$ (g):	0		30	12	7	14.3	15%	0.0134
			Dry mass of soil past #10 (g):	50		60	8	3	15.0	6%	0.0097
			W (dry mass of soil represented) (g):	51.2		120	6.3	1.3	15.3	3%	0.0069
			Temperature (° F):	68		250	5.6	0.6	15.4	1%	0.0048
			G_s correction factor (ASTM D 422, Table 1); Interpolated!:	1.11		500	5.3	0.3	15.4	1%	0.0034
			K (ASTM eq. 4, based on temp and G_s):	0.0194		1440	5	0	15.5	0%	0.0020
			% Passing #10 Sieve:	97.7%							

Summary												
$\Sigma Mass_{Ovendry}$ =	762.77	g										
				Checks on Relative Density of Individual Slices:								
Mass =	1039.5	g										
Weight =	2.292	lb		Knowns:								
Volume =	37.31	in^3		V_{s1} =	148.57	cm^3	Slice 1:					
	611.43	cm^3		V_{s2} =	217.14	cm^3	V_{S_S1} =	72.48	cm^3	e_{S1} =	1.05	
Density =	0.061	lb/in^3		V_{s3} =	245.71	cm^3	V_{G_S1} =	76.09	cm^3	D_{rS1} =	27%	
	1.70	g/cm^3		m_{s1} =	237.0	g						
				m_{s2} =	367.1	g	Slice 2:					
M_{DRIED_FINES} =	1.3	g		m_{s3} =	435.4	g	V_{S_S2} =	122.88	cm^3	e_{S2} =	0.77	
M_{DRY_SAMPLE} =	763.0	g		ρ_{S1} =	1.60	g/cm^3	V_{G_S2} =	94.26	cm^3	D_{rS2} =	79%	
V_{SOLIDS} =	343.69	cm^3		ρ_{S2} =	1.69	g/cm^3						
	20.97	in^3		ρ_{S3} =	1.77	g/cm^3	Slice 3:					
V_{VOIDS} =	267.74	cm^3		G_s =	2.22		V_{S_S3} =	155.51	cm^3	e_{S3} =	0.58	
	16.34	in^3		G_{gel} =	1.000		V_{G_S3} =	90.20	cm^3	D_{rS3} =	113%	
e =	0.78									e_{avg} =	0.80	
				M_{DRY_SAMPLE} =	778.9496685		V_{TOT} =	611.43	cm^3	D_{r_avg} =	73%	
D_r =	76.5%											

Specimen 3 Preparation Sheet:

D_{rTAR} =	70%	
M_{ash} =	764.3	g
w (%) =	29.2%	
M_{moist} =	987.8	g

Location	Target H_{TP} (in)	H_{BP} (in)	H_S (in)
Front	4.724	**12.247**	6.168
Back	4.724	**12.253**	6.174
Right	4.724	**12.249**	6.170
Left	4.724	**12.251**	6.172

Location	Initial H_{TP} (in)	Final H_{TP} (in)	H_{BP} (in)	H_{SI} (in)	H_{SF} (in)
Front	4.447	4.735	**12.247**	6.446	6.157
Back	4.449	4.734	**12.253**	6.449	6.164
Right	4.451	4.734	**12.249**	6.443	6.160
Left	4.446	4.735	**12.251**	6.450	6.161

Fines Lost:		
Tare Name:	Cindy	
Tare:	475.0	g
Gross:	477.3	g
Net:	2.3	g
% Loss:	0.23%	

$G_{gelatin}$:		
Concentration:	0.75% by mass	
Tare:	126.8	g
Gross:	225.55	g
Net:	98.75	g
Volume:	98	cm^3
$G_{gelatin}$:	1.008	

Approximate Placement D_r:		
D_{COLLAR} =	2.825	
H_{IS_AVG} =	0.262	in
V_{CYL1} =	33.66	in^3
V_{CYL2} =	4.52	in^3
V_{CYL3} =	1.61	in^3
V_{TOT} =	39.79	in^3
V_{SOLIDS} =	20.95	in^3
V_{VOIDS} =	18.84	in^3
e =	0.90	
D_r =	55%	

Approximate Densified D_r:		
V_{CYL2} =	4.32	in^3
V_{TOT} =	37.98	in^3
	622.34	cm^3
V_{SOLIDS} =	20.95	in^3
	343.24	cm^3
V_{VOIDS} =	17.03	in^3
	279.10	cm^3
e =	0.81	
D_r =	70.34%	

Specimen 3 Fabric Testing Sheet:

Volume Calculation Information:

D_{beaker} =	3.33162	in
$V_{1/100"}$ =	0.087	in^3
	1.43	cm^3

Top Slice

Mass =	257.6	g
Weight =	0.568	lb
Volume =	10.20	in^3
	167.14	cm^3
Density =	0.056	lb/in^3
	1.54	g/cm^3
$Mass_{Ovendry}$ =	174.8	g
$Mass_{Ovenwash}$ =	42.7	g
$\%Pass_{\#200}$ =	76%	

Sieve Analysis

Tare Name:	Tare 1
Tare Mass (g):	329.2
Tare + Dry Soil Mass (g):	504.0
Tare + Dry Soil Mass After Washing (g):	374.0

Subtract this from $Mass_{Ovenwash}$ =>

Sieve No.	Nominal diameter, mm	wt. retained (g)	% retained	% passing
#4	4.75	1.2	0.7%	99.3%
#10	2	1.8	1.7%	98.3%
#20	0.841	0.8	2.2%	97.8%
#30	0.595	0.3	2.3%	97.7%
#40	0.425	0.4	2.6%	97.4%
#60	0.25	2.9	4.2%	95.8%
#100	0.15	9.4	9.6%	90.4%
#200	0.075	26.1	24.5%	75.5%
Pan		2.6	100.0%	0.0%
	% lost:	-0.11%		

Hydrometer Analysis

Time readings begin:	6/16/2012 12:57
Hydrometer Type:	152H
Composite Correction:	5.3
Dry mass of soil tested (g):	50.0
$M_{retained\ on\ \#10\ seive}$ (g):	1.2
Dry mass of soil past #10 (g):	48.8
W (dry mass of soil represented) (g):	49.7
Temperature (° F):	71.6
G_s correction factor (ASTM D 422, Table 1); Interpolated!:	1.11
K (ASTM eq. 4, based on temp and G_s):	0.0190
% Passing #10 Sieve:	98.3%

Elapsed time (min)	Reading	Comp. Reading	L (cm) (ASTM table 2)	P (ASTM eqn. 2)	D (mm) (ASTM eqn. 4)
1	39	33.7	9.9	75%	0.0597
2	34	28.7	10.7	64%	0.0439
4	31	25.7	11.2	57%	0.0317
8	26.3	21	12.0	47%	0.0232
15	20.5	15.2	12.9	34%	0.0176
30	18.5	13.2	13.3	29%	0.0126
60	13	7.7	14.2	17%	0.0092
120	10	4.7	14.7	10%	0.0066
250	9	3.7	14.8	8%	0.0046
500	8	2.7	15.0	6%	0.0033
1440	5.3	0	15.4	0%	0.0020

Middle Slice											
						Sieve No.	Nominal diameter, mm	wt. retained (g)	% retained	% passing	
			Sieve Analysis			#4	4.75	0.4	0.2%	99.8%	
Mass =	349.9	g				#10	2	1.2	0.6%	99.4%	
Weight =	0.771	lb	Tare Name:	Tare 2		#20	0.841	1.3	1.1%	98.9%	
Volume =	12.64	in^3	Tare Mass (g):	332.5		#30	0.595	0.9	1.5%	98.5%	
	207.14	cm^3	Tare + Dry Soil Mass (g):	588.8		#40	0.425	1.5	2.1%	97.9%	
Density =	0.061	lb/in^3	Tare + Dry Soil Mass After Washing (g):	406.4		#60	0.25	8.6	5.4%	94.6%	
	1.69	g/cm^3				#100	0.15	18.6	12.7%	87.3%	
						#200	0.075	38.4	27.7%	72.3%	
$Mass_{Ovendry}$ =	256.3	g		Subtract this from $Mass_{Ovenwash}$ =>		Pan		2.9	100.0%	0.0%	
$Mass_{Ovenwash}$ =	71.3	g									
$\%Pass_{\#200}$ =	72%						% lost:	0.16%			
						Elapsed time (min)	Reading	Comp. Reading	L (cm) (ASTM table 2)	P (ASTM eqn. 2)	D (mm) (ASTM eqn. 4)
			Hydrometer Analysis			1	34	28.7	10.7	63%	0.0621
			Time readings begin:	152H		2	28.3	23	11.7	51%	0.0458
			Hydrometer Type:	6/16/2012 13:30		4	24.6	19.3	12.3	42%	0.0332
			Composite Correction:	5.3		8	20	14.7	13.0	32%	0.0242
			Dry mass of soil tested (g):	50		15	17	11.7	13.5	26%	0.0180
			$M_{retained\ on\ \#10\ seive}$ (g):	0		30	13.2	7.9	14.1	17%	0.0130
			Dry mass of soil past #10 (g):	50		60	8	2.7	15.0	6%	0.0095
			W (dry mass of soil represented) (g):	50.31409501		120	6.6	1.3	15.2	3%	0.0068
			Temperature (° F):	71.6		250	6	0.7	15.3	2%	0.0047
			G_s correction factor (ASTM D 422, Table 1); Interpolated!:	1.11		500	5.3	0	15.4	0%	0.0033
			K (ASTM eq. 4, based on temp and G_s):	0.0190		1440	5.3	0	15.4	0%	0.0020
			% Passing #10 Sieve:	99.4%							

Bottom Slice												
						Sieve No.	Nominal diameter, mm	wt. retained (g)	% retained	% passing		
Mass =	410.1	g	Sieve Analysis			#4	4.75	1	0.3%	99.7%		
Weight =	0.904	lb				#10	2	4.4	1.7%	98.3%		
Volume =	14.12	in^3	Tare Name:	Tare 3		#20	0.841	6.6	3.8%	96.2%		
	231.43	cm^3	Tare Mass (g):	333.6		#30	0.595	3	4.8%	95.2%		
Density =	0.064	lb/in^3	Tare + Dry Soil Mass (g):	646.3		#40	0.425	4.7	6.3%	93.7%		
	1.77	g/cm^3	Tare + Dry Soil Mass After Washing (g):	441.7		#60	0.25	16.1	11.4%	88.6%		
						#100	0.15	24.6	19.3%	80.7%		
$Mass_{Ovendry}$ =	312.7	g				#200	0.075	42.1	32.8%	67.2%		
$Mass_{Ovenwash}$ =	103.1	g		Subtract this from $Mass_{Ovenwash}$ =>		Pan		5.4	100.0%	0.0%		
$\%Pass_{\#200}$ =	67%											
							% lost:	0.19%				
					Elapsed time (mi		Reading	Comp. Reading	L (cm) (ASTM table 2)	P (ASTM eqn. 2)	D (mm) (ASTM eqn. 4)	
			Hydrometer Analysis			1	30	24.7	11.4	54%	0.0640	
			Time readings begin:	152H		2	26.5	21.2	11.9	46%	0.0463	
			Hydrometer Type:	6/16/2012 14:03		4	20.5	15.2	12.9	33%	0.0341	
			Composite Correction:	5.3		8	18.3	13	13.3	28%	0.0244	
			Dry mass of soil tested (g):	50		15	15.3	10	13.8	22%	0.0182	
			$M_{retained\ on\ \#10\ seive}$ (g):	0.02		30	11.3	6	14.4	13%	0.0132	
			Dry mass of soil past #10 (g):	49.98		60	8.5	3.2	14.9	7%	0.0094	
			W (dry mass of soil represented) (g):	50.9		120	8.4	3.1	14.9	7%	0.0067	
			Temperature (° F):	71.6		250	6	0.7	15.3	2%	0.0047	
			G_s correction factor (ASTM D 422, Table 1); Interpolated!:	1.11		500	5.6	0.3	15.4	1%	0.0033	
						1440	5.3	0	15.4	0%	0.0020	
			K (ASTM eq. 4, based on temp and G_s):	0.0190								
			% Passing #10 Sieve:	98.3%								

Summary											
$\Sigma Mass_{Ovendry}$ =	743.8	g									
				Checks on Relative Density of Individual Slices:							
Mass =	1017.6	g									
Weight =	2.243	lb		Knowns:							
Volume =	36.96	in^3		V_{s1} =	167.14	cm^3	Slice 1:				
	605.71	cm^3		V_{s2} =	207.14	cm^3	V_{S_S1} =	73.56	cm^3	e_{S1} =	1.27
Density =	0.061	lb/in^3		V_{s3} =	231.43	cm^3	V_{G_S1} =	93.58	cm^3	D_{rS1} =	-13%
	1.68	g/cm^3		m_{s1} =	257.6	g					
				m_{s2} =	349.9	g	Slice 2:				
M_{DRIED_FINES} =	2.3	g		m_{s3} =	410.1	g	V_{S_S2} =	116.40	cm^3	e_{S2} =	0.78
M_{DRY_SAMPLE} =	762.0	g		ρ_{S1} =	1.54	g/cm^3	V_{G_S2} =	90.74	cm^3	D_{rS2} =	76%
V_{SOLIDS} =	343.24	cm^3		ρ_{S2} =	1.69	g/cm^3					
	20.95	in^3		ρ_{S3} =	1.77	g/cm^3	Slice 3:				
V_{VOIDS} =	262.48	cm^3		G_s =	2.22		V_{S_S3} =	145.92	cm^3	e_{S3} =	0.59
	16.02	in^3		G_{gel} =	1.008		V_{G_S3} =	85.51	cm^3	D_{rS3} =	112%
e =	0.76									e_{avg} =	0.88
				M_{DRY_SAMPLE} =	745.65		V_{TOT} =	605.71	cm^3	D_{r_avg} =	58%
D_r =	79.1%										
Note: Top Slice not cured; bottom two slices were											

APPENDIX D

Dallman Boring Log and Cross Section

PSI Information To Build On
Engineering • Consulting • Testing

August 30, 2010

City Water, Light & Power
Environmental Health & Safety
201 East Lake Shore Drive
Springfield, Illinois 62712

Attn: Ms. Sue Corcoran
Tel: 217-757-8610
Fax: 217-757-8615

Re: Piezometer Installation
CWLP Ash Ponds
East Lake Shore Drive
Springfield, Illinois
PSI Report No. 0020522-1 Rev. 1 Page 1 of 22 (including attachments)

Dear Ms. Corcoran:

In general accordance with your instructions, Professional Service Industries, Inc. (PSI) has completed the installation of four (4) temporary piezometers at the periphery of CWLP's ash pond area in Springfield, Illinois. Additionally, certain laboratory analysis was performed, as was in situ hydraulic conductivity (slug) testing. The piezometer locations are identified on the attached location plan. Boring depths and static water levels are shown in the table below.

	AP-1	AP-2	AP-3	AP-4
Date drilled	4/21/2010	4/21/2010	4/21/2010	4/20/2010
Total boring depth (ft)	31.5	20	19.5	60
Piezometer depth from top of first casing above ground surface (ft)	33.15	19.47	19.63	58.93
Piezometer depth from ground surface (ft)	28.34	17.18	17.91	58.31
Well screen length (ft)	10	10	10	10
Static water level from ground surface (5/5/2010)	4.81	3.89	5.16	5.95

The borings were drilled to depths ranging from approximately 17.2 to 58.3 feet below the existing ground surface, respectively. It is PSI's understanding that the purpose for these soil borings is to aid CWLP in assessing the groundwater quality outside the existing CWLP ash ponds. The general boring locations were determined and located in the field by CWLP personnel. With the approval of Ms. Corcoran, AP-2 was offset to the north of the clarifier pond drainage pipe. Depths on the attached boring logs are relative to the ground surface at each boring location.

Water level observations were made during and upon completion of the boring operations and are noted on the boring logs presented herewith. In addition, static water levels were observed

at the time of the slug testing. In relatively impervious soils, the accurate determination of the groundwater elevation may not be possible even after several days of observation. Seasonal variations, temperature and recent rainfall conditions may influence the levels of the groundwater table and volumes of water will depend on the permeability of the soils.

Soil samples were visually classification in the field for logging purposes. The limited laboratory testing program included grain size analysis. Where soil tests are reported, they have been performed in accordance with generally acceptable or applicable standards. Sieve analysis worksheets are appended. Soil samples were conveyed to CWLP upon completion of the well installation activities.

A copy of the boring logs are appended. The stratification of the soils on the log represents the soil conditions in the actual boring location. Lines of demarcation represent the approximate boundaries between the soil types, but the transition may be gradual.

On May 5, 2010, in situ rising head hydraulic conductivity (slug) testing was performed on each of the four piezometers. Testing was conducted by rapidly removing one bailer (1 liter) of groundwater from the well while recording the rate of recovery using a Solinst 3001 level logger. Hydraulic conductivity was estimated using the Hvorslev method. Based on this method, the average hydraulic conductivity was estimated at 2.50E-02. Slug test results and hydraulic conductivity calculations are appended.

PSI appreciates the opportunity to perform these services and if we can be of further service, please contact our office at (217) 544-6663.

Respectfully submitted,
PROFESSIONAL SERVICE INDUSTRIES, INC.

James Gerloff, E.I.
Branch Manager

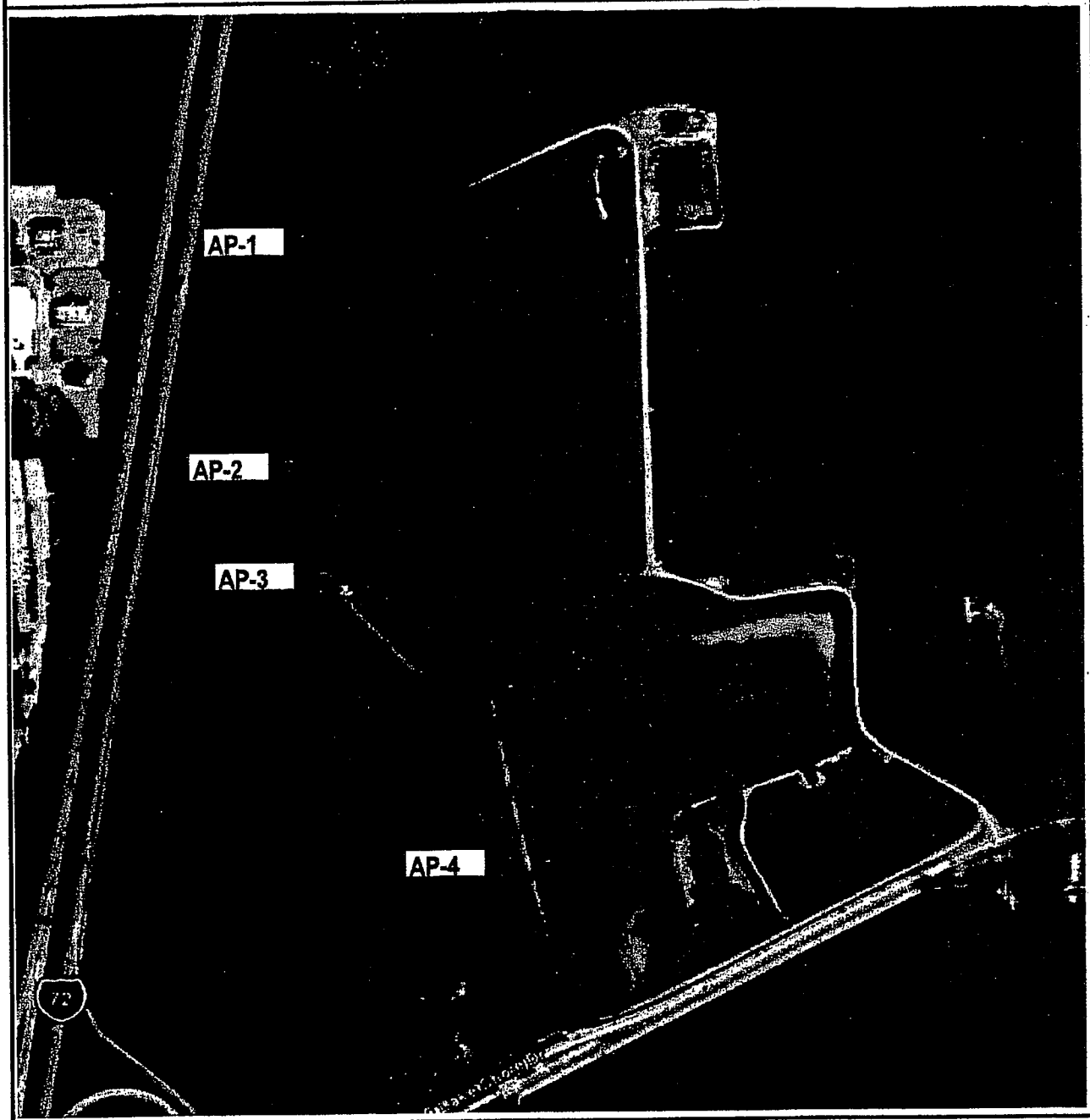
William P. Pongracz, P.E.
Vice President

Attachments: Key to Symbols
Boring Logs (4 pages)
Piezometer Location Plan
In-Situ Hydraulic Conductivity Results (6 pages)
Sieve Analysis Worksheets (8 pages)

Distribution: (1) above

PIEZOMETER LOCATION PLAN

SOURCE:	DATE:	SCALE:	
Google © 2010 / DigitalGlobe © 2010	Nov-05	No Scale	



psi Information To Build On
Engineering • Consulting • Testing
480 North Street, Springfield, Illinois 62704
phone 217/544-6663 fax 217/544-6148

PIEZOMETER LOCATION PLAN

PSI PROJECT No.:	0020522
Project:	Piezometer Installation
Location:	CWLP Ash Pond
	East Lake Shore Drive
	Springfield, Illinois

KEY TO SYMBOLS


Fill (made ground)


USCS Low Plasticity Clay


USCS Silt


USCS Low Plasticity Sandy Clay


USCS Clayey Sand


USCS Well-graded Sand with Silt


USCS Poorly-graded Sand


USCS Well-graded Sand

HSA = Hollow Stem Auger

CFA = Continuous Flight Auger

SPT = Standard Penetration Test

DCP = Dynamic Cone Penetrometer

SS = Split-spoon Sampler

ST = Shelby Tube Sampler

RC = Rock Core

DD = Dry Density

LL = Liquid Limit

PL = Plastic Limit

Qu = Unconfined Compressive Strength

Qp = Pocket Penetrometer

RQD = Rock Quality Designation

REC'D = Rock Core Recovery Percentage

PID = Photo Ionic Detector (ppm)

MR* = Unable to determine depth of water due to mud rotary drilling methods

The borings were advanced into the ground using hollow stem augers. At regular intervals throughout the boring depths, soil samples were obtained with either a 1.4-inch I.D., 2.0-inch O.D., split-spoon sampler or a 3-inch diameter Shelby tube. The split-spoon sampler was first seated 6-inches to penetrate any loose cuttings and then driven an additional foot where possible with blows of a 140 pound hammer falling 30-inches. The number of hammer blows required to drive the sampler each 6-inch increment is recorded in the field. The penetration resistance "N-value" is redesignated as the number of hammer blows required to drive the sampler the final foot and, when properly evaluated, is an index to cohesion for clays and relative density for sands. The split-spoon sampling procedures used during this exploration are in general accordance with ASTM Designation D 1586.

Relatively undisturbed Shelby tube samples were obtained by forcing a section of 3-inch diameter steel tubing into the soil at the desired sampling levels. This sampling procedure was in general accordance with ASTM Designation D 1587. Each tube, together with the encased soil, was carefully removed from the ground, sealed and transported to the laboratory for testing.

Professional Service Industries, Inc.
480 North Street
Springfield, Illinois 62704
Telephone: 217/544-6663
Fax: 217/544-6143

PSI Job No.: 0020522
Project: Piezometer Installation
Location: CWLP Ash Pond
East Lake Shore Drive
Springfield, Illinois

Professional Service Industries, Inc.
480 North Street
Springfield, Illinois 62704
Telephone: 217/544-6663
Fax: 217/544-6143

LOG OF BORING AP-1

PSI Job No.: 0020522
Project: Piezometer Installation
Location: CWLP Ash Pond
East Lake Shore Drive
Springfield, Illinois

Drilling Method: Hollow Stem Auger
Sampling Method: Split Spoon
Hammer Type: CME Automatic; ETR = 86%
Boring Location: See attached boring location plan.

WATER LEVELS	
While Drilling	9 feet
Upon Completion	N/A
Delay	N/A

Station: N/A
Offset: N/A

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %
	0			1	18	Dark brown silty CLAY, very stiff, slightly moist	CL	7-8-9 N_{60}=24	
	5			2	18	Dark brown clayey SILT, stiff, slightly moist	ML	5-5-5 N_{60}=14	
				3	18	Gray clayey SILT, trace brown, firm, moist		2-2-3 N_{60}=7	
	10			4	18		ML	2-2-3 N_{60}=7	
				5	18			1-2-2 N_{60}=6	
	15			6	18	Gray silty CLAY, few brown sand, firm, saturated	CL	1-2-2 N_{60}=6	
				7	18	Gray sandy CLAY, stiff, saturated	CLS	4-3-4 N_{60}=10	
	20			8	18	Blue-gray clayey SILT, soft to very stiff, moist to saturated		3-3-4 N_{60}=10	
	25			9	18		ML	1-2-1 N_{60}=4	
	30			10	18	Gray SAND with SILT, medium dense/very stiff, saturated	SW-SM	6-7-6 N_{60}=19	
				11	6	Gray SHALE, hard, slightly moist	CL	50/6"	
	35					Boring terminated ay -31.5'			

STANDARD PENETRATION TEST DATA
N in blows/ft ●
× Moisture ◪ PL ✚ LL
0 25 50
STRENGTH, tsf
▲ Qu ✳ Qp
0 2.0 4.0

Additional Remarks

Well Diagram: J-Plug; Concrete Cap; 2" PVC Solid Riser; Bentonite Seal; Sand Filter Pack; 0.01" PVC Slotted Well Screen

Completion Depth: 35.0 ft
Date Boring Started: 4/21/10
Date Boring Completed: 4/21/10
Logged By: Rob Preuss
Drilling Contractor: PSI, Inc.

Sample Types:
Auger Cutting
Split-Spoon
Rock Core
Shelby Tube
Hand Auger
Texas Cone

Latitude:
Longitude:
Drill Rig: ATV D50
Remarks: N_{60} denotes the normalization to 60% efficiency as described in ASTM D4633. Moistures determined by visual methods.

The stratification lines represent approximate boundaries. The transition may be gradual.

Professional Service Industries, Inc.
480 North Street
Springfield, Illinois 62704
Telephone: 217/544-6663
Fax: 217/544-6143

LOG OF BORING AP-2

PSI Job No.: 0020522
Project: Piezometer Installation
Location: CWLP Ash Pond
East Lake Shore Drive
Springfield, Illinois

Drilling Method: Hollow Stem Auger
Sampling Method: Split Spoon
Hammer Type: CME Automatic; ETR = 86%
Boring Location: See attached boring location plan.

WATER LEVELS	
While Drilling	9 feet
Upon Completion	N/A
Delay	N/A

Station: N/A
Offset: N/A

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft @ × Moisture ◪ PL ✚ LL (0 · 25 · 50) STRENGTH, tsf ▲ Qu ✳ Qp (0 · 2.0 · 4.0)	Additional Remarks	Well Diagram
	0			1	10	Dark brown silty CLAY, some sand, stiff, slightly moist (FILL)	CL	4-4-6 N_{60}=14				J-Plug
	5			2	8	Dark brown silty CLAY, soft to firm, moist	CL	2-2-2 N_{60}=6				Concrete Cap
				3	6	Gray silty CLAY, soft to firm, moist	CL	1-1-2 N_{60}=4				2" PVC Solid Riser
	10			4	18	Gray clayey SILT, soft to firm, saturated		2-2-2 N_{60}=6				Bentonite Seal
				5	18		ML	2-1-1 N_{60}=3				Sand Filter Pack
				6	18			2-1-2 N_{60}=4				
	15			7	18	Light gray SAND, dense, saturated	SP	4-9-16 N_{60}=36				0.01" PVC Slotted Well Screen
	20			8	14	Gray SHALE, hard, slightly moist Boring terminate at -20'	CL	19-24-50/2"				

Completion Depth: 20.0 ft
Date Boring Started: 4/21/10
Date Boring Completed: 4/21/10
Logged By: Rob Preuss
Drilling Contractor: PSI, Inc.

Sample Types:
Auger Cutting
Split-Spoon
Rock Core
Shelby Tube
Hand Auger
Texas Cone

Latitude:
Longitude:
Drill Rig: ATV D50
Remarks: N_{60} denotes the normalization to 60% efficiency as described in ASTM D4633. Moistures determined by visual methods.

The stratification lines represent approximate boundaries. The transition may be gradual.

Professional Service Industries, Inc.
480 North Street
Springfield, Illinois 62704
Telephone: 217/544-6663
Fax: 217/544-6143

LOG OF BORING AP-3

PSI Job No.: 0020522
Project: Piezometer Installation
Location: CWLP Ash Pond
East Lake Shore Drive
Springfield, Illinois

Drilling Method: Hollow Stem Auger
Sampling Method: Split Spoon
Hammer Type: CME Automatic; ETR = 86%
Boring Location: See attached boring location plan.

WATER LEVELS
While Drilling None feet
Upon Completion N/A
Delay N/A

Station: N/A
Offset: N/A

Elevation (feet)	Depth, (feet)	Graphic Log	Sample Type	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %	STANDARD PENETRATION TEST DATA N in blows/ft ● × Moisture ◪ PL ✚ LL 0 25 50 STRENGTH, tsf ▲ Qu ✳ Qp 0 2.0 4.0	Additional Remarks	Well Diagram
	0					Dark brown silty CLAY, very stiff, slightly moist	CL	6-7-8 N_{60}=21				J-Plug
	5			1	18							Concrete Cap
				2	18	Gray/brown clayey SILT, soft to stiff, moist to saturated		3-3-4 N_{60}=10				2" PVC Solid Riser
				3	18		ML	1-1-1 N_{60}=3				Bentonite Seal
	10			4	18	Gray clayey SILT, soft to very stiff, saturated		2-1-2 N_{60}=4				
				5	18			2-2-4 N_{60}=9				Sand Filter Pack
	15			6	16		ML	2-2-4 N_{60}=9				0.01" PVC Slotted Well Screen
				7	18			4-4-6 N_{60}=14				
	20			8	10	Gray SHALE, hard, slightly moist	CL	32-50/3"		>>		
						Boring terminated at -19.5						

Completion Depth: 20.0 ft
Date Boring Started: 4/21/10
Date Boring Completed: 4/21/10
Logged By: Rob Preuss
Drilling Contractor: PSI, Inc.

Sample Types:
Auger Cutting
Split-Spoon
Rock Core
Shelby Tube
Hand Auger
Texas Cone

Latitude:
Longitude:
Drill Rig: ATV D50
Remarks: N_{60} denotes the normalization to 60% efficiency as described in ASTM D4633. Moistures determined by visual methods.

The stratification lines represent approximate boundaries. The transition may be gradual.

Professional Service Industries, Inc.
480 North Street
Springfield, Illinois 62704
Telephone: 217/544-6663
Fax: 217/544-6143

LOG OF BORING AP-4

Sheet 1 of 1

PSI Job No.: 0020522
Project: Piezometer Installation
Location: CWLP Ash Pond
East Lake Shore Drive
Springfield, Illinois

Drilling Method: Hollow Stem Auger
Sampling Method: Split Spoon
Hammer Type: CME Automatic; ETR = 86%
Boring Location: See attached boring location plan.

WATER LEVELS	
While Drilling	11 feet
Upon Completion	N/A
Delay	N/A

Station: N/A
Offset: N/A

Elevation (feet)	Depth, (feet)	Sample No.	Recovery (inches)	MATERIAL DESCRIPTION	USCS Classification	SPT Blows per 6-inch (SS)	Moisture, %
	0	1	17	Brown silty CLAY, some brown sand, firm to stiff, slightly moist (FILL)	CL	4-4-3 N_{60}=10	
	5	2	18	Brown silty CLAY, trace roots, firm to stiff, moist (FILL)	CL	4-3-2 N_{60}=7	
		3	10	Brown SILT, trace gray, firm to stiff, moist (FILL)	ML	6-3-2 N_{60}=7	
	10	4	12	5" Brown SAND transitioning to Black FLY ASH at 9.4', stiff to very stiff, slightly moist (FILL)		2-2-4 N_{60}=9	
		5	18		SAND/FLY ASH	2-2-2 N_{60}=6	
	15	6	16			2-1-1 N_{60}=3	
		7	16	Black FLY ASH, some fine sub-round gravel, stiff to very stiff, moist to saturated (FILL)	FLY ASH	6-6-5 N_{60}=16	
	20	8	18	Gray/green (organic?) CLAY, stiff, trace fine sand, moist to saturated		3-3-3 N_{60}=9	
	25	9	1		CL	3-3-4 N_{60}=10	
	30	10	18	Brown/gray silty CLAY, fiorm to stiff, saturated	CL	2-2-3 N_{60}=7	
	35	11	18	Gray SILT, stiff to very stiff, saturated		3-3-4 N_{60}=10	
	40	12	18		ML	4-4-4 N_{60}=11	
	45	13	18			4-4-6 N_{60}=14	
	50	14	18	Gray fine to coarse SAND, medium dense, saturated		4-5-7 N_{60}=17	
	55	15	18		SW	5-5-7 N_{60}=17	
		16	1	Gray SHALE, hard, moist	CL	50/1"	
	60			Boring terminated at -60'			

STANDARD PENETRATION TEST DATA
N in blows/ft
Moisture
PL
LL
0 25 50
STRENGTH, tsf
Qu
Qp
0 2.0 4.0

Additional Remarks

Well Diagram
J-Plug
Concrete Cap
2" PVC Solid Riser
Bentonite Seal
Sand Filter Pack
0.01" PVC Slotted Screen

Completion Depth: 60.0 ft
Date Boring Started: 4/20/10
Date Boring Completed: 4/20/10
Logged By: Rob Preuss
Drilling Contractor: PSI, Inc.

Sample Types:
Auger Cutting
Split-Spoon
Rock Core
Shelby Tube
Hand Auger
Texas Cone

Latitude:
Longitude:
Drill Rig: ATV D50
Remarks: N_{60} denotes the normalization to 60% efficiency as described in ASTM D4633. Moistures determined by visual methods.

The stratification lines represent approximate boundaries. The transition may be gradual.

In-Situ Hydraulic Conductivity Test Analysis
Utlizing the Hvorslev Slug Test Method[1]

GOVERNING EQUATION:

$$K = (r^2 * \ln(L_e/R))/(2L_eT_o)$$

K is the hydraulic conductivity (cm/sec)
r is the radius of the well casing (cm)
R is the radius of the borehole (cm)
L_e is the length of the well screen (cm)
T_o is the time it takes for the water level to rise or fall 37% of the initial change (sec)

CWLP Ash Ponds, East Lake Shore Drive, Springfield, Illinois **In-Situ Hydraulic Conductivity Analysis[2]**

Test Number	Test Type	L_e (ft)	L_e (cm)	T_o (min)	T_o (sec)	K (cm/sec)
AP-4	Rising Head	10.0	304.8	0.025	1.500	7.64E-02
AP-3	Rising Head	10.0	304.8	0.083	4.980	2.30E-02
AP-2.1	Rising Head	10.0	304.8	0.150	9.000	1.27E-02
AP-2.2	Rising Head	10.0	304.8	0.167	10.020	1.14E-02
AP-1	Rising Head	10.0	304.8	1.667	100.020	1.15E-03

AVERAGE: 2.50E-02

CONSTANTS

r (inch)	r (cm)	R (inch)	R (cm)
2.0	5.08	8.0	20.3

HVORSLEV CALCULATIONS

Test	L_e/R (-)	$\ln(L_e/R)$ (-)	L_eT_o (cm*sec)	K (cm/sec)	
AP-4	15.00	2.71	4.57E+02	**7.64E-02**	
AP-3	15.00	2.71	1.52E+03	**2.30E-02**	
AP-2.1	15.00	2.71	2.74E+03	1.27E-02	
AP-2.2	15.00	2.71	3.05E+03	1.14E-02	AP-2 AVG: **1.21E-02**
AP-1	15.00	2.71	3.05E+04	**1.15E-03**	

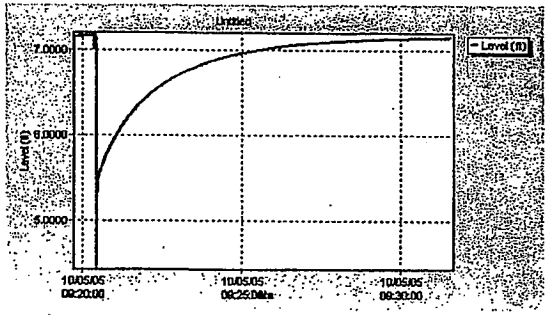
Notes:

[1] Hvorslev slug test method applied as described by C.W. Fetter in Applied Hydrology (Third Edition) published by Prentice-Hall in New Jersey in 1994 on pages 247-251.

[2] In-situ hydraulic conductivity tests conducted on monitoring wells, MW-1 thru MW-4 on May 5, 2010.

Solinst	3001
Report generated:	5/11/2010
Report from file:	...\mw-4.csv
Serial number:	1032388
Unit name:	Solinst 3001
Test name:	AP-1 Test 1
Test defined on:	5/5/2010
Test started on:	5/5/2010 9:20:28
Test stopped on:	5/5/2010 9:21:41
Data gathered using Linear testing	
Time between data points:	1 Seconds
Number of data samples:	75
TOTAL DATA SAMPLES	75
Channel number [1]	
Measurement type:	Level
Unit	feet
Channel number [2]	
Measurement type:	Temperature
Unit	Deg C
Sensor Range:	
Specific gravity:	
Mode:	TOC
User-defined reference*:	33.15 Feet H2O
Referenced on:	test start
Pressure head at reference:	Feet H2O

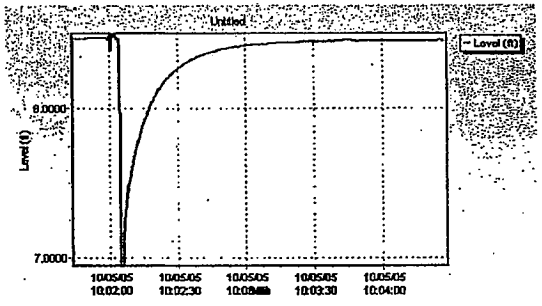
*Well depth to top of first casing terminating above ground. Does not include above ground extensions.



	Date	Time	ET (sec)	Time (min)	Test Time (min)	Temperature	Level	Water Level Bottom of well to TOC* (ft)	Change of Static Water Level (ft)	Water Column	
1	5/5/2010	9:20:27	0	0.000		11.254	7.1703	25.980	0		TEST START
2	5/5/2010	9:20:28	1	0.017	0.000	11.252	5.298	27.852	1.8723		SLUG REMOVED
3	5/5/2010	9:20:29	2	0.033	0.017	11.254	5.3992	27.751	1.7711	0.9460486831	
4	5/5/2010	9:20:30	3	0.050	0.033	11.254	5.4584	27.692	1.7119	0.9147629993	
5	5/5/2010	9:20:31	4	0.067	0.050	11.257	5.4885	27.662	1.6818	0.8989254455	
6	5/5/2010	9:20:32	5	0.083	0.067	11.255	5.519	27.631	1.6513	0.8828453361	
7	5/5/2010	9:20:33	6	0.100	0.083	11.258	5.5421	27.608	1.6282	0.8706925592	
8	5/5/2010	9:20:34	7	0.117	0.100	11.257	5.5658	27.584	1.6045	0.8582057859	
9	5/5/2010	9:20:35	8	0.133	0.117	11.258	5.5919	27.558	1.5784	0.8443272991	
10	5/5/2010	9:20:36	9	0.150	0.133	11.257	5.6074	27.543	1.5629	0.8347487705	
11	5/5/2010	9:20:37	10	0.167	0.150	11.257	5.6237	27.526	1.5466	0.8260423835	
12	5/5/2010	9:20:38	11	0.183	0.167	11.258	5.6423	27.508	1.528	0.8161003351	
13	5/5/2010	9:20:39	12	0.200	0.183	11.259	5.6595	27.491	1.5108	0.8069219068	
14	5/5/2010	9:20:40	13	0.217	0.200	11.258	5.676	27.474	1.4943	0.7981109277	
15	5/5/2010	9:20:41	14	0.233	0.217	11.259	5.6922	27.458	1.4781	0.7894568819	
16	5/5/2010	9:20:42	15	0.250	0.233	11.261	5.7084	27.442	1.4619	0.7808043458	
17	5/5/2010	9:20:43	16	0.267	0.250	11.259	5.7226	27.427	1.4477	0.7732220104	
18	5/5/2010	9:20:44	17	0.283	0.267	11.259	5.7383	27.412	1.432	0.7648634668	
19	5/5/2010	9:20:45	18	0.300	0.283	11.26	5.7519	27.398	1.4184	0.7575709021	
20	5/5/2010	9:20:46	19	0.317	0.300	11.259	5.768	27.384	1.4043	0.7500400455	
21	5/5/2010	9:20:47	20	0.333	0.317	11.261	5.7815	27.369	1.3888	0.741716147	
22	5/5/2010	9:20:48	21	0.350	0.333	11.259	5.7955	27.355	1.3748	0.7342284099	
23	5/5/2010	9:20:49	22	0.367	0.350	11.259	5.8088	27.341	1.3615	0.7271804731	
24	5/5/2010	9:20:50	23	0.383	0.367	11.26	5.8224	27.328	1.3479	0.7199016481	
25	5/5/2010	9:20:51	24	0.400	0.383	11.259	5.8355	27.315	1.3348	0.7129119938	
26	5/5/2010	9:20:52	25	0.417	0.400	11.26	5.8489	27.301	1.3214	0.7057852966	
27	5/5/2010	9:20:53	26	0.433	0.417	11.261	5.8621	27.288	1.3082	0.6987128132	
28	5/5/2010	9:20:54	27	0.450	0.433	11.26	5.875	27.275	1.2953	0.6918226823	
29	5/5/2010	9:20:55	28	0.467	0.450	11.261	5.8867	27.263	1.2836	0.6855738831	
30	5/5/2010	9:20:56	29	0.483	0.467	11.26	5.8996	27.250	1.2707	0.6787883172	
31	5/5/2010	9:20:57	30	0.500	0.150	11.259	5.9124	27.238	1.2579	0.67184746	
32	5/5/2010	9:20:58	31	0.517	0.500	11.259	5.9238	27.226	1.2467	0.6658668618	
33	5/5/2010	9:20:59	32	0.533	0.517	11.259	5.9351	27.215	1.2352	0.6597243436	
34	5/5/2010	9:21:00	33	0.550	0.533	11.26	5.9479	27.202	1.2224	0.6528868274	
35	5/5/2010	9:21:01	34	0.567	0.550	11.259	5.9589	27.191	1.2114	0.6470516077	
36	5/5/2010	9:21:02	35	0.583	0.567	11.258	5.9699	27.180	1.2004	0.641128657	
37	5/5/2010	9:21:03	36	0.600	0.583	11.259	5.9803	27.170	1.19	0.6355551905	
38	5/5/2010	9:21:04	37	0.617	0.600	11.258	5.9928	27.157	1.1775	0.6289056274	
39	5/5/2010	9:21:05	38	0.633	0.617	11.26	6.0028	27.147	1.1675	0.6236648	
40	5/5/2010	9:21:06	39	0.650	0.633	11.258	6.0142	27.136	1.1561	0.6174756332	
41	5/5/2010	9:21:07	40	0.667	0.650	11.257	6.025	27.125	1.1453	0.6117078225	
42	5/5/2010	9:21:08	41	0.683	0.667	11.259	6.0346	27.115	1.1357	0.6065580142	
43	5/5/2010	9:21:09	42	0.700	0.683	11.258	6.0448	27.105	1.1255	0.601132287	
44	5/5/2010	9:21:10	43	0.717	0.700	11.259	6.0554	27.095	1.1149	0.5954704411	
45	5/5/2010	9:21:11	44	0.733	0.717	11.258	6.0658	27.084	1.1045	0.5899161749	
46	5/5/2010	9:21:12	45	0.750	0.733	11.259	6.0765	27.074	1.0938	0.584210126	
47	5/5/2010	9:21:13	46	0.767	0.750	11.257	6.0864	27.064	1.0839	0.5789138383	
48	5/5/2010	9:21:14	47	0.783	0.767	11.257	6.096	27.054	1.0743	0.5737960252	
49	5/5/2010	9:21:15	48	0.800	0.783	11.257	6.1055	27.045	1.0648	0.5687212276	
50	5/5/2010	9:21:16	49	0.817	0.800	11.259	6.1144	27.036	1.0559	0.5639587767	
51	5/5/2010	9:21:17	50	0.833	0.817	11.257	6.1235	27.027	1.0468	0.5590966436	
52	5/5/2010	9:21:18	51	0.850	0.833	11.259	6.1332	27.017	1.0371	0.5541017641	
53	5/5/2010	9:21:19	52	0.867	0.850	11.257	6.1423	27.008	1.028	0.5492067309	
54	5/5/2010	9:21:20	53	0.883	0.867	11.256	6.1513	26.999	1.019	0.5442903147	
55	5/5/2010	9:21:21	54	0.900	0.883	11.257	6.1613	26.989	1.009	0.5389090363	
56	5/5/2010	9:21:22	55	0.917	0.900	11.258	6.1693	26.981	1.001	0.5346436243	
57	5/5/2010	9:21:23	56	0.933	0.917	11.257	6.1788	26.971	0.9917	0.529659181	
58	5/5/2010	9:21:24	57	0.950	0.933	11.257	6.1869	26.963	0.9834	0.5252826345	
59	5/5/2010	9:21:25	58	0.967	0.950	11.257	6.196	26.954	0.9743	0.5210376008	
60	5/5/2010	9:21:26	59	0.983	0.967	11.258	6.2045	26.946	0.9658	0.5166836137	
61	5/5/2010	9:21:27	60	1.000	0.983	11.257	6.213	26.937	0.9573	0.5123296267	
62	5/5/2010	9:21:28	61	1.017	1.000	11.256	6.2215	26.929	0.9488	0.5079756396	
63	5/5/2010	9:21:29	62	1.033	1.017	11.258	6.2287	26.921	0.9416	0.5042810953	
64	5/5/2010	9:21:30	63	1.050	1.033	11.255	6.2371	26.913	0.9332	0.4999243481	
65	5/5/2010	9:21:31	64	1.067	1.050	11.257	6.2466	26.903	0.9237	0.4950360426	
66	5/5/2010	9:21:32	65	1.083	1.067	11.257	6.2524	26.898	0.9179	0.4920526393	
67	5/5/2010	9:21:33	66	1.100	1.083	11.255	6.2615	26.889	0.9088	0.4873692488	
68	5/5/2010	9:21:34	67	1.117	1.100	11.256	6.268	26.882	0.9023	0.4839208632	
69	5/5/2010	9:21:35	68	1.133	1.117	11.255	6.2752	26.874	0.8941	0.4795840892	
70	5/5/2010	9:21:36	69	1.150	1.133	11.255	6.2835	26.867	0.8868	0.4756420145	
71	5/5/2010	9:21:37	70	1.167	1.150	11.255	6.2923	26.858	0.878	0.4708941941	
72	5/5/2010	9:21:38	71	1.183	1.167	11.256	6.2979	26.852	0.8724	0.4679050904	
73	5/5/2010	9:21:39	72	1.200	1.183	11.256	6.3053	26.845	0.865	0.4639088611	
74	5/5/2010	9:21:40	73	1.217	1.200	11.255	6.3128	26.837	0.8577	0.4599088611	
75	5/5/2010	9:21:41	74	1.233	1.217	11.254	6.3208	26.829	0.8495	0.4556770074	

Solinst	3001
Report generated:	5/11/2010
Report from file:	...\mw-3_1.csv
Serial number:	1032308
Unit name:	Solinst 3001
Test name:	AP-2 Test 1
Test defined on:	5/5/2010
Test started on:	5/5/2010 10:02:05
Test stopped on:	5/5/2010 10:02:58
Data gathered using Linear testing	
Time between data points:	1 Seconds.
Number of data samples:	55
TOTAL DATA SAMPLES	55
Channel number [1]	
Measurement type:	Level
Unit	feet
Channel number [2]	
Measurement type:	Temperature
Unit	Deg C
Sensor Range:	
Specific gravity:	
Mode:	TOC
User-defined reference*:	19.47 Feet H2O
Referenced on:	test start
Pressure head at reference:	Feet H2O

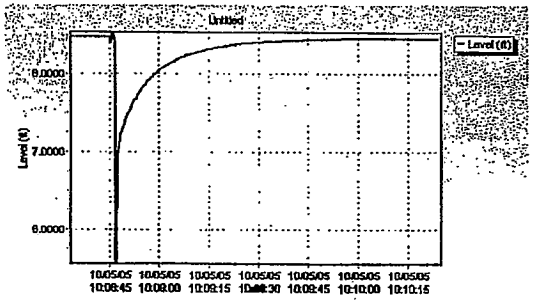
*Well depth to top of first casing terminating above ground. Does not include above ground extensions.



	Date	Time	ET (sec)	Time (min)	Test Time (min)	Temperature	Level	Water Level Bottom of well to TOC* (ft)	Change of Static Water Level (ft)	ln(y/yo)	
1	5/5/2010	10:02:04	0	0.000		11.23	8.4182	11.052	0		TEST START
2	5/5/2010	10:02:05	1	0.017	0.000	11.231	6.9143	12.556	1.5039		SLUG REMOVED
3	5/5/2010	10:02:06	2	0.033	0.017	11.231	7.2562	12.214	1.162	0.0720657	
4	5/5/2010	10:02:07	3	0.050	0.033	11.231	7.3727	12.097	1.0455	0.0951925	
5	5/5/2010	10:02:08	4	0.067	0.050	11.231	7.4828	11.987	0.9354	0.1218628	
6	5/5/2010	10:02:09	5	0.083	0.067	11.231	7.5707	11.899	0.8475	0.1438534	
7	5/5/2010	10:02:10	6	0.100	0.083	11.231	7.6472	11.823	0.771	0.1625671	
8	5/5/2010	10:02:11	7	0.117	0.100	11.231	7.715	11.755	0.7032	0.1787584	
9	5/5/2010	10:02:12	8	0.133	0.117	11.232	7.7747	11.695	0.6435	0.1927574	
10	5/5/2010	10:02:13	9	0.150	0.133	11.232	7.8285	11.642	0.5897	0.2052837	
11	5/5/2010	10:02:14	10	0.167	0.150	11.232	7.878	11.592	0.5402	0.2165199	
12	5/5/2010	10:02:15	11	0.183	0.167	11.231	7.9204	11.550	0.4978	0.2310605	
13	5/5/2010	10:02:16	12	0.200	0.183	11.232	7.9625	11.508	0.4557	0.2430121	
14	5/5/2010	10:02:17	13	0.217	0.200	11.232	8.0004	11.470	0.4178	0.2778[illegible]	
15	5/5/2010	10:02:18	14	0.233	0.217	11.232	8.0325	11.438	0.3857	0.2564[illegible]	
16	5/5/2010	10:02:19	15	0.250	0.233	11.232	8.0633	11.407	0.3549	0.2589[illegible]	
17	5/5/2010	10:02:20	16	0.267	0.250	11.231	8.0906	11.379	0.3276	0.2767[illegible]	
18	5/5/2010	10:02:21	17	0.283	0.267	11.23	8.1151	11.355	0.3031	0.2015[illegible]	
19	5/5/2010	10:02:22	18	0.300	0.283	11.23	8.1395	11.331	0.2787	0.1853[illegible]	
20	5/5/2010	10:02:23	19	0.317	0.300	11.23	8.1616	11.308	0.2566	0.1706[illegible]	
21	5/5/2010	10:02:24	20	0.333	0.317	11.23	8.1805	11.290	0.2377	0.1580[illegible]	
22	5/5/2010	10:02:25	21	0.350	0.333	11.229	8.2001	11.270	0.2181	0.1450[illegible]	
23	5/5/2010	10:02:26	22	0.367	0.350	11.229	8.2158	11.254	0.2024	0.1346[illegible]	
24	5/5/2010	10:02:27	23	0.383	0.367	11.229	8.2315	11.239	0.1867	0.1241[illegible]	
25	5/5/2010	10:02:28	24	0.400	0.383	11.229	8.2454	11.225	0.1728	0.1149[illegible]	
26	5/5/2010	10:02:29	25	0.417	0.400	11.228	8.2589	11.211	0.1593	0.1058[illegible]	
27	5/5/2010	10:02:30	26	0.433	0.417	11.228	8.2709	11.199	0.1473	0.0978[illegible]	
28	5/5/2010	10:02:31	27	0.450	0.433	11.227	8.2821	11.188	0.1361	0.0904[illegible]	
29	5/5/2010	10:02:32	28	0.467	0.450	11.228	8.2931	11.177	0.1251	0.0831[illegible]	
30	5/5/2010	10:02:33	29	0.483	0.467	11.227	8.3028	11.167	0.1153	0.0766[illegible]	
31	5/5/2010	10:02:34	30	0.500	0.150	11.226	8.3123	11.158	0.1059	0.0704[illegible]	
32	5/5/2010	10:02:35	31	0.517	0.500	11.226	8.3207	11.149	0.0975	0.0648[illegible]	
33	5/5/2010	10:02:36	32	0.533	0.517	11.225	8.3292	11.141	0.089	0.0591[illegible]	
34	5/5/2010	10:02:37	33	0.550	0.533	11.225	8.3355	11.135	0.0827	0.0549[illegible]	
35	5/5/2010	10:02:38	34	0.567	0.550	11.224	8.3418	11.128	0.0764	0.0508[illegible]	
36	5/5/2010	10:02:39	35	0.583	0.567	11.224	8.3491	11.121	0.0691	0.0459[illegible]	
37	5/5/2010	10:02:40	36	0.600	0.583	11.223	8.3548	11.115	0.0634	0.0421[illegible]	
38	5/5/2010	10:02:41	37	0.617	0.600	11.223	8.3615	11.109	0.0567	0.0377[illegible]	
39	5/5/2010	10:02:42	38	0.633	0.617	11.223	8.3654	11.105	0.0528	0.0351[illegible]	
40	5/5/2010	10:02:43	39	0.650	0.633	11.222	8.3729	11.097	0.0453	0.0301[illegible]	
41	5/5/2010	10:02:44	40	0.667	0.650	11.222	8.3781	11.094	0.0421	0.0279[illegible]	
42	5/5/2010	10:02:45	41	0.683	0.667	11.221	8.3803	11.090	0.0379	0.0252[illegible]	
43	5/5/2010	10:02:46	42	0.700	0.683	11.221	8.385	11.085	0.0332	0.0220[illegible]	
44	5/5/2010	10:02:47	43	0.717	0.700	11.22	8.3888	11.081	0.0294	0.0195[illegible]	
45	5/5/2010	10:02:48	44	0.733	0.717	11.22	8.3922	11.078	0.026	0.0172[illegible]	
46	5/5/2010	10:02:49	45	0.750	0.733	11.22	8.3959	11.074	0.0223	0.0147[illegible]	
47	5/5/2010	10:02:50	46	0.767	0.750	11.219	8.3983	11.072	0.0199	0.0132[illegible]	
48	5/5/2010	10:02:51	47	0.783	0.767	11.219	8.4029	11.067	0.0153	0.0101[illegible]	
49	5/5/2010	10:02:52	48	0.800	0.783	11.218	8.4042	11.066	0.014	0.0093[illegible]	
50	5/5/2010	10:02:53	49	0.817	0.800	11.218	8.4084	11.062	0.0098	0.0065[illegible]	
51	5/5/2010	10:02:54	50	0.833	0.817	11.218	8.4099	11.060	0.0083	0.0055[illegible]	
52	5/5/2010	10:02:55	51	0.850	0.833	11.218	8.4117	11.058	0.0065	0.0043[illegible]	
53	5/5/2010	10:02:56	52	0.867	0.850	11.218	8.4145	11.056	0.0037	0.0024[illegible]	
54	5/5/2010	10:02:57	53	0.883	0.867	11.217	8.416	11.054	0.0022	0.0014[illegible]	
55	5/5/2010	10:02:58	54	0.900	0.883	11.216	8.4182	11.052	0		

Solinst	3001
Report generated:	5/11/2010
Report from file:	...\mw-3_2.csv
Serial number:	1032308
Unit name:	Solinst 3001
Test name:	AP-2 Test 2
Test defined on:	5/5/2010
Test started on:	5/5/2010 10:08:48
Test stopped on:	5/5/2010 10:09:43
Data gathered using Linear testing	
Time between data points:	1 Seconds.
Number of data samples:	57
TOTAL DATA SAMPLES	57
Channel number [1]	
Measurement type:	Level
Unit	feet
Channel number [2]	
Measurement type:	Temperature
Unit	Deg C
Sensor Range:	
Specific gravity:	
Mode:	TOC
User-defined reference*:	19.47 Feet H2O
Referenced on:	test start
Pressure head at reference:	Feet H2O

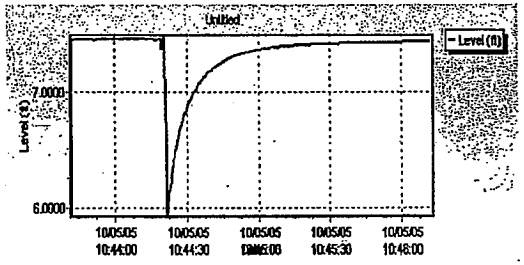
*Well depth to top of first casing terminating above ground. Does not include above ground extensions.



	Date	Time	ET (sec)	Time (min)	Test Time (min)	Temperature	Level	Water Level Bottom of well to TOC* (ft)	Change of Static Water Level (ft)	Drop	
1	5/5/2010	10:08:47	0	0.000		11.111	8.4246	11.045	0		
2	5/5/2010	10:08:48	1	0.017	0.000	11.114	6.9757	12.494	1.4489	1.4489	TEST START
3	5/5/2010	10:08:49	2	0.033	0.017	11.114	7.2067	12.263	1.2179	0.2310	SLUG REMOVED
4	5/5/2010	10:08:50	3	0.050	0.033	11.116	7.3457	12.123	1.0779	0.1400	
5	5/5/2010	10:08:51	4	0.067	0.050	11.117	7.4618	12.008	0.9627	0.1152	
6	5/5/2010	10:08:52	5	0.083	0.067	11.117	7.5593	11.911	0.8653	0.0974	
7	5/5/2010	10:08:53	6	0.100	0.083	11.117	7.6431	11.827	0.7815	0.0838	
8	5/5/2010	10:08:54	7	0.117	0.100	11.118	7.7197	11.750	0.7049	0.0766	
9	5/5/2010	10:08:55	8	0.133	0.117	11.121	7.7838	11.686	0.6408	0.0641	
10	5/5/2010	10:08:56	9	0.150	0.133	11.12	7.8425	11.628	0.5821	0.0587	
11	5/5/2010	10:08:57	10	0.167	0.150	11.12	7.8942	11.576	0.5304	0.0517	
12	5/5/2010	10:08:58	11	0.183	0.167	11.123	7.9419	11.528	0.4827	0.0477	
13	5/5/2010	10:08:59	12	0.200	0.183	11.123	7.9837	11.486	0.4409	0.0418	
14	5/5/2010	10:09:00	13	0.217	0.200	11.123	8.0214	11.449	0.4032	0.0377	
15	5/5/2010	10:09:01	14	0.233	0.217	11.124	8.0533	11.417	0.3713	0.0319	
16	5/5/2010	10:09:02	15	0.250	0.233	11.124	8.0854	11.385	0.3392	0.0321	
17	5/5/2010	10:09:03	16	0.267	0.250	11.125	8.1137	11.356	0.3109	0.0283	
18	5/5/2010	10:09:04	17	0.283	0.267	11.125	8.1388	11.333	0.2878	0.0231	
19	5/5/2010	10:09:05	18	0.300	0.283	11.127	8.1636	11.308	0.261	0.0268	
20	5/5/2010	10:09:06	19	0.317	0.300	11.126	8.1829	11.287	0.2417	0.0193	
21	5/5/2010	10:09:07	20	0.333	0.317	11.127	8.2006	11.269	0.224	0.0177	
22	5/5/2010	10:09:08	21	0.350	0.333	11.127	8.2186	11.251	0.206	0.0180	
23	5/5/2010	10:09:09	22	0.367	0.350	11.126	8.2347	11.235	0.1899	0.0161	
24	5/5/2010	10:09:10	23	0.383	0.367	11.127	8.2493	11.221	0.1753	0.0146	
25	5/5/2010	10:09:11	24	0.400	0.383	11.128	8.2622	11.208	0.1624	0.0129	
26	5/5/2010	10:09:12	25	0.417	0.400	11.128	8.275	11.195	0.1496	0.0128	
27	5/5/2010	10:09:13	26	0.433	0.417	11.128	8.2863	11.184	0.1383	0.0113	
28	5/5/2010	10:09:14	27	0.450	0.433	11.128	8.2973	11.173	0.1273	0.0110	
29	5/5/2010	10:09:15	28	0.467	0.450	11.13	8.3084	11.162	0.1162	0.0111	
30	5/5/2010	10:09:16	29	0.483	0.467	11.13	8.3162	11.155	0.1094	0.0068	
31	5/5/2010	10:09:17	30	0.500	0.150	11.128	8.3253	11.145	0.0993	0.0101	
32	5/5/2010	10:09:18	31	0.517	0.500	11.13	8.3319	11.138	0.0927	0.0066	
33	5/5/2010	10:09:19	32	0.533	0.517	11.132	8.3386	11.131	0.086	0.0067	
34	5/5/2010	10:09:20	33	0.550	0.533	11.132	8.3487	11.121	0.0759	0.0101	
35	5/5/2010	10:09:21	34	0.567	0.550	11.131	8.3532	11.117	0.0714	0.0045	
36	5/5/2010	10:09:22	35	0.583	0.567	11.132	8.3595	11.111	0.0651	0.0063	
37	5/5/2010	10:09:23	36	0.600	0.583	11.132	8.3639	11.106	0.0607	0.0044	
38	5/5/2010	10:09:24	37	0.617	0.600	11.133	8.3697	11.100	0.0549	0.0058	
39	5/5/2010	10:09:25	38	0.633	0.617	11.133	8.3747	11.095	0.0499	0.0050	
40	5/5/2010	10:09:26	39	0.650	0.633	11.133	8.3806	11.089	0.044	0.0059	
41	5/5/2010	10:09:27	40	0.667	0.650	11.134	8.3842	11.086	0.0404	0.0036	
42	5/5/2010	10:09:28	41	0.683	0.667	11.134	8.3879	11.082	0.0367	0.0037	
43	5/5/2010	10:09:29	42	0.700	0.683	11.134	8.3903	11.080	0.0343	0.0024	
44	5/5/2010	10:09:30	43	0.717	0.700	11.135	8.3943	11.076	0.0303	0.0040	
45	5/5/2010	10:09:31	44	0.733	0.717	11.134	8.3975	11.073	0.0271	0.0032	
46	5/5/2010	10:09:32	45	0.750	0.733	11.135	8.3985	11.072	0.0261	0.0010	
47	5/5/2010	10:09:33	46	0.767	0.750	11.135	8.4027	11.067	0.0219	0.0042	
48	5/5/2010	10:09:34	47	0.783	0.767	11.138	8.4058	11.064	0.0188	0.0031	
49	5/5/2010	10:09:35	48	0.800	0.783	11.135	8.4085	11.062	0.0161	0.0027	
50	5/5/2010	10:09:36	49	0.817	0.800	11.136	8.4115	11.059	0.0131	0.0030	
51	5/5/2010	10:09:37	50	0.833	0.817	11.136	8.4124	11.058	0.0122	0.0009	
52	5/5/2010	10:09:38	51	0.850	0.833	11.137	8.4148	11.055	0.0098	0.0024	
53	5/5/2010	10:09:39	52	0.867	0.850	11.138	8.4159	11.054	0.0087	0.0011	
54	5/5/2010	10:09:40	53	0.883	0.867	11.138	8.4178	11.052	0.0068	0.0019	
55	5/5/2010	10:09:41	54	0.900	0.883	11.137	8.4188	11.051	0.0058	0.0010	
56	5/5/2010	10:09:42	55	0.917	0.900	11.137	8.4221	11.048	0.0025	0.0033	
57	5/5/2010	10:09:43	56	0.933	0.917	11.138	8.4239	11.046	0.0007	0.0018	

Solinst	3001
Report generated:	5/11/2010
Report from file:	...\mw-2_1.csv
Serial number:	1032308
Unit name:	Solinst 3001
Test name:	AP-3 Test 1
Test defined on:	5/5/2010
Test started on:	5/5/2010 10:44:21
Test stopped on:	5/5/2010 11:46:28
Data gathered using Linear testing	
Time between data points:	1 Seconds
Number of data samples:	69
TOTAL DATA SAMPLES	69
Channel number [1]	
Measurement type:	Level
Unit	feet
Channel number [2]	
Measurement type:	Temperature
Unit	Deg C
Sensor Range:	
Specific gravity:	
Mode:	TOC
User-defined reference*:	19.83 Feet H2O
Referenced on:	test start
Pressure head at reference:	Feet H2O

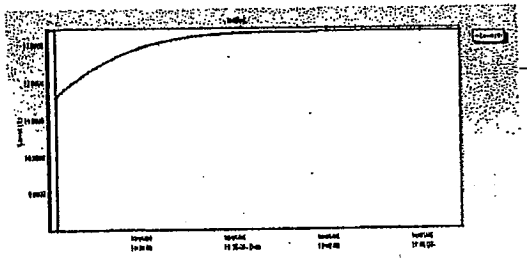
*Well depth to top of first casing terminating above ground. Does not include above ground extensions.



	Date	Time	ET (sec)	Time (min)	Test Time (min)	Temperature	Level	Water Level Bottom of well to TOC* (ft)	Change of Static Water Level (ft)	ln(h/h0)	
1	5/5/2010	10:44:20	0	0.000		11.841	7.4264	12.204	0		TEST START
2	5/5/2010	10:44:21	1	0.017	0.000	11.841	4.946	14.684	2.4804	0	SLUG REMOVED
3	5/5/2010	10:44:22	2	0.033	0.017	11.841	6.031	13.599	1.3954	-0.582570553	
4	5/5/2010	10:44:23	3	0.050	0.033	11.841	6.2314	13.399	1.195	-0.48777183	
5	5/5/2010	10:44:24	4	0.067	0.050	11.839	6.374	13.256	1.0524	-0.424288405	
6	5/5/2010	10:44:25	5	0.083	0.067	11.841	6.4939	13.136	0.9325	-0.375947425	
7	5/5/2010	10:44:26	6	0.100	0.083	11.841	6.5856	13.034	0.8308	-0.334845976	
8	5/5/2010	10:44:27	7	0.117	0.100	11.84	6.6611	12.949	0.7453	-0.300475731	
9	5/5/2010	10:44:28	8	0.133	0.117	11.841	6.7553	12.875	0.5711	-0.27055612	
10	5/5/2010	10:44:29	9	0.150	0.133	11.84	6.8204	12.810	0.606	-0.244316433	
11	5/5/2010	10:44:30	10	0.167	0.150	11.837	6.8768	12.753	0.5496	-0.221577165	
12	5/5/2010	10:44:31	11	0.183	0.167	11.839	6.9267	12.703	0.4997	-0.201459442	
13	5/5/2010	10:44:32	12	0.200	0.183	11.837	6.9731	12.657	0.4533	-0.182782782	
14	5/5/2010	10:44:33	13	0.217	0.200	11.837	7.0111	12.619	0.4153	-0.167432872	
15	5/5/2010	10:44:34	14	0.233	0.217	11.839	7.0481	12.582	0.3783	-0.152515723	
16	5/5/2010	10:44:35	15	0.250	0.233	11.836	7.0792	12.551	0.3472	-0.139977423	
17	5/5/2010	10:44:36	16	0.267	0.250	11.837	7.1094	12.521	0.317	-0.127801967	
18	5/5/2010	10:44:37	17	0.283	0.267	11.837	7.1355	12.495	0.2908	-0.117279471	
19	5/5/2010	10:44:38	18	0.300	0.283	11.837	7.1579	12.472	0.2685	-0.108248678	
20	5/5/2010	10:44:39	19	0.317	0.300	11.834	7.1803	12.450	0.2461	-0.099217868	
21	5/5/2010	10:44:40	20	0.333	0.317	11.834	7.1981	12.432	0.2283	-0.092041806	
22	5/5/2010	10:44:41	21	0.350	0.333	11.836	7.2175	12.413	0.2089	-0.084220287	
23	5/5/2010	10:44:42	22	0.367	0.350	11.834	7.2342	12.396	0.1922	-0.077481502	
24	5/5/2010	10:44:43	23	0.383	0.367	11.831	7.2477	12.382	0.1787	-0.072044631	
25	5/5/2010	10:44:44	24	0.400	0.383	11.833	7.2613	12.369	0.1651	-0.066561645	
26	5/5/2010	10:44:45	25	0.417	0.400	11.831	7.2733	12.357	0.1531	-0.061728153	
27	5/5/2010	10:44:46	26	0.433	0.417	11.83	7.2842	12.346	0.1422	-0.057329483	
28	5/5/2010	10:44:47	27	0.450	0.433	11.829	7.2947	12.335	0.1317	-0.053096275	
29	5/5/2010	10:44:48	28	0.467	0.450	11.829	7.3038	12.326	0.1226	-0.049427612	
30	5/5/2010	10:44:49	29	0.483	0.467	11.828	7.313	12.317	0.1134	-0.045718433	
31	5/5/2010	10:44:50	30	0.500	0.150	11.83	7.3204	12.310	0.106	-0.042735043	
32	5/5/2010	10:44:51	31	0.517	0.500	11.83	7.3277	12.302	0.0987	-0.039791966	
33	5/5/2010	10:44:52	32	0.533	0.517	11.827	7.3358	12.294	0.0906	-0.036529367	
34	5/5/2010	10:44:53	33	0.550	0.533	11.828	7.3408	12.289	0.0856	-0.034510563	
35	5/5/2010	10:44:54	34	0.567	0.550	11.827	7.3465	12.284	0.0799	-0.032212846	
36	5/5/2010	10:44:55	35	0.583	0.567	11.827	7.3529	12.277	0.0735	-0.029632317	
37	5/5/2010	10:44:56	36	0.600	0.583	11.825	7.3567	12.273	0.0697	-0.028100306	
38	5/5/2010	10:44:57	37	0.617	0.600	11.826	7.3618	12.268	0.0646	-0.026044185	
39	5/5/2010	10:44:58	38	0.633	0.617	11.825	7.3666	12.263	0.0598	-0.024108015	
40	5/5/2010	10:44:59	39	0.650	0.633	11.823	7.3705	12.260	0.0559	-0.022536688	
41	5/5/2010	10:45:00	40	0.667	0.650	11.824	7.3748	12.255	0.0516	-0.020803096	
42	5/5/2010	10:45:01	41	0.683	0.667	11.823	7.3783	12.252	0.0481	-0.019392034	
43	5/5/2010	10:45:02	42	0.700	0.683	11.823	7.3814	12.249	0.045	-0.018142235	
44	5/5/2010	10:45:03	43	0.717	0.700	11.821	7.3848	12.245	0.0416	-0.016771458	
45	5/5/2010	10:45:04	44	0.733	0.717	11.82	7.3878	12.242	0.0386	-0.015562006	
46	5/5/2010	10:45:05	45	0.750	0.733	11.82	7.3908	12.239	0.0356	-0.014352824	
47	5/5/2010	10:45:06	46	0.767	0.750	11.819	7.3935	12.237	0.0329	-0.01326399	
48	5/5/2010	10:45:07	47	0.783	0.767	11.818	7.3943	12.236	0.0321	-0.012941461	
49	5/5/2010	10:45:08	48	0.800	0.783	11.817	7.3971	12.233	0.0293	-0.011812611	
50	5/5/2010	10:45:09	49	0.817	0.800	11.816	7.3997	12.230	0.0267	-0.010764393	
51	5/5/2010	10:45:10	50	0.833	0.817	11.819	7.4032	12.227	0.0232	-0.009333333	
52	5/5/2010	10:45:11	51	0.850	0.833	11.816	7.4038	12.226	0.0226	-0.009111434	
53	5/5/2010	10:45:12	52	0.867	0.850	11.817	7.4051	12.225	0.0213	-0.008587325	
54	5/5/2010	10:45:13	53	0.883	0.867	11.816	7.4083	12.222	0.0181	-0.007297211	
55	5/5/2010	10:45:14	54	0.900	0.883	11.815	7.4088	12.221	0.0178	-0.007176262	
56	5/5/2010	10:45:15	55	0.917	0.900	11.813	7.411	12.219	0.0154	-0.006208678	
57	5/5/2010	10:45:16	56	0.933	0.917	11.815	7.4116	12.218	0.0148	-0.005966476	
58	5/5/2010	10:45:17	57	0.950	0.933	11.814	7.4149	12.215	0.0115	-0.004636346	
59	5/5/2010	10:45:18	58	0.967	0.950	11.813	7.4155	12.215	0.0109	-0.004394453	
60	5/5/2010	10:45:19	59	0.983	0.967	11.811	7.4162	12.214	0.0102	-0.00411224	
61	5/5/2010	10:45:20	60	1.000	0.983	11.811	7.4175	12.212	0.0088	-0.003547815	
62	5/5/2010	10:45:21	61	1.017	1.000	11.81	7.4187	12.211	0.0077	-0.003104339	
63	5/5/2010	10:45:22	62	1.033	1.017	11.81	7.4192	12.211	0.0072	-0.002902758	
64	5/5/2010	10:45:23	63	1.050	1.033	11.808	7.4215	12.209	0.0049	-0.001975486	
65	5/5/2010	10:45:24	64	1.067	1.050	11.809	7.4218	12.208	0.0046	-0.00185454	
66	5/5/2010	10:45:25	65	1.083	1.067	11.811	7.4231	12.207	0.0033	-0.001330451	
67	5/5/2010	10:45:26	66	1.100	1.083	11.81	7.4244	12.206	0.002	-0.000806422	
68	5/5/2010	10:45:27	67	1.117	1.100	11.809	7.424	12.206	0.0024	-0.000967686	
69	5/5/2010	10:45:28	68	1.133	1.117	11.807	7.4257	12.204	0.0007	-0.000282213	
70											
71											
72											
73											
74											

Solinst	3001
Report generated:	5/11/2010
Report from file:	...\MW-1.lev
Serial number:	1032308
Unit name:	Solinst 3001
Test name:	AP-4
Test defined on:	5/5/2010
Test started on:	5/5/2010 11:25:32
Test stopped on:	5/5/2010 11:25:51
Data gathered using Linear testing	
Time between data points:	0.5 Seconds
Number of data samples:	41
TOTAL DATA SAMPLES	41
Channel number [1]	
Measurement type:	Level
Unit	feet
Channel number [2]	
Measurement type:	Temperature
Unit	Deg C
Sensor Range:	
Specific gravity:	
Mode:	TOC
User-defined reference*:	58.93 Feet H2O
Referenced on:	test start
Pressure head at reference:	Feet H2O

*Well depth to top of first casing terminating above ground. Does not include above ground extensions.



	Date	Time	ET (sec)	Time (min)	Test Time (min)	Temperature	Level	Water Level Bottom of well to TOC* (ft)	Change of Static Water Level (ft)	Ratio	
1	5/5/2010	11:25:31	0	0.000		12.799	13.4081	45.522	0		TEST START
2	5/5/2010	11:25:31	0	0.000	0.000	12.789	11.9721	46.958	1.436		
3	5/5/2010	11:25:32	0.5	0.008	0.008	12.794	8.02838	50.904	5.38172		SLUG REMOVED
4	5/5/2010	11:25:32	1	0.017	0.017	12.785	11.2523	47.678	2.1558	0.400578264	
5	5/5/2010	11:25:33	1.5	0.025	0.025	12.79	11.5307	47.399	1.8774	0.34884766	
6	5/5/2010	11:25:33	2	0.033	0.033	12.781	11.5481	47.382	1.86	0.246614413	
7	5/5/2010	11:25:34	2.5	0.042	0.042	12.785	11.6979	47.332	1.8102	0.336380868	
8	5/5/2010	11:25:34	3	0.050	0.050	12.776	11.5927	47.337	1.8154	0.337327	
9	5/5/2010	11:25:35	3.5	0.058	0.058	12.78	11.6036	47.326	1.8045	0.335301225	
10	5/5/2010	11:25:35	4	0.067	0.067	12.771	11.6202	47.310	1.7879	0.332217209	
11	5/5/2010	11:25:36	4.5	0.075	0.075	12.775	11.8344	47.296	1.7737	0.329578648	
12	5/5/2010	11:25:36	5	0.083	0.083	12.766	11.6361	47.294	1.772	0.329282764	
13	5/5/2010	11:25:37	5.5	0.092	0.092	12.771	11.6445	47.286	1.7636	0.32770192	
14	5/5/2010	11:25:37	6	0.100	0.100	12.763	11.6514	47.279	1.7567	0.326410606	
15	5/5/2010	11:25:38	6.5	0.108	0.108	12.767	11.6587	47.271	1.7494	0.325063363	
16	5/5/2010	11:25:38	7	0.117	0.117	12.758	11.6626	47.267	1.7455	0.324336567	
17	5/5/2010	11:25:39	7.5	0.125	0.125	12.762	11.669	47.261	1.7391	0.323148479	
18	5/5/2010	11:25:39	8	0.133	0.133	12.752	11.6739	47.256	1.7342	0.322238987	
19	5/5/2010	11:25:40	8.5	0.142	0.142	12.758	11.6784	47.251	1.7297	0.321217009	
20	5/5/2010	11:25:40	9	0.150	0.150	12.749	11.6836	47.246	1.7245	0.320436569	
21	5/5/2010	11:25:41	9.5	0.158	0.158	12.753	11.6884	47.242	1.7197	0.319544461	
22	5/5/2010	11:25:41	10	0.167	0.167	12.743	11.6921	47.238	1.716	0.318867169	
23	5/5/2010	11:25:42	10.5	0.175	0.175	12.746	11.6969	47.233	1.7112	0.31796528	
24	5/5/2010	11:25:42	11	0.183	0.183	12.739	11.7013	47.229	1.7068	0.317147676	
25	5/5/2010	11:25:43	11.5	0.192	0.192	12.745	11.7049	47.225	1.7032	0.316476747	
26	5/5/2010	11:25:43	12	0.200	0.200	12.735	11.7092	47.221	1.6989	0.315679749	
27	5/5/2010	11:25:44	12.5	0.208	0.208	12.74	11.7131	47.217	1.695	0.314966607	
28	5/5/2010	11:25:44	13	0.217	0.217	12.731	11.7157	47.214	1.6924	0.314470953	
29	5/5/2010	11:25:45	13.5	0.225	0.225	12.735	11.7212	47.209	1.6869	0.313449976	
30	5/5/2010	11:25:45	14	0.233	0.233	12.726	11.7248	47.205	1.6833	0.312781044	
31	5/5/2010	11:25:46	14.5	0.242	0.075	12.731	11.7288	47.201	1.6793	0.312037787	
32	5/5/2010	11:25:46	15	0.250	0.250	12.722	11.7311	47.199	1.677	0.311610415	
33	5/5/2010	11:25:47	15.5	0.258	0.258	12.727	11.7354	47.195	1.6727	0.3108141	
34	5/5/2010	11:25:47	16	0.267	0.267	12.719	11.7394	47.191	1.6687	0.310068157	
35	5/5/2010	11:25:48	16.5	0.275	0.275	12.723	11.743	47.187	1.6651	0.309389228	
36	5/5/2010	11:25:48	17	0.283	0.283	12.713	11.7467	47.183	1.6614	0.308711713	
37	5/5/2010	11:25:49	17.5	0.292	0.292	12.718	11.75	47.180	1.6581	0.308098625	
38	5/5/2010	11:25:49	18	0.300	0.300	12.709	11.7528	47.177	1.6552	0.307569645	
39	5/5/2010	11:25:50	18.5	0.308	0.308	12.714	11.7568	47.173	1.6513	0.306834486	
40	5/5/2010	11:25:50	19	0.317	0.317	12.705	11.7612	47.169	1.6469	0.306017407	
41	5/5/2010	11:25:51	19.5	0.325	0.325	12.709	11.7641	47.166	1.644	0.305478546	

SIEVE ANALYSIS WORKSHEET

CLIENT: CWLP
Environmental Health & Safety

PROJECT: Piezometer Installation
CWLP Ash Ponds
Springfield, IL

DATE: April 26, 2010

PSI REPORT NO. 0020522-1

GENERAL SAMPLE INFORMATION

SAMPLE TYPE: Clayey SILT, Some Fine to Coarse Sand	SAMPLED BY: PSI DATE SAMPLED: 4/21/2010
SAMPLE SOURCE: AP-1, 3'-7'	TESTED BY: Don Reed DATE TESTED: April 26, 2010
SPECIFICATIONS: ASTM C136	NOTES/OBSERVATIONS NP=Not Provided to PSI

SIEVE ANALYSIS DATA/RESULTS		TEST METHOD
Original "Wet" Sample Mass (OSM) + Pan:	996.3	ASTM C136
Pan Weight:	93.2	
Original "Wet" Sample Mass (OSM):	903.1	
Total "Dry" Sample Mass (TSM) + Pan:	820.4	
Pan Weight:	93.2	
Total "Dry" Sample Mass (TSM):	727.2	
Total "Dry" Washed Sample Mass (TWM) + Pan Wt.	182.6	
Pan Weight:	93.2	
Total "Dry" Washed Sample Mass (TWM), grams	89.4	

Sieve Size metric (English)	Individual Weight (g)	Cumulative Weight (g)	Percent Retained (%)	Percent Passing (%)	Specification
37.5 (1 1/2)	0.0	0.0	0.0	100.0	NP
25 (1)	0.0	0.0	0.0	100.0	NP
19 (3/4)	0.0	0.0	0.0	100.0	NP
16 (5/8)	0.0	0.0	0.0	100.0	NP
12.5 (1/2)	0.0	0.0	0.0	100.0	NP
9.5 (3/8)	0.0	0.0	0.0	100.0	NP
6.3 (1/4)	0.4	0.4	0.1	99.9	NP
4.75 (4)	1.2	1.6	0.2	99.8	NP
2.36 (8)	3.0	4.6	0.6	99.4	NP
1.18 (16)	2.1	6.7	0.9	99.1	NP
0.6 (30)	5.3	12.0	1.7	98.3	NP
0.425 (40)	0.0	12.0	1.7	98.3	NP
0.3 (50)	7.9	19.9	2.7	97.3	NP
0.15 (100)	27.4	47.3	6.5	93.5	NP
0.075 (200)	39.3	86.6	11.9	88.1	NP
Pan					

SIEVE ANALYSIS WORKSHEET

CLIENT: CWLP
Environmental Health & Safety

PROJECT: Piezometer Installation
CWLP Ash Ponds
Springfield, IL

DATE: April 26, 2010

PSI REPORT NO. 0020522-1

GENERAL SAMPLE INFORMATION

SAMPLE TYPE: Clayey SILT, Some Fine to Coarse Sand	SAMPLED BY: PSI DATE SAMPLED: 4/21/2010
SAMPLE SOURCE: AP-1, 10'-15'	TESTED BY: Don Reed DATE TESTED: April 26, 2010
SPECIFICATIONS: ASTM C136	NOTES/OBSERVATIONS NP=Not Provided to PSI

SIEVE ANALYSIS DATA/RESULTS		TEST METHOD
Original "Wet" Sample Mass (OSM) + Pan:	1030.6	ASTM C136
Pan Weight:	93.5	
Original "Wet" Sample Mass (OSM):	937.1	
Total "Dry" Sample Mass (TSM) + Pan:	814.4	
Pan Weight:	93.5	
Total "Dry" Sample Mass (TSM):	720.9	
Total "Dry" Washed Sample Mass (TWM) + Pan Wt.	247.0	
Pan Weight:	93.5	
Total "Dry" Washed Sample Mass (TWM), grams	153.5	

Sieve Size metric (English)	Individual Weight (g)	Cumulative Weight (g)	Percent Retained (%)	Percent Passing (%)	Specification
37.5 (1 1/2)	0.0	0.0	0.0	100.0	NP
25 (1)	0.0	0.0	0.0	100.0	NP
19 (3/4)	0.0	0.0	0.0	100.0	NP
16 (5/8)	0.0	0.0	0.0	100.0	NP
12.5 (1/2)	0.0	0.0	0.0	100.0	NP
9.5 (3/8)	0.9	0.9	0.1	99.9	NP
6.3 (1/4)	0.9	1.8	0.2	99.8	NP
4.75 (4)	3.1	4.9	0.7	99.3	NP
2.36 (8)	21.1	26.0	3.6	96.4	NP
1.18 (16)	40.7	66.7	9.3	90.7	NP
0.6 (30)	31.2	97.9	13.6	86.4	NP
0.425 (40)	0.0	97.9	13.6	86.4	NP
0.3 (50)	14.4	112.3	15.6	84.4	NP
0.15 (100)	14.7	127.0	17.6	82.4	NP
0.075 (200)	25.6	152.6	21.2	78.8	NP
Pan					

SIEVE ANALYSIS WORKSHEET

CLIENT: CWLP
Environmental Health & Safety

PROJECT: Piezometer Installation
CWLP Ash Ponds
Springfield, IL

DATE: April 26, 2010

PSI REPORT NO. 0020522-1

GENERAL SAMPLE INFORMATION

SAMPLE TYPE: Clayey SILT, Some Fine to Coarse Sand	SAMPLED BY: PSI DATE SAMPLED: 4/21/2010
SAMPLE SOURCE: AP-2, 3'-7'	TESTED BY: Don Reed DATE TESTED: April 26, 2010
SPECIFICATIONS: ASTM C136	NOTES/OBSERVATIONS NP=Not Provided to PSI

SIEVE ANALYSIS DATA/RESULTS		TEST METHOD
Original "Wet" Sample Mass (OSM) + Pan:	1706.4	ASTM C136
Pan Weight:	90.7	
Original "Wet" Sample Mass (OSM):	1615.7	
Total "Dry" Sample Mass (TSM) + Pan:	1381.0	
Pan Weight:	90.7	
Total "Dry" Sample Mass (TSM):	1290.3	
Total "Dry" Washed Sample Mass (TWM) + Pan Wt.	420.6	
Pan Weight:	90.7	
Total "Dry" Washed Sample Mass (TWM), grams	329.9	

Sieve Size metric (English)	Individual Weight (g)	Cumulative Weight (g)	Percent Retained (%)	Percent Passing (%)	Specification
37.5 (1 1/2)	0.0	0.0	0.0	100.0	NP
25 (1)	0.0	0.0	0.0	100.0	NP
19 (3/4)	0.0	0.0	0.0	100.0	NP
16 (5/8)	0.0	0.0	0.0	100.0	NP
12.5 (1/2)	0.0	0.0	0.0	100.0	NP
9.5 (3/8)	3.5	3.5	0.3	99.7	NP
6.3 (1/4)	2.3	5.8	0.4	99.6	NP
4.75 (4)	2.7	8.5	0.7	99.3	NP
2.36 (8)	6.6	15.1	1.2	98.8	NP
1.18 (16)	7.0	22.1	1.7	98.3	NP
0.6 (30)	8.0	30.1	2.3	97.7	NP
0.425 (40)	0.0	30.1	2.3	97.7	NP
0.3 (50)	18.1	48.2	3.7	96.3	NP
0.15 (100)	119.7	167.9	13.0	87.0	NP
0.075 (200)	156.2	324.1	25.1	74.9	NP
Pan					

SIEVE ANALYSIS WORKSHEET

CLIENT:	CWLP Environmental Health & Safety	PROJECT:	Piezometer Installation CWLP Ash Ponds Springfield, IL
DATE:	April 26, 2010	PSI REPORT NO.	0020522-1 Page 4 of 8

GENERAL SAMPLE INFORMATION

SAMPLE TYPE: Clayey SILT, Some Fine to Coarse Sand	SAMPLED BY: PSI DATE SAMPLED: 4/21/2010
SAMPLE SOURCE: AP-2, 9'-16'	TESTED BY: Don Reed DATE TESTED: April 26, 2010
SPECIFICATIONS: ASTM C136	NOTES/OBSERVATIONS NP=Not Provided to PSI

SIEVE ANALYSIS DATA/RESULTS		TEST METHOD
Original "Wet" Sample Mass (OSM) + Pan:	1461.6	ASTM C136
Pan Weight:	173.0	
Original "Wet" Sample Mass (OSM):	1288.6	
Total "Dry" Sample Mass (TSM) + Pan:	1178.1	
Pan Weight:	173.0	
Total "Dry" Sample Mass (TSM):	1005.1	
Total "Dry" Washed Sample Mass (TWM) + Pan Wt.	319.2	
Pan Weight:	173.0	
Total "Dry" Washed Sample Mass (TWM), grams	146.2	

Sieve Size metric (English)	Individual Weight (g)	Cumulative Weight (g)	Percent Retained (%)	Percent Passing (%)	Specification
37.5 (1 1/2)	0.0	0.0	0.0	100.0	NP
25 (1)	0.0	0.0	0.0	100.0	NP
19 (3/4)	0.0	0.0	0.0	100.0	NP
16 (5/8)	0.0	0.0	0.0	100.0	NP
12.5 (1/2)	0.0	0.0	0.0	100.0	NP
9.5 (3/8)	0.0	0.0	0.0	100.0	NP
6.3 (1/4)	0.8	0.8	0.1	99.9	NP
4.75 (4)	1.2	2.0	0.2	99.8	NP
2.36 (8)	1.5	3.5	0.3	99.7	NP
1.18 (16)	2.8	6.3	0.6	99.4	NP
0.6 (30)	5.7	12.0	1.2	98.8	NP
0.425 (40)	0.0	12.0	1.2	98.8	NP
0.3 (50)	7.2	19.2	1.9	98.1	NP
0.15 (100)	42.1	61.3	6.1	93.9	NP
0.075 (200)	82.8	144.1	14.3	85.7	NP
Pan					

SIEVE ANALYSIS WORKSHEET

CLIENT: CWLP
Environmental Health & Safety

PROJECT: Piezometer Installation
CWLP Ash Ponds
Springfield, IL

DATE: April 26, 2010

PSI REPORT NO. 0020522-1

GENERAL SAMPLE INFORMATION

SAMPLE TYPE: Clayey SILT, Some Fine to Coarse Sand, Trace Subround Gravel	SAMPLED BY: PSI DATE SAMPLED: 4/21/2010
SAMPLE SOURCE: AP-3, 3'-6'	TESTED BY: Don Reed DATE TESTED: April 26, 2010
SPECIFICATIONS: ASTM C136	NOTES/OBSERVATIONS NP=Not Provided to PSI

SIEVE ANALYSIS DATA/RESULTS		TEST METHOD
Original "Wet" Sample Mass (OSM) + Pan:	816.4	ASTM C136
Pan Weight:	94.6	
Original "Wet" Sample Mass (OSM):	721.8	
Total "Dry" Sample Mass (TSM) + Pan:	663.7	
Pan Weight:	94.6	
Total "Dry" Sample Mass (TSM):	569.1	
Total "Dry" Washed Sample Mass (TWM) + Pan Wt.	195.2	
Pan Weight:	94.6	
Total "Dry" Washed Sample Mass (TWM), grams	100.6	

Sieve Size metric (English)	Individual Weight (g)	Cumulative Weight (g)	Percent Retained (%)	Percent Passing (%)	Specification
37.5 (1 1/2)	0.0	0.0	0.0	100.0	NP
25 (1)	0.0	0.0	0.0	100.0	NP
19 (3/4)	0.0	0.0	0.0	100.0	NP
16 (5/8)	0.0	0.0	0.0	100.0	NP
12.5 (1/2)	0.0	0.0	0.0	100.0	NP
9.5 (3/8)	2.5	2.5	0.4	99.6	NP
6.3 (1/4)	0.4	2.9	0.5	99.5	NP
4.75 (4)	0.4	3.3	0.6	99.4	NP
2.36 (8)	1.3	4.6	0.8	99.2	NP
1.18 (16)	3.6	8.2	1.4	98.6	NP
0.6 (30)	7.6	15.8	2.8	97.2	NP
0.425 (40)	0.0	15.8	2.8	97.2	NP
0.3 (50)	10.2	26.0	4.6	95.4	NP
0.15 (100)	31.7	57.7	10.1	89.9	NP
0.075 (200)	41.5	99.2	17.4	82.6	NP
Pan					

SIEVE ANALYSIS WORKSHEET

CLIENT: CWLP
Environmental Health & Safety

PROJECT: Piezometer Installation
CWLP Ash Ponds
Springfield, IL

DATE: April 26, 2010

PSI REPORT NO. 0020522-1

GENERAL SAMPLE INFORMATION

SAMPLE TYPE: Clayey SILT, Some Fine to Coarse Sand	SAMPLED BY: PSI DATE SAMPLED: 4/21/2010
SAMPLE SOURCE: AP-3, 10'-15'	TESTED BY: Don Reed DATE TESTED: April 26, 2010
SPECIFICATIONS: ASTM C136	NOTES/OBSERVATIONS NP=Not Provided to PSI

SIEVE ANALYSIS DATA/RESULTS		TEST METHOD
Original "Wet" Sample Mass (OSM) + Pan:	1010.5	ASTM C136
Pan Weight:	104.2	
Original "Wet" Sample Mass (OSM):	906.3	
Total "Dry" Sample Mass (TSM) + Pan:	812.2	
Pan Weight:	104.2	
Total "Dry" Sample Mass (TSM):	708.0	
Total "Dry" Washed Sample Mass (TWM) + Pan Wt.	250.7	
Pan Weight:	104.2	
Total "Dry" Washed Sample Mass (TWM), grams	146.5	

Sieve Size metric (English)	Individual Weight (g)	Cumulative Weight (g)	Percent Retained (%)	Percent Passing (%)	Specification
37.5 (1 1/2)	0.0	0.0	0.0	100.0	NP
25 (1)	0.0	0.0	0.0	100.0	NP
19 (3/4)	0.0	0.0	0.0	100.0	NP
16 (5/8)	0.0	0.0	0.0	100.0	NP
12.5 (1/2)	0.0	0.0	0.0	100.0	NP
9.5 (3/8)	0.0	0.0	0.0	100.0	NP
6.3 (1/4)	1.8	1.8	0.3	99.7	NP
4.75 (4)	0.4	2.2	0.3	99.7	NP
2.36 (8)	3.4	5.6	0.8	99.2	NP
1.18 (16)	5.5	11.1	1.6	98.4	NP
0.6 (30)	7.4	18.5	2.6	97.4	NP
0.425 (40)	0.0	18.5	2.6	97.4	NP
0.3 (50)	16.6	35.1	5.0	95.0	NP
0.15 (100)	52.0	87.1	12.3	87.7	NP
0.075 (200)	56.8	143.9	20.3	79.7	NP
Pan					

SIEVE ANALYSIS WORKSHEET

CLIENT: CWLP
Environmental Health & Safety

PROJECT: Piezometer Installation
CWLP Ash Ponds
Springfield, IL

DATE: April 26, 2010

PSI REPORT NO. 0020522-1

GENERAL SAMPLE INFORMATION

SAMPLE TYPE: Composite of FLY ASH and Silty CLAY, With Fine to Coarse Sand, Trace Subround gravel	SAMPLED BY: PSI
	DATE SAMPLED: 4/20/2010
SAMPLE SOURCE: AP-4, 18'-23'	TESTED BY: Don Reed
	DATE TESTED: April 26, 2010
SPECIFICATIONS: ASTM C136	NOTES/OBSERVATIONS NP=Not Provided to PSI

SIEVE ANALYSIS DATA/RESULTS		TEST METHOD
Original "Wet" Sample Mass (OSM) + Pan:	1931.9	ASTM C136
Pan Weight:	147.6	
Original "Wet" Sample Mass (OSM):	1784.3	
Total "Dry" Sample Mass (TSM) + Pan:	1596.1	
Pan Weight:	147.6	
Total "Dry" Sample Mass (TSM):	1448.5	
Total "Dry" Washed Sample Mass (TWM) + Pan Wt.	752.6	
Pan Weight:	147.6	
Total "Dry" Washed Sample Mass (TWM), grams	605.0	

Sieve Size metric (English)	Individual Weight (g)	Cumulative Weight (g)	Percent Retained (%)	Percent Passing (%)	Specification
37.5 (1 1/2)	0.0	0.0	0.0	100.0	NP
25 (1)	0.0	0.0	0.0	100.0	NP
19 (3/4)	0.0	0.0	0.0	100.0	NP
16 (5/8)	8.2	8.2	5.6	94.4	NP
12.5 (1/2)	0.0	8.2	0.6	99.4	NP
9.5 (3/8)	2.5	10.7	0.7	99.3	NP
6.3 (1/4)	12.3	23.0	1.6	98.4	NP
4.75 (4)	10.8	33.8	2.3	97.7	NP
2.36 (8)	52.2	86.0	5.9	94.1	NP
1.18 (16)	144.3	230.3	15.9	84.1	NP
0.6 (30)	132.2	362.5	25.0	75.0	NP
0.425 (40)	0.0	362.5	25.0	75.0	NP
0.3 (50)	110.4	472.9	32.6	67.4	NP
0.15 (100)	75.1	548.0	37.8	62.2	NP
0.075 (200)	53.5	601.5	41.5	58.5	NP
Pan					

SIEVE ANALYSIS WORKSHEET

CLIENT: CWLP
Environmental Health & Safety

PROJECT: Piezometer Installation
CWLP Ash Ponds
Springfield, IL

DATE: April 26, 2010

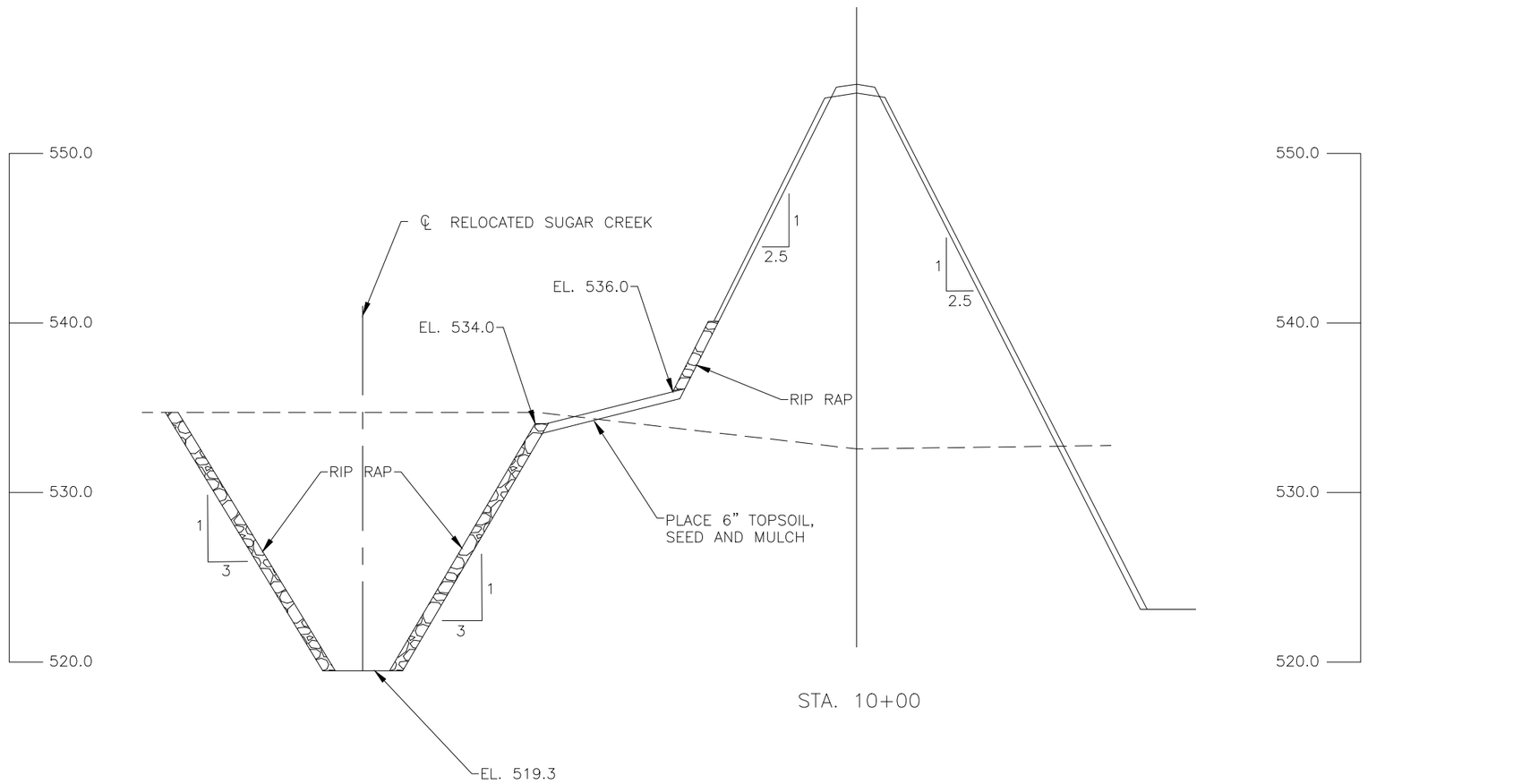
PSI REPORT NO. 0020522-1

GENERAL SAMPLE INFORMATION

SAMPLE TYPE: Clayey SILT With Fine to Coarse Sand, Trace Subround Gravel	SAMPLED BY: PSI DATE SAMPLED: 4/20/2010
SAMPLE SOURCE: AP-4, 45'-55'	TESTED BY: Don Reed DATE TESTED: April 26, 2010
SPECIFICATIONS: ASTM C136	NOTES/OBSERVATIONS NP=Not Provided to PSI

SIEVE ANALYSIS DATA/RESULTS		TEST METHOD
Original "Wet" Sample Mass (OSM) + Pan:	1855.4	ASTM C136
Pan Weight:	99.7	
Original "Wet" Sample Mass (OSM):	1755.7	
Total "Dry" Sample Mass (TSM) + Pan:	1509.0	
Pan Weight:	99.7	
Total "Dry" Sample Mass (TSM):	1409.3	
Total "Dry" Washed Sample Mass (TWM) + Pan Wt.	584.6	
Pan Weight:	99.7	
Total "Dry" Washed Sample Mass (TWM), grams	484.9	

Sieve Size metric (English)	Individual Weight (g)	Cumulative Weight (g)	Percent Retained (%)	Percent Passing (%)	Specification
37.5 (1 1/2)	0.0	0.0	0.0	100.0	NP
25 (1)	0.0	0.0	0.0	100.0	NP
19 (3/4)	0.0	0.0	0.0	100.0	NP
16 (5/8)	0.0	0.0	0.0	100.0	NP
12.5 (1/2)	0.0	0.0	0.0	100.0	NP
9.5 (3/8)	2.7	2.7	0.2	99.8	NP
6.3 (1/4)	6.7	9.4	0.7	99.3	NP
4.75 (4)	11.0	20.4	1.4	98.6	NP
2.36 (8)	31.4	51.8	3.7	96.3	NP
1.18 (16)	35.3	87.1	6.2	93.8	NP
0.6 (30)	55.9	143.0	10.1	89.9	NP
0.425 (40)	0.0	143.0	10.1	89.9	NP
0.3 (50)	162.8	305.8	21.7	78.3	NP
0.15 (100)	94.7	400.5	28.4	71.6	NP
0.075 (200)	82.5	483.0	34.3	65.7	NP
Pan					



STA. 10+00

HORIZ. 0 20 40 80
VERT. 0 4 8 16
SCALE: IN FEET

NOTES:
CROSS-SECTION BASED ON CONSTRUCTION PLAN DRAWINGS
PREPARED BY BURNS & McDONNEL IN AUGUST 1976

REVISIONS

NO.	DATE	DESCRIPTION	BY

ANDREWS ENGINEERING, INC.
3300 GINGER CREEK DRIVE
SPRINGFIELD, ILLINOIS 62711-7233
PH (217) 787-2334 FAX (217) 787-9495
PONTIAC, IL • LOMBARD, IL • INDIANAPOLIS, IN • WARRENTON, MO
PROFESSIONAL DESIGN ENGINEERING AND LAND SURVEYING FIRM #184001541

APPROVED BY: PMV | DESIGNED BY: PMV | DRAWN BY: RMC

DALLMAN ASH POND CROSS-SECTION AT STA. 10+00

PLANS PREPARED FOR
CITY, WATER, LIGHT & POWER
SPRINGFIELD, SANGAMON COUNTY, ILLINOIS

DATE: OCTOBER 2016

PROJECT ID: 150077/0011

SHEET NUMBER:

X-SEC.

© 2016 Andrews Engineering, Inc.

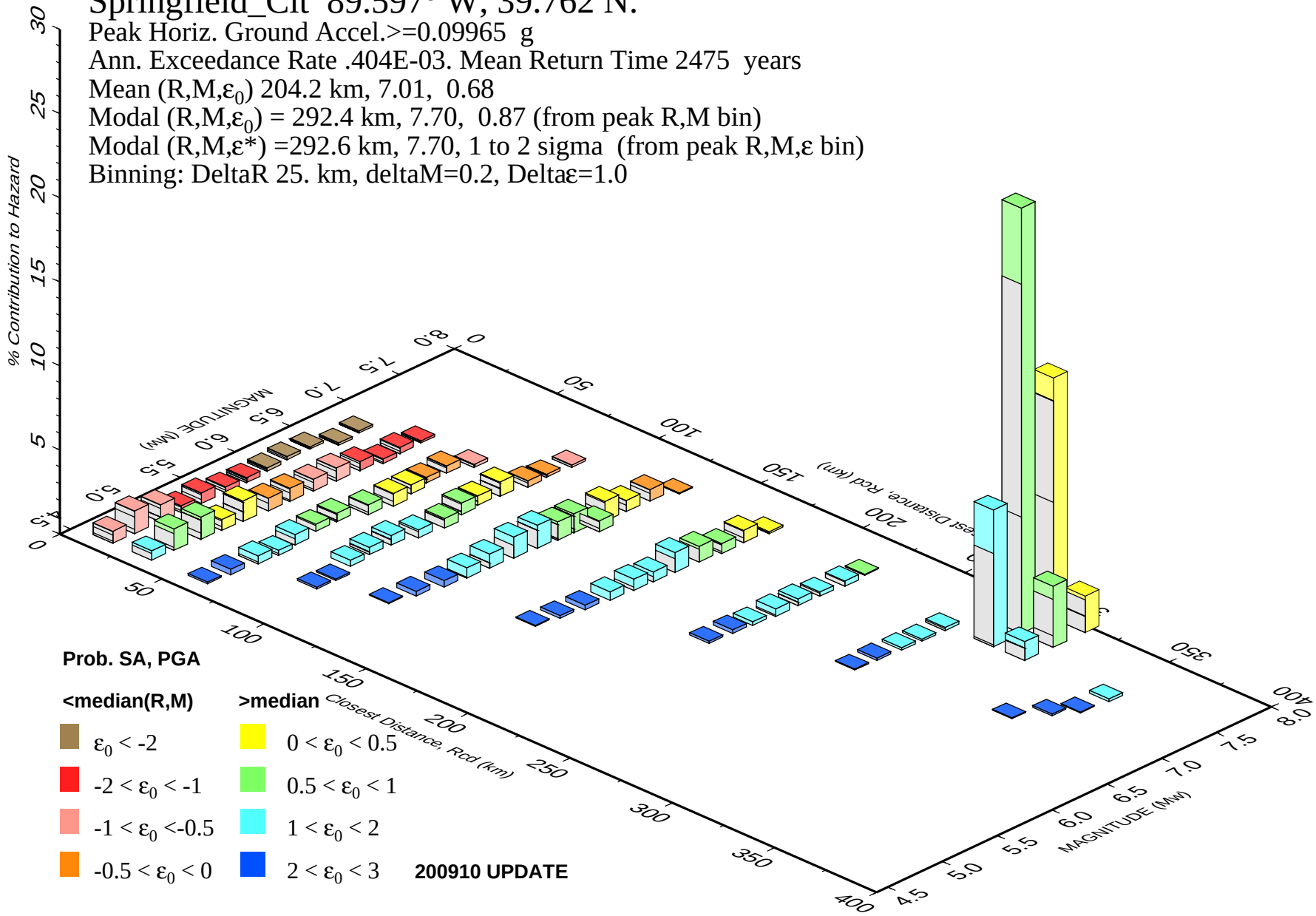
J:\S\Springfield CWLP\CWLP\dwg\DALLMAN X-SEC.dwg Tab: Layout1 Last Saved: October 7, 2016, by Ryan Curtis Plotted: Friday, October 07, 2016 4:17:38 PM

APPENDIX E

USGS Earthquake Hazards Program
Probabilistic Seismic Hazard Analysis

PSH Deaggregation on NEHRP BC rock
Springfield_Cit 89.597º W, 39.762 N.

Peak Horiz. Ground Accel.>=0.09965 g
Ann. Exceedance Rate .404E-03. Mean Return Time 2475 years
Mean (R,M,ε_0) 204.2 km, 7.01, 0.68
Modal (R,M,ε_0) = 292.4 km, 7.70, 0.87 (from peak R,M bin)
Modal (R,M,ε*) =292.6 km, 7.70, 1 to 2 sigma (from peak R,M,ε bin)
Binning: DeltaR 25. km, deltaM=0.2, Deltaε=1.0

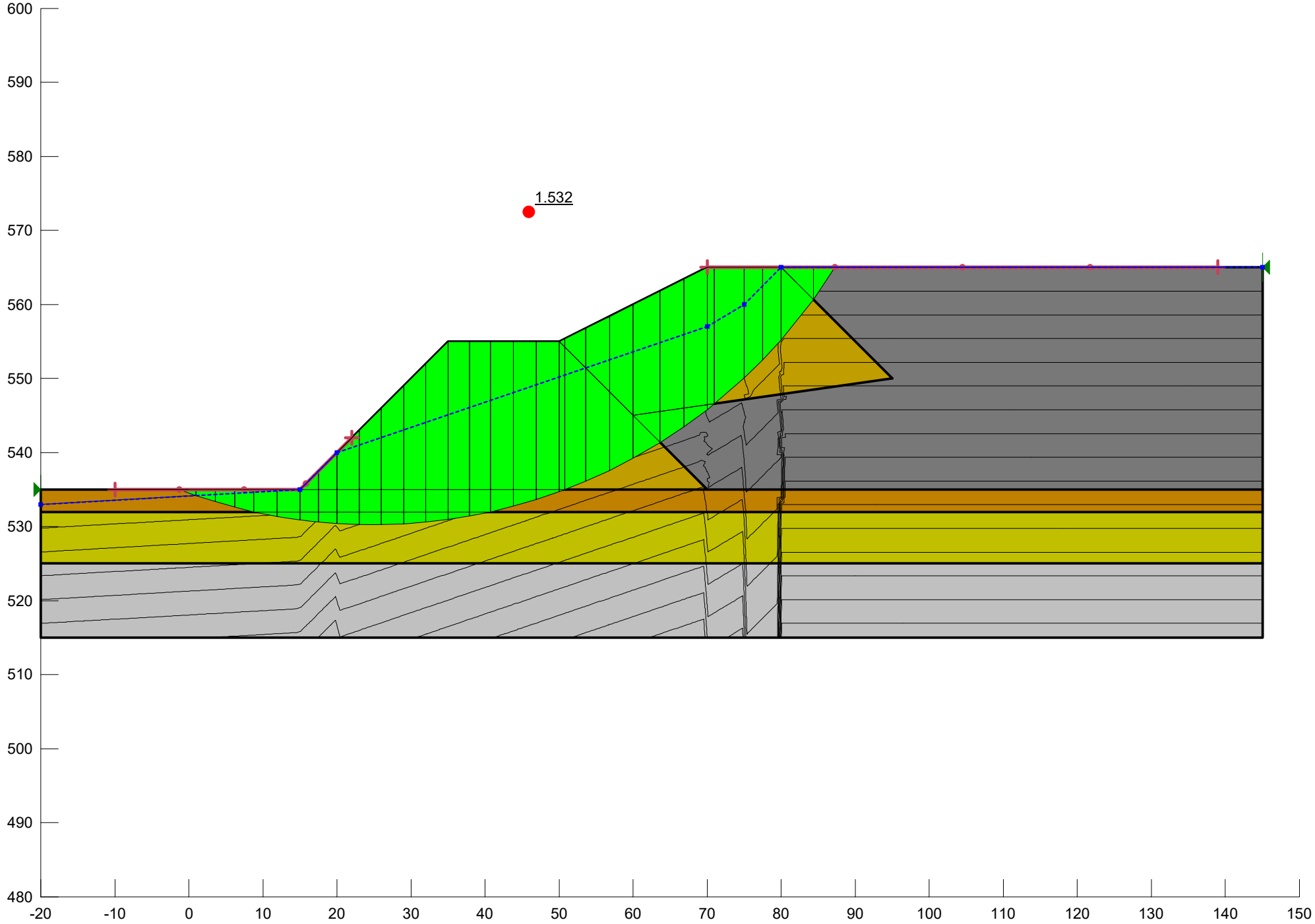


APPENDIX F

Lakeside Ash Pond Slope Stability Analysis

APPENDIX F-1

Long-Term Static Slope Stability Analysis


1.532
600
590
580
570
560
550
540
530
520
510
500
490
480
-20
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150

CWLP Lakeside Long Term Static

Report generated using GeoStudio 2012. Copyright © 1991-2014 GEO-SLOPE International Ltd.

File Information

File Version: 8.14
Created By: Karl Finke
Last Edited By: Karl Finke
Revision Number: 47
Date: 10/3/2016
Time: 2:09:57 PM
Tool Version: 8.14.1.10087
File Name: CWLP Lakeside Long Term Section 2.gsz
Directory: J:\CWLP Factor of Safety Report\SlopeW\
Last Solved Date: 10/3/2016
Last Solved Time: 2:09:59 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

CWLP Lakeside Long Term Static

Description: CWLP Lakeside
Kind: SLOPE/W
Method: Morgenstern-Price
Settings
    Side Function
        Interslice force function option: Half-Sine
    PWP Conditions Source: Piezometric Line
    Apply Phreatic Correction: Yes
    Use Staged Rapid Drawdown: No
Slip Surface
    Direction of movement: Right to Left
    Use Passive Mode: No
    Slip Surface Option: Entry and Exit
    Critical slip surfaces saved: 1

Resisting Side Maximum Convex Angle: 1 °
Driving Side Maximum Convex Angle: 5 °
Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Brn Gry Sandy Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 145 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Brn Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 190 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Yel Brn Gry VF Sandy Silt

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 190 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gray Clayey Shale

Model: Mohr-Coulomb

Unit Weight: 130 pcf
Cohesion': 2,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Ash

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-10, 535) ft
Left-Zone Right Coordinate: (22, 542) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (70, 565) ft
Right-Zone Right Coordinate: (139, 565) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (-20, 535) ft
Right Coordinate: (145, 565) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-20	533
Coordinate 2	15	535
Coordinate 3	20	540
Coordinate 4	70	557
Coordinate 5	75	560
Coordinate 6	80	565
Coordinate 7	145	565

Points

	X (ft)	Y (ft)
Point 1	15	535
Point 2	35	555
Point 3	50	555
Point 4	60	545
Point 5	70	535
Point 6	70	565
Point 7	80	565
Point 8	95	550
Point 9	145	565
Point 10	-20	535
Point 11	145	535
Point 12	-20	532
Point 13	145	532
Point 14	-20	525
Point 15	145	525
Point 16	-20	515
Point 17	145	515

Regions

	Material	Points	Area (ft²)
Region 1	Brn Gry Sandy Silty Clay	1,2,3,4,5	700
Region 2	Brn Gry Sandy Silty Clay	3,6,7,8,4	550
Region 3	Brn Silty Clay	10,1,5,11,13,12	495
Region 4	Yel Brn Gry VF Sandy Silt	12,14,15,13	1,155
Region 5	Ash	8,4,5,11,9,7	2,000
Region 6	Gray Clayey Shale	14,16,17,15	1,650

Current Slip Surface

Slip Surface: 33
F of S: 1.532
Volume: 1,258.2941 ft³
Weight: 150,210.74 lbs
Resisting Moment: 5,434,428.4 lbs-ft
Activating Moment: 3,545,823.9 lbs-ft
Resisting Force: 68,187.197 lbs
Activating Force: 44,512.413 lbs
F of S Rank: 1
Exit: (-1.2751263, 535) ft
Entry: (87.25, 565) ft
Radius: 73.560778 ft
Center: (24.754863, 603.80136) ft

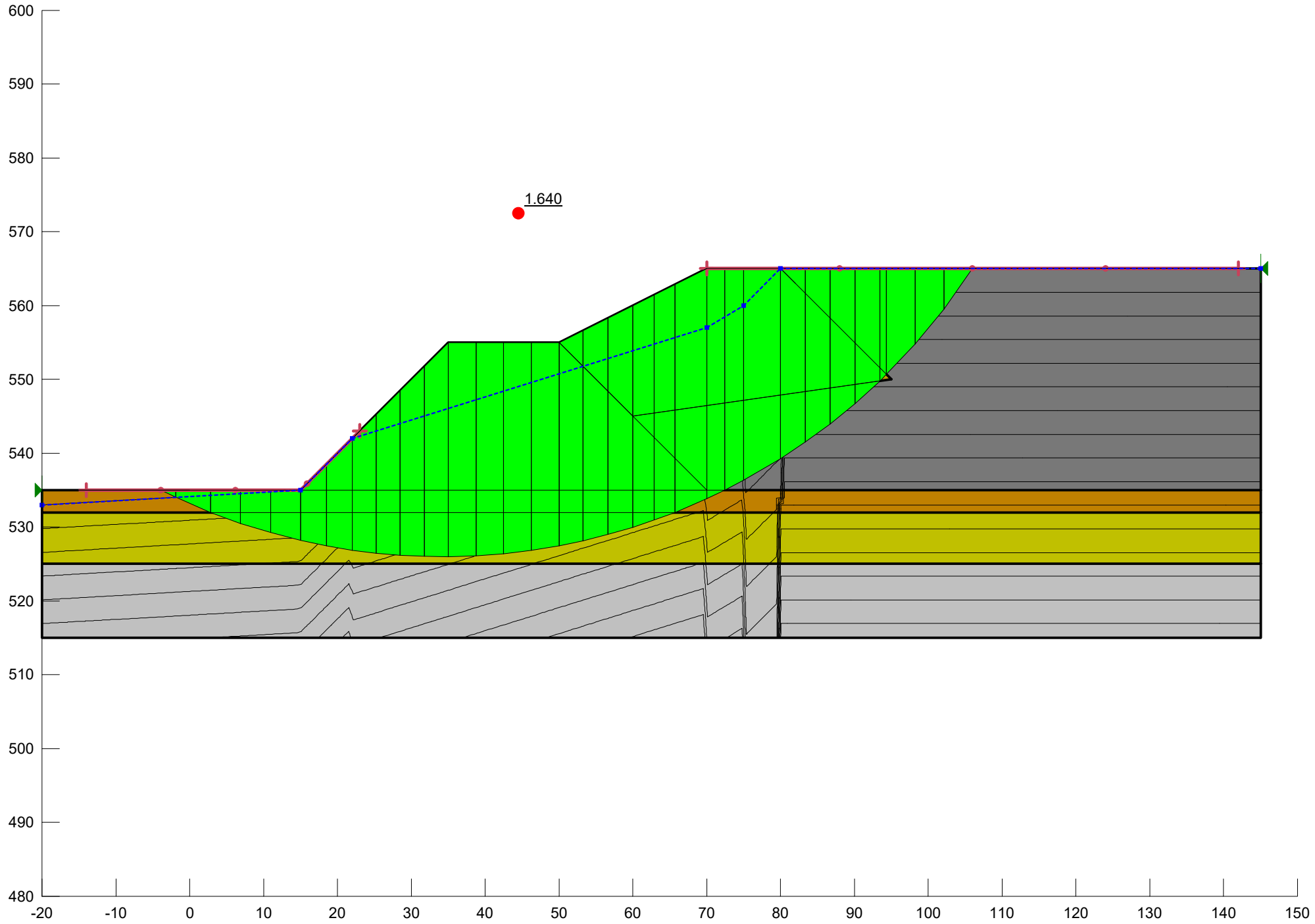
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	-0.16048362	534.59869	-28.921787	116.63294	72.880347	190
Slice 2	2.2555676	533.77922	30.633885	239.91856	130.77557	190
Slice 3	4.8583846	532.99536	88.638254	357.95512	168.28786	190
Slice 4	7.4612017	532.31483	140.21555	463.62052	202.08585	190
Slice 5	10.321958	531.68791	189.37551	562.23057	232.9857	190
Slice 6	13.440653	531.13303	234.97122	647.75213	257.93414	190
Slice 7	16.25	530.74473	343.52879	872.41907	330.48732	190
Slice 8	18.75	530.49682	514.99863	1,237.8844	451.70913	190
Slice 9	21.5	530.32797	569.52187	1,633.4497	664.81587	190
Slice 10	24.5	530.25632	630.58214	2,026.2219	872.09255	190
Slice 11	27.5	530.30715	684.79174	2,374.6858	1,055.963	190
Slice 12	30.5	530.48071	732.13642	2,676.6103	1,215.0422	190
Slice 13	33.5	530.77789	772.56714	2,932.1543	1,349.4598	190
Slice 14	36.436779	531.18867	805.44064	2,961.7079	1,347.3854	190
Slice 15	39.310336	531.70991	830.93376	2,787.6141	1,222.6696	190
Slice 16	42.289263	532.3786	850.1832	2,595.7963	1,090.7801	190
Slice 17	45.373558	533.20762	862.4684	2,390.7241	954.96017	190
Slice 18	48.457853	534.1831	866.56169	2,182.7153	822.42405	190
Slice 19	50.392426	534.85408	865.82212	2,074.5141	755.2746	190
Slice 20	52.183471	535.56217	860.27695	2,045.1601	740.39712	145
Slice 21	55.186567	536.85367	845.14961	1,991.516	716.32925	145
Slice 22	58.395522	538.40841	819.21351	1,925.9735	691.58041	145
Slice 23	61.820519	540.29639	778.74635	1,813.4119	646.53076	145
Slice 24	65.230778	542.40704	725.54379	1,765.7584	485.06005	0
Slice 25	68.410259	544.62796	661.78492	1,717.5015	492.28874	0
Slice 26	70.482325	546.18359	509.56053	1,647.8538	530.79489	0
Slice 27	72.982325	548.32026	480.3485	1,367.3352	554.25078	145
Slice 28	76.25	551.30019	310.43404	1,075.0936	477.81232	145
Slice	78.75	553.87819	308.00034	862.30889	346.37042	145

29						
Slice 30	82.16908	557.94599	440.16994	557.72891	73.458995	145
Slice 31	85.79408	562.83092	135.35062	184.12653	22.744581	0

APPENDIX F-2

Short-Term Static Slope Stability Analysis


1.640
600
590
580
570
560
550
540
530
520
510
500
490
480
-20
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150

CWLP Lakeside Short Term Static

Report generated using GeoStudio 2012. Copyright © 1991-2014 GEO-SLOPE International Ltd.

File Information

File Version: 8.14
Created By: Karl Finke
Last Edited By: Karl Finke
Revision Number: 48
Date: 10/3/2016
Time: 2:12:27 PM
Tool Version: 8.14.1.10087
File Name: CWLP Lakeside Short Term Section 2.gsz
Directory: J:\CWLP Factor of Safety Report\SlopeW\

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

CWLP Lakeside Short Term Static

Description: CWLP Lakeside
Kind: SLOPE/W
Method: Morgenstern-Price
Settings
    Side Function
        Interslice force function option: Half-Sine
    PWP Conditions Source: Piezometric Line
    Apply Phreatic Correction: Yes
    Use Staged Rapid Drawdown: No
Slip Surface
    Direction of movement: Right to Left
    Use Passive Mode: No
    Slip Surface Option: Entry and Exit
    Critical slip surfaces saved: 1
    Resisting Side Maximum Convex Angle: 1 °
    Driving Side Maximum Convex Angle: 5 °

Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Brn Gry Sandy Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,400 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Brn Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,800 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Yel Brn Gry VF Sandy Silt

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gray Clayey Shale

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 2,000 psf

Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Ash

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-14, 535) ft
Left-Zone Right Coordinate: (23, 543) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (70, 565) ft
Right-Zone Right Coordinate: (142, 565) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (-20, 535) ft
Right Coordinate: (145, 565) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-20	533
Coordinate 2	15	535
Coordinate 3	22	542
Coordinate 4	70	557
Coordinate 5	75	560
Coordinate 6	80	565
Coordinate 7	145	565

Points

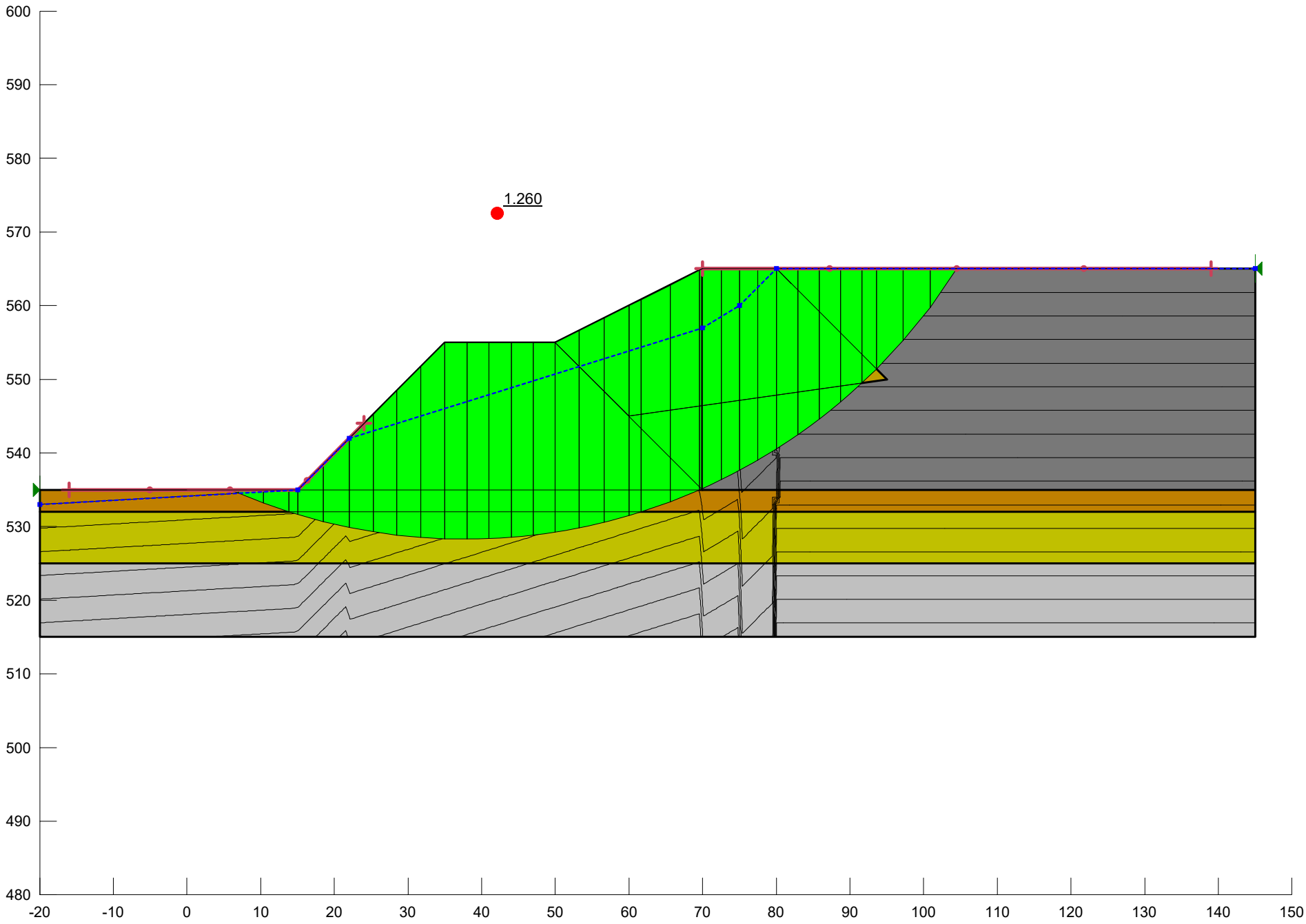
	X (ft)	Y (ft)
Point 1	15	535
Point 2	35	555
Point 3	50	555
Point 4	60	545
Point 5	70	535
Point 6	70	565
Point 7	80	565
Point 8	95	550
Point 9	145	565
Point 10	-20	535
Point 11	145	535
Point 12	-20	532
Point 13	145	532
Point 14	-20	525
Point 15	145	525
Point 16	-20	515
Point 17	145	515

Regions

	Material	Points	Area (ft^2)
Region 1	Brn Gry Sandy Silty Clay	1,2,3,4,5	700
Region 2	Brn Gry Sandy Silty Clay	3,6,7,8,4	550
Region 3	Brn Silty Clay	10,1,5,11,13,12	495
Region 4	Yel Brn Gry VF Sandy Silt	12,14,15,13	1,155
Region 5	Ash	8,4,5,11,9,7	2,000
Region 6	Gray Clayey Shale	14,16,17,15	1,650

APPENDIX F-3

Lakeside Seismic Slope Stability Analysis


1.260
600
590
580
570
560
550
540
530
520
510
500
490
480
-20
-10
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150

CWLP Lakeside Short Term Seismic

Report generated using GeoStudio 2012. Copyright © 1991-2014 GEO-SLOPE International Ltd.

File Information

File Version: 8.14
Created By: Karl Finke
Last Edited By: Karl Finke
Revision Number: 52
Date: 10/3/2016
Time: 2:14:02 PM
Tool Version: 8.14.1.10087
File Name: CWLP Lakeside Short Term Seismic Section 2.gsz
Directory: J:\CWLP Factor of Safety Report\SlopeW\
Last Solved Date: 10/3/2016
Last Solved Time: 2:14:06 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

CWLP Lakeside Short Term Seismic

Description: CWLP Lakeside
Kind: SLOPE/W
Method: Morgenstern-Price
Settings
    Side Function
        Interslice force function option: Half-Sine
    PWP Conditions Source: Piezometric Line
    Apply Phreatic Correction: Yes
    Use Staged Rapid Drawdown: No
Slip Surface
    Direction of movement: Right to Left
    Use Passive Mode: No
    Slip Surface Option: Entry and Exit
    Critical slip surfaces saved: 1

Resisting Side Maximum Convex Angle: 1 °
Driving Side Maximum Convex Angle: 5 °
Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Brn Gry Sandy Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,400 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Brn Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,800 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Yel Brn Gry VF Sandy Silt

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gray Clayey Shale

Model: Mohr-Coulomb

Unit Weight: 130 pcf
Cohesion': 2,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Ash

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (-16, 535) ft
Left-Zone Right Coordinate: (24, 544) ft
Left-Zone Increment: 4
Right Projection: Range
Right-Zone Left Coordinate: (70, 565) ft
Right-Zone Right Coordinate: (139, 565) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (-20, 535) ft
Right Coordinate: (145, 565) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	-20	533
Coordinate 2	15	535
Coordinate 3	22	542
Coordinate 4	70	557
Coordinate 5	75	560
Coordinate 6	80	565
Coordinate 7	145	565

Seismic Coefficients

Horz Seismic Coef.: 0.1
Vert Seismic Coef.: 0

Points

	X (ft)	Y (ft)
Point 1	15	535
Point 2	35	555
Point 3	50	555
Point 4	60	545
Point 5	70	535
Point 6	70	565
Point 7	80	565
Point 8	95	550
Point 9	145	565
Point 10	-20	535
Point 11	145	535
Point 12	-20	532
Point 13	145	532
Point 14	-20	525
Point 15	145	525
Point 16	-20	515
Point 17	145	515

Regions

	Material	Points	Area (ft²)
Region 1	Brn Gry Sandy Silty Clay	1,2,3,4,5	700
Region 2	Brn Gry Sandy Silty Clay	3,6,7,8,4	550
Region 3	Brn Silty Clay	10,1,5,11,13,12	495
Region 4	Yel Brn Gry VF Sandy Silt	12,14,15,13	1,155
Region 5	Ash	8,4,5,11,9,7	2,000
Region 6	Gray Clayey Shale	14,16,17,15	1,650

Current Slip Surface

Slip Surface: 63
F of S: 1.260
Volume: 1,901.9136 ft³
Weight: 220,860.5 lbs
Resisting Moment: 7,130,465.7 lbs-ft
Activating Moment: 5,657,637.6 lbs-ft
Resisting Force: 85,224.85 lbs
Activating Force: 67,622.745 lbs
F of S Rank: 1

Exit: (5.863961, 535) ft
Entry: (104.5, 565) ft
Radius: 79.109148 ft
Center: (37.720356, 607.41151) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	6.3985031	534.76952	-16.235239	666.78022	0	1,800
Slice 2	8.6540842	533.85892	48.417777	824.15224	0	1,800
Slice 3	12.096162	532.5894	139.61124	1,052.2735	0	1,800
Slice 4	14.408601	531.81762	195.83209	915.79274	0	1,000
Slice 5	16.75	531.15401	349.18995	1,237.5437	0	1,000
Slice 6	20.25	530.27641	622.35204	1,804.3101	0	1,000
Slice 7	23.625	529.58574	734.59908	2,313.1757	0	1,000
Slice 8	26.875	529.06648	821.85486	2,760.4465	0	1,000
Slice 9	30.125	528.68475	901.29201	3,161.9008	0	1,000
Slice 10	33.375	528.43857	973.0241	3,515.7678	0	1,000
Slice 11	36.5	528.32601	1,034.9389	3,637.264	0	1,000
Slice 12	39.5	528.33662	1,087.631	3,541.0214	0	1,000
Slice 13	42.5	528.46119	1,133.8449	3,421.4585	0	1,000
Slice 14	45.5	528.70025	1,173.5497	3,282.3533	0	1,000
Slice 15	48.5	529.05487	1,206.6858	3,127.2166	0	1,000
Slice 16	51.619048	529.55023	1,233.9353	3,039.0174	0	1,000
Slice 17	54.928571	530.21608	1,254.8771	3,014.6722	0	1,000
Slice 18	58.309524	531.04871	1,267.6066	2,974.7747	0	1,000
Slice 19	60.811756	531.75225	1,272.0639	2,922.9997	0	1,000
Slice 20	63.611822	532.68895	1,268.5574	2,836.2034	0	1,800
Slice 21	67.588442	534.18895	1,253.9299	2,627.4289	0	1,800
Slice 22	69.723473	535.0649	1,242.0626	2,534.1139	0	1,400
Slice 23	69.935097	535.15874	1,240.4874	2,588.738	361.26267	0
Slice 24	71.25	535.77273	1,008.3689	2,514.1676	403.47755	0
Slice 25	73.75	536.99738	1,021.0026	2,378.8723	363.8401	0
Slice 26	76.25	538.3342	714.97294	2,233.9803	407.0168	0

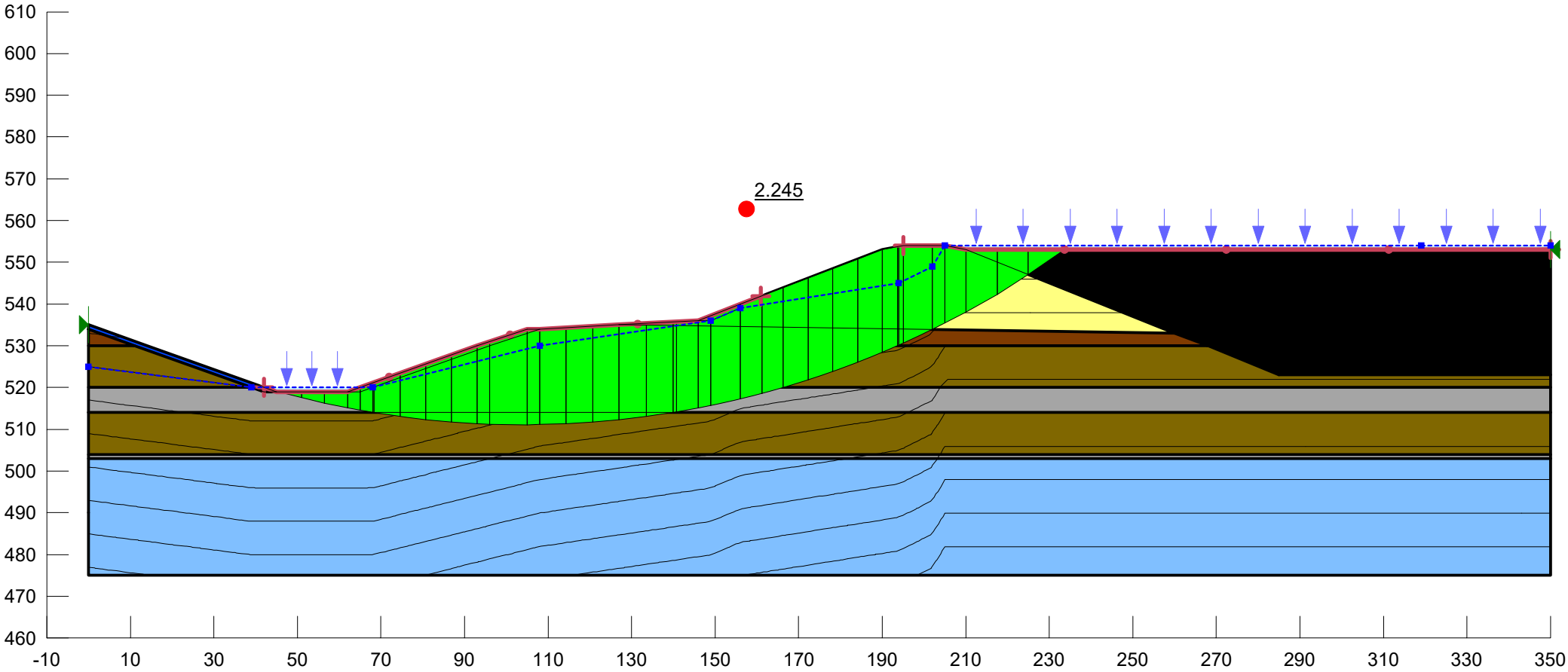
Slice 27	78.75	539.78986	747.55632	2,103.0434	363.20167	0
Slice 28	81.454318	541.51348	1,465.559	1,988.8949	140.22742	0
Slice 29	84.362954	543.54069	1,339.0611	1,797.0107	122.70723	0
Slice 30	87.27159	545.77183	1,199.8378	1,598.0888	106.71104	0
Slice 31	90.180226	548.23008	1,046.4432	1,386.8062	91.199981	0
Slice 32	92.613771	550.46311	907.10183	416.08203	-0	1,400
Slice 33	95.410831	553.34674	727.16315	925.16796	53.055228	0
Slice 34	99.046499	557.52099	466.69001	618.90263	40.785248	0
Slice 35	102.68217	562.37775	163.62838	227.05533	16.995201	0

APPENDIX G

Dallman Ash Pond Slope Stability Analysis

APPENDIX G-1

Long-Term Static Slope Stability Analysis


2.245
610
600
590
580
570
560
550
540
530
520
510
500
490
480
470
460
-10
10
30
50
70
90
110
130
150
170
190
210
230
250
270
290
310
330
350

Dallman Long Term Static

Report generated using GeoStudio 2012. Copyright © 1991-2014 GEO-SLOPE International Ltd.

File Information

File Version: 8.14
Created By: Karl Finke
Last Edited By: Karl Finke
Revision Number: 45
Date: 10/3/2016
Time: 2:45:37 PM
Tool Version: 8.14.1.10087
File Name: CWLP Dallman Long Term Static.gsz
Directory: J:\CWLP Factor of Safety Report\SlopeW\
Last Solved Date: 10/3/2016
Last Solved Time: 2:45:42 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Dallman Long Term Static

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
    Side Function
        Interslice force function option: Half-Sine
    PWP Conditions Source: Piezometric Line
    Apply Phreatic Correction: No
    Use Staged Rapid Drawdown: No
Slip Surface
    Direction of movement: Right to Left
    Use Passive Mode: No
    Slip Surface Option: Entry and Exit
    Critical slip surfaces saved: 1
    Resisting Side Maximum Convex Angle: 1 °

Driving Side Maximum Convex Angle: 5 °
Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Embankment

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 145 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Dk Brn Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 190 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Clayey Silt

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 190 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gry Snd Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf

Cohesion': 190 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gry Sand w/Silt

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Shale

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 2,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Rip-Rap

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Ash

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 25 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (42, 520) ft
Left-Zone Right Coordinate: (161, 541.91176) ft
Left-Zone Increment: 4

Right Projection: Range
Right-Zone Left Coordinate: (195, 554) ft
Right-Zone Right Coordinate: (350, 553) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 535) ft
Right Coordinate: (350, 553) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	525
Coordinate 2	39	520
Coordinate 3	68	520
Coordinate 4	108	530
Coordinate 5	149	536
Coordinate 6	156	539
Coordinate 7	194	545
Coordinate 8	202	549
Coordinate 9	205	554
Coordinate 10	319	554
Coordinate 11	350	554

Seismic Coefficients

Horz Seismic Coef.: 0
Vert Seismic Coef.: 0

Points

	X (ft)	Y (ft)
Point 1	0	535
Point 2	105	534
Point 3	146	536
Point 4	190	553
Point 5	195	554
Point 6	205	554
Point 7	210	553
Point 8	260	533
Point 9	285	523

Point 10	319	523
Point 11	108	534
Point 12	149	536
Point 13	156	539
Point 14	156	540
Point 15	127	535
Point 16	0	534
Point 17	0	530
Point 18	0	520
Point 19	0	514
Point 20	0	504
Point 21	0	503
Point 22	0	490
Point 23	319	490
Point 24	319	503
Point 25	319	504
Point 26	319	514
Point 27	319	520
Point 28	268	530
Point 29	96	530
Point 30	93	530
Point 31	68	520
Point 32	65	520
Point 33	65	519
Point 34	62	519
Point 35	45	519
Point 36	42	519
Point 37	42	520
Point 38	39	520
Point 39	14	530
Point 40	11	530
Point 41	319	553
Point 42	319	554
Point 43	0	475
Point 44	319	475
Point 45	350	475
Point 46	350	503
Point 47	350	504
Point 48	350	514
Point 49	350	520
Point 50	350	523
Point 51	350	553
Point 52	350	554

Regions

	Material	Points	Area (ft²)
Region 1	Embankment	15,3,12,13,14,4,5,6,7,8	1,329

Region 2	Dk Brn Silty Clay	8,28,29,11,15	653.5
Region 3	Dk Brn Silty Clay	16,17,40	22
Region 4	Clayey Silt	17,18,38,40	250
Region 5	Clayey Silt	31,29,28,9,50,49	2,165.5
Region 6	Gry Snd Silty Clay	18,19,48,49,31,33,34,35,36,38	2,074
Region 7	Clayey Silt	19,20,47,48	3,500
Region 8	Gry Sand w/Silt	20,21,46,47	350
Region 9	Shale	21,22,43,45,46	9,800
Region 10	Rip-Rap	14,13,12,3	9.5
Region 11	Rip-Rap	11,2,30,32,34,33,31,29	45
Region 12	Rip-Rap	1,16,40,38,36,35,37,39	46
Region 13	Ash	50,9,28,8,7,51	3,072.5

Current Slip Surface

Slip Surface: 7
F of S: 2.245
Volume: 3,200.3592 ft³
Weight: 383,171.01 lbs
Resisting Moment: 36,423,187 lbs-ft
Activating Moment: 16,221,979 lbs-ft
Resisting Force: 158,991.47 lbs
Activating Force: 70,815.407 lbs
F of S Rank: 1
Exit: (45.522783, 519) ft
Entry: (233.67574, 553) ft
Radius: 221.12319 ft
Center: (104.14305, 732.21147) ft

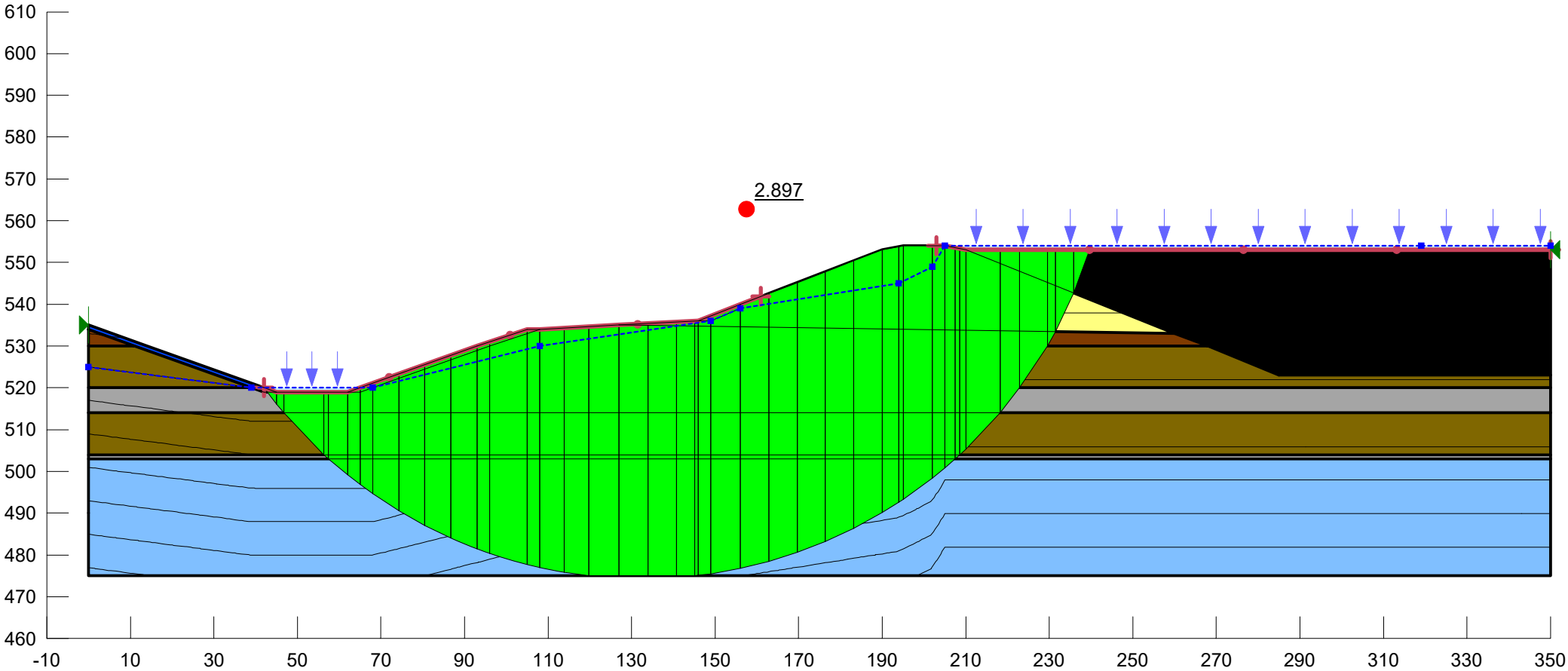
Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	48.268985	518.28274	107.15674	178.87139	44.812287	190
Slice 2	53.761391	516.92283	192.01571	353.71493	101.04088	190
Slice 3	59.253797	515.71076	267.64836	511.69752	152.49884	190
Slice 4	63.5	514.86088	320.68133	660.9906	212.64883	190
Slice 5	66.5	514.32124	354.35436	839.15316	302.93591	190
Slice 6	68.188424	514.03105	375.40183	956.76282	363.27466	190
Slice 7	71.454742	513.5399	457.00431	1,171.6028	446.53067	190
Slice 8	77.61053	512.70776	604.96029	1,562.4615	598.31313	190
Slice 9	83.766318	512.05084	741.98189	1,926.5541	740.20288	190
Slice 10	89.922106	511.5676	868.16684	2,261.6771	870.76189	190
Slice 11	94.5	511.30374	956.04651	2,488.3181	957.46953	190
Slice 12	100.5	511.1641	1,058.3602	2,738.6197	1,049.9427	190
Slice 13	106.5	511.10593	1,155.5902	2,901.8597	1,091.1903	190

Slice 14	111.16667	511.22256	1,200.6293	2,877.0302	1,047.5315	190
Slice 15	117.5	511.51486	1,240.2241	2,843.683	1,001.9523	190
Slice 16	123.83333	511.98965	1,268.4315	2,784.2952	947.21677	190
Slice 17	130.22731	512.6562	1,285.2263	2,699.9685	884.02907	190
Slice 18	136.68194	513.51981	1,290.2789	2,592.4107	813.66226	190
Slice 19	140.33133	514.07002	1,289.2711	2,525.18	772.28159	190
Slice 20	143.3767	514.61303	1,283.1968	2,460.0575	735.38418	190
Slice 21	147.5	515.38596	1,272.6186	2,435.0091	726.34218	190
Slice 22	152.5	516.4704	1,312.2468	2,513.0909	750.37068	190
Slice 23	158.57153	517.90802	1,341.4759	2,572.8352	769.43867	190
Slice 24	163.71458	519.28057	1,306.5016	2,609.0957	813.95114	190
Slice 25	169.25034	520.91337	1,259.1564	2,631.83	857.74164	190
Slice 26	175.17882	522.83241	1,197.8192	2,639.2275	900.69184	190
Slice 27	181.10729	524.93876	1,124.7941	2,628.7031	939.74661	190
Slice 28	187.03576	527.2382	1,039.7203	2,600.2125	975.10375	190
Slice 29	191.80962	529.21848	963.18591	2,530.9234	979.63114	190
Slice 30	193.80962	530.08446	928.85427	2,475.0325	966.15936	190
Slice 31	194.5	530.39277	927.09136	2,455.6885	955.17346	190
Slice 32	198.5	532.26834	934.8556	2,265.3266	831.37054	190
Slice 33	203.5	534.67452	1,049.9097	2,031.1828	613.16748	145
Slice 34	207.5	536.75096	1,076.3401	1,798.7329	451.40109	145
Slice 35	213.74088	540.20827	860.60409	1,381.2735	325.35038	145
Slice 36	221.22264	544.6791	581.62409	853.3867	169.81613	145
Slice 37	229.31963	550.0073	249.14466	341.52741	43.078784	0

APPENDIX G-2

Short-Term Static Slope Stability Analysis


2.897
610
600
590
580
570
560
550
540
530
520
510
500
490
480
470
460
-10
10
30
50
70
90
110
130
150
170
190
210
230
250
270
290
310
330
350

Dallman Short Term Static

Report generated using GeoStudio 2012. Copyright © 1991-2014 GEO-SLOPE International Ltd.

File Information

File Version: 8.14
Created By: Karl Finke
Last Edited By: Karl Finke
Revision Number: 40
Date: 10/3/2016
Time: 1:54:59 PM
Tool Version: 8.14.1.10087
File Name: CWLP Dallman Short Term Static.gsz
Directory: J:\CWLP Factor of Safety Report\SlopeW\
Last Solved Date: 10/3/2016
Last Solved Time: 1:55:04 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Dallman Short Term Static

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
    Side Function
        Interslice force function option: Half-Sine
    PWP Conditions Source: Piezometric Line
    Apply Phreatic Correction: No
    Use Staged Rapid Drawdown: No
Slip Surface
    Direction of movement: Right to Left
    Use Passive Mode: No
    Slip Surface Option: Entry and Exit
    Critical slip surfaces saved: 1
    Resisting Side Maximum Convex Angle: 1 °

Driving Side Maximum Convex Angle: 5 °
Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Embankment

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,400 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Dk Brn Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,800 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Clayey Silt

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,400 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gry Snd Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf

Cohesion': 1,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gry Sand w/Silt

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Shale

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 2,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Rip-Rap

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Ash

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (42, 520) ft
Left-Zone Right Coordinate: (161, 541.91176) ft
Left-Zone Increment: 4

Right Projection: Range
Right-Zone Left Coordinate: (203, 554) ft
Right-Zone Right Coordinate: (350, 553) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 535) ft
Right Coordinate: (350, 553) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	525
Coordinate 2	39	520
Coordinate 3	68	520
Coordinate 4	108	530
Coordinate 5	149	536
Coordinate 6	156	539
Coordinate 7	194	545
Coordinate 8	202	549
Coordinate 9	205	554
Coordinate 10	319	554
Coordinate 11	350	554

Seismic Coefficients

Horz Seismic Coef.: 0
Vert Seismic Coef.: 0

Points

	X (ft)	Y (ft)
Point 1	0	535
Point 2	105	534
Point 3	146	536
Point 4	190	553
Point 5	195	554
Point 6	205	554
Point 7	210	553
Point 8	260	533
Point 9	285	523

Point 10	319	523
Point 11	108	534
Point 12	149	536
Point 13	156	539
Point 14	156	540
Point 15	127	535
Point 16	0	534
Point 17	0	530
Point 18	0	520
Point 19	0	514
Point 20	0	504
Point 21	0	503
Point 22	0	490
Point 23	319	490
Point 24	319	503
Point 25	319	504
Point 26	319	514
Point 27	319	520
Point 28	268	530
Point 29	96	530
Point 30	93	530
Point 31	68	520
Point 32	65	520
Point 33	65	519
Point 34	62	519
Point 35	45	519
Point 36	42	519
Point 37	42	520
Point 38	39	520
Point 39	14	530
Point 40	11	530
Point 41	319	553
Point 42	319	554
Point 43	0	475
Point 44	319	475
Point 45	350	475
Point 46	350	503
Point 47	350	504
Point 48	350	514
Point 49	350	520
Point 50	350	523
Point 51	350	553
Point 52	350	554

Regions

	Material	Points	Area (ft²)
Region 1	Embankment	15,3,12,13,14,4,5,6,7,8	1,329

Region 2	Dk Brn Silty Clay	8,28,29,11,15	653.5
Region 3	Dk Brn Silty Clay	16,17,40	22
Region 4	Clayey Silt	17,18,38,40	250
Region 5	Clayey Silt	31,29,28,9,50,49	2,165.5
Region 6	Gry Snd Silty Clay	18,19,48,49,31,33,34,35,36,38	2,074
Region 7	Clayey Silt	19,20,47,48	3,500
Region 8	Gry Sand w/Silt	20,21,46,47	350
Region 9	Shale	21,22,43,45,46	9,800
Region 10	Rip-Rap	14,13,12,3	9.5
Region 11	Rip-Rap	11,2,30,32,34,33,31,29	45
Region 12	Rip-Rap	1,16,40,38,36,35,37,39	46
Region 13	Ash	50,9,28,8,7,51	3,072.5

Current Slip Surface

Slip Surface: 9
F of S: 2.897
Volume: 9,136.4623 ft³
Weight: 1,093,861.8 lbs
Resisting Moment: 47,499,602 lbs-ft
Activating Moment: 16,395,280 lbs-ft
Resisting Force: 357,222.23 lbs
Activating Force: 123,292.08 lbs
F of S Rank: 1
Exit: (42, 520) ft
Entry: (239.67574, 553) ft
Radius: 112.36371 ft
Center: (132.46693, 586.64336) ft

Slip Slices

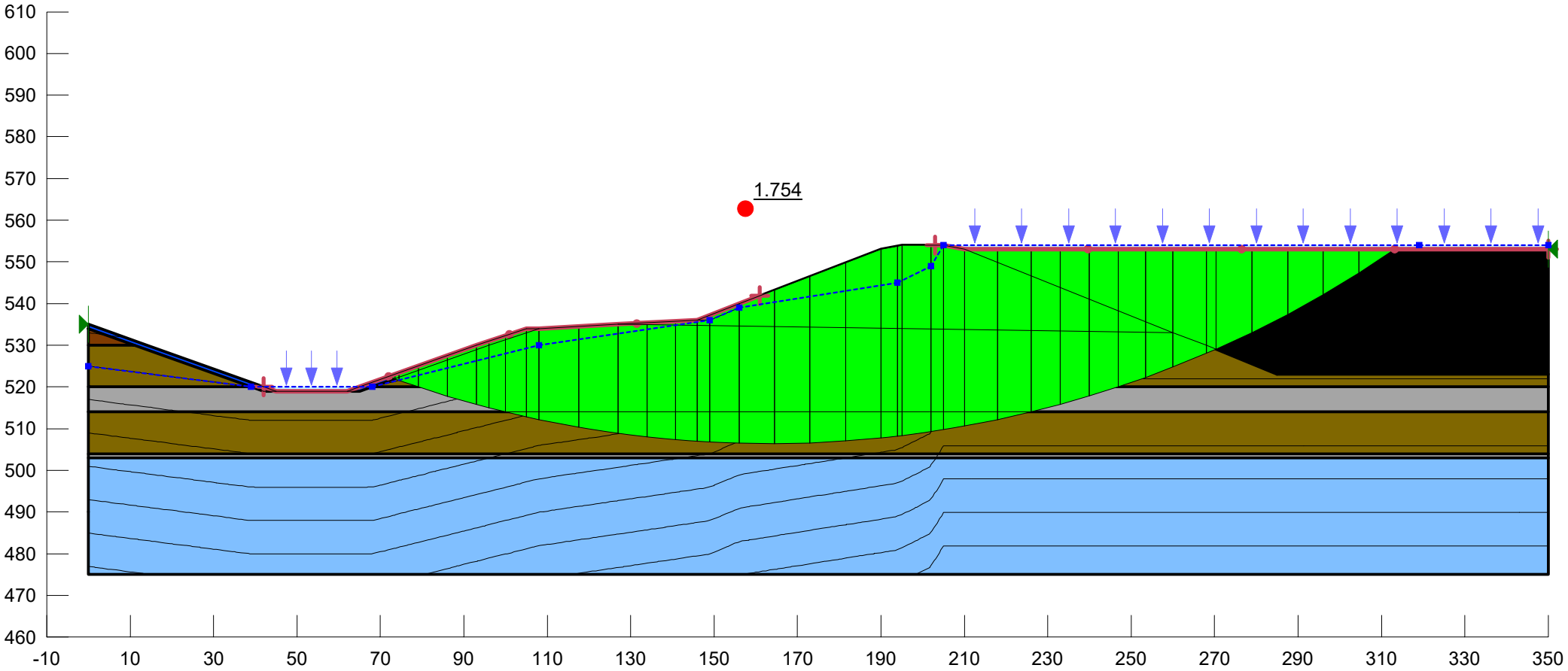
	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	42.372628	519.5	31.2	73.027936	35.097806	0
Slice 2	43.872628	517.55435	152.60873	711.94304	0	1,000
Slice 3	45.871637	515.05435	308.60873	974.73547	0	1,000
Slice 4	51.540427	509	686.4	1,850.0351	0	1,400
Slice 5	56.88762	503.5	1,029.6	2,336.2148	881.32283	0
Slice 6	59.71883	501.06093	1,181.7983	3,000.1174	0	2,000
Slice 7	63.5	497.9554	1,375.5833	3,409.4613	0	2,000
Slice 8	66.5	495.70089	1,516.2646	3,784.4612	0	2,000
Slice 9	71.125	492.57502	1,760.0687	4,370.811	0	2,000
Slice 10	77.375	488.77803	2,094.5006	5,106.8708	0	2,000
Slice 11	83.625	485.50966	2,395.9473	5,767.5331	0	2,000
Slice 12	89.875	482.71971	2,667.54	6,353.5021	0	2,000
Slice 13	94.5	480.90039	2,853.2155	6,740.4066	0	2,000

Slice 14	100.5	479.02514	3,063.8314	7,152.3338	0	2,000
Slice 15	106.5	477.33213	3,263.075	7,458.84	0	2,000
Slice 16	110.94101	476.40154	3,371.4003	7,514.7108	0	2,000
Slice 17	116.82303	475.41364	3,486.7583	7,567.0138	0	2,000
Slice 18	123.38202	475	3,572.4641	7,392.9072	0	2,000
Slice 19	130.43835	475	3,636.9005	7,390.4633	0	2,000
Slice 20	137.31506	475	3,699.6965	7,383.8323	0	2,000
Slice 21	142.96161	475	3,751.2592	7,375.7445	0	2,000
Slice 22	145.58491	475.04879	3,772.1697	7,172.558	0	2,000
Slice 23	147.5	475.30011	3,773.9755	7,179.3671	0	2,000
Slice 24	152.5	476.13713	3,829.0431	7,210.3691	0	2,000
Slice 25	159.4	477.61149	3,864.1417	7,194.7724	0	2,000
Slice 26	166.2	479.52204	3,811.9215	7,137.3757	0	2,000
Slice 27	173	481.90854	3,730.0017	7,036.0639	0	2,000
Slice 28	179.8	484.80463	3,616.2836	6,889.9686	0	2,000
Slice 29	186.6	488.25558	3,467.9422	6,695.9509	0	2,000
Slice 30	192	491.37608	3,326.4275	6,468.2458	0	2,000
Slice 31	194.5	492.95696	3,263.0859	6,318.1096	0	2,000
Slice 32	198.5	495.83306	3,208.4168	5,963.0255	0	2,000
Slice 33	203.5	499.60223	3,238.4207	5,489.861	0	2,000
Slice 34	206.2481	501.91318	3,250.2175	5,189.8481	0	2,000
Slice 35	208.04624	503.5	3,151.2	5,153.528	1,350.5873	0
Slice 36	209.29814	504.65773	3,078.9575	4,990.2829	0	1,400
Slice 37	214.09529	509.65773	2,766.9575	4,364.4456	0	1,400
Slice 38	220.56223	517	2,308.8	3,606.2371	0	1,000
Slice 39	226.22135	525	1,809.6	2,420.3273	0	1,400

Slice 40	230.46996	531.7148	1,390.5962	1,289.2997	-0	1,800
Slice 41	233.64675	538.04232	995.7594	636.10168	-0	1,400
Slice 42	237.76908	547.82751	385.16317	531.44729	39.196713	0

APPENDIX G-3

Seismic Slope Stability Analysis


1.754
610
600
590
580
570
560
550
540
530
520
510
500
490
480
470
460
-10
10
30
50
70
90
110
130
150
170
190
210
230
250
270
290
310
330
350

Dallman Short Term Seismic

Report generated using GeoStudio 2012. Copyright © 1991-2014 GEO-SLOPE International Ltd.

File Information

File Version: 8.14
Created By: Karl Finke
Last Edited By: Karl Finke
Revision Number: 39
Date: 10/3/2016
Time: 2:01:36 PM
Tool Version: 8.14.1.10087
File Name: CWLP Dallman Short Term Seismic.gsz
Directory: J:\CWLP Factor of Safety Report\SlopeW\
Last Solved Date: 10/3/2016
Last Solved Time: 2:01:42 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Dallman Short Term Seismic

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
    Side Function
        Interslice force function option: Half-Sine
    PWP Conditions Source: Piezometric Line
    Apply Phreatic Correction: No
    Use Staged Rapid Drawdown: No
Slip Surface
    Direction of movement: Right to Left
    Use Passive Mode: No
    Slip Surface Option: Entry and Exit
    Critical slip surfaces saved: 1
    Resisting Side Maximum Convex Angle: 1 °

Driving Side Maximum Convex Angle: 5 °
Optimize Critical Slip Surface Location: No
Tension Crack
Tension Crack Option: (none)
F of S Distribution
F of S Calculation Option: Constant
Advanced
Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Embankment

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,400 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Dk Brn Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,800 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Clayey Silt

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 1,400 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gry Snd Silty Clay

Model: Mohr-Coulomb
Unit Weight: 120 pcf

Cohesion': 1,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gry Sand w/Silt

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Shale

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 2,000 psf
Phi': 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Rip-Rap

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Ash

Model: Mohr-Coulomb
Unit Weight: 100 pcf
Cohesion': 0 psf
Phi': 15 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (42, 520) ft
Left-Zone Right Coordinate: (161, 541.91176) ft
Left-Zone Increment: 4

Right Projection: Range
Right-Zone Left Coordinate: (203, 554) ft
Right-Zone Right Coordinate: (350, 553) ft
Right-Zone Increment: 4
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 535) ft
Right Coordinate: (350, 553) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X (ft)	Y (ft)
Coordinate 1	0	525
Coordinate 2	39	520
Coordinate 3	68	520
Coordinate 4	108	530
Coordinate 5	149	536
Coordinate 6	156	539
Coordinate 7	194	545
Coordinate 8	202	549
Coordinate 9	205	554
Coordinate 10	319	554
Coordinate 11	350	554

Seismic Coefficients

Horz Seismic Coef.: 0.1
Vert Seismic Coef.: 0

Points

	X (ft)	Y (ft)
Point 1	0	535
Point 2	105	534
Point 3	146	536
Point 4	190	553
Point 5	195	554
Point 6	205	554
Point 7	210	553
Point 8	260	533
Point 9	285	523

Point 10	319	523
Point 11	108	534
Point 12	149	536
Point 13	156	539
Point 14	156	540
Point 15	127	535
Point 16	0	534
Point 17	0	530
Point 18	0	520
Point 19	0	514
Point 20	0	504
Point 21	0	503
Point 22	0	490
Point 23	319	490
Point 24	319	503
Point 25	319	504
Point 26	319	514
Point 27	319	520
Point 28	268	530
Point 29	96	530
Point 30	93	530
Point 31	68	520
Point 32	65	520
Point 33	65	519
Point 34	62	519
Point 35	45	519
Point 36	42	519
Point 37	42	520
Point 38	39	520
Point 39	14	530
Point 40	11	530
Point 41	319	553
Point 42	319	554
Point 43	0	475
Point 44	319	475
Point 45	350	475
Point 46	350	503
Point 47	350	504
Point 48	350	514
Point 49	350	520
Point 50	350	523
Point 51	350	553
Point 52	350	554

Regions

	Material	Points	Area (ft²)
Region 1	Embankment	15,3,12,13,14,4,5,6,7,8	1,329

Region 2	Dk Brn Silty Clay	8,28,29,11,15	653.5
Region 3	Dk Brn Silty Clay	16,17,40	22
Region 4	Clayey Silt	17,18,38,40	250
Region 5	Clayey Silt	31,29,28,9,50,49	2,165.5
Region 6	Gry Snd Silty Clay	18,19,48,49,31,33,34,35,36,38	2,074
Region 7	Clayey Silt	19,20,47,48	3,500
Region 8	Gry Sand w/Silt	20,21,46,47	350
Region 9	Shale	21,22,43,45,46	9,800
Region 10	Rip-Rap	14,13,12,3	9.5
Region 11	Rip-Rap	11,2,30,32,34,33,31,29	45
Region 12	Rip-Rap	1,16,40,38,36,35,37,39	46
Region 13	Ash	50,9,28,8,7,51	3,072.5

Current Slip Surface

Slip Surface: 42
F of S: 1.754
Volume: 6,598.2566 ft³
Weight: 766,725.5 lbs
Resisting Moment: 71,665,768 lbs-ft
Activating Moment: 40,847,042 lbs-ft
Resisting Force: 263,139.9 lbs
Activating Force: 149,983.87 lbs
F of S Rank: 1
Exit: (71.965012, 522.4875) ft
Entry: (313.22525, 553) ft
Radius: 265.53272 ft
Center: (162.97654, 771.93595) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	72.710494	522.21803	-64.921586	84.576094	70.967769	0
Slice 2	73.938352	521.77687	-18.238546	472.45788	0	1,400
Slice 3	76.758491	520.80259	86.550781	718.90818	0	1,400
Slice 4	82.57219	518.89551	296.24629	1,134.4225	0	1,000
Slice 5	89.524063	516.79035	536.05734	1,710.1262	0	1,000
Slice 6	94.5	515.38931	701.10704	2,105.3764	0	1,000
Slice 7	97.957845	514.49447	810.88759	2,362.8992	0	1,000
Slice 8	102.45784	513.40492	949.07567	2,767.0697	0	1,400
Slice 9	106.5	512.48332	1,069.641	2,986.2009	0	1,400
Slice 10	112.75	511.24165	1,213.8969	3,170.3135	0	1,400
Slice 11	122.25	509.5891	1,403.7668	3,429.6314	0	1,400
Slice 12	130.43835	508.42715	1,551.0464	3,605.8766	0	1,400
Slice 13	137.31506	507.6687	1,661.1696	3,715.8515	0	1,400

Slice 14	143.3767	507.14065	1,749.4733	3,787.6752	0	1,400
Slice 15	147.5	506.8589	1,804.7072	3,890.9901	0	1,400
Slice 16	152.5	506.63311	1,926.094	4,125.6573	0	1,400
Slice 17	160.25	506.45125	2,072.9157	4,430.4254	0	1,400
Slice 18	168.75	506.50004	2,153.6184	4,724.8943	0	1,400
Slice 19	177.25	506.8213	2,217.3194	4,975.4526	0	1,400
Slice 20	185.75	507.41601	2,263.9567	5,186.2206	0	1,400
Slice 21	192	508.00184	2,288.98	5,279.8551	0	1,400
Slice 22	194.5	508.28155	2,306.8313	5,276.83	0	1,400
Slice 23	198.5	508.81386	2,398.4152	5,183.9269	0	1,400
Slice 24	203.5	509.51802	2,619.6756	5,051.391	0	1,400
Slice 25	207.5	510.17489	2,734.6872	4,909.4629	0	1,400
Slice 26	214.00935	511.38541	2,659.1506	4,657.9989	0	1,400
Slice 27	222.02804	513.08535	2,553.0742	4,341.2089	0	1,400
Slice 28	229.50729	514.89814	2,439.9562	4,038.4685	0	1,000
Slice 29	236.4471	516.79547	2,321.5624	3,744.462	0	1,000
Slice 30	243.38691	518.89734	2,190.4062	3,435.4115	0	1,000
Slice 31	250.14261	521.14201	2,050.3384	3,081.8957	0	1,400
Slice 32	256.7142	523.52391	1,901.7079	2,742.488	0	1,400
Slice 33	264	526.40963	1,721.6393	2,341.8376	0	1,400
Slice 34	269.14655	528.55562	1,587.7296	2,046.5904	0	1,400
Slice 35	274.58632	531.04491	1,432.3974	2,013.5709	155.72496	0
Slice 36	283.17275	535.21394	1,172.2503	1,660.0611	130.7085	0
Slice 37	291.75918	539.77533	887.61932	1,267.4716	101.78111	0
Slice 38	300.3456	544.75278	577.02659	827.27814	67.054701	0
Slice 39	308.93203	550.17436	238.71985	329.37161	24.290066	0

The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 3

AECOM

Submitted to
Illinois Power Resources
Generating, LLC
7800 S. Cilco Lane
Bartonville, IL 61607

Submitted by
AECOM
1001 Highlands Plaza Drive West
Suite 300
St. Louis, MO 63110

October 2016

CCR Rule Report: Initial Safety Factor Assessment

For

Ash Pond

At Edwards Power Station

1 Introduction

This Coal Combustion Residual (CCR) Rule Report documents that the Ash Pond at the Illinois Power Resources Generating, LLC Edwards Power Station meets the safety factor assessment requirements specified in 40 Code of Federal Regulations (CFR) §257.73(e). The Ash Pond is located near Bartonville, Illinois in Peoria County, approximately 0.1 miles west of the Edwards Power Station. The Ash Pond serves as the wet impoundment basin for CCR material produced by the Edwards Power Station.

The Ash Pond is an existing CCR surface impoundment as defined by 40 CFR §257.53. The CCR Rule requires that the initial safety factor assessment for an existing CCR surface impoundment be completed by October 17, 2016.

The owner or operator of the CCR unit must obtain a certification from a qualified professional engineer stating that the initial safety factor assessment meets the requirements of 40 CFR § 257.73(e). The owner or operator must prepare a safety factor assessment every five years.

2 Initial Safety Factor Assessment

40 CFR §257.73(e)(1)
The owner or operator must conduct initial and periodic safety factor assessments for each CCR unit and document whether the calculated factors of safety for each CCR unit achieve the minimum safety factors specified in (e)(1)(i) through (iv) of this section for the critical cross section of the embankment. The critical cross section is the cross section anticipated to be the most susceptible of all cross sections to structural failure based on appropriate engineering considerations, including loading conditions. The safety factor assessments must be supported by appropriate engineering calculations.

(i) The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.

(ii) The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.

(iii) The calculated seismic factor of safety must equal or exceed 1.00.

(iv) For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

A geotechnical investigation program and stability analyses were performed to evaluate the design, performance, and condition of the earthen dikes of the Ash Pond. The exploration consisted of auger borings, cone penetrating testing, and laboratory program including index, strength, and consolidation testing. Data collected from the geotechnical investigation, available design drawings, construction records, inspection reports, previous engineering investigations, and other pertinent historic documents were utilized to perform the safety factor assessment and geotechnical analyses.

In general, the subsurface conditions at the Ash Pond consist of a soft to very stiff compacted ash and clay dike, overlying stiff alluvial clay, overlying soft to medium stiff alluvial clay, which in turn overlies shale bedrock. Phreatic water is typically located above the embankment/foundation interface beneath the crest of the dike, and at the embankment/foundation interface near the toe of the dike.

Ten (10) representative cross sections were analyzed using limit equilibrium slope stability analysis software to evaluate stability of the perimeter dike system and foundations. The cross sections were located to represent critical surface geometry, subsurface stratigraphy, and phreatic conditions across the site. Each cross section was evaluated for each of the loading conditions stipulated in §257.73(e)(1).

The Soils Susceptible to Liquefaction loading condition, §257.73(e)(1)(iv), was not evaluated because a liquefaction susceptibly evaluation did not find soils susceptible to liquefaction within the Ash Pond dikes. As a result, this loading condition is not applicable to the Ash Pond at the Edwards Power Station.

Results of the Initial Safety Factor Assessments, for the critical cross-section, (i.e., the lowest calculated factor of safety out of the cross sections analyzed for each loading condition) are listed in Table 1.

Table 1 – Summary of Initial Safety Factor Assessment

Loading Conditions	§257.73(e)(1) Subsection	Minimum Factor of Safety	Calculated Factor of Safety
Maximum Storage Pool Loading	(i)	1.50	1.54
Maximum Surcharge Pool Loading	(ii)	1.40	1.54
Seismic	(iii)	1.00	1.08
Soils Susceptible to Liquefaction	(iv)	1.20	Not Applicable

Based on this evaluation, the Ash Pond meets the requirements in §257.73(e)(1).

3 Certification Statement

CCR Unit: Illinois Power Resources Generating, LLC; Edwards Power Station; Ash Pond

I, Victor A. Modeer, being a Registered Professional Engineer in good standing in the State of Illinois, do hereby certify, to the best of my knowledge, information, and belief that the information contained in this CCR Rule Report, and the underlying data in the operating record, has been prepared in accordance with the accepted practice of engineering. I certify, for the above-referenced CCR Unit, that the initial safety factor assessment dated October 13, 2016 meets the requirements of 40 CFR §257.73(e).

VICTOR A MODEER JR

Printed Name

10/13/16

Date



About AECOM

AECOM (NYSE: ACM) is a global provider of professional technical and management support services to a broad range of markets, including transportation, facilities, environmental, energy, water and government. With nearly 100,000 employees around the world, AECOM is a leader in all of the key markets that it serves. AECOM provides a blend of global reach, local knowledge, innovation, and collaborative technical excellence in delivering solutions that enhance and sustain the world's built, natural, and social environments. A Fortune 500 company, AECOM serves clients in more than 100 countries and has annual revenue in excess of $19 billion.

More information on AECOM and its services can be found at www.aecom.com.

1001 Highlands Plaza Drive West
Suite 300
St. Louis, MO 63110
1-314-429-0100

The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 4

Geosyntec consultants

16644 West Bernardo Drive, Suite 301
San Diego, CA 92127
Phone: 858.674.6559
Fax: 858.674.6586
www.geosyntec.com

STRUCTURAL STABILITY AND FACTOR OF SAFETY ASSESSMENT
ASH POND 2
JOLIET 29 STATION
OCTOBER 2016

This report presents the initial periodic structural stability and initial safety factor assessment of the Ash Pond 2 at the Joliet 29 Station (Site) in Joliet, Illinois (Figure 1). This report addresses the initial structural stability and safety factor assessment requirements of the Coal Combustion Residuals (CCR) regulations, Code of Federal Regulations Title 40, Part 257, Subpart D (referred to as the CCR Rule). These regulations were published in the Federal Register on 17 April 2015 and became effective on 19 October 2015. The Joliet 29 Station is owned and operated by Midwest Generation, LLC (Midwest Generation). Based on the results provided in this report, Ash Pond 2 meets the requirements of §257.73(d) and §257.73(e) of the CCR Rule.

The work presented in this report was performed under the direction of Ms. Jane Soule, P.E., of Geosyntec Consultants, Inc. (Geosyntec) in accordance with §257.73(d) and §257.73(e). Mr. Robert White reviewed this report in accordance with Geosyntec's senior review policy.

1. Regulation Requirements - §257.73

Structural integrity criteria for existing CCR impoundments is described in §257.73 and includes structural stability and factor of safety assessments. Ash Pond 2 meets the minimum size and capacity criteria under §257.73(b) and is subject to the periodic structural stability and safety factor assessments required.

2. Site Conditions

Ash Pond 2 is approximately 500 feet by 280 feet in plan area and is located approximately 70 feet south of U.S. Route 6, east of Pond 1, west of the east entrance to the Joliet 29 Station, and north of the silo building at the Site. The pond is surrounded by embankments on the south, east, and west. There are no embankments on the north side of the pond where existing ground elevations generally increase to the north toward U.S. Route 6. Ash Pond 2 is currently lined with a 60-mil high density polyethylene (HDPE) geomembrane. A concrete retaining wall is located along the southern perimeter of Ash Pond 2, north of the silo building.

Based on available documentation and discussions with site personnel, Ash Pond 2, in its current configuration, was constructed in the late 1970s. A history of construction for the pond was prepared in accordance with §257.73(c) and describes the design of the Ash Pond 2 and its construction (Geosyntec, 2016a).

3. Structural Stability Assessment

The following subsections address the components of §257.73(d)(1).

3.1 Foundations and Abutments – §257.73(d)(1)(i)

Site observations and construction documents show Ash Pond 2 is surrounded by embankments on the south, east, and west. There are no embankments on the north side of the pond where existing ground elevations generally increase to the north; however, Site investigations indicate that fill material may be present along the northern boundary. For engineering purposes, material located along the northern embankment is considered consistent with embankment fill. Native materials do not provide lateral support for the embankments and therefore the pond does not include abutments. The remainder of this section addresses the foundation materials for the pond's embankments.

Previous subsurface investigations performed at the Site indicate that the foundation materials underlying the embankments for Ash Pond 2 generally consist of approximately 20 to 30 feet of medium dense to very dense sand and gravel (Geosyntec, 2016b). Due to the granular nature of the foundation soils (sand and gravel), foundation settlement associated with the construction and operation of Ash Pond 2 is anticipated to be predominately elastic settlement, which would have likely occurred soon after construction in the late 1970s. Because of the age of the embankments (over 35 years old), it is very likely that any potential consolidation and secondary compression settlement has also occurred. Further, the Ash Pond 2 embankments were not constructed with abutments or separate engineered zones that would be most susceptible to the adverse effects of differential settlement. During the initial annual inspection performed for Ash Pond 2 in accordance with §257.83(b), no visual evidence of adverse effects resulting from settlement was observed (Geosyntec, 2016c). There are no proposed changes in operation which would increase loading conditions on the foundation; therefore, no significant settlement of the foundation materials underlying the embankments is anticipated to occur in the future and the settlement of the foundation is not anticipated to impact the integrity of the impoundment embankments.

A factor of safety against the triggering of liquefaction was calculated for saturated foundation materials underlying the Ash Pond 2 embankments. The factor of safety was calculated based methods outlined in Idriss and Boulanger (2008) using information obtained from field explorations, including borings, Cone Penetration Test (CPT) soundings, and laboratory data (Geosyntec, 2016b) and seismic data (Geosyntec, 2016d). The triggering analysis indicated a very low likelihood of liquefaction occurring in the foundation materials underlying the embankments (Geosyntec, 2016d).

3.2 Upstream Slope Protection – §257.73(d)(1)(ii)

Ash Pond 2 is lined with a 60-mil high density polyethylene (HDPE) geomembrane that protects the interior pond slopes from erosion, the effects of wave action, and mitigates effects of rapid drawdown.

3.3 Dike Compaction – §257.73(d)(1)(iii)

Because as-built construction documentation for Ash Pond 2 was not available at the time of this assessment, no quantitative evaluation of the degree of compaction of the embankments was performed. However, slope stability analyses show that the embankments for Ash Pond 2 are sufficient to withstand the range of loading conditions in the CCR unit (Geosyntec, 2016e).

3.4 Downstream Slope Protection – §257.73(d)(1)(iv)

The western downstream slope for Ash Pond 2 is the interior slope of Pond 1 and is lined with a geomembrane that provides erosion protection. Based on site observations in October 2015, the surfaces of eastern and southern downstream slopes for the Ash Pond 2 embankments consist of sandy gravel, gravelly sand, gravel, and some cobbles and include sparse vegetation. Based on site observations, the existing surface conditions of the slopes provide adequate slope protection.

3.5 Spillway – §257.73(d)(1)(v)

Ash Pond 2 was designed and constructed, and is operated and maintained, without an emergency spillway. Ash Pond 2 was constructed with elevated embankments on the south, east, and west perimeters. There are no embankments on the north side of the pond where existing ground elevations generally increase to the north. There is a 5-foot high, non-structural berm that exists between Ash Pond 2 and US route 6, which prevents run-on from US route 6. There is no significant run-on to the basins. Inflows for the pond consist solely of regulated flows from plant operations and precipitation that falls within the surface area of the pond and embankment crests. Surface water levels are maintained by regulating inflow from plant operations and maintaining operating levels. An inflow design flood control system plan has been prepared to document that the Basins adequately manage flow from the 1,000 year flood event (Geosyntec, 2016f).

3.6 Structural Integrity of Hydraulic Structures – §257.73(d)(1)(vi)

Hydraulic structures passing through or beneath the embankments of Ash Pond 2 consist of outlet pipes associated with Pond 1 and Ash Pond 2, as presented in Figure 2. These pipes were inspected on 9 June 2016 by a company specializing in video camera pipe inspections. No significant deterioration, deformation, distortion, bedding deficiencies, sedimentation, or

debris that would negatively affect operation of the pipes was observed during inspection of these outlet pipes.

3.7 Downstream Slopes Adjacent to Water Bodies – §257.73(d)(1)(vii)

The only water body adjacent to Ash Pond 2 is Pond 1, located west of Ash Pond 2. When operated, Pond 1 will impound water against the western downstream slope of Ash Pond 2. The slope stability analyses presented in Geosyntec (2016e) consider a "low pool" condition for Pond 1 where no water is present in Pond 1 to provide a stabilizing force on the downstream face of the western slope of Ash Pond 2.

When Pond 1 is operated and water is impounded against the downstream face of the western slope of Ash Pond 2, the impounded water is unlikely to infiltrate into the embankment because Pond 1 is lined with a 60-mil HDPE geomembrane. Therefore, a rapid drawdown condition is not applicable to the western embankment of Ash Pond 2 and was not analyzed.

3.8 Structural Stability Assessment Deficiencies - §257.73(d)(2)

No structural stability deficiencies associated with Ash Pond 2 were identified in this initial structural stability assessment and no corrective measures are required.

3.9 Annual Inspection Requirement - §257.83(b)(4)(ii)

In accordance with §257.83(b)(4)(ii), submittal of this structural stability assessment precludes the requirement of an annual inspection under §257.83(b) for Ash Pond 2 during the 2016 calendar year.

4. Safety Factor Assessment

This section describes the initial safety factor assessment for Ash Pond 2 and the methodology used to perform the assessment in accordance with §257.73(e)(1). This assessment summarizes slope stability analyses of the critical embankment cross-section, shown in Figure 3, and evaluation of stability of the retaining wall southeast of the pond.

4.1 Slope Stability Methodology

Limit equilibrium slope stability analyses were performed to evaluate the stability of the embankments for Ash Pond 2. The process involved performing two-dimensional analyses on the critical cross-section for Ash Pond 2 using Spencer's Method as coded in the computer program SLOPE/W (Version 8.15.4.11512, www.geoslope.com) which satisfies vertical and horizontal force equilibrium and moment equilibrium (Geosyntec, 2016e). For each cross section analyzed, the program searches for the sliding surface that produces the lowest factor of safety

(FS). Factor of safety is defined as the ratio of the shear forces/moments resisting movement along a sliding surface to the forces/moments driving the instability.

Subsurface stratigraphy, groundwater conditions, and engineering parameters for the embankment and foundation materials were developed based on previous subsurface investigations performed at the Site (Geosyntec, 2016b and Geosyntec, 2016e).

4.2 Slope Stability Analyses

Four cases were analyzed to satisfy the safety factor assessment requirements in §257.73(e) (Geosyntec, 2016e).

4.2.1 Static, Long-Term Maximum Storage Pool Loading – §257.73(e)(1)(i)

Pursuant to §257.73(e)(1)(i) a static, long-term condition with the maximum operating pool loading on the embankments was evaluated. For Ash Pond 2, this condition included a pool elevation at 2 feet below the top of the embankments (Geosyntec, 2016e).

4.2.2 Static, Maximum Storage Pool Loading – §257.73(e)(1)(ii)

The conditions for §257.73(e)(1)(ii) are identical to §257.73(e)(1)(i) with the exception of the pool elevation, which is set at the top of the embankment (Geosyntec, 2016e).

4.2.3 Seismic – §257.73(e)(1)(iii)

Pursuant to §257.73(e)(1)(iii), a seismic condition for Ash Pond 2 was also analyzed. Seismic stability was evaluated with a pseudostatic analysis that uses constant horizontal accelerations to represent the effects of earthquake shaking. The horizontal accelerations are represented in SLOPE/W by a horizontal seismic coefficient. The horizontal seismic coefficient used for analysis was based on a peak ground acceleration with a 2 percent probability of exceedance in 50 years (Geosyntec, 2016g).

4.2.4 Liquefaction – §257.73(e)(1)(i)

The Ash Pond 2 embankment soils are assumed to be unsaturated. Based on quarterly groundwater monitoring in the vicinity of Ash Pond 2, groundwater is approximately 8 feet below the bottom of the pond. Further, the embankments are lined with an HDPE geomembrane liner that limits infiltration into the embankments and makes saturation of the embankments unlikely. Because the embankment soils are unlikely to be saturated and therefore are not considered susceptible to liquefaction, the calculation of a factor of safety for post-liquefaction slope stability is not required.

4.3 Results

The results of the slope stability analysis for the critical cross section of the Ash Pond 2 embankments are summarized in Table 1 below and presented in Figures 4 through 6 (Geosyntec 2016e).

Table 1: Safety Factor Results

Section	Safety Factor			
	257.73(e)(1)(i)	**257.73(e)(1)(ii)**	**257.73(e)(1)(iii)**	**257.73(e)(1)(iv)**
1	≥1.50	≥1.40	≥1.00	N/A

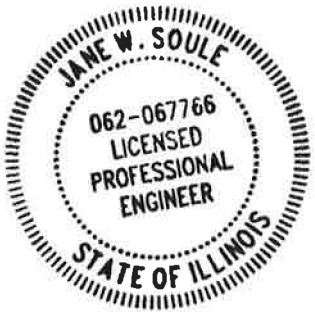
The results of the slope stability analyses meet the minimum safety factors requirements presented in §257.73(e)(1)(i) through §257.73(e)(1)(iii).

4.4 Retaining Wall Analyses

Stability of the retaining wall located on the southwest portion of the southern embankment of Ash Pond 2 was also evaluated (Geosyntec, 2016h). Construction drawings for the wall and site observations indicate that it is a reinforced concrete cantilever type wall. As-built construction documentation for the wall was not available. Inputs for the analyses were based on information provided in the construction drawings and developed from subsurface investigations at the Site (Geosyntec, 2016h and Geosyntec, 2016b). Factors of safety for bearing capacity, overturning, and sliding were calculated for the wall and results indicate that the factors of safety exceed minimum industry standard values (Geosyntec, 2016h).

5. Limitations and Certification

This initial periodic structural stability and safety factor assessment meets the requirements of §257.73(d) and §257.73(e) of the Code of Federal Regulations Title 40, Part 257, Subpart D, and was prepared in accordance with current practices and the standard of care exercised by scientists and engineers performing similar tasks in the field of civil engineering. The contents of this report are based solely on the observations of the conditions observed by Geosyntec personnel and information provided to Geosyntec by Midwest Generation. Consistent with applicable professional standards of care, our opinions and recommendations were based in part on data furnished by others, which was consistent with other information that we developed in the course of our performance of the scope of services. The information contained in this report is intended for use solely by Midwest Generation and their subconsultants.



Jane W. Soule, P.E.
Illinois Professional Engineer No. 062-067766
Expiration Date: 11/30/2017

6. References

Geosyntec (2016a). History of Construction Report, Ash Pond 2, Joliet 29 Station, October.

Geosyntec (2016b). Soil Properties Calculations, Joliet 29 Station, October.

Geosyntec (2016c). Annual Inspection Report, Ash Pond 2, Joliet 29 Station, 18 January 2016.

Geosyntec (2016d). Liquefaction Calculations, Ash Pond 2, Joliet 29 Station, October.

Geosyntec (2016e). Slope Stability Calculations, Joliet 29 Station, October.

Geosyntec (2016f). Inflow Design Flood Control System Plan, Ash Pond 2, Joliet 29 Generating Station, October.

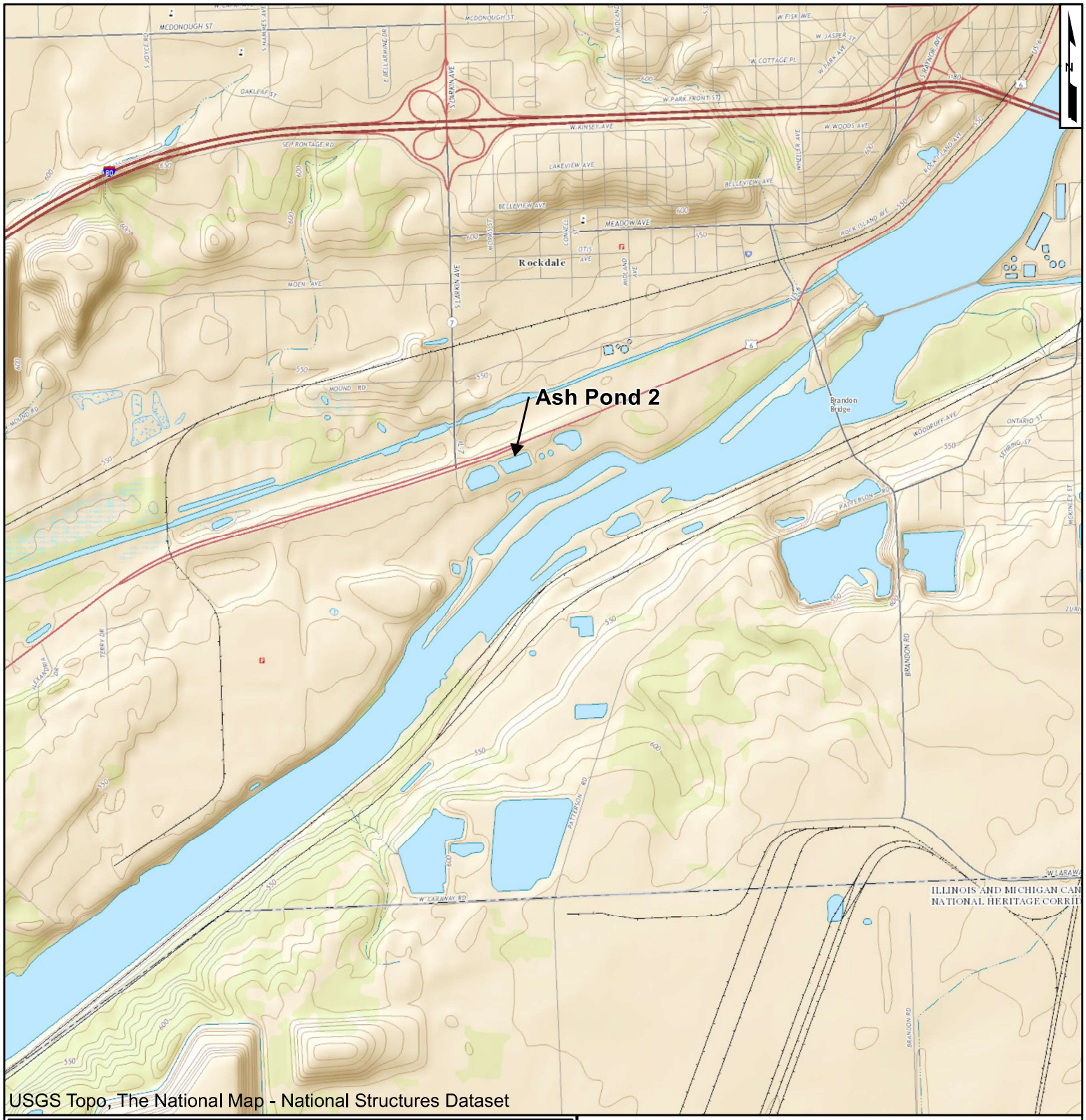
Geosyntec (2016g). Seismic Coefficient Calculations, Joliet 29 Station, October.

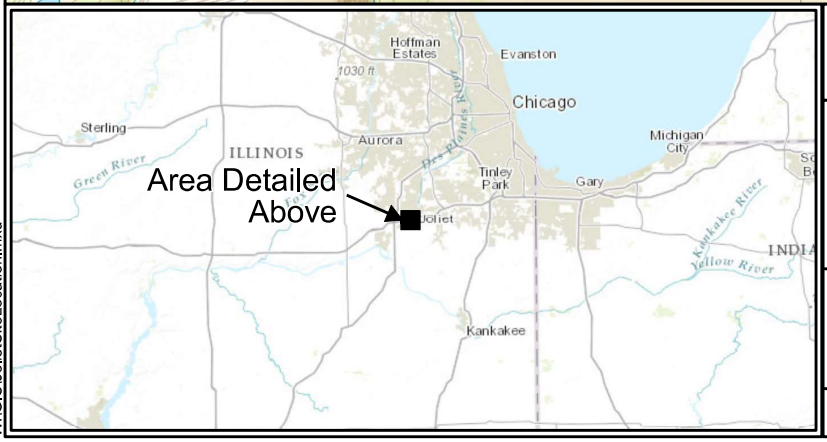
Geosyntec (2016h). Retaining Wall Calculations, Joliet 29 Station, October.

Idriss and Boulanger (2008). "Soil Liquefaction During Earthquakes". Earthquake Engineering Research Institute, MNO-12.

Attachments

Figure 1 – Site Location
Figure 2 – Hydraulic Structure Locations
Figure 3 – Critical Cross Section
Figure 4 – Slope Stability Output, Section 1 - 257.73(e)(1)(i)
Figure 5 – Slope Stability Output, Section 1 - 257.73(e)(1)(ii)
Figure 6 – Slope Stability Output, Section 1 - 257.73(e)(1)(iii)





2,000 1,000 0 2,000 Feet

Site Location

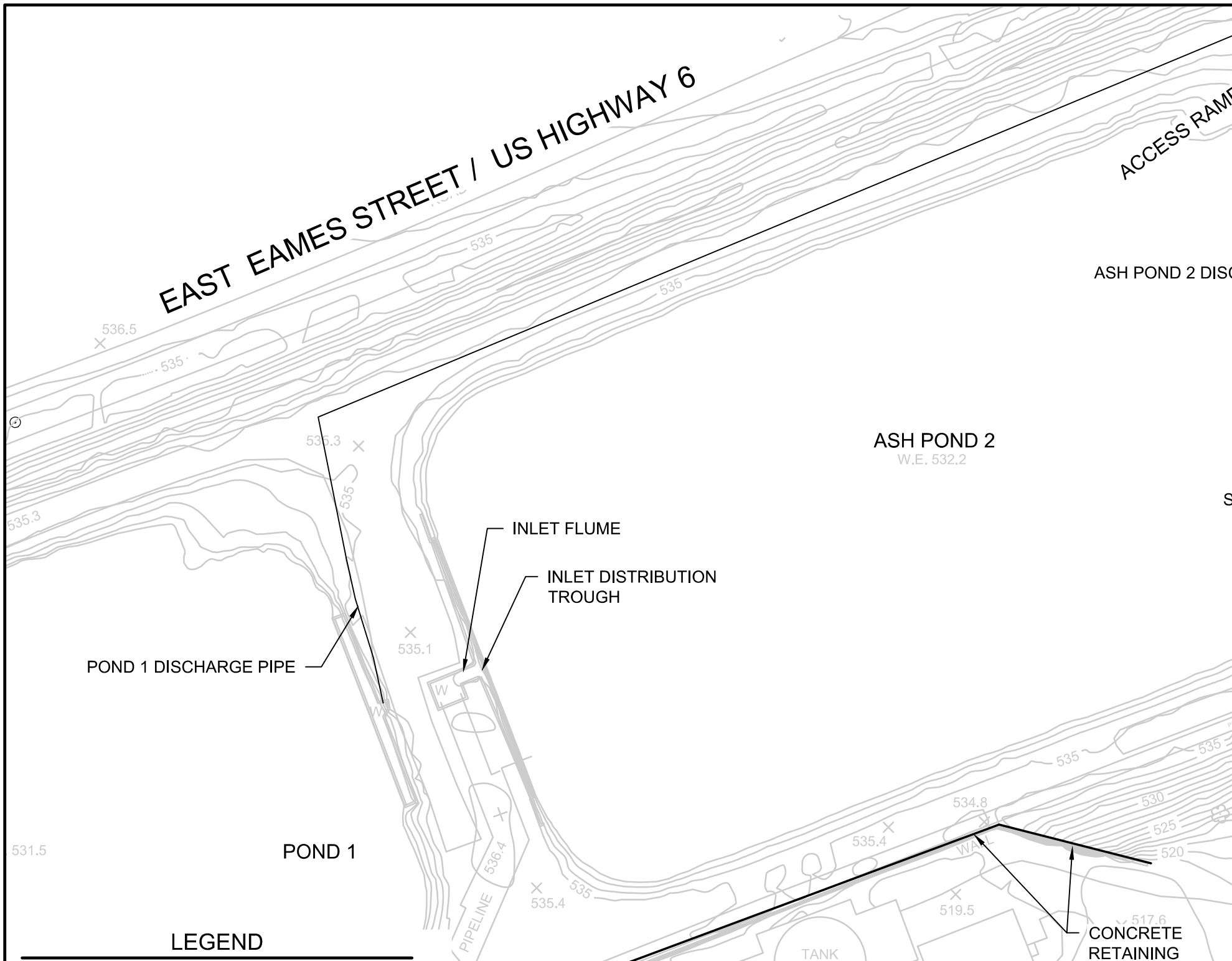
Ash Pond 2
Joliet 29 Station
Joliet, Illinois

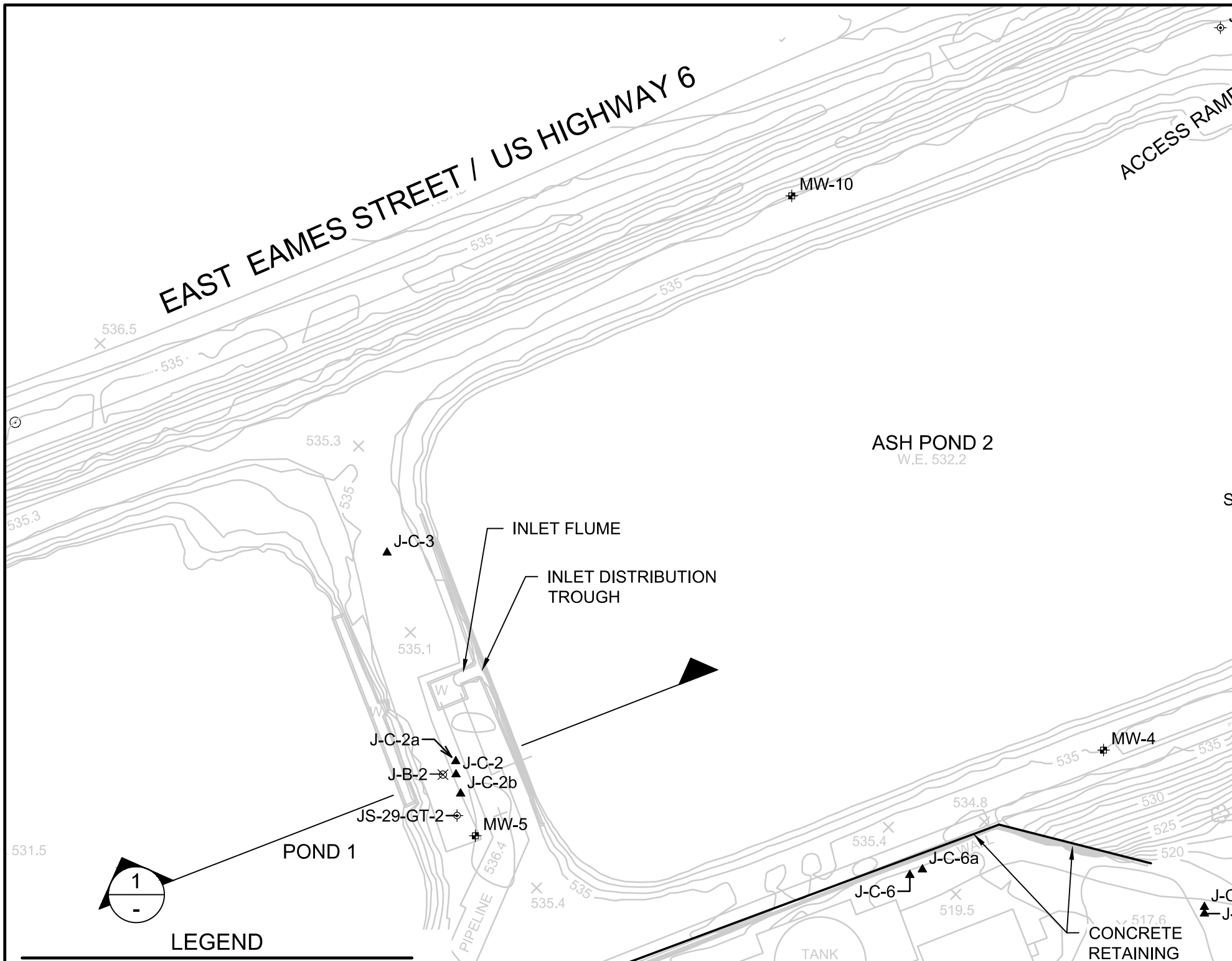
Geosyntec consultants

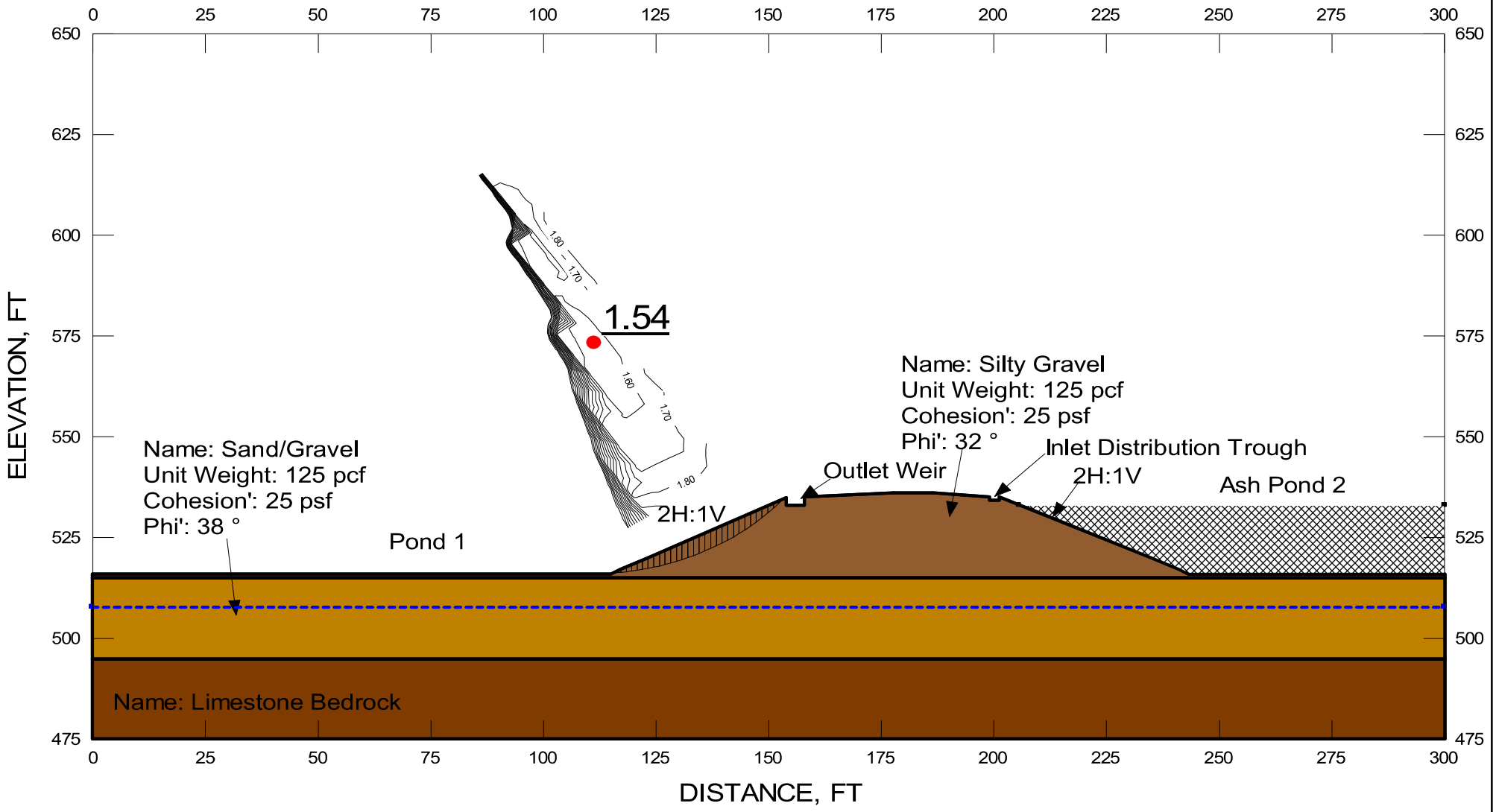
San Diego | October 2016

Figure 1

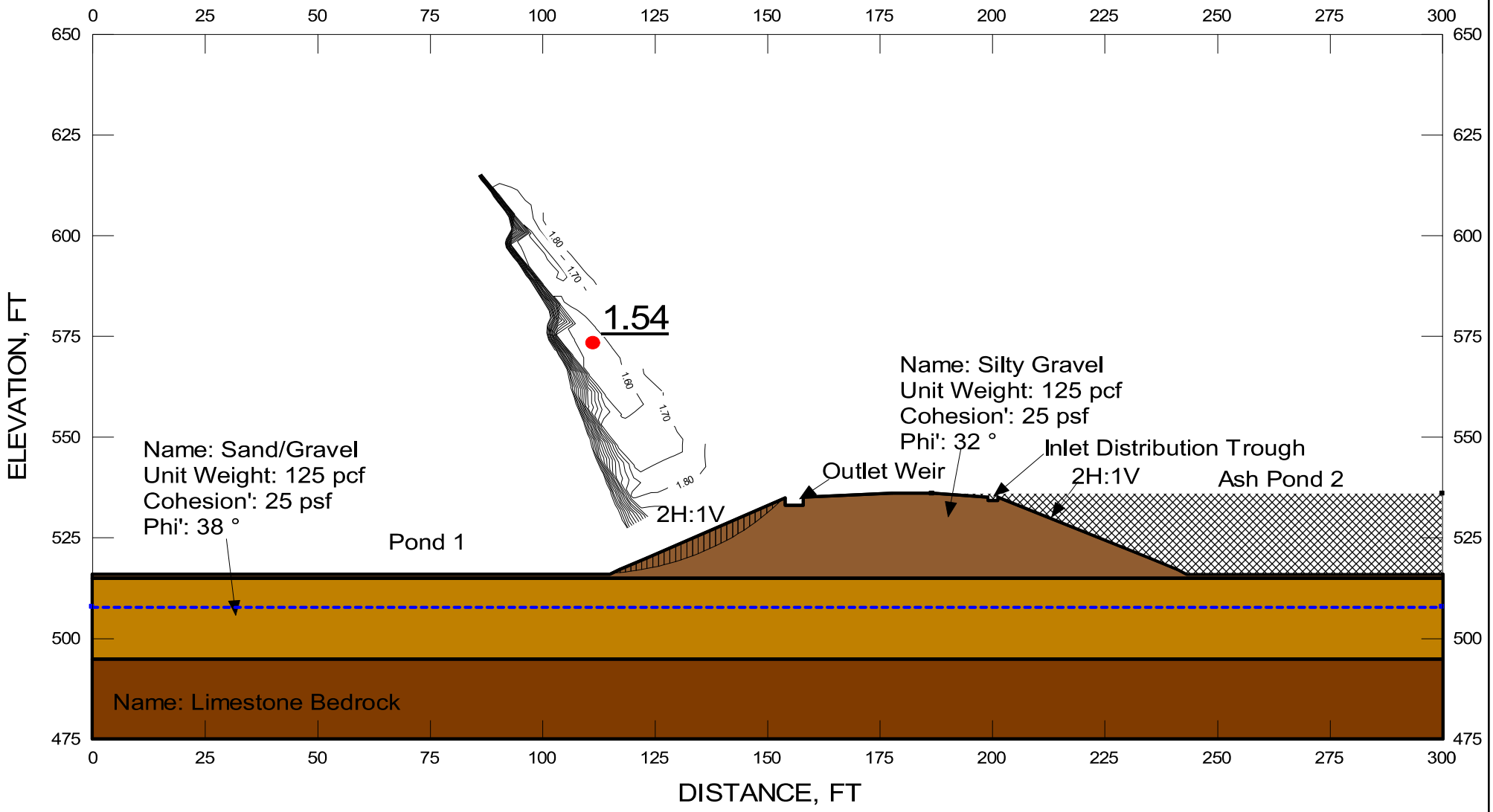
W:\GIS\JolietSiteLocation.mxd


EAST EAMES STREET / US HIGHWAY 6
ACCESS RAMP
ASH POND 2 DISC
ASH POND 2
W.E. 532.2
INLET FLUME
INLET DISTRIBUTION TROUGH
POND 1 DISCHARGE PIPE
POND 1
PIPELINE
TANK
CONCRETE RETAINING
536.5
535
535.3
535.1
536.4
534.8
535.4
519.5
517.6
531.5
530
525
520
LEGEND
HYDRAULIC STRUCTURES

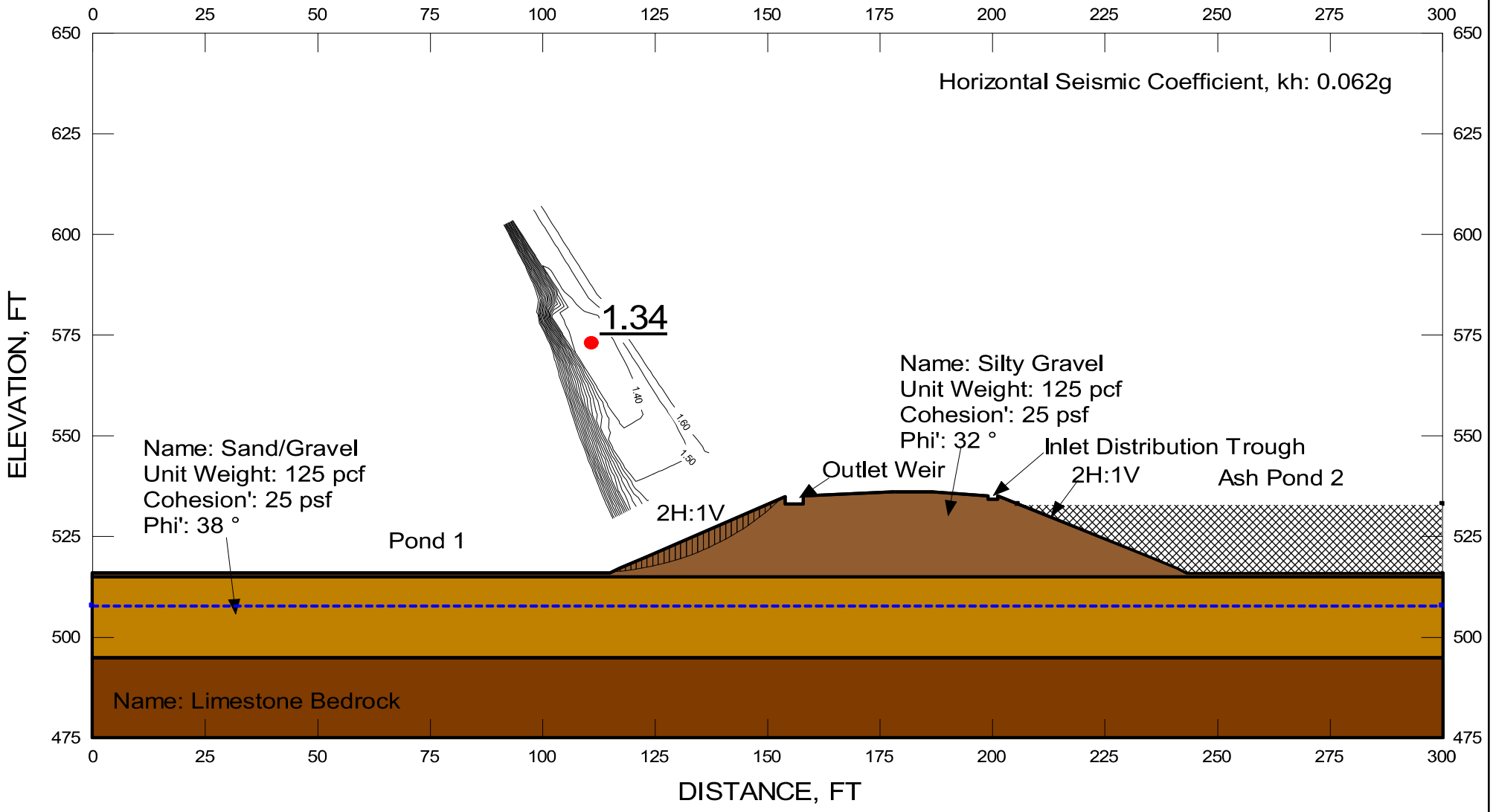

EAST EAMES STREET / US HIGHWAY 6
ACCESS RAMP
MW-10
ASH POND 2
W.E. 532.2
INLET FLUME
INLET DISTRIBUTION TROUGH
J-C-3
J-C-2a
J-C-2
J-B-2
J-C-2b
JS-29-GT-2
MW-5
MW-4
POND 1
J-C-6a
J-C-6
CONCRETE RETAINING
PIPELINE
TANK
1
-
LEGEND
ABILITY SECTIONS (CRITICAL)



Geosyntec consultants	Analysis: Section 1 - §257.73(e)(1)(i): Long Term, Maximum Storage Pool Loading		FIGURE 4
	Project: Joliet Ash Pond 2	Analysis By: Cory Russell	
	File Name: Joliet Ash Pond 2.Section 1.gsz	Date: October 2016	



Geosyntec consultants	Analysis: Section 1 - §257.73(e)(1)(ii): Maximum Surcharge Pool Loading		FIGURE 5
	Project: Joliet Ash Pond 2	Analysis By: Cory Russell	
	File Name: Joliet Ash Pond 2.Section 1.gsz	Date: October 2016	



Geosyntec consultants	Analysis: Section 1 - §257.73(e)(1)(iii): Long Term, Maximum Storage Pool Loading with Seismic		FIGURE 6
	Project: Joliet Ash Pond 2	Analysis By: Cory Russell	
	File Name: Joliet Ash Pond 2.Section 1.gsz	Date: October 2016	

The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 5

AECOM

Submitted to
Electric Energy, Inc.
2200 Portland Road
Metropolis, IL 62960

Submitted by
AECOM
1001 Highlands Plaza Drive West
Suite 300
St. Louis, MO 63110

October 2016

CCR Rule Report: Initial Safety Factor Assessment

For

East Ash Pond

At Joppa Power Station

1 Introduction

This Coal Combustion Residual (CCR) Rule Report documents that the East Ash Pond at the Electric Energy, Inc. (EEI) Joppa Power Station meets the safety factor assessment requirements specified in 40 Code of Federal Regulations (CFR) §257.73(e). The East Ash Pond is located near Joppa, Illinois in Massac County, approximately 0.1 miles northeast of the Joppa Power Station. The East Ash Pond serves as the ash impoundment basin for CCRs produced at the Joppa Power Station.

The East Ash Pond is an existing CCR surface impoundment as defined by 40 CFR §257.53. The CCR Rule requires that the initial safety factor assessment for an existing CCR surface impoundment be completed by October 17, 2016.

The owner or operator of the CCR unit must obtain a certification from a qualified professional engineer stating that the initial safety factor assessment meets the requirements of 40 CFR § 257.73(e). The owner or operator must prepare a safety factor assessment every five years.

2 Initial Safety Factor Assessment

40 CFR §257.73(e)(1)
The owner or operator must conduct initial and periodic safety factor assessments for each CCR unit and document whether the calculated factors of safety for each CCR unit achieve the minimum safety factors specified in (e)(1)(i) through (iv) of this section for the critical cross section of the embankment. The critical cross section is the cross section anticipated to be the most susceptible of all cross sections to structural failure based on appropriate engineering considerations, including loading conditions. The safety factor assessments must be supported by appropriate engineering calculations.

(i) The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.
(ii) The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.
(iii) The calculated seismic factor of safety must equal or exceed 1.00.
(iv) For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

A geotechnical investigation program and stability analyses were performed to evaluate the design, performance, and condition of the earthen dikes of the East Ash Pond. The exploration consisted of hollow-stem auger borings, cone penetration testing with seismic wave velocity measurements and pore pressure dissipation testing, piezometer installation and monitoring, and a laboratory program including strength and index testing. Data collected from the geotechnical investigation, available design drawings, construction records, inspection reports, previous engineering investigations, and other pertinent historic documents were utilized to perform the safety factor assessment and geotechnical analyses.

The East Ash Pond embankment is generally medium stiff to stiff and overlies predominantly alluvial foundation materials. The alluvial foundation consists of soft to stiff clay overlying medium dense to dense sand. A zone of sluiced flyash that existed before the embankment dike was constructed was encountered below the compacted embankment in the southeast corner. The zone of sluiced flyash was modified by the installation of Deep Mixing Method (DMM) ground improvement technology using the wet soil mixing method. Explorations were terminated in the soil overburden and were not extended to bedrock. The phreatic surface is typically at or slightly above the embankment/foundation interface.

Six (6) representative cross sections were analyzed using limit equilibrium slope stability analysis software to evaluate stability of the perimeter dike system and foundations. The cross sections were located to represent critical surface geometry, subsurface stratigraphy, and phreatic conditions across the CCR unit. Each cross section was evaluated for each of the loading conditions stipulated in §257.73(e)(1).

The Soils Susceptible to Liquefaction loading condition, §257.73(e)(1)(iv), was not evaluated because a liquefaction susceptibly evaluation did not find soils susceptible to liquefaction within the East Ash Pond dikes. As a result, this loading condition is not applicable to the East Ash Pond at the Joppa Power Station.

Results of the Initial Safety Factor Assessments, for the critical cross-section for each loading condition (i.e., the lowest calculated factor of safety out of the cross sections analyzed for each loading condition), are listed in Table 1.

Table 1 – Summary of Initial Safety Factor Assessments

Loading Conditions	§257.73(e)(1) Subsection	Minimum Factor of Safety	Calculated Factor of Safety
Maximum Storage Pool Loading	(i)	1.50	1.59
Maximum Surcharge Pool Loading	(ii)	1.40	1.57
Seismic	(iii)	1.00	1.01
Soils Susceptible to Liquefaction	(iv)	1.20	Not Applicable

Based on this evaluation, the East Ash Pond meets the requirements in §257.73(e)(1).

3 Certification Statement

CCR Unit: Electric Energy, Inc.; Joppa Power Station; East Ash Pond

I, Victor A. Modeer, being a Registered Professional Engineer in good standing in the State of Illinois, do hereby certify, to the best of my knowledge, information, and belief that the information contained in this CCR Rule Report, and the underlying data in the operating record, has been prepared in accordance with the accepted practice of engineering. I certify, for the above-referenced CCR Unit, that the initial safety factor assessment dated October 14, 2016 meets the requirements of 40 CFR §257.73.

Victor A. Modeer Jr

Printed Name

10/14/16

Date



About AECOM

AECOM (NYSE: ACM) is a global provider of professional technical and management support services to a broad range of markets, including transportation, facilities, environmental, energy, water and government. With nearly 100,000 employees around the world, AECOM is a leader in all of the key markets that it serves. AECOM provides a blend of global reach, local knowledge, innovation, and collaborative technical excellence in delivering solutions that enhance and sustain the world's built, natural, and social environments. A Fortune 500 company, AECOM serves clients in more than 100 countries and has annual revenue in excess of $19 billion.

More information on AECOM and its services can be found at www.aecom.com.

1001 Highlands Plaza Drive West
Suite 300
St. Louis, MO 63110
1-314-429-0100

ATTACHMENT 6

AECOM

Submitted to
Kincaid Generation, LLC
199 Route 104
Kincaid, IL 62540

Submitted by
AECOM
1001 Highlands Plaza Drive West
Suite 300
St. Louis, MO 63110

October 2016

CCR Rule Report: Initial Safety Factor Assessment

For

Kincaid Ash Pond

At Kincaid Power Station

1 Introduction

This Coal Combustion Residual (CCR) Rule Report documents that the Kincaid Ash Pond at the Kincaid Generation, LLC Kincaid Power Station meets the safety factor assessment requirements specified in 40 Code of Federal Regulations (CFR) §257.73(e). The Kincaid Ash Pond is located near Kincaid, Illinois in Christian County, approximately 0.1 miles northeast of the Kincaid Power Station. The Kincaid Ash Pond serves as the wet impoundment basin for CCR produced by the Kincaid Power Station.

The Kincaid Ash Pond is an existing CCR surface impoundment as defined by 40 CFR §257.53. The CCR Rule requires that the initial safety factor assessment for an existing CCR surface impoundment be completed by October 17, 2016.

The owner or operator of the CCR unit must obtain a certification from a qualified professional engineer stating that the initial safety factor assessment meets the requirements of 40 CFR § 257.73(e). The owner or operator must prepare a safety factor assessment every five years.

2 Initial Safety Factor Assessment

40 CFR §257.73(e)(1)
The owner or operator must conduct initial and periodic safety factor assessments for each CCR unit and document whether the calculated factors of safety for each CCR unit achieve the minimum safety factors specified in (e)(1)(i) through (iv) of this section for the critical cross section of the embankment. The critical cross section is the cross section anticipated to be the most susceptible of all cross sections to structural failure based on appropriate engineering considerations, including loading conditions. The safety factor assessments must be supported by appropriate engineering calculations.

(i) The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.

(ii) The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.

(iii) The calculated seismic factor of safety must equal or exceed 1.00.

(iv) For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

A geotechnical investigation program and stability analyses were performed to evaluate the design, performance, and condition of the earthen dikes of the Kincaid Ash Pond. The exploration consisted of hollow-stem auger borings, cone penetration tests, installation of piezometers, and laboratory program including strength, hydraulic conductivity, consolidation, and index testing. Data collected from the geotechnical investigation, available design drawings, construction records, inspection reports, previous engineering investigations, and other pertinent historic documents were utilized to perform the safety factor assessment and geotechnical analyses.

In general, the subsurface conditions at the Kincaid Ash Pond consist of medium stiff to very stiff embankment fill (clay) overlying soft to very stiff clay foundation soils, which in turn overlies hard glacial till (clay). Phreatic water is typically at or slightly above the embankment/foundation interface.

Five (5) representative cross sections were analyzed using limit equilibrium slope stability analysis software to evaluate stability of the perimeter dike system and foundations. The cross sections were located to represent critical surface geometry, subsurface stratigraphy, and phreatic conditions across the site. Each cross section was evaluated for each of the loading conditions stipulated in §257.73(e)(1).

The Soils Susceptible to Liquefaction loading condition, §257.73(e)(1)(iv), was not evaluated because a liquefaction susceptibly evaluation did not find soils susceptible to liquefaction within the Kincaid Ash Pond dikes. As a result, this loading condition is not applicable to the Kincaid Ash Pond.

Results of the Initial Safety Factor Assessments for the critical cross-section for each loading condition are listed in Table 1 (i.e. the table identifies the lowest calculated safety of factor calculated for any one of the five analyzed cross sections for each loading condition).

Table 1 – Summary of Initial Safety Factor Assessments

Loading Conditions	§257.73(e)(1) Subsection	Minimum Factor of Safety	Calculated Factor of Safety
Maximum Storage Pool Loading	(i)	1.50	1.57
Maximum Surcharge Pool Loading	(ii)	1.40	1.57
Seismic	(iii)	1.00	1.27
Soils Susceptible to Liquefaction	(iv)	1.20	Not Applicable

Based on this evaluation, the Kincaid Ash Pond meets the requirements in §257.73(e)(1).

3 Certification Statement

CCR Unit: Kincaid Generation, LLC; Kincaid Power Station; Kincaid Ash Pond

I, Victor A. Modeer, being a Registered Professional Engineer in good standing in the State of Illinois, do hereby certify, to the best of my knowledge, information, and belief that the information contained in this CCR Rule Report, and the underlying data in the operating record, has been prepared in accordance with the accepted practice of engineering. I certify, for the above-referenced CCR Unit, that the initial safety factor assessment dated October 13, 2016 meets the requirements of 40 CFR §257.73(e).

VICTOR A MODEER
Printed Name

10/13/16
Date



About AECOM

AECOM (NYSE: ACM) is a global provider of professional technical and management support services to a broad range of markets, including transportation, facilities, environmental, energy, water and government. With nearly 100,000 employees around the world, AECOM is a leader in all of the key markets that it serves. AECOM provides a blend of global reach, local knowledge, innovation, and collaborative technical excellence in delivering solutions that enhance and sustain the world's built, natural, and social environments. A Fortune 500 company, AECOM serves clients in more than 100 countries and has annual revenue in excess of $19 billion.

More information on AECOM and its services can be found at www.aecom.com.

1001 Highlands Plaza Drive West
Suite 300
St. Louis, MO 63110
1-314-429-0100

ATTACHMENT 7

AECOM

Submitted to
Illinois Power Generating Company
6725 North 500th Street
Newton, IL 62448

Submitted by
AECOM
1001 Highlands Plaza Drive West
Suite 300
St. Louis, MO 63110

October 2016

CCR Rule Report: Initial Safety Factor Assessment

For

Primary Ash Pond

At Newton Power Station

1 Introduction

This Coal Combustion Residual (CCR) Rule Report documents that the Primary Ash Pond at the Illinois Power Generating Company Newton Power Station meets the safety factor assessment requirements specified in 40 Code of Federal Regulations (CFR) §257.73(e). The Primary Ash Pond is located near Newton, Illinois in Jasper County, approximately 0.2 miles southwest of the Newton Power Station. The Primary Ash Pond serves as the wet impoundment basin for CCR produced by the Newton Power Station.

The Primary Ash Pond is an existing CCR surface impoundment as defined by 40 CFR §257.53. The CCR Rule requires that the initial safety factor assessment for an existing CCR surface impoundment be completed by October 17, 2016.

The owner or operator of the CCR unit must obtain a certification from a qualified professional engineer stating that the initial safety factor assessment meets the requirements of 40 CFR § 257.73(e). The owner or operator must prepare a safety factor assessment every five years.

2 Initial Safety Factor Assessment

40 CFR §257.73(e)(1)
The owner or operator must conduct initial and periodic safety factor assessments for each CCR unit and document whether the calculated factors of safety for each CCR unit achieve the minimum safety factors specified in (e)(1)(i) through (iv) of this section for the critical cross section of the embankment. The critical cross section is the cross section anticipated to be the most susceptible of all cross sections to structural failure based on appropriate engineering considerations, including loading conditions. The safety factor assessments must be supported by appropriate engineering calculations.

(i) The calculated static factor of safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.

(ii) The calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.40.

(iii) The calculated seismic factor of safety must equal or exceed 1.00.

(iv) For dikes constructed of soils that have susceptibility to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

A geotechnical investigation program and stability analyses were performed to evaluate the design, performance, and condition of the earthen dikes of the Primary Ash Pond. The exploration consisted of hollow-stem auger borings, cone penetration testing, piezometer installation and laboratory program including strength, hydraulic conductivity, consolidation, and index testing. Data collected from the geotechnical investigation, available design drawings, construction records, inspection reports, previous engineering investigations, and other pertinent historic documents were utilized to perform the safety factor assessment and geotechnical analyses.

In general, the subsurface conditions at the Primary Ash Pond consist of medium stiff to stiff embankment fill (clay) overlying stiff to hard clay, which in turn overlies very stiff to very hard glacial till. Phreatic water is above the embankment/foundation of the Primary Ash Pond.

Ten (10) representative cross sections were analyzed using limit equilibrium slope stability analysis software to evaluate stability of the perimeter dike system and foundations. The cross sections were located to represent critical surface geometry, subsurface stratigraphy, and phreatic conditions across the site. Each cross section was evaluated for each of the loading conditions stipulated in §257.73(e)(1).

The Soils Susceptible to Liquefaction loading condition, §257.73(e)(1)(iv), was not evaluated because a liquefaction susceptibly evaluation did not find soils susceptible to liquefaction within the Primary Ash Pond dikes. As a result, this loading condition is not applicable to the Primary Ash Pond at the Newton Power Station.

Results of the Initial Safety Factor Assessments for the critical cross-section for each loading condition (i.e., the lowest calculated factor of safety out of the 10 cross sections analyzed for each loading condition) are listed in Table 1.

Table 1 – Summary of Initial Safety Factor Assessments

Loading Conditions	§257.73(e)(1) Subsection	Minimum Factor of Safety	Calculated Factor of Safety
Maximum Storage Pool Loading	(i)	1.50	1.66
Maximum Surcharge Pool Loading	(ii)	1.40	1.66
Seismic	(iii)	1.00	1.07
Soils Susceptible to Liquefaction	(iv)	1.20	Not Applicable

Based on this evaluation, the Primary Ash Pond meets the requirements in §257.73(e)(1).

3 Certification Statement

CCR Unit: Illinois Power Generating Company; Newton Power Station; Primary Ash Pond

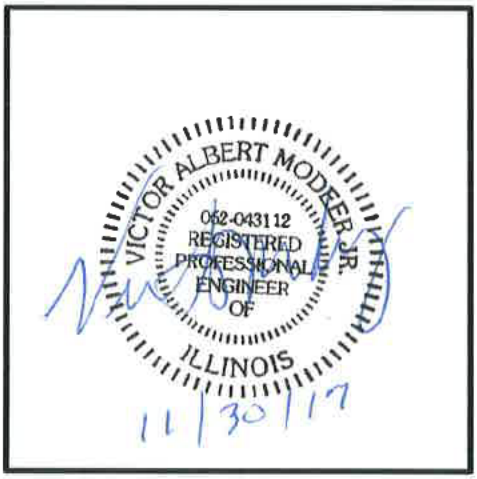
I, Victor A. Modeer, being a Registered Professional Engineer in good standing in the State of Illinois, do hereby certify, to the best of my knowledge, information, and belief that the information contained in this CCR Rule Report, and the underlying data in the operating record, has been prepared in accordance with the accepted practice of engineering. I certify, for the above-referenced CCR Unit, that the initial safety factor assessment dated October 13, 2016 meets the requirements of 40 CFR §257.73(e).

VICTOR A MODEER SR.

Printed Name

10/13/16

Date



About AECOM

AECOM (NYSE: ACM) is a global provider of professional technical and management support services to a broad range of markets, including transportation, facilities, environmental, energy, water and government. With nearly 100,000 employees around the world, AECOM is a leader in all of the key markets that it serves. AECOM provides a blend of global reach, local knowledge, innovation, and collaborative technical excellence in delivering solutions that enhance and sustain the world's built, natural, and social environments. A Fortune 500 company, AECOM serves clients in more than 100 countries and has annual revenue in excess of $19 billion.

More information on AECOM and its services can be found at www.aecom.com.

1001 Highlands Plaza Drive West
Suite 300
St. Louis, MO 63110
1-314-429-0100

ATTACHMENT 8

Geosyntec consultants

16644 West Bernardo Drive, Suite 301
San Diego, CA 92127
Phone: 858.674.6559
Fax: 858.674.6586
www.geosyntec.com

STRUCTURAL STABILITY AND FACTOR OF SAFETY ASSESSMENT
EAST AND WEST ASH BASINS
WAUKEGAN STATION
OCTOBER 2016

This report presents the initial periodic structural stability and initial safety factor assessment of the East and West Ash Basins (the Basins) at the Waukegan Station (Site) in Waukegan, Illinois (Figure 1). This report addresses the initial structural stability and safety factor assessment requirements of the Coal Combustion Residuals (CCR) regulations, Code of Federal Regulations Title 40, Part 257, Subpart D (referred to as the CCR Rule). These regulations were published in the Federal Register on 17 April 2015 and became effective on 19 October 2015. The Waukegan Station is owned and operated by Midwest Generation, LLC (Midwest Generation). Based on the results provided in this report, the East and West Ash Ponds meet the requirements of §257.73(d) and §257.73(e) of the CCR Rule.

The work presented in this report was performed under the direction of Ms. Jane Soule, P.E., of Geosyntec Consultants Inc. (Geosyntec) in accordance with §257.73(d) and §257.73(e). Mr. Robert White reviewed this report in accordance with Geosyntec's senior review policy.

1. Regulation Requirements - §257.73

Structural integrity criteria for existing CCR impoundments is described in §257.73 and includes structural stability and factor of safety assessments. The East and West Ash Basins meet the minimum size and capacity criteria under §257.73(b) and are subject to the structural stability and safety factor assessments required.

2. Site Conditions

The Basins are co-located in the southeastern portion of the Waukegan Station. A divider berm extends north-south between the Basins. The Basins are irregular in shape, and each includes a finger berm extending from the northern boundary southward approximately 715 feet. The West Ash Basin is approximately 470 feet by 975 feet in plan dimensions with a total plan area of approximately 11.0 acres (including the finger berm and embankment crests). The East Ash Basin is approximately 470 feet by 1,030 feet in plan dimensions with a total plan area of approximately 11.8 acres (including the finger berm and embankment crests).

A retaining wall is located on the downstream side of the north embankment, north of the outlet structures for the Basins.

Based on available documentation and discussions with site personnel, the Basins, in their current configuration, were constructed in the late 1970s. A history of construction for the Basins

engineers | scientists | innovators

was prepared in accordance with §257.73(c) and describes the design of the Basins and their construction (Geosyntec, 2016a).

3. Structural Stability Assessment

The following subsections address the components of §257.73(d)(1).

3.1 Foundations and Abutments – §257.73(d)(1)(i)

The East and West Ash Basins consist of fill embankments on all sides. The area west of the West Ash Basin includes fill graded to approximately the same elevation as the west embankment crest. Because no formational material provides lateral structural support for the embankments, there are no abutments associated with the Basins. The remainder of this section addresses the foundation materials for the East and West Ash Basins.

Previous subsurface investigations performed at the Site indicate the foundation materials underlying the embankments for the East and West Ash Basins generally consist of approximately 30 feet of dense, poorly graded sand with some gravel, and silt and silty sand associated with the Henry Formation (Geosyntec, 2016b). Due to the granular nature of the foundation soils (mostly sand and gravel), settlement associated with the construction and operation of the Basins is anticipated to be predominately elastic settlement, which would likely have occurred soon after construction in the late 1970s. Because of the age of the embankments (over 35 years old), the majority of potential consolidation and secondary compression settlement has likely already occurred. Further, the embankments of the Basins were not constructed with abutments or separate engineered zones that would be most susceptible to the adverse effects of differential settlement.

During the initial annual inspection performed for the Basins in accordance with §257.83(b), no visual evidence of adverse effects resulting from settlement was observed (Geosyntec, 2016c). There are no proposed changes in operation which would increase loading conditions on the foundation; therefore, no significant settlement of the foundation materials underlying the embankments is anticipated to occur in the future and the settlement of the foundation is not anticipated to impact the integrity of the impoundment embankments.

A factor of safety against the triggering of liquefaction was calculated for saturated foundation materials underlying the Basins' embankments. The factor of safety was calculated based methods outlined in Idriss and Boulanger (2008) using information obtained from field explorations, including borings, Cone Penetration Test (CPT) soundings, laboratory data (Geosyntec, 2016b), and seismic data (Geosyntec, 2016d). The liquefaction triggering analyses shows a very low likelihood of liquefaction occurring in the foundation materials underlying the embankments (Geosyntec, 2016d).

3.2 Upstream Slope Protection – §257.73(d)(1)(ii)

The West and East Basins are lined with a 60-mil high density polyethylene (HDPE) geomembrane that protects the interior basin slopes from erosion, the effects of wave action, and mitigates potential effects of rapid drawdown.

3.3 Dike Compaction – §257.73(d)(1)(iii)

Documentation of as-built construction conditions for the East and West Ash Basin embankments was not available at the time of this report. However, available construction drawings from 1977 indicated that embankment fill was to be compacted to a minimum of 95 percent relative compaction as determined by Modified Proctor testing. No recent quantitative evaluation of the degree of compaction of the embankments was performed on the embankments in their current state; however, slope stability analyses shows the embankments for the East and West Ash Basins are sufficient to withstand the range of loading conditions in the CCR units (Geosyntec, 2016e).

3.4 Downstream Slope Vegetation – §257.73(d)(1)(iv)

The northern and southern downstream slopes of the West and East Ash Basins are covered with established vegetation. The eastern downstream slope of the East Ash Basin has been recently covered in erosion control matting and seeded. Based on site observations, the existing surface conditions of the slopes provide adequate slope protection.

3.5 Spillway – §257.73(d)(1)(v)

The West and East Basins were designed and constructed, and are operated and maintained, without spillways. Inflows for the Basins consist solely of regulated flows from plant operations and precipitation that falls within the surface area of the Basins and embankment crests. There is no significant run-on to the Basins. Subsequently, surface water levels are maintained by regulating inflow from plant operations, regulating outflow quantities, and monitoring and maintaining freeboard to accommodate precipitation from the design storm event. An inflow design flood control system plan has been prepared to document that the Basins adequately manage flow from the design event (Geosyntec, 2016f).

3.6 Structural Integrity of Hydraulic Structures – §257.73(d)(1)(vi)

Hydraulic structures passing through or beneath the embankments of the East and West Ash Basins consist of six pipes and conveyance structures associated with the inlet and outlet structures of the Basins. These structures and pipes were inspected between 1 June 2016 and 7 June 2016 by a company specializing in video camera pipe inspections. Inspections consisted

only of the length of the pipe or structure that passes through or beneath the Basins' embankments. The inspected structures and pipes related to the East and West Ash Basins are presented on Figure 2.

The video inspections showed no significant deterioration, deformation, distortion, bedding deficiencies, sedimentation, or debris that would negatively affect the operation of Pipes 1, 2, 3, and 5. The video inspections identified isolated areas of deformation and deterioration of Pipes 4E and 4W, which are 24-inch diameter concrete pipes with invert locations at the bottom of the outlet structures for the East and West Ash Basins, respectively. These pipes are located under the north embankment and are utilized for dewatering the outlet structure. Repairs were made to Pipe 4E to mitigate the isolated areas of deformation and deterioration identified during the inspection. The valve for controlling flow into Pipe 4W has been closed by Site personnel, and Pipe 4W will not be used until a repair is completed. Pipe 4W is not required for normal operation of the West Ash Basin.

3.7 Downstream Slopes Adjacent to Water Bodies – §257.73(d)(1)(vii)

Water bodies near the East and West Ash Basins include a drainage channel located south of the Basins and marsh area east of the Basins. Stability analyses presented in Section 3 demonstrate structural stability with the water body at a "low pool" condition where there is little or no stabilizing force present on the downstream slope of the embankments.

Significant inundation of the downstream slopes of the East and West Ash Basins from the water body is unlikely, and the generally coarse-grained embankment fill materials that are relatively free-draining make a rapid drawdown analysis not applicable. Therefore, a rapid drawdown condition is not anticipated to impact structural stability of the impoundment embankments.

3.8 Structural Stability Assessment Deficiencies - §257.73(d)(2)

A structural stability deficiency associated Pipe 4W was identified in this initial structural stability assessment. Geosyntec suggests relining the interior of the deficient portions of the pipe as a corrective action. The pipe will remain out of service until the repair is complete. Documentation detailing the corrective measures taken to repair the pipe will be prepared after the repair is complete.

3.9 Annual Inspection Requirement - §257.83(b)(4)(ii)

In accordance with §257.83(b)(4)(ii), submittal of this structural stability assessment precludes the requirement of an annual inspection under §257.83(b) for the East and West Ash Basins during the 2016 calendar year. Deficiencies identified in the initial annual inspection for the East

and West Ash Basins were corrected as documented in the Notice of Remedy prepared in response to the initial annual inspection.

4. Safety Factor Assessment

This section describes the initial safety factor assessment for the East and West Ash Basins and the methodology used to perform the assessment in accordance with §257.73(e)(1). This assessment includes slope stability analyses of the critical embankment cross-sections for each basin, shown in Figure 3, and evaluation of stability of the retaining wall north of the Basins.

4.1 Slope Stability Methodology

Limit equilibrium slope stability analyses were performed to evaluate the stability of the embankments for the East and West Ash Basins. The process involved performing two-dimensional analyses on the critical cross-sections for each basin using Spencer's Method as coded in the computer program SLOPE/W (Version 8.15.4.11512, www.geoslope.com) which satisfies vertical and horizontal force equilibrium and moment equilibrium (Geosyntec, 2016e). For each cross section analyzed, the program searches for the sliding surface that produces the lowest factor of safety (FS). Factor of safety is defined as the ratio of the shear forces/moments resisting movement along a sliding surface to the forces/moments driving the instability.

Subsurface stratigraphy, groundwater conditions, and engineering parameters for the embankment and foundation materials were developed based on previous subsurface investigations performed at the Site (Geosyntec, 2016b and Geosyntec, 2016e).

4.2 Slope Stability Analyses

As presented in Table 1, four cases were analyzed to satisfy the safety factor assessment requirements in §257.73(e) (Geosyntec, 2016e).

4.2.1 Static, Long-Term Maximum Storage Pool Loading – §257.73(e)(1)(i)

Pursuant to §257.73(e)(1)(i) a static, long-term condition with the maximum operating pool loading on the embankments was evaluated. For the East and West Ash Basins, this condition included a pool elevation 2 feet below the lowest point of the embankment crest (Geosyntec, 2016e).

4.2.2 Static, Maximum Storage Pool Loading – §257.73(e)(1)(ii)

The conditions for §257.73(e)(1)(ii) are identical to §257.73(e)(1)(i) with the exception of the pool elevation, which is set at the lowest points of the embankment crest (Geosyntec, 2016e).

4.2.3 Seismic – §257.73(e)(1)(iii)

Pursuant to §257.73(e)(1)(iii), a seismic condition for East and West Ash Basins was also analyzed. Seismic stability was evaluated with a pseudostatic analysis that uses constant horizontal accelerations to represent the effects of earthquake shaking. The horizontal accelerations are represented in SLOPE/W by a horizontal seismic coefficient. The horizontal seismic coefficient used for analysis was based on a peak ground acceleration with a 2 percent probability of exceedance in 50 years (Geosyntec, 2016g).

4.2.4 Liquefaction – §257.73(e)(1)(iv)

The majority of the embankment soils for the East and West Ash Basins are not considered susceptible to liquefaction because saturation of the embankment soils is unlikely based on the presence of a geomembrane liner system. Based on the design phreatic surface discussed in Geosyntec (2016b), a limited portion of the bottom of the embankments may become saturated from groundwater. Liquefaction triggering analyses of these saturated embankment soils indicate that liquefaction and associated post-liquefaction shear strength loss is unlikely for the seismic design event (Geosyntec, 2016d). Because the likelihood of liquefaction and associated shear strength loss of the embankment soils is very low, post-liquefaction conditions are represented by the static factor of safety analyses.

4.3 Results

The results of the slope stability analysis for the critical cross sections of the East and West Ash Basin embankments are summarized in Table 1 below and presented in Figures 4 through 9 (Geosyntec 2016e).

Section	Safety Factor			
	257.73(e)(1)(i)	257.73(e)(1)(ii)	257.73(e)(1)(iii)	257.73(e)(1)(iv)
1	≥1.50	≥1.40	≥1.00	≥1.20
2	≥1.50	≥1.40	≥1.00	≥1.20

These results meet the factor of safety requirements presented in §257.73(e)(1)(i) through §257.73(e)(1)(iv).

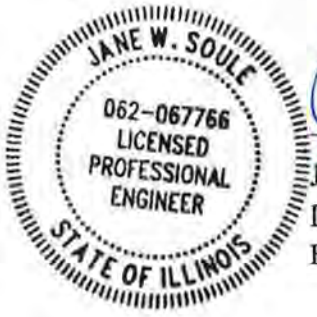
4.4 Retaining Wall Analyses

Stability of the retaining wall located north of the East and West Ash Basins was also evaluated (Geosyntec, 2016h). Construction drawings for the wall were not available, but Geosyntec personnel observed that the wall is a metal bin wall, a form of gravity retaining structure similar to a crib wall, built by combining “bins”, or cells filled with soil. Inputs for the analyses were based on field observations and measurements of the wall the subsurface investigations at the

Site (Geosyntec, 2016h and Geosyntec, 2016b). Factors of safety for bearing capacity, overturning, and sliding were calculated for the wall based on methods for evaluating a cantilever retaining wall in Das (2007). Results show that the factors of safety for the wall exceed minimum industry standard values (Geosyntec, 2016h).

5. Limitations and Certification

This initial periodic structural stability and safety factor assessment meets the requirements of §257.73(d) and §257.73(e) of the Code of Federal Regulations Title 40, Part 257, Subpart D, and was prepared in accordance with current practices and the standard of care exercised by scientists and engineers performing similar tasks in the field of civil engineering. The contents of this report are based solely on the observations of the conditions observed by Geosyntec personnel and information provided to Geosyntec by Midwest Generation. Consistent with applicable professional standards of care, our opinions and recommendations were based in part on data furnished by others, which was consistent with other information that we developed in the course of our performance of the scope of services. The information contained in this report is intended for use solely by Midwest Generation and their subconsultants.



Jane W. Soule, P.E.
Illinois Professional Engineer No. 062-067766
Expiration Date: 11/30/2017

6. References

Das, 2007. "Principles of Foundation Engineering," Sixth edition. Thomson Canada Limited.

Geosyntec, 2016a. History of Construction Report, East and West Ash Basins, Waukegan Station, October.

Geosyntec, 2016b. East and West Ash Basin – Soil Properties Calculation, Waukegan Station, October.

Geosyntec, 2016c. Annual Inspection Report, East and West Ash Basin, Waukegan Station, 18 January 2016.

Geosyntec, 2016d. East and West Ash Basin – Liquefaction Calculations, Waukegan Station, October.

Geosyntec, 2016e. East and West Ash Basin – Slope Stability Calculations, Waukegan Station, October.

Geosyntec, 2016f. Inflow Design Flood Control System Plan, West and East Ash Basins, Waukegan Generating Station, October.

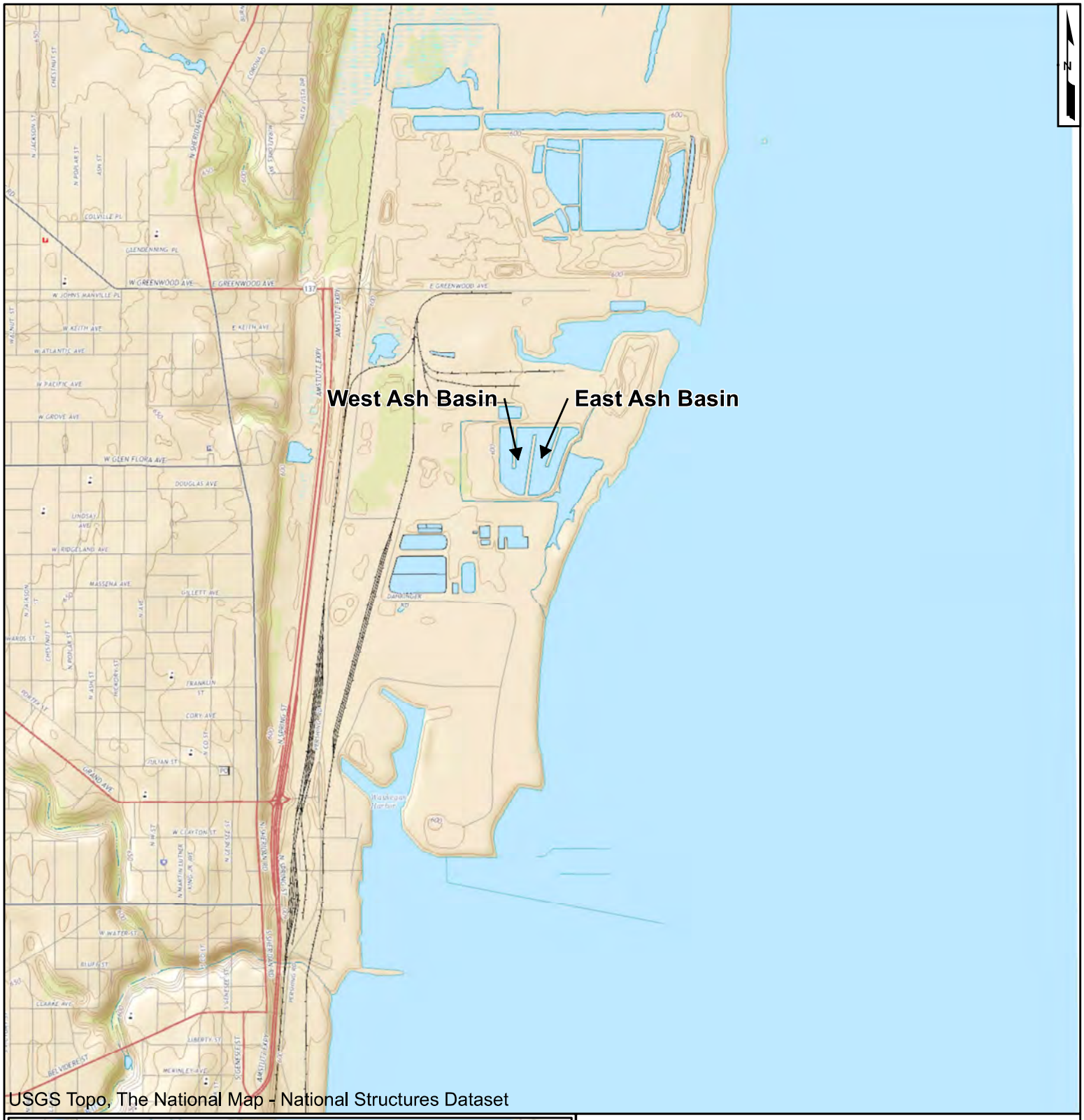
Geosyntec, 2016g. East and West Ash Basin – Seismic Coefficient Calculations, Waukegan Station, October.

Geosyntec, 2016h. East and West Ash Basin – Retaining Wall Calculations, Waukegan, October.

Idriss and Boulanger, 2008. "Soil Liquefaction During Earthquakes". Earthquake Engineering Research Institute, MNO-12.

Attachments

Figure 1 – Site Location
Figure 2 – Pipe Locations
Figure 3 – Slope Stability Cross Sections
Figure 4 – Slope Stability Output, Section 1 - 257.73(e)(1)(i)
Figure 5 – Slope Stability Output, Section 1 - 257.73(e)(1)(ii)
Figure 6 – Slope Stability Output, Section 1 - 257.73(e)(1)(iii)
Figure 7 – Slope Stability Output, Section 2 - 257.73(e)(1)(i)
Figure 8 – Slope Stability Output, Section 2 - 257.73(e)(1)(ii)
Figure 9 – Slope Stability Output, Section 2 - 257.73(e)(1)(iii)





2,000 1,000 0 2,000 Feet

Site Location

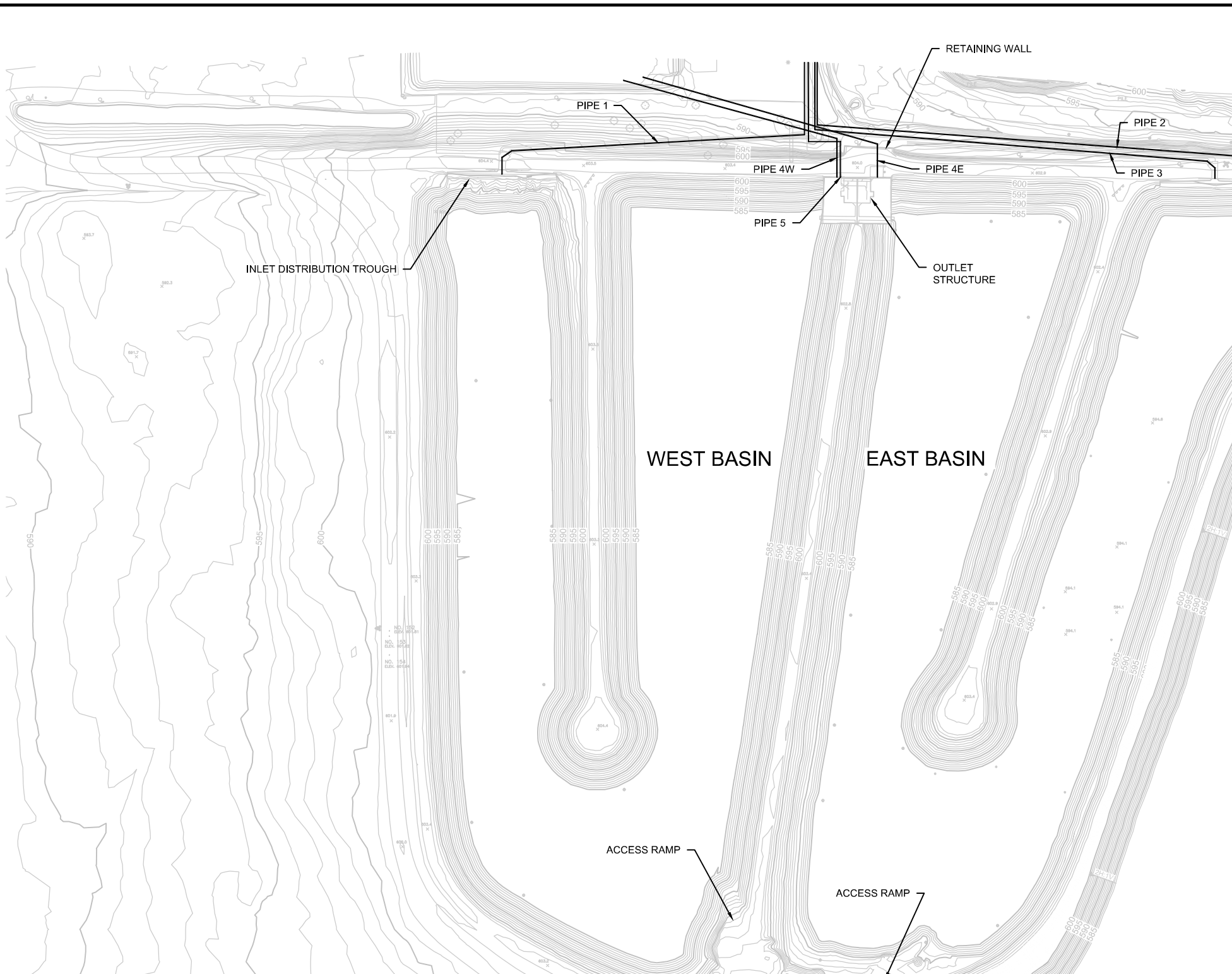
East and West Ash Basins
Waukegan Station
Waukegan, Illinois

Geosyntec consultants

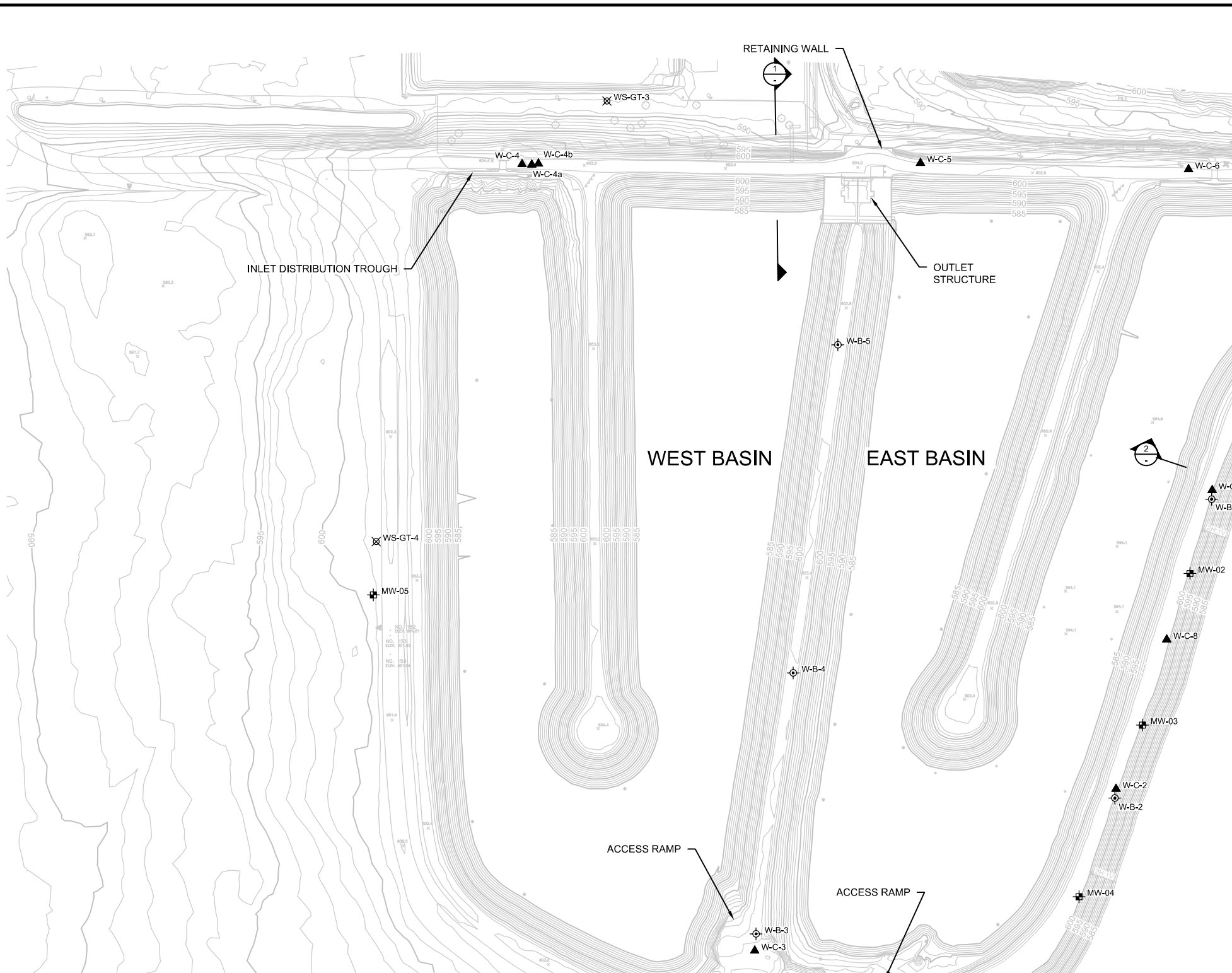
San Diego | October 2016

Figure 1

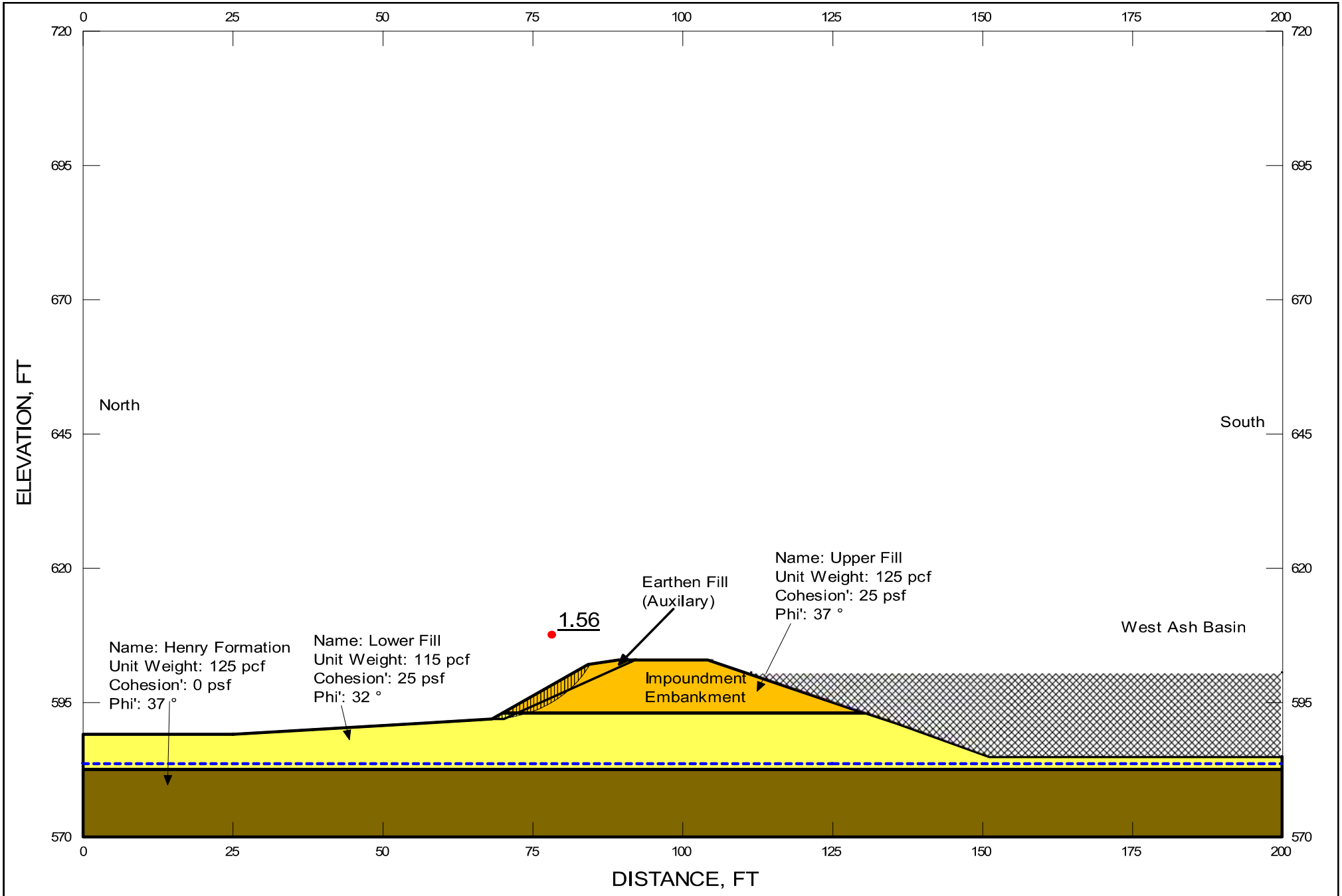
K:\GIS\WaukegantSiteLocation.mxd,JGordon



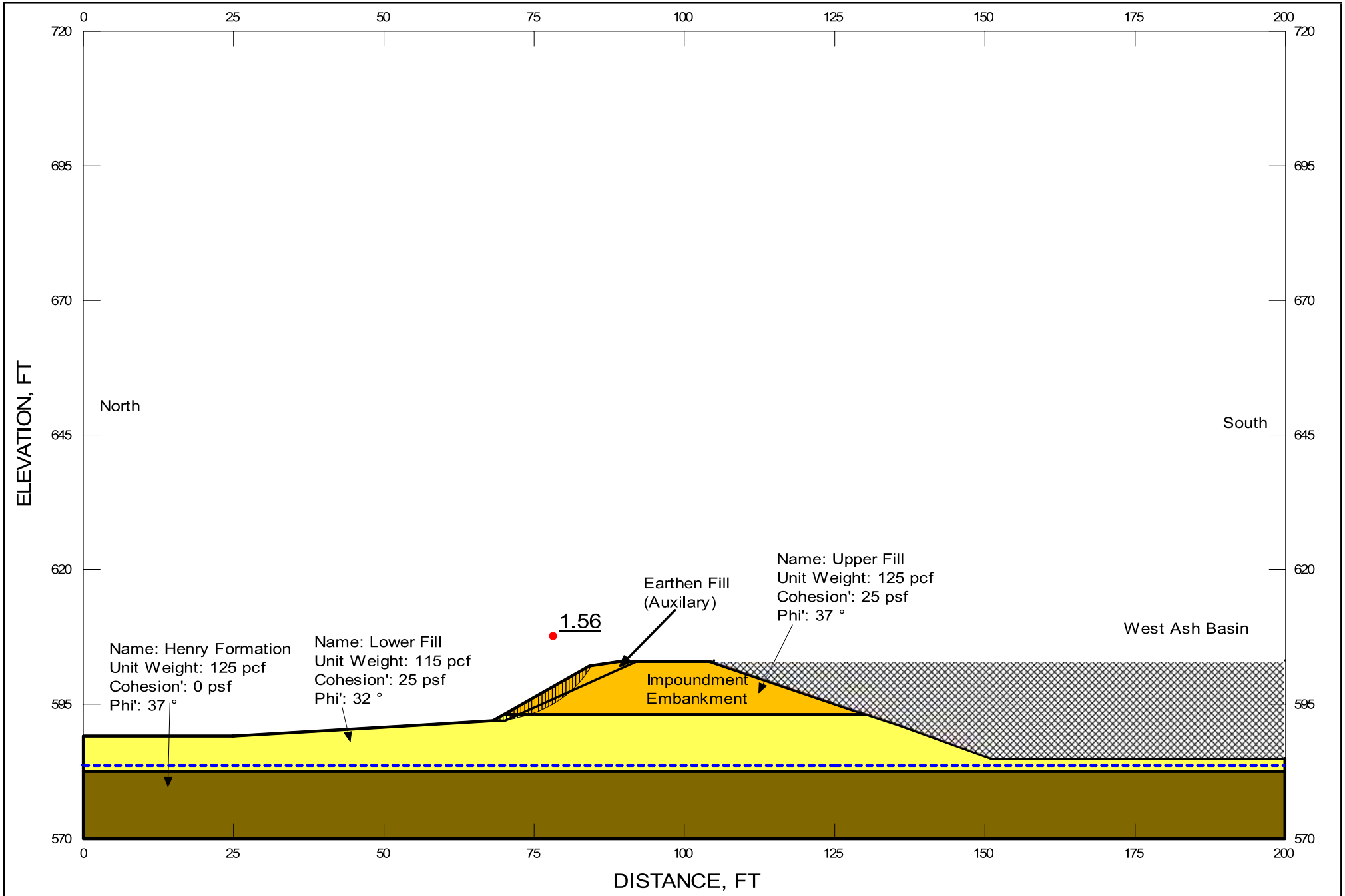
F02–PIPE LOCATIONS



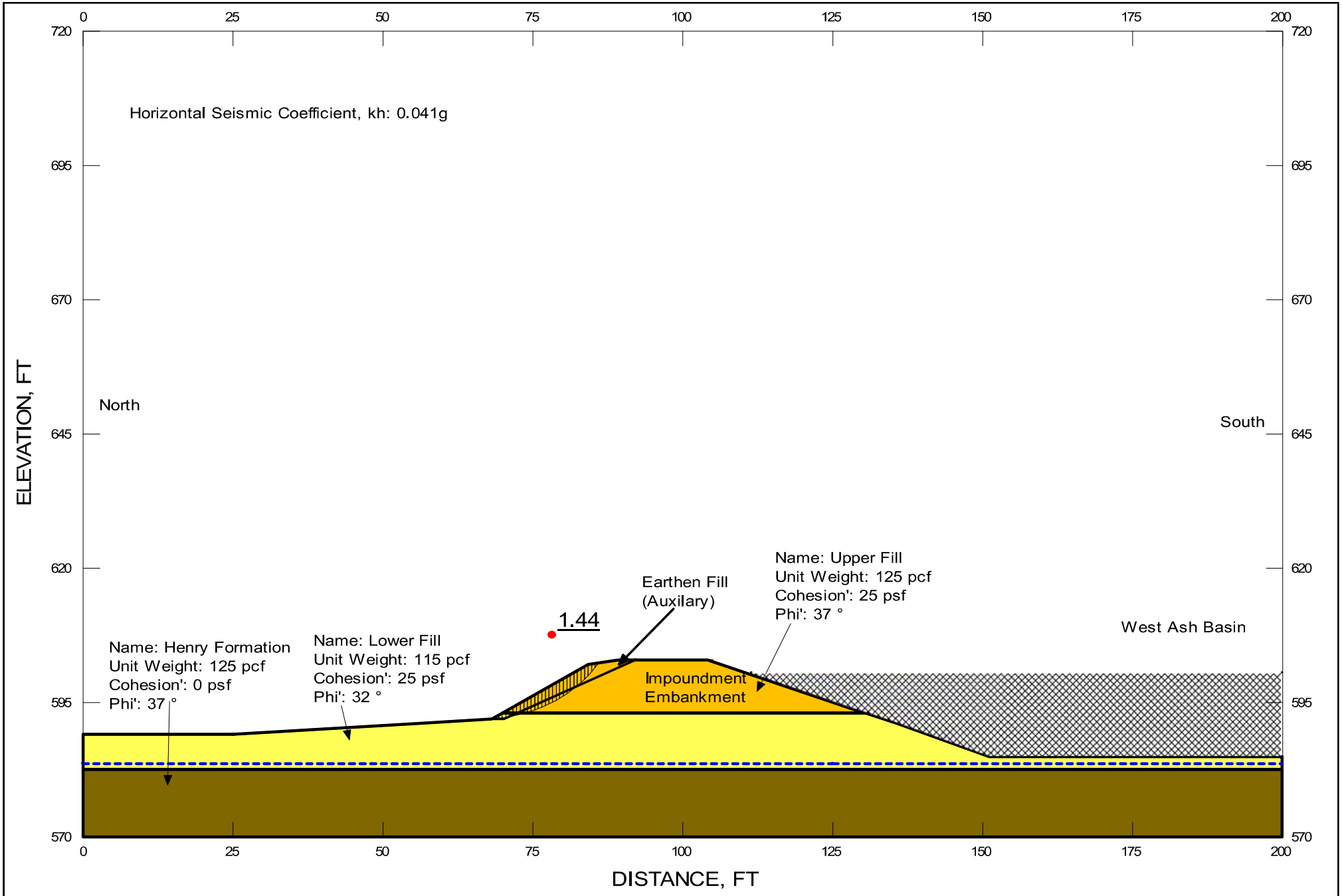
F03-STABILITY SECTIONS 1-2



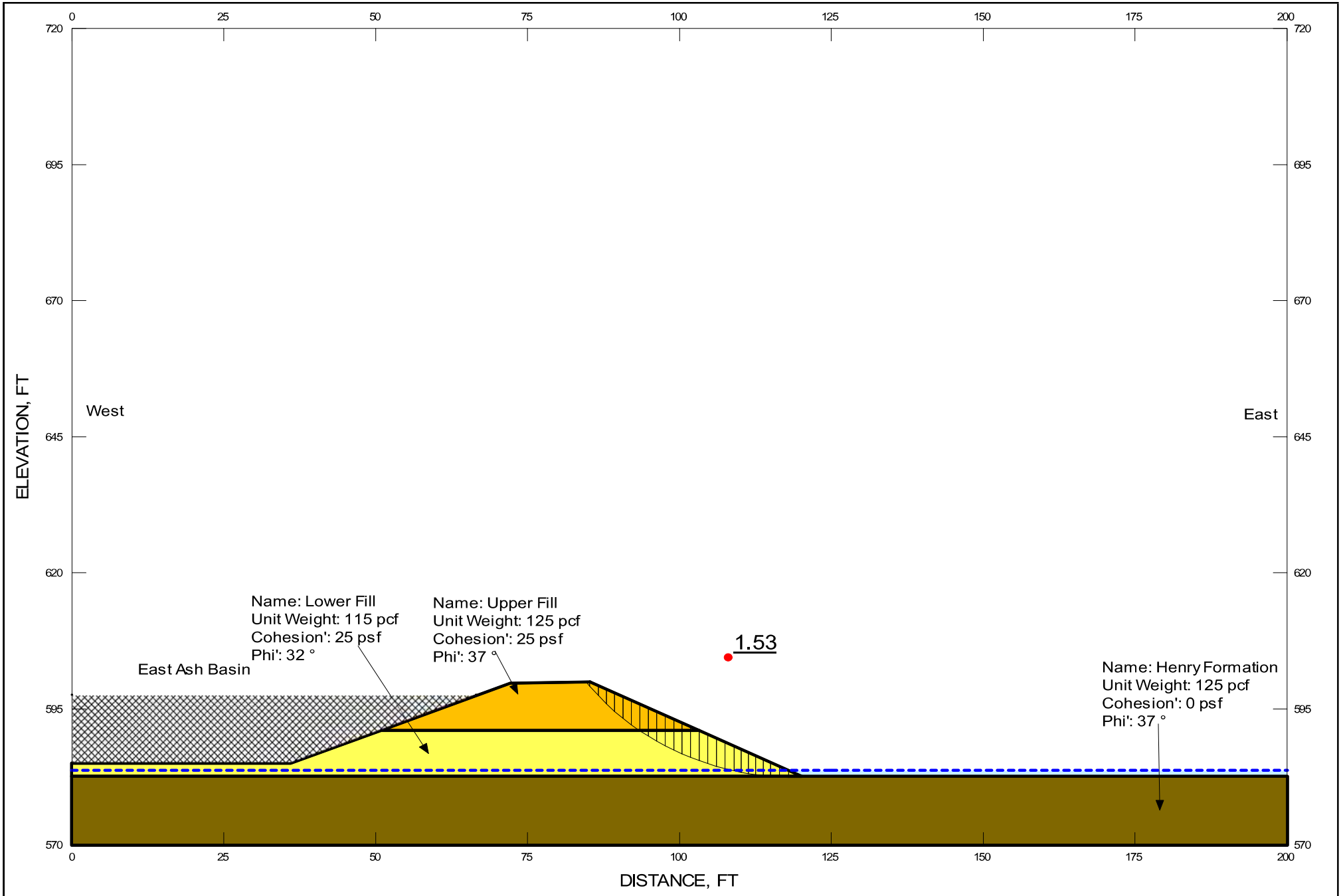
Geosyntec consultants	Analysis: Section 1 - §257.73(e)(1)(i): Long Term, Maximum Storage Pool Loading		FIGURE 4
	Project: Waukegan East and West Ash Basins	Analysis By: Jay Griffin	
	File Name: Waukegan Section 1.gsz	Date: October 2016	



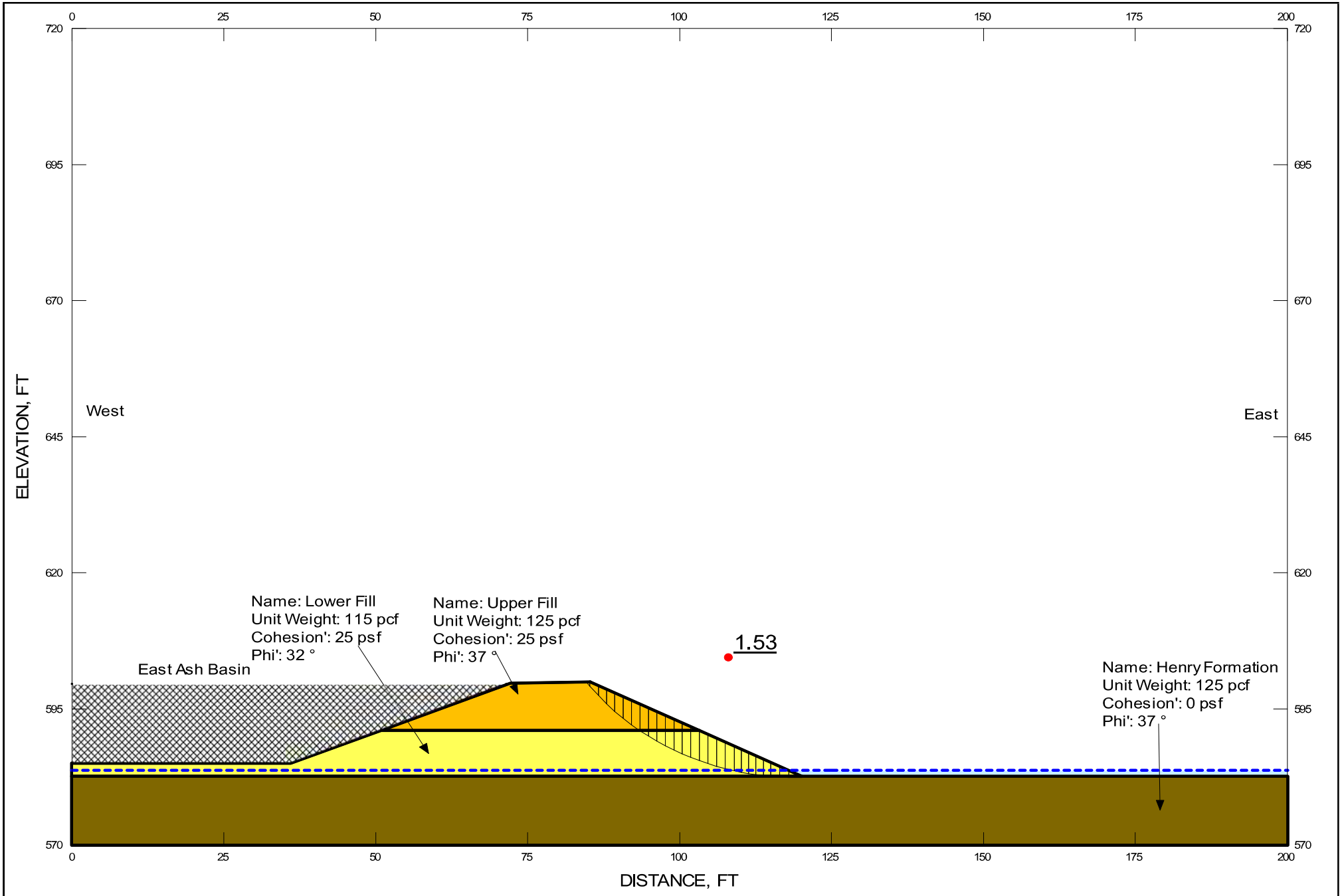
Geosyntec consultants	Analysis: Section 1 - §257.73(e)(1)(ii): Maximum Surcharge Pool Loading		FIGURE 5
	Project: Waukegan East and West Ash Basins	Analysis By: Jay Griffin	
	File Name: Waukegan Section 1.gsz	Date: October 2016	



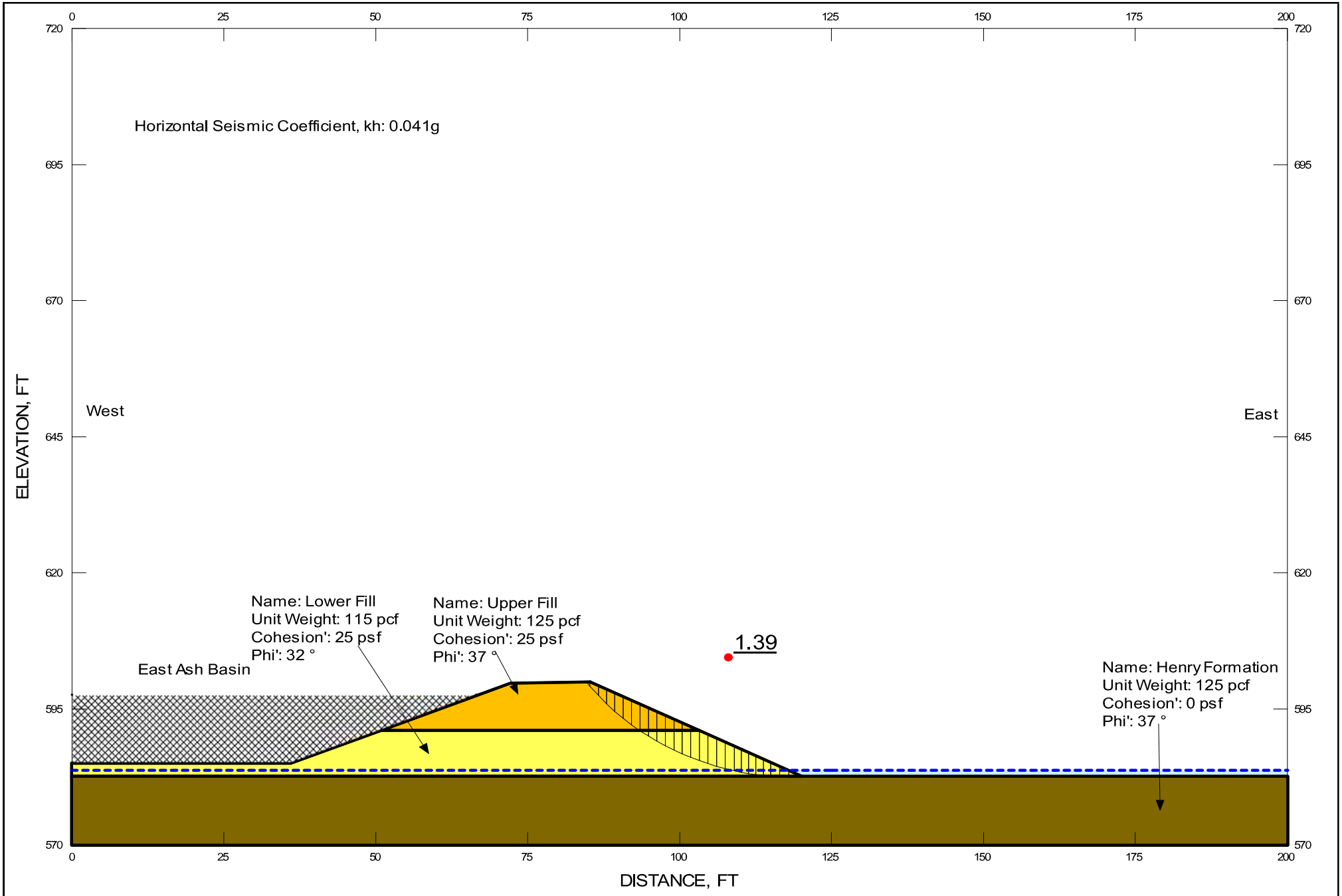
Geosyntec consultants	Analysis: Section 1 - §257.73(e)(1)(iii): Long Term, Maximum Storage Pool Loading with Seismic		FIGURE 6
	Project: Waukegan East and West Ash Basins	Analysis By: Jay Griffin	
	File Name: Waukegan Section 1.gsz	Date: October 2016	



Geosyntec consultants	Analysis: Section 2 - §257.73(e)(1)(i): Long Term, Maximum Storage Pool Loading		FIGURE 7
	Project: Waukegan East and West Ash Basins	Analysis By: Jay Griffin	
	File Name: Waukegan Section 2.gsz	Date: October 2016	



Geosyntec consultants	Analysis: Section 2 - §257.73(e)(1)(ii): Maximum Surcharge Pool Loading		FIGURE 8
	Project: Waukegan East and West Ash Basins	Analysis By: Jay Griffin	
	File Name: Waukegan Section 2.gsz	Date: October 2016	



Geosyntec consultants	Analysis: Section 2 - §257.73(e)(1)(iii): Long Term, Maximum Storage Pool Loading with Seismic		FIGURE 9
	Project: Waukegan East and West Ash Basins	Analysis By: Jay Griffin	
	File Name: Waukegan Section 2.gsz	Date: October 2016	

The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 9



FINAL REPORT
ROUND 10 DAM ASSESSMENT
DYNEGY MIDWEST GENERATION, LLC – HENNEPIN POWER STATION
ACTIVE EAST ASH POND SYSTEM, EAST ASH POND SYSTEM, WEST ASH POND SYSTEM
HENNEPIN, ILLINOIS

PREPARED FOR:

U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460

PREPARED BY:

GZA GeoEnvironmental, Inc.
One Edgewater Drive
Norwood, Ma 02062
GZA File No. 01.0170142.30



FINAL REPORT
ROUND 10 DAM ASSESSMENT
DYNEGY MIDWEST GENERATION, LLC – HENNEPIN POWER STATION
ACTIVE EAST ASH POND SYSTEM, EAST ASH POND SYSTEM, WEST ASH POND SYSTEM
HENNEPIN, ILLINOIS

PREPARED FOR:

U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460

PREPARED BY:

GZA GeoEnvironmental, Inc.
One Edgewater Drive
Norwood, Ma 02062
GZA File No. 01.0170142.30

GZA
GeoEnvironmental, Inc.

Engineers and
Scientists

December 6, 2012
GZA File No. 170142.30

Mr. Stephen Hoffman
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460

RE: FINAL Assessment of Dam Safety of Coal Combustion Surface Impoundments at the Hennepin Power Station

Dear Mr. Hoffman,

One Edgewater Drive
Norwood,
Massachusetts 02062
Phone: 781-278-3700
Fax: 781-278-5701
http://www.gza.com

In accordance with our proposal 01.P0000177.11 dated March 28, 2011, and U.S. Environmental Protection Agency (EPA) Contract No. EP10W001313, Order No. EP-B115-00049, GZA GeoEnvironmental, Inc. (GZA) has completed our assessment of the Hennepin Power Station Coal Combustion Waste (CCW) Impoundments located in Hennepin, Illinois. The site visit was conducted on May 23, 2011. The purpose of our efforts was to provide the EPA with a site specific assessment of the impoundments to assist EPA in assessing the structural stability of the impoundments under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 104(e). We are submitting one hard copy and one CD-ROM copy of this Final Report directly to the EPA.

Based on our visual assessment, and in accordance with the EPA's criteria, the Active East Ash Pond System, West Ash Pond System, and East Ash Pond System are currently in **POOR** condition in our opinion. Further discussion of our evaluation and recommended actions are presented in the Task 3 Dam Assessment Report. The report includes: (a) a completed Coal Combustion Dam Assessment Checklist Form for each Basin; (b) a field sketch; and (c) selected photographs with captions. Our services and report are subject to the Limitations found in **Appendix A** and the Terms and Conditions of our contract agreement.

We are happy to have been able to assist you with this inspection and appreciate the opportunity to continue to provide you with dam engineering consulting services. Please contact the undersigned if you have any questions or comments regarding the content of this Task 3 Dam Assessment Report.

Sincerely,

GZA GeoEnvironmental, Inc.

Doug P. Simon, P.E
Geologic Engineer
doug.simon@gza.com

Patrick J. Harrison, P.E.
Senior Geotechnical Consultant
patrick.harrison@gza.com

Peter H. Baril, P.E. (MA)
Consultant Reviewer
peter.baril@gza.com

Copyright© 2012 GZA GeoEnvironmental, Inc.

An Equal Opportunity Employer M/F/V/H

PREFACE

The assessment of the general condition of the dams/impoundment structures reported herein was based upon available data and visual inspections. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations were beyond the scope of this report.

In reviewing this report, it should be realized that the reported condition of the dams and/or impoundment structures was based on observations of field conditions at the time of inspection, along with data available to the inspection team. In cases where an impoundment is lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions, which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is critical to note that the condition of the dam and/or impoundment structures depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the reported condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Prepared by:

GZA GeoEnvironmental, Inc.



Patrick Harrison, P.E.

License No.: 062.034946
Senior Geotechnical Consultant
GZA GeoEnvironmental, Inc.

EXECUTIVE SUMMARY

This Assessment Report presents the results of a visual assessment of the Dynegy Midwest Generation, LLC. (Dynegy) – Hennepin Power Station (HPS) Coal Combustion Waste (CCW) Impoundments located at 13498 E 800th Street, Hennepin, Illinois. These assessments were performed on May 23, 2011 by representatives of GZA GeoEnvironmental, Inc (GZA), accompanied by representatives of Dynegy.

The HPS is a two-unit coal-fired power plant, with a maximum generating capacity of approximately 310 Megawatts. Commercial operation of the facility began in the 1950's. Earthen and fly ash embankment CCW Impoundments (Active East Ash Pond System, East Ash Pond System, and West Ash Pond System) were constructed in conjunction with the HPS facility for the purpose of storing and disposing non-recyclable CCW from the HPS facility and clarification of water prior to discharge.

The current HPS operations use the Active East Ash Pond (AEAPS) for disposal of CCW products. The AEAPS consists of three (3) pond units. The first two units, known as the Primary and Secondary Cells, were designed as two chambered wet ash ponds and placed in service in 1997. After several years of operation, the Primary Cell's settling efficiency was reduced due to ash deposition and a third pond, Pond 2 East (2E) was added to the system in 2010.

There are two impoundments areas at the HPS which have been decommissioned and include: 1) East Ash Pond System Ponds 2 and 4 (EAPS) which are located adjacent to AEAPS and have been out of service since 1995; and, 2) West Ash Pond System Ponds 1 and 3 (WAPS) which are located west of the HPS and have been out of service since 1997. Pond 2E was constructed within the eastern footprint of the decommissioned Pond 2 area of the EAPS. The remaining portion of the Pond 2 area of the EAPS has being permitted as a dry fly ash landfill facility.

Process water and sluiced CCW are currently discharged into the Primary Cell of the AEAPS, where the CCW is allowed to settle and water is discharged into Pond 2E. Solids are further settled in Pond 2E prior to water discharge to the adjoining Secondary Cell (refer to Figure 2). Water flows sequentially through the Primary Cell, Pond 2E, and the Secondary Cell prior to discharge through a 5 foot stoplog weir structure and into the system outlet works. The AEAPS final outlet works include a Parshall flume for flow measurement and a final sampling manhole. Flow is then discharged to the Illinois River through NPDES outfall 003.

For the purposes of this EPA-mandated assessment, the sizes of the impoundments were based on U. S. Army Corps of Engineers (COE) criteria. Based on the maximum crest height of 18 feet and a storage volume of approximately 36 acre-feet, the WAPS is classified as a **Small** sized structure. Based on the maximum crest height of 52 feet and a storage volume of approximately 1,560 acre-feet, the AEAPS is classified as an **Intermediate** sized

structure. Because there was no pool area associated with the EAPS, no size classification was estimated for the EAPS.

According to guidelines established by the COE, dams with a storage volume less than 1,000 acre-feet and/or a height less than 40 feet are classified as Small sized structures and dams with a storage volume between 1,000 acre-feet and 50,000 acre-feet and/or a height between 40 feet and 100 feet are classified as Intermediate sized structures.

Under the EPA classification system, as presented on page 2 of the EPA check list (**Appendix C**) and Definitions section (**Appendix B**), it is GZA's opinion that the AEAPS, EAPS and the WAPS would be considered as having a **Significant** hazard potential. The hazard potential rating is based on no probable loss of human life due to failure and the potential environmental impacts outside of Utility owned property.

Assessments

In general, the overall condition of the EAPS impoundment was judged to be **POOR**. The EAPS impoundment was found to have the following deficiencies:

1. Trees were present along the upstream and downstream slopes;
2. Minor potholes and rutting along the crest gravel access road; and,
3. The stability analysis completed indicates that the 1979 embankments that support the underlying ash along the Illinois River have a calculated factor of safety less than the generally accepted value and assumptions in the analysis about subsurface conditions should be verified.

In general, the overall condition of the AEAPS impoundments was judged to be **POOR**. The AEAPS impoundment was found to have the following deficiencies:

1. Minor potholes and rutting along the crest gravel access road;
2. Trees were present along the downstream slope of the northern embankment; and,
3. The stability analysis completed indicates that the 1979 embankments that support the underlying ash along the Illinois River have a calculated factor of safety less than the generally accepted value.

In general, the overall condition of the WAPS impoundment was judged to be **POOR**. In GZA's professional opinion, the embankment(s) visually appear to be sound and no immediate remedial action appears to be necessary. However, based on EPA's assessment criteria, the impoundment has been given a POOR Condition Rating, because complete hydraulic and geotechnical computations were not provided/available for GZA's for review. Thus, the stability of the embankment(s) could not be independently verified. The WAPS impoundment was found to have the following deficiencies:

1. Thick vegetation and trees along the downstream slopes;
2. Minor potholes and rutting along the crest gravel access road;

3. Erosion along the downstream slope of the northern embankment;

4. No seepage and/or stability analysis has been performed for the WAPS; and

5. No hydraulic/hydrologic analysis has been performed to confirm adequate freeboard and decant capacity at the design storm event.

The following recommendations and remedial measures generally describe the recommended approach to address current deficiencies at the impoundments. Prior to undertaking recommended maintenance, repairs, or remedial measures, the applicability of permits needs to be determined for activities that may occur under the jurisdiction of the appropriate regulatory agencies.

Studies and Analyses

GZA recommends that HPS/Dynegy conduct the following studies and analysis:

1. Conduct an analysis of the hydraulic/hydrologic condition of the WAPS to establish the rise in water level that occurs during the 100-year, 24-hour rain event to confirm that adequate freeboard is maintained and adequate decant and spillway capacity is available. The loading conditions established during the design storm event should be used in the evaluation of the seepage and stability evaluation of the embankments.

2. Perform a complete structural and seepage stability analysis of the WAPS impoundment including static, seismic and liquefaction loading.

3. Generate a remedial design to address the inadequate factor of safety along the northern embankment of the EAPS and AEAPS adjacent to the Illinois River.

Recurrent Operation & Maintenance Recommendations

GZA recommends the following operation and maintenance level activities:

1. Increased mowing of the grasses on the embankments to facilitate assessments and reduce the risk of burrowing animals;

2. Repair wave action erosion on the downstream slope of the WAPS;

3. Repair the potholes present in the gravel crest access roads. Grade the road to provide better drainage and reduce future potholing; and,

4. Clear trees and other deep rooted vegetation from the slopes and crests of the embankments.

Repair Recommendations

GZA recommends the following repairs to address observed deficiencies that may affect the stability of the embankments. The recommendations may require design by a professional engineer and construction contractor experienced in impoundment construction.

1. Pending the results of the hydraulic/hydrologic analysis, modify the design or operation of the WAPS to provide adequate capacity.

2. Pending the results of the complete seepage and stability analysis for the WAPS, modify the design or operation of the impoundments to provide conditions that result in embankments that meet the generally accepted factors of safety.

3. Based on the geotechnical results for the EAPS and AEAPS embankments, which produced inadequate minimum factors of safety, develop design modifications for those embankments along the Illinois River. These improvements are to result in the embankments meeting generally accepted factors of safety and protect the slope from future erosion.

Alternatives

There are no practical alternatives to the repairs itemized above.

TABLE OF CONTENTS

1.0 DESCRIPTION OF PROJECT 1

1.1 General 1
1.1.1 Authority 1
1.1.2 Purpose of Work 1
1.1.3 Definitions 1
1.2 Description of Project 2
1.2.1 Location 2
1.2.2 Owner/Caretaker 2
1.2.3 Purpose of the Impoundments 2
1.2.4 Description of the EAPS Impoundment and Appurtenances 3
1.2.5 Description of the AEAPS Primary Cell, Secondary Cell and Appurtenances . 4
1.2.6 Description of the AEAPS Pond 2E and Appurtenances 5
1.2.7 Description of the WAPS Impoundment and Appurtenances 6
1.2.8 Operations and Maintenance 7
1.2.9 Size Classification 7
1.2.10 Hazard Potential Classification 7
1.3 Pertinent Engineering Data 8
1.3.1 Drainage Area 8
1.3.2 Reservoir 8
1.3.3 Discharges at the Impoundment Sites 8
1.3.4 General Elevations (feet – MSL) 8
1.3.5 Design and Construction Records and History 9
1.3.6 Operating Records 9
1.3.7 Previous Assessment Reports 9

2.0 ASSESSMENT 10

2.1 Visual Assessment 10
2.1.1 EAPS Impoundment General Findings 10
2.1.2 EAPS Upstream Slope (Photos 18, 22, 24, and 74) 10
2.1.3 EAPS Crest of Impoundment (Photos 32 though 35, 45, 52, 71 through 73).. 10
2.1.4 EAPS Downstream Slope (Photos 25 through 28, 55 through 57, 69, and 70) 10
2.1.5 EAPS Discharge Pipes (Photo 44) 11
2.1.6 AEAPS Impoundment General Findings 11
2.1.7 AEAPS Upstream Slope (Photos 35 through 43, 45 through 53) 11
2.1.8 AEAPS Crest of Impoundment (Photos 35 through 43, 45 through 53) 11
2.1.9 AEAPS Downstream Slope (Photos 29 through 31) 11
2.1.10 AEAPS Discharge Structures (Photos 58 through 68) 11
2.1.11 WAPS Impoundment General Findings 12
2.1.12 WAPS Upstream Slope (Photos 18, 22, and 24) 12
2.1.13 WAPS Crest of Impoundment (Photos 14 through 20) 12
2.1.14 WAPS Downstream Slope (Photos 1 through 13) 12
2.1.15 WAPS Discharge Pipes (Photos 21 and 22) 12
2.2 Caretaker Interview 12

TABLE OF CONTENTS (CONT'D)

2.3 Operation and Maintenance Procedures 13
2.4 Emergency Action Plan 13
2.5 Hydrologic/Hydraulic Data 13
2.6 Structural and Seepage Stability 13

3.0 ASSESSMENTS AND RECOMMENDATIONS 14

3.1 Assessments 14
3.2 Studies and Analyses 15
3.3 Recurrent Operation & Maintenance Recommendations 15
3.4 Repair Recommendations 16
3.5 Alternatives 16

4.0 ENGINEER'S CERTIFICATION 16

FIGURES

Figure 1 Site Location Map
Figure 2 Overall Ash Basin Plan
Figure 3 East Ash Pond Typical Sections of the 1989 Embankment Raise
Figure 4 East Ash Pond Additional Sections of the 1989 Embankment Raise
Figure 5 Boring Location Plan
Figure 6 AEAPS and EAPS
Figure 7 Pond 2E Profiles and Details
Figure 8 Pond 2E Structure Details
Figure 9 Typical Section of Liner Extension
Figure 10 WAPS

APPENDICES

Appendix A Limitations
Appendix B Definitions
Appendix C Assessment Checklists
Appendix D Previous Assessment Reports
Appendix E Photographs
Appendix F References

1.0 DESCRIPTION OF PROJECT

1.1 General

1.1.1 Authority

The United States Environmental Protection Agency (EPA), has retained GZA GeoEnvironmental, Inc. (GZA) to perform a visual assessment and develop a report of conditions for the Dynegy Midwest Generation,LLC, (Dynegy, Owner) Hennepin Power Station (HPS, Site) Coal Combustion Waste (CCW) Impoundments in Putnam **C**ounty, Illinois. This assessment was authorized by the EPA under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 104(e). This assessment and report were performed in accordance with Request for Quote (RFQ) RFQ-DC-16, dated March 16, 2011 and EPA Contract No. EP10W001313, Order No. EP-B11S-00049. The assessment generally conformed to the requirements of the Federal Guidelines for Dam Safety[1], and this report is subject to the limitations contained in **Appendix A** and the Terms and Conditions of our Contract Agreement.

1.1.2 Purpose of Work

The purpose of this investigation was to visually inspect and evaluate the present condition of the impoundments and appurtenant structures (the management unit) to attempt to identify conditions that may adversely affect their structural stability and functionality, to note the extent of any deterioration that may be observed, review the status of maintenance and needed repairs, and to evaluate the conformity with current design and construction standards of care.

The investigation was divided into five parts: 1) obtain and review available reports, investigations, and data from the Owner pertaining to the impoundment and appurtenant structures; 2) perform a review with the Owner of available design, assessment, and maintenance data and procedures for the management unit; 3) perform a visual assessment of the site; 4) prepare and submit a field assessment checklist; and 5) prepare and submit a draft and a final report presenting the evaluation of the structure, including recommendations and proposed remedial actions.

1.1.3 Definitions

To provide the reader with a better understanding of the report, definitions of commonly used terms associated with dams are provided in **Appendix B**. Many of these terms may be included in this report. The terms are presented under common categories associated with dams which include: 1) orientation; 2) dam components; 3) size classification; 4) hazard classification; 5) general; and 6) condition rating.

[1] FEMA/ICODS, April 2004: http://www.ferc.gov/industries/hydropower/safety/guidelines/fema-93.pdf

1.2 Description of Project

1.2.1 Location

The HPS is located in Sections 26 and 27, Township 33 North, Range 2 West, in Putnam County, Illinois at approximately 41°18'11"N, 89°18'55"W. The HPS is adjacent to the Illinois River at river mile 211.5, approximately four (4) miles north of Hennepin, Illinois. The HPS CCW impoundments are located to the east and west of the power plant. A Site locus of the impoundments and surrounding area is shown in **Figure 1**. An aerial photograph of the impoundments and surrounding area is provided as **Figure 2**. The impoundments can be accessed by vehicles from earthen access roads from the HPS.

1.2.2 Owner/Caretaker

The CCW impoundments are owned by Dynegy Midwest Generation, LLC and operated by the HPS.

	Dam Owner/Caretaker
Name	Dynegy Midwest Generation, LLC, Hennepin Power Station
Mailing Address	13498 E 800th St Hennepin, IL 61327
City, State, Zip	Hennepin, Illinois 62327
Contact	Ted Lindenbusch
Title	Managing Director
E-Mail	Ted.Lindenbusch@dynegy.com
Daytime Phone	815-339-9210
Emergency Phone	911

1.2.3 Purpose of the Impoundments

The HPS is a two-unit coal-fired power plant, with a maximum generating capacity of approximately 310 Megawatts. Commercial operation of the facility began in the 1950's. Earthen and fly ash embankment CCW Impoundments (Active East Ash Pond System, East Ash Pond System, and West Ash Pond System) were constructed in conjunction with the HPS facility for the purpose of storing and disposing non-recyclable CCW from the HPS facility and clarification of water prior to discharge.

The current HPS operations use the Active East Ash Pond (AEAPS) for disposal of CCW products. The AEAPS consists of three (3) pond units. The first two units, known as the Primary and Secondary Cells, were designed as two chambered wet ash ponds and placed in service in 1997. After several years of operation, the Primary Cell's settling efficiency was reduced due to ash deposition and a third pond, Pond 2 East (2E) was added to the system in 2010.

There are two impoundments areas at the HPS which have been decommissioned and include: 1) East Ash Pond System Ponds 2 and 4 (EAPS) which are located adjacent to AEAPS

and have been out of service since 1995; and, 2) West Ash Pond System Ponds 1 and 3 (WAPS) which are located west of the HPS and have been out of service since 1997. Pond 2E was constructed within the eastern footprint of the decommissioned Pond 2 area of the EAPS. The remaining portion of the Pond 2 area of the EAPS will be operated as a dry fly ash landfill facility. Impoundments that are not formally closed through the state and can impound water are within the purview of the EPA's assessment criteria.

Process water and sluiced CCW are currently discharged into the Primary Cell of the AEAPS, where the CCW is allowed to settle and water is discharged into Pond 2E. Solids are further settled in Pond 2E prior to water discharge to the adjoining Secondary Cell (refer to Figure 2). Water flows sequentially through the Primary Cell, Pond 2E, and the Secondary Cell prior to discharge through a 5 foot stoplog weir structure and into the system outlet works. The AEAPS final outlet works include a Parshall flume for flow measurement and a final sampling manhole. Flow is then discharged to the Illinois River through outfall 003.

1.2.4 Description of the EAPS Impoundment and Appurtenances

The EAPS was designed by Illinois Power Company. However, available information regarding the original design and/or construction of the EAPS was limited to drawings related to subsequent embankment modifications and references in various documents prepared by Civil & Environmental Consultants, Inc. (CEC) for the design and construction of Pond 2E. The following description of the EAPS is based on the limited available information and observations made by GZA during our Site visit.

Based on the available information, the embankments surrounding the EAPS were constructed in three phases. The original embankments were constructed in 1958, with subsequent modifications in 1978 and 1989. The original embankments were constructed to about elevation 474 feet (MSL) and the north, east and west sides of the EAPS were tied into the bluff on the south side which is also the northern embankment of the Primary and Secondary Cells. In 1978, the embankments were raised to elevation 484 feet (MLS), and to elevation 494 feet (MLS) in 1989. Typical sections of the 1989 embankment extensions are shown on **Figures 3 and 4**.

Borings were performed in 2009 by CEC in the area of the EAPS as part of the design for Pond 2E. Seven of the borings were drilled through the top of the 1989 embankment (at approximate elevation 494 (MLS)) and two borings through the 1978 embankment (at approximate elevation 484 (MLS)). The borings encountered gravelly clays and sands interbedded with layers of loose to medium dense sand, gravel and gravelly sands and clays; stiff to very stiff sandy and silty clays; and loose to very loose, moist to wet, laminated silt with zones of fly ash with a consistency of fine and/or silty sand. There was no evidence that the impoundment embankments were built over wet ash or slag. Several other borings drilled in the EAPS disposal area encountered CCW materials to depths ranging from about 24 to 35 feet below the existing surface grades or elevations ranging about 456 to 453 (MSL), respectively. The boring locations are provided on **Figure 5.**

The original embankment slopes of the EAPS were variable and appear to have been constructed with downstream and upstream slopes that range from approximately 2.5H:1V to about 1.5H:1V. The EAPS crest length is approximately 1 mile with a maximum height (from the lowest downstream toe elevation to the crest of the impoundment) of approximately 52 feet

corresponding to a crest elevation of 494.0 (MSL). The upstream and downstream slopes of the raised embankments sections were constructed at approximately 2.5H:1V.

A dry ash landfill has been constructed on the western portion of the Pond 2 area of the EAPS. The landfill has been constructed with a liner placed on the existing ash fill that was subsequently covered with several feet of ash during construction of Pond 2E. The landfill is permitted to extend to a height of 66 feet above the current embankment corresponding to an elevation of approximately 560 feet (MSL). Please note that the embankments of the EAPS are not regulated as a dam by the Illinois Department of Water Resources.

1.2.5 Description of the AEAPS Primary Cell, Secondary Cell and Appurtenances

The embankments of the Primary Cell and Secondary Cells were designed by Illinois Power Company. The following description of the impoundment is based on information provided in various Illinois Power Company Drawings and Documents, various Design Documents prepared by Civil & Environmental Consultants, Inc. (CEC), other information received from HPS, and observations made by GZA during our Site visit.

The AEAPS Primary and Secondary Cells are located east of the HPS and were originally constructed by reshaping an area that was an existing gravel pit to form the current surface impoundment. The ground elevation surrounding most of gravel pit at the time of construction was described to be equal to or greater than the maximum elevation proposed for the impoundments. The northeast corner of the impoundment however required the construction of an embankment with a portion of it being approximately 20 feet above the existing ground level. This area was described as having uneven natural terrain and was stabilized by leveling the existing ground surface and adding fill to the leveled elevation. The natural slopes in this area gave the northeast corner a height of about 32 feet.

The AEAPS Primary and Secondary Cells function as sedimentation basins for coal combustion wastes (CCW) including bottom ash, fly ash, miscellaneous station low volume waste, and coal pile runoff streams which are piped from the plant and discharged into the impoundment. Fly ash is conditioned and transported dry to the primary cell. The CCW enters the Primary Cell through two 12 inch diameter HDPE pipes and two 10 inch diameter steel pipes which are located near the northeast corner of the Primary Cell. Miscellaneous station low volume waste streams and coal pile runoff also enter the Primary Cell to the west of the northeast corner. The CCW settles in the Primary Cell and flow through the pond is discharged into Pond 2E through an 18 inch diameter reinforced concrete pipe (RCP) outlet structure which is located near the northeast corner of the Primary Cell.

The Secondary Cell receives flow from Pond 2E through a 24 inch diameter RCP which is located near the northwest corner of the Secondary Cell. Flow from the Secondary Cell is discharged through a five foot stop log weir structure into a 36 inch diameter RCP which conveys the flows into the final outlet works and into the Illinois River through outfall structure 003. The locations of the discharge pipes and structures are shown in **Figure 6**. Details of the discharge pipes and structures are shown on **Figures 7 and 8**. Prior to the construction of Pond 2E, flow through the Primary Cell was discharged into the Secondary Cell through a five-foot stoplog decant structure. The decant structure was abandoned as part of the construction of Pond 2E.

The AEAPS Primary and Secondary Cells consist of sand and gravel earthen embankments with a crest length of approximately 0.6 miles and 0.4 miles, respectively and a maximum height (from the lowest downstream toe elevation to the crest of the impoundment) of approximately 32 feet corresponding to a crest elevation of 494.0 Mean Sea Level (MSL). The bottom of the impoundments is at approximately Elevation 458.0 (MSL). The embankments of the cells were constructed in 1995 and 1996 and placed in service in 1997 with 4-foot horizontal to one-foot vertical (4H:1V) upstream and downstream slopes consisting of native sand and gravel materials. There was no evidence that the impoundment embankments were built over wet ash or slag. A 4-foot thick clay liner was constructed on the bottom of the cells and up the upstream side slopes of the cells to a height of approximately 20 feet above the base of the impoundments. The upper 12 feet of the upstream slopes were not lined at the time of the initial construction. After construction, operating water levels in the cells were maintained at or below the top elevation of the clay liner. Over the next several years, CCW filled the Primary Cell to levels that required that the upstream liner be raised to provide full depth operating levels for CCW transport, clarification and deposition. The liner in both cells was raised in 2003 by extending the existing liner up the upstream slopes from the original 20 foot level an additional 12 feet to the top of the crest. The construction of the extended liner consisted of 45-mil HDPE geomembrane over a 12-inch layer of compacted clay. A typical section for the liner extension is shown in **Figure 9.**

The intermediate embankment between the AEAPS Primary and Secondary Cells is regulated by the Illinois Department of Transportation, Division of Water Resources (IDOT/DWR) as a small-size, Class III dam under permit no. 21922, issued November 10, 1994. According to guidelines established by the DWR, dams with a storage volume less than 1,000 acre-feet and/or a height less than 40 feet are classified as Small sized structures. *Class III* structures are those for which failure has a low probability of causing loss of life or substantial environmental damage.

Instrumentation near the AEAPS Primary and Secondary Cells include six groundwater monitoring wells, numbered 12 through 16, which are located as shown on **Figure 6**.

1.2.6 Description of the AEAPS Pond 2E and Appurtenances

Pond 2E was constructed within the footprint of the eastern portion of Pond 2 of the EAPS and follows the same history as the EAPS, as discussed in Section 1.2.4, until 2009. Construction of Pond 2E began in 2009 and was completed in 2010. CCW flows are discharged directly from the Primary Cell into Pond 2E along with surface water runoff from EAPS Pond 2. Flow is routed from the Primary Cell through Pond 2E and into the Secondary Pond before discharging to the Illinois River through the system outlet works. According to HPS personnel, Pond 2E was designed to increase the efficiency of the existing pond system by adding additional storage and settling capacity. The associated design plans and calculations for a dry ash landfill which would be located on the EAPS west of Pond 2E have been submitted to IEPA Bureau of Land Management. It should be noted that a landfill permit approval is not required. Once the dry ash landfill has been constructed, Pond 2E will provide sediment control, storm flow storage, and leachate detention.

Pond 2E is located on the eastern portion of the decommissioned EAPS Pond 2 and was constructed by excavating and removing a portion of the ash fill. Flow is routed from the AEAPS Primary Cell to Pond 2E through an 18 inch diameter reinforced concrete pressure pipe

(RCPP) discharge culvert which was installed during the construction of Pond 2E. Operational flows exit Pond 2E through the principal spillway, a 2-foot wide by 1-foot tall orifice, of Pond 2E's concrete outlet structure. The concrete outlet structure includes an auxiliary spillway which is a 3-foot wide by 1-foot tall weir, and an emergency spillway which is a 6-foot by 4-foot drop inlet. The principal and auxiliary spillways were designed to pass the 100-year frequency storm without the emergency spillway functioning. Flows through all three spillways are discharged through a 24-inch diameter RCP into the Secondary Cell.

Pond 2E's earth embankment structure is approximately 11 feet to 52 feet high and 1300 feet long. It has a crest elevation of approximately 494 feet (MLS) and an upstream face with a 3H:1V (horizontal: vertical) slope. A 60-mil smooth HDPE geomembrane was installed on the bottom and upstream slopes of Pond 2E. The liner also caps the underlying ash along the eastern portion of the former ash impoundment. A concrete culvert and headwalls were installed on the southwest side of Pond 2E to allow inflow from the Primary Cell. A gate valve was installed on the Primary Cell headwall to provide flow control, if required, for repairs. A plan view and typical sections of the Pond 2E embankments and other details are provided on **Figures 7 and 8**.

Instrumentation near the AEAPS Pond 2E includes groundwater monitoring wells, numbered 12 through 16, which are located as shown on **Figure 6**.

1.2.7 Description of the WAPS Impoundment and Appurtenances

The WAPS is located to the west of the HPS and based on available records was designed by Illinois Power Company. The following description of the impoundment is based on information provided on various Illinois Power Company drawings, information received from Dynegy and observations made by GZA during our site visit. Information for the original design and construction of the WAPS was limited to drawings which were prepared for the 1989 raise of the original impoundment embankments.

The original WAPS was constructed in 1950's and designated as Ponds 1 and 3. The ponds appear to have been constructed as unlined earthen embankments which consist of sand and gravel materials. The north embankment of WAPS abuts the south bank of the Illinois River. The general height of the original embankments (from the lowest downstream toe elevation to the top of the impoundment) was about 10 feet, corresponding to a crest elevation of 460.0 (MSL). The WAPS embankments were raised in 1989 by adding an average of 5 feet of new fill to the existing embankments, increasing the crest elevation to 465.0 (MSL). There was no evidence that the impoundment embankments were built over wet ash or slag. The perimeter of the WAPS was also extended at that time to enclose Ponds 1 and 3 into a single pond. The crest length of the combined ponds is about 1.2 miles. The WAPS was decommissioned in 1995 and was not receiving or discharging flows at the time of GZA's site visit. The WAPS is not regulated as a dam by the IDNR.

Instrumentation near the WAPS includes groundwater monitoring wells numbered as follows; 21 through 27, 31 through 36 and, L1 and L4, which are located as shown on **Figure 10**. The wells are monitored quarterly and as a condition of the 1996 IEPA approved Closure Work Plan (CWP) for the WAPS.

1.2.8 Operations and Maintenance

The impoundments are operated and maintained by HPS personnel. Operation of the Primary Cell, Secondary Cell and Pond 2E includes periodic adjustment of the decant elevations and includes monitoring of groundwater and repair of the gravel access roads as needed.

Discharges of the HPS facility are regulated by the EPA under the National Pollutant Discharge Elimination System (NPDES) Permit No. IL0001554. A portion of outer embankments of Primary and Secondary Cell of the AEAPS are considered to be a dam that is regulated by the Illinois Department of Natural Resources, Office of Water Resources under permit number DS2004119. As part of the dam permit, there is an Operation and Maintenance Plan that was developed for the Primary and Secondary Cells. That plan includes regular mowing, vegetation management, semi-annual assessments, and assessments by a register professional engineer every 5 years.

An operation and maintenance plan was developed by CEC for Pond 2E. The plan included information about the frequency and scope of periodic assessments. The plan requires assessment of the impoundment on a quarterly basis by HPS staff and every 5 years by a registered professional engineer. The plan also requires maintenance of an emergency drawdown pump at the facility.

1.2.9 Size Classification

For the purposes of this EPA-mandated assessment, the sizes of the impoundments were based on U. S. Army Corps of Engineers (COE) criteria. Based on the maximum crest height of 18 feet and a storage volume of approximately 36 acre-feet, the WAPS is classified as a **Small** sized structure. Based on the maximum crest height of 52 feet and a storage volume of approximately 1,560 acre-feet, the AEAPS is classified as an **Intermediate** sized structure. Because there was no pool area associated with the EAPS, no size classification was estimated for the EAPS.

According to guidelines established by the COE, dams with a storage volume less than 1,000 acre-feet and/or a height less than 40 feet are classified as Small sized structures and dams with a storage volume between 1,000 acre-feet and 50,000 acre-feet and/or a height between 40 feet and 100 feet are classified as Intermediate sized structures.

1.2.10 Hazard Potential Classification

Under the EPA classification system, as presented on page 2 of the EPA check list (**Appendix C**) and Definitions section (**Appendix B**), it is GZA's opinion that the AEAPS, EAPS and the WAPS would be considered as having a **Significant** hazard potential. The hazard potential rating is based on no probable loss of human life due to failure and the potential environmental impacts outside of Utility owned property. The hazard rating for the AEAPS differs from the hazard rating given to the Primary and Secondary Cells by the IDNR due to the inclusion of Pond 2E in the AEAPS since IDNR rating.

1.3 Pertinent Engineering Data

1.3.1 Drainage Area

The existing impoundments are surrounded by exterior dikes with crest elevations that are above the surrounding geographical features. This confines the rainfall sub-basin areas to the impoundment areas themselves resulting in no additional overland flow being introduced to the system.

1.3.2 Reservoir

Based on estimates made by GZA[2], the WAPS has a surface area of 2 acres and a storage volume of approximately 36 acre feet at a pool elevation of 455.6 feet MSL. The AEAPS has a surface area of approximately 30 acres and a storage volume of approximately 1,560 acre feet at a pool elevation of 489.5 feet MSL. The EAPS no longer actively impounds water and therefore a reservoir volume was not calculated. The pool areas observed on GZA's May 23, 2011 Site visit are consistent with the surfaces areas noted above.

1.3.3 Discharges at the Impoundment Sites

According to HPS personnel, under normal operating conditions, approximately 2.4 million gallons of water per day (MGD) are discharged from the Secondary Cell to the Illinois River.

1.3.4 General Elevations (feet – MSL)

Elevations were taken from design drawings, reports, and data provided by HPS. Elevations were based upon the USGS topographic map MSL vertical datum.

AEAPS Impoundment

Primary Cell

A. Top of Embankment (Minimum)	± 494 feet
B. Upstream Water at Time of Assessment	± 489.5 feet
C. Downstream Tail Water at Time of Assessment	485.2 feet (Pond 2E)
D. Maximum Pond Water Elevation	489.5 feet

Secondary Cell

A. Top of Embankment (Minimum)	± 494 feet
B. Upstream Water at Time of Assessment	479.5 feet
C. Downstream Tail Water at Time of Assessment	448 feet (Illinois River)
D. Maximum Pond Water Elevation	480.5 feet

[2] Surface area estimates generated using Google Earth Professional software and available aerial photographs.

Pond 2E

A. Top of Embankment (Minimum)	±494 feet
B. Upstream Water at Time of Assessment	485.2 feet
C. Downstream Tail Water at Time of Assessment	479.5 feet (Secondary Cell)
D. Maximum Pond Water Elevation	480 feet

EAPS Impoundment

A. Top of Embankment (Minimum)	494 feet
B. Upstream Water at Time of Assessment	N/A
C. Downstream Tail Water at Time of Assessment	442 feet
D. Maximum Pond Water Elevation	Unknown

WAPS Impoundment

A. Top of Embankment (Minimum)	465.0 feet
B. Upstream Water at Time of Assessment	455.6 feet
C. Downstream Tail Water at Time of Assessment[3]	± 448 feet
D. Maximum Pond Water Elevation	Unknown

1.3.5 Design and Construction Records and History

The EAPS and WAPS were designed by Illinois Power Company. However, available information regarding the original design and/or construction of the EAPS was limited to drawings related to subsequent embankment modifications and references in various documents prepared by CEC for the design and construction of Pond 2E. The documentation included information about the dimensions of the slopes and the materials used but not about the construction techniques or quality control during construction.

Construction of Pond 2E was documented in a December 2010 report generated by CEC. The report included documentation of the excavation of Pond 2E into the existing ash and construction of the liner on the upstream slopes. The construction did not include modification of the embankments of the existing pond.

1.3.6 Operating Records

No operating records of the impoundments were provided to GZA.

1.3.7 Previous Assessment Reports

The HPS personnel perform visual assessments of the impoundments on a weekly basis and the assessment results are documented in a field log book. Every 5 years the Primary and Secondary Cells are inspected by a consulting engineer. GZA was provided with the 5-year assessments reports from 2001, 2006, and 2010 in Appendix D. The assessment completed March 29, 2010 was conducted by Mr. Kenneth M. Berry, P.E. of URS and indicated no deficiencies for the Primary and Secondary Cells at that time. Observed deficiencies at the WAPS include thick vegetation and trees.

[3] Downstream tail water elevation based on visual estimates made by GZA during the Site Visit.

2.0 ASSESSMENT

2.1 Visual Assessment

The HSP impoundments were inspected on May 23, 2011 by Patrick J. Harrison, P.E., and Douglas P. Simon, P.E. (Wisconsin), of GZA GeoEnvironmental, Inc., and accompanied by Phil Morris of Dynegy. The weather was partly cloudy with temperatures in the 70°s to 80°s Fahrenheit. Photographs to document the current conditions of the impoundments were taken during the assessment and are included in **Appendix E**. The water levels in the impoundments at the time of the assessment were as provided in Section 1.3.4. Underwater areas were not inspected, as this level of investigation was beyond of GZA's scope of services. Copies of the EPA Checklists are included in **Appendix C**.

With respect to our visual assessment, there was no evidence of prior releases, failures, or repairs observed by GZA for most of the impoundment areas. It appeared that the downstream slope of the northwestern embankment of the WAPS had been regraded within the last year.

2.1.1 EAPS Impoundment General Findings

In general, the HPS EAPS Impoundment was found to be in **POOR** condition. An overall Site plan showing the impoundments is provided as **Figure 2**. The location and orientation of photographs provided in **Appendix E** is shown on the Photo Plan in **Figure 6**.

2.1.2 EAPS Upstream Slope (Photos 18, 22, 24, and 74)

The northern portion of the EAPS has been permitted for a dry ash landfill and the upstream slopes are covered with ash along that portion of the impoundment. The southern portion of the EAPS that includes the former Pond 4 is no longer active. The upstream embankments along that portion of the EAPS were generally vegetated with grass that had not been recently mowed. Trees up to 12 inches in diameter were present on the slope.

2.1.3 EAPS Crest of Impoundment (Photos 32 though 35, 45, 52, 71 through 73)

The crest of the EAPS Impoundment generally had a gravel access road along the northern portion of the impoundment. The crest of impoundment had occasional pot holes along its entire length. The alignment of the crest appeared generally level, with no large depressions or irregularities observed. Based on information provided by HPS personnel, the crest elevation is approximately elevation 494 feet MSL. No significant settlement was observed at the time of our assessment. There was no water present in the EAPS at the time of our assessment.

2.1.4 EAPS Downstream Slope (Photos 25 through 28, 55 through 57, 69, and 70)

The downstream slope of the impoundment was generally covered in thick grass vegetation making it difficult to observe during our assessments. In addition, the rough terrain and steep slopes along the northern portion of the impoundment created a personnel safety risk to access the slope. Therefore, our observations along that portion of the impoundment were limited to that which could be observed from the crest of the 1979 embankment. Trees up to 24 inches in diameter generally characterized northern embankment along the Illinois River. No grass was present along that portion of the embankment. The western and southwestern

embankment was generally covered with grass that had not been recently mowed. No unusual movement or displacement was observed on the slope.

2.1.5 EAPS Discharge Pipes (Photo 44)

The EAPS no longer functions as an active ash impoundment and no CCW sluice piping is present. Storm water drains have been installed along portions of the perimeter of the permitted landfill as shown in Photo 44. The drains appeared to be in good condition at the time of our assessment.

2.1.6 AEAPS Impoundment General Findings

In general, the HPS AEAPS Impoundment was found to be in **POOR** condition. An overall Site plan showing the impoundments is provided as **Figure 2**. The location and orientation of photographs provided in **Appendix E** is shown on the Photo Plan in **Figure 6**.

2.1.7 AEAPS Upstream Slope (Photos 35 through 43, 45 through 53)

The water surface elevation at the time of assessment was approximately at elevation 489.5 feet, 489.0 feet, and 479.5 feet MSL in the Primary Cell, Pond 2E and Secondary Cell, respectively. Therefore, the lower portion of the upstream slope was below the water level and not visible. Where visible, the upstream slope of Pond 2E was covered with a HDPE liner that was in good condition. The upstream slopes of the Primary and Secondary Cells were generally covered with grass above the water level.

2.1.8 AEAPS Crest of Impoundment (Photos 35 through 43, 45 through 53)

The crest of the AEAPS Impoundment was generally covered by a gravel access road. The crest of impoundment had occasional pot holes along its entire length. The alignment of the crest appeared generally level, with no large depressions or irregularities observed. Based on information provided by HPS personnel, the crest elevation is approximately elevation 494 feet MSL. No significant settlement was observed at the time of our assessment. There was approximately 4 feet to 14 feet of free board at the time of our assessment.

2.1.9 AEAPS Downstream Slope (Photos 29 through 31)

The AEAPS Impoundment shares a common embankment with the EAPS along the western portion of the impoundment and is incised along the southern portion. Therefore, no downstream slope was visible or present along those portions of the impoundment. The northern embankment of the impoundment abuts the Illinois River and is characterized by trees up to 24-inches in diameter. The eastern embankment was covered with grass that had not been recently mowed.

2.1.10 AEAPS Discharge Structures (Photos 58 through 68)

GZA observed the outlet structures that transmit flow from the Primary Cell to Pond 2E and then to the Secondary Cell. Based on our observations, the structures appeared to be in good condition with no defects noted. GZA also observed the condition of the decant structure

in the Secondary Cell and the partial flume. Both structures appeared to be in good condition based on our observations.

2.1.11 WAPS Impoundment General Findings

In general, the HPS WAPS Impoundment was found to be in **POOR** condition. An overall Site plan showing the impoundments is provided as **Figure 2**. The location and orientation of photographs provided in **Appendix E** is shown on the Photo Plan in **Figure 10**.

2.1.12 WAPS Upstream Slope (Photos 18, 22, and 24)

The eastern portion of the WAPS has been filled with ash and the upstream slopes along that portion were not visible. The water surface elevation at the time of assessment was approximately at elevation 455.6 feet MSL along the western portion of the impoundment. Therefore, the lower portion of the upstream slope was below the water level and not visible. Where visible, the upstream slope was generally vegetated with grass that had not been recently mowed. Trees and shrubs up to 4 inches in diameter were noted along several portions of the upstream slope.

2.1.13 WAPS Crest of Impoundment (Photos 14 through 20)

The crest of the WAPS Impoundment was generally covered by a gravel access road. The crest of impoundment had occasional pot holes along its entire length. The alignment of the crest appeared generally level, with no large depressions or irregularities observed. Based on information provided by HPS personnel, the crest elevation is approximately elevation 460 feet MSL. No significant settlement was observed at the time of our assessment. There was approximately 8 feet of free board at the time of our assessment.

2.1.14 WAPS Downstream Slope (Photos 1 through 13)

The downstream slope of the impoundment was generally wooded along the northern portion of the impoundment adjacent to the Illinois River. Trees up to 24-inches in diameter were present along the downstream slope of the northern embankment. The remaining embankments were generally covered with grass that had not been recently mowed. Trees up to 12 inches in diameter were noted along the southern embankment and smaller trees and shrubs were noted along the eastern embankment. There was erosion (likely due to wave action) of the downstream slope of the northern embankment.

2.1.15 WAPS Discharge Pipes (Photos 21 and 22)

The decant structure for the WAPS Impoundment consists of a 12-inch diameter steel pipe with a trash rack as shown in Photo 21. The pipe discharges into the Illinois River and the discharge pipe is shown in Photo 22. The decant and discharge portions of the pipe appeared to be in good condition at the time of our assessment.

2.2 Caretaker Interview

Maintenance of the impoundments is the responsibility of HPS personnel. GZA met with HPS personnel and discussed the operations and maintenance procedures, regulatory requirements,

and the history of the impoundments since their construction. Information gathered during that discussion is reflected in this report.

2.3 Operation and Maintenance Procedures

As discussed in Section 1.2.7, HPS personnel are responsible for the regular operations and maintenance of the impoundments. No formal maintenance plan has been developed for the WAPS and EAPS impoundments. An operation and maintenance plan for the Primary and Secondary Cells has been developed along with a separate operation and maintenance plan for Pond 2E. Based on our discussions with HPS personnel, the roadways and slopes are repaired as needed.

2.4 Emergency Action Plan

An Emergency Action Plan (EAP) has not been developed for the impoundments. An emergency action plan is not required for Class III structure per Illinois regulations. Note that the hazard potential classification for the dam is discussed in Section 1.2.11.

2.5 Hydrologic/Hydraulic Data

Illinois Power Company performed a hydrologic/hydraulic analysis in 1994 for the AEAP Primary and Secondary Cells as part of the original impoundment design. The results are provided in the "Hennepin Power Station Ash Surface Impoundment, Hydrologic/Hydraulic Analysis" report. The analysis was used to determine the maximum discharge rates and water elevations the facility would obtain and also to size the discharge piping and determine the required freeboard.

A hydrologic/hydraulic analysis was also conducted in 2009 by CEC for the AEAP Primary and Secondary Cells and for Pond 2E. The results are provided in the "Engineering Basis of Design, Application for a Permit to Construct a New Leachate and Storm Water Runoff Collection Pond, Dynegy – Hennepin Power Station, Hennepin, Illinois" report. In addition to the HPS operating flows and the future effects from the new landfill portion of the EAPS, the ponds were determined by CEC to have sufficient capacity to safely pass the 24-hour 25-year and the 24-hour 100-year frequency rainfall events with a minimum free-broad of more than 2 feet,

Based on the available information, a hydrologic/hydraulic analysis has not been performed for the WAPS.

GZA did not perform an independent assessment of the hydraulics and hydrology for the impoundments as this was beyond our scope of services.

2.6 Structural and Seepage Stability

Illinois Power Company performed a stability and seepage analysis for the AEAP Primary and Secondary Cells as part of the original impoundment design. The results are provided in the "Hennepin Power Station Ash Surface Impoundment, Geotechnical/Structural Design" report. Based on the results of the stability analysis, the factor of safety was calculated for several load conditions. The critical load conditions were determined to be the end of construction and rapid drawdown conditions. Both static and seismic conditions were evaluated. The results indicted

minimum static and seismic factors of safety of 2.0 and 1.7, respectively for the upstream embankments and 2.3 and 2.0, respectively for the downstream embankments. The results for the original embankments were within the range of acceptable factors of safety for the types of embankments and load conditions evaluated.

CEC performed a stability analysis for a section of the existing EAPS 1979 embankment as part of the new landfill design. The 1979 embankment is common to the AEAP and the EAP; the ponds were separated into different units in association with the construction of Pond 2E at a later date. Since the embankment is common to both impoundments, we would expect the CEC analyses for the 1979 embankment for the EAP are to be applicable to the 1979 embankment for the AEAP. Based on the results provided, the calculated factor of safety against wedge failure of the 1978 embankment without seismic loading was 1.009. After submittal of the draft report, Dynegy provided additional analysis and discussion for the 1978 embankment. The additional analysis indicated a factor of safety of 1.4 for static loading conditions. This result is less than generally acceptable factors of safety of 1.5 for the types of embankments and load conditions evaluated, in GZA's opinion. In addition, it is our opinion that the assumption of the discontinuity of the stream bed deposits in the analysis should be verified.

No engineering evaluation is available for the WAPS embankments which were designed by Illinois Power Company.

GZA did not perform an independent assessment of the hydraulics and hydrology for the impoundments as this was beyond our scope of services.

3.0 ASSESSMENTS AND RECOMMENDATIONS

3.1 Assessments

In general, the overall condition of the EAPS impoundment was judged to be **POOR**. The EAPS impoundment was found to have the following deficiencies:

1. Trees were present along the upstream and downstream slopes;
2. Minor potholes and rutting along the crest gravel access road; and,
3. The stability analysis completed indicates that the 1979 embankments that support the underlying ash along the Illinois River have a calculated factor of safety less than the generally accepted value and assumptions in the analysis about subsurface conditions should be verified.

In general, the overall condition of the AEAPS impoundments was judged to be **POOR**. The AEAPS impoundment was found to have the following deficiencies:

1. Minor potholes and rutting along the crest gravel access road;
2. Trees were present along the downstream slope of the northern embankment; and,

3. The stability analysis completed indicates that the 1979 embankments that support the underlying ash along the Illinois River have a calculated factor of safety less than the generally accepted value.

In general, the overall condition of the WAPS impoundment was judged to be **POOR**. In GZA's professional opinion, the embankment(s) visually appear to be sound and no immediate remedial action appears to be necessary. However, based on EPA's assessment criteria, the impoundment has been given a POOR Condition Rating, because complete hydraulic and geotechnical computations were not provided/available for GZA's for review. Thus, the stability of the embankment(s) could not be independently verified. The WAPS impoundment was found to have the following deficiencies:

1. Thick vegetation and trees along the downstream slopes;
2. Minor potholes and rutting along the crest gravel access road;
3. Erosion along the downstream slope of the northern embankment;
4. No seepage and/or stability analysis has been performed for the WAPS; and
5. No hydraulic/hydrologic analysis has been performed to confirm adequate freeboard and decant capacity at the design storm event.

The following recommendations and remedial measures generally describe the recommended approach to address current deficiencies at the impoundments. Prior to undertaking recommended maintenance, repairs, or remedial measures, the applicability of permits needs to be determined for activities that may occur under the jurisdiction of the appropriate regulatory agencies.

3.2 Studies and Analyses

GZA recommends that HPS/Dynegy conduct the following studies and analysis:

1. Conduct an analysis of the hydraulic/hydrologic condition of the WAPS to establish the rise in water level that occurs during the 100-year, 24-hour rain event to confirm that adequate freeboard is maintained and adequate decant and spillway capacity is available. The loading conditions established during the design storm event should be used in the evaluation of the seepage and stability evaluation of the embankments.

2. Perform a complete structural and seepage stability analysis of the WAPS impoundment including static, seismic and liquefaction loading.

3. Generate a remedial design to address the inadequate factor of safety along the northern embankment of the EAPS and AEAPS adjacent to the Illinois River.

3.3 Recurrent Operation & Maintenance Recommendations

GZA recommends the following operation and maintenance level activities:

1. Increased mowing of the grasses on the embankments to facilitate assessments and reduce the risk of burrowing animals;

2. Repair wave action erosion on the downstream slope of the WAPS;

3. Repair the potholes present in the gravel crest access roads. Grade the road to provide better drainage and reduce future potholing; and,

4. Clear trees and other deep rooted vegetation from the slopes and crests of the embankments.

3.4 Repair Recommendations

GZA recommends the following repairs to address observed deficiencies that may affect the stability of the embankments. The recommendations may require design by a professional engineer and construction contractor experienced in impoundment construction.

1. Pending the results of the hydraulic/hydrologic analysis, modify the design or operation of the WAPS to provide adequate capacity.

2. Pending the results of the complete seepage and stability analysis for the WAPS, modify the design or operation of the impoundments to provide conditions that result in embankments that meet the generally accepted factors of safety.

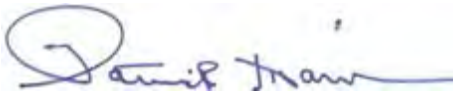
3. Based on the geotechnical results for the EAPS and AEAPS embankments, which produced inadequate minimum factors of safety, develop design modifications for those embankments along the Illinois River. These improvements are to result in the embankments meeting generally accepted factors of safety and protect the slope from future erosion.

3.5 Alternatives

There are no practical alternatives to the repairs itemized above.

4.0 ENGINEER'S CERTIFICATION

I acknowledge that the management unit referenced herein, the HPS WAPS, AEAPS, and EAPS Impoundments have been assessed to be in **POOR** condition on May 23, 2011.



Patrick J. Harrison, P.E.
Senior Consultant

FIGURES



SOURCE: U.S.G.S. QUADRANGLE MAP
DEPUE, IL (1966)
PHOTOREVISED (1979)

NO.	ISSUE/DESCRIPTION	BY	DATE

UNLESS SPECIFICALLY STATED BY WRITTEN AGREEMENT, THIS DRAWING IS THE SOLE PROPERTY OF GZA GEOENVIRONMENTAL, INC. (GZA). THE INFORMATION SHOWN ON THE DRAWING IS SOLELY FOR USE BY GZA'S CLIENT OR THE CLIENT'S DESIGNATED REPRESENTATIVE FOR THE SPECIFIC PROJECT AND LOCATION IDENTIFIED ON THE DRAWING. THE DRAWING SHALL NOT BE TRANSFERRED, REUSED, COPIED, OR ALTERED IN ANY MANNER FOR USE AT ANY OTHER LOCATION OR FOR ANY OTHER PURPOSE WITHOUT THE PRIOR WRITTEN CONSENT OF GZA. ANY TRANSFER, REUSE, OR MODIFICATION TO THE DRAWING BY THE CLIENT OR OTHERS, WITHOUT THE PRIOR WRITTEN EXPRESS CONSENT OF GZA, WILL BE AT THE USER'S SOLE RISK AND WITHOUT ANY RISK OR LIABILITY TO GZA.

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
20900 SWENSON DRIVE, SUITE 150
WAUKESHA, WISCONSIN 53186
(262) 754-2560

PREPARED FOR:

SITE LOCATION MAP

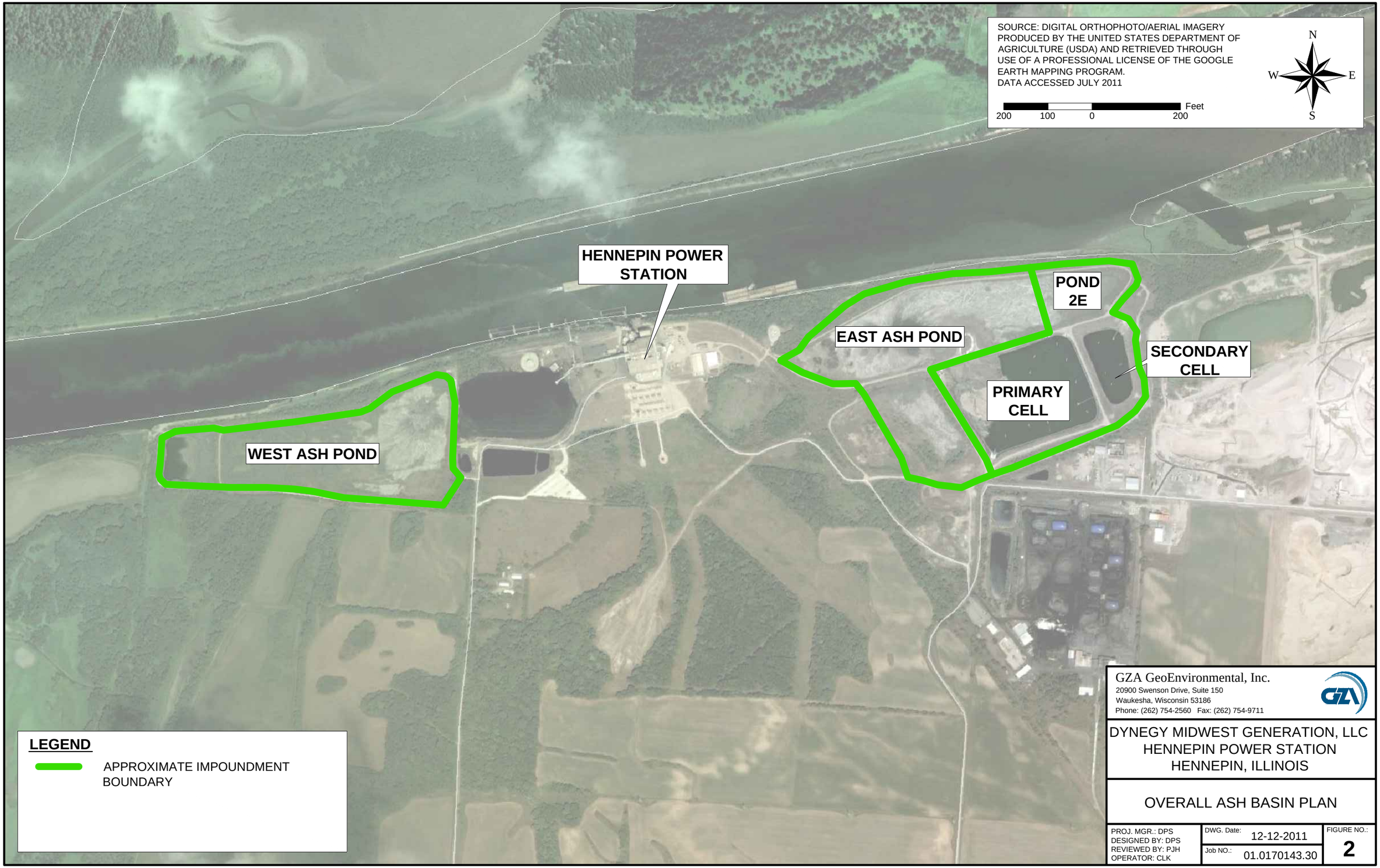
DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

FIGURE 1

SHEET NO.

PROJ MGR: DPS	REVIEWED BY: PJH	CHECKED BY: DS	DATE 12/12/11	PROJECT NO. 01.0170142.30	REVISION NO.
DESIGNED BY: DS	DRAWN BY: CLK	SCALE: 1 : 24000			

©2011 – GZA GeoEnvironmental, Inc. GZA-J:\GZA_USA#\01.0170142.30 Ash Imp. Round 10\01.0170142.30 Task 8 - Hennepin\Drawings\Autocad\SITE LOCATION.dwg [FIGURE 1 - SITE LOCATION] December 12, 2011 - 9:23am justin.hegarty



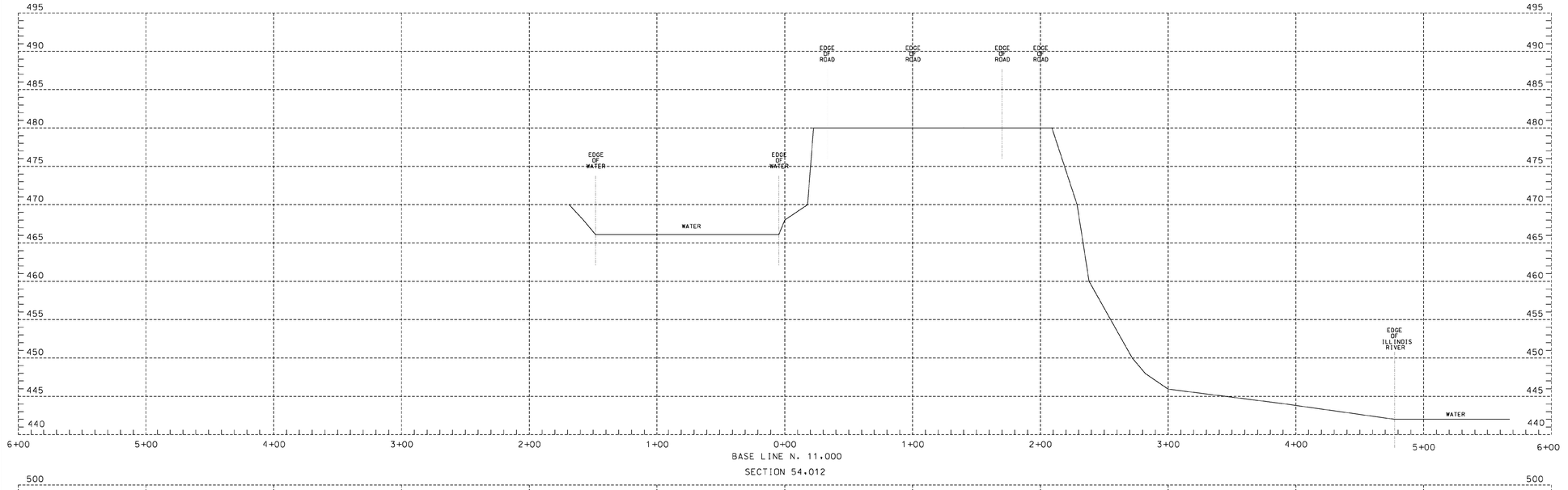
GZA GeoEnvironmental, Inc.
20900 Swenson Drive, Suite 150
Waukesha, Wisconsin 53186
Phone: (262) 754-2560 Fax: (262) 754-9711

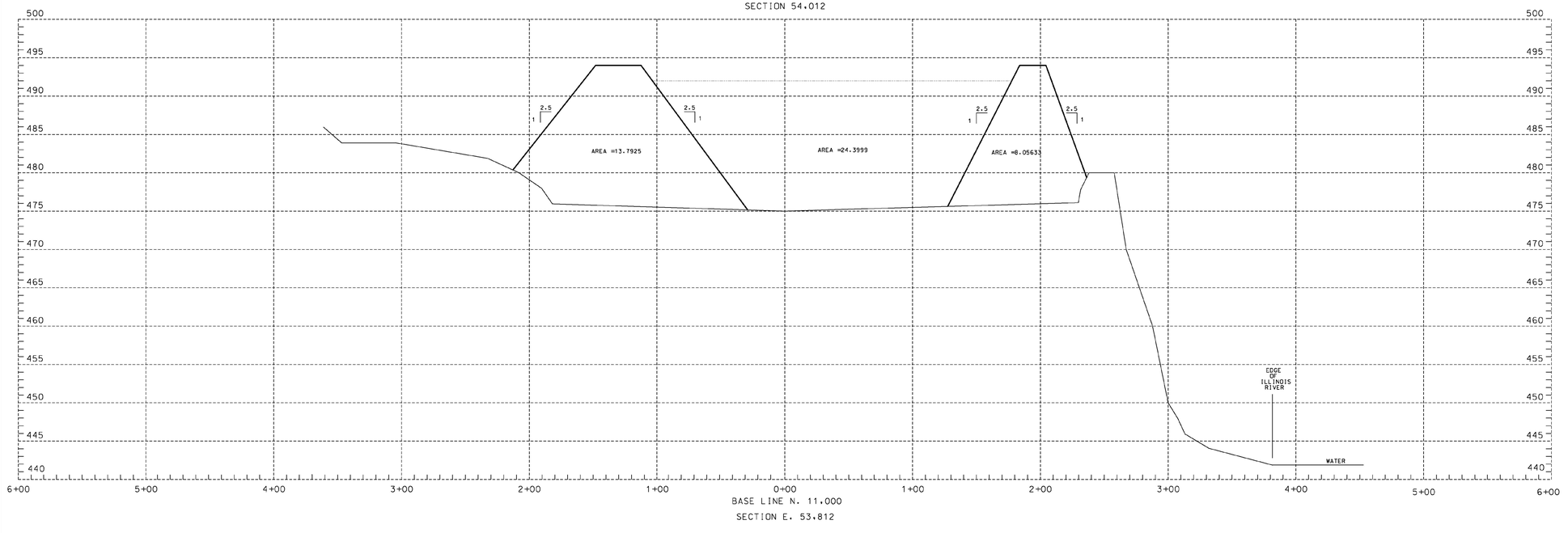
DYNEGY MIDWEST GENERATION, LLC
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

OVERALL ASH BASIN PLAN

PROJ. MGR.: DPS DESIGNED BY: DPS REVIEWED BY: PJH OPERATOR: CLK	DWG. Date: 12-12-2011 Job NO.: 01.0170143.30	FIGURE NO.: 2

G:\GZA_USA#\01.0170142.30 Ash Imp. Round 10\01.0170142.30 Task 8 - Hennepin\Drawings\Autocad\SITE PLANS.dwg [FIG 2] December 12, 2011 - 11:29am justin.hegarty





NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

1. DATA COLLECTED FROM TOPO ON DWG. CE-HEN1-B-450 DATED NOV. 4. 1987. REV. 0
2. COORDINATES WERE SUPPLIED BY G. DECKARD FIELD INFORMATION TIEING TO J.L. FISHER'S PANELS.

REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD
0

ILLINOIS POWER COMPANY
DECATUR

CROSS SECTIONS
EAST ASH POND EXTENSION
HENNEPIN POWER STATION

DR	WJM	CAD	WJM
CK		CKD	
APP		PLOTTED	03-08-90
APP		DATE	1-11-89
		SCALE	1"=5' V. 1"=30' H.
			CE-HEN1-B458-1

REV. NO.	BY	DATE	DESCRIPTION

PROJ MGR: DPS
DESIGNED BY: DPS
REVIEWED BY: PJH
OPERATOR: CLK
DATE: 12-12-11

NOTE:
IMAGE HAS BEEN REDUCED AND IS NO LONGER TO A SCALE

GZA
GeoEnvironmental, Inc.
20900 Swenson Drive, Suite 150
Waukesha, Wisconsin ◆ 53186 ◆ Phone
(262) 754-2560 ◆ Fax (262) 754-9711
www.gza.com

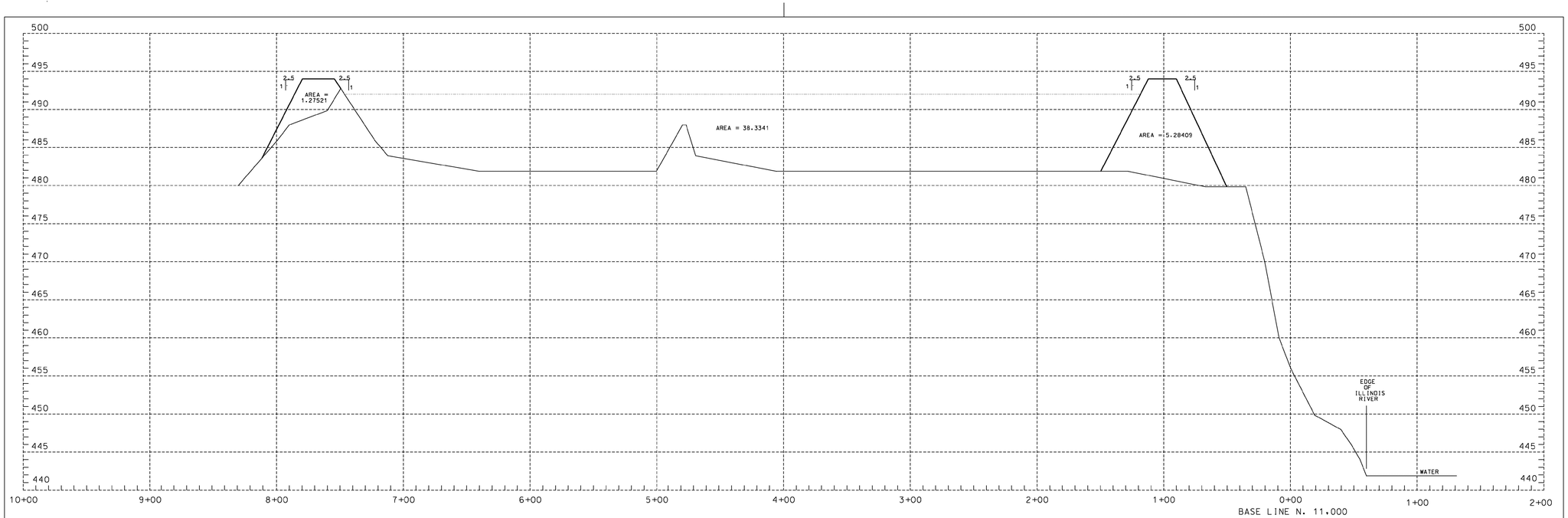
DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

EAST ASH POND TYPICAL SECTIONS
OF 1989 EMBANKMENT RAISE

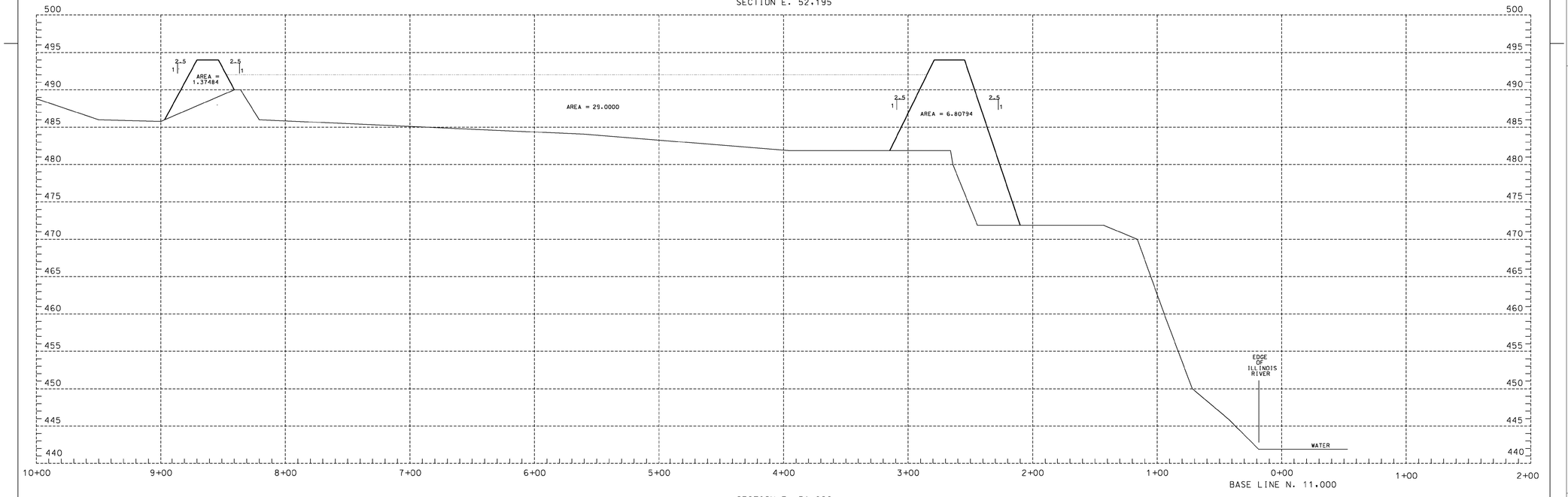
JOB NO.
01.0170142.30

FIGURE NO.
3

© 2011 GZA GeoEnvironmental, Inc.



SECTION E. 52.195



SECTION E. 51.920

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

1. DATA COLLECTED FROM TOPO ON DWG. CE-HEN1-B-450 DATED NOV. 4, 1987, REV. 0
2. COORDINATES WERE SUPPLIED BY G. DECKARD FIELD INFORMATION TIEING TO J.L. FISHER'S PANELS.

REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD
0

ILLINOIS POWER COMPANY
DECATUR
CROSS SECTIONS
EAST ASH POND EXTENSION
HENNEPIN POWER STATION

DR	WJM	CAD WJM	DATE 1-12-89
CK		CKD	SCALE 1"=5' V. 1"=30' H.
APP		PLOTTED 03-08-90	CE-HEN1-B458-5
APP			

REV. NO.	DESCRIPTION	BY	DATE

PROJ MGR: DPS
DESIGNED BY: DPS
REVIEWED BY: PJH
OPERATOR: CLK
DATE: 12-12-11

NOTE:
IMAGE HAS BEEN REDUCED AND IS NO LONGER TO A SCALE

GZA
GeoEnvironmental, Inc.
20900 Swenson Drive, Suite 150
Waukesha, Wisconsin ◆ 53186 ◆ Phone
(262) 754-2560 ◆ Fax (262) 754-9711
www.gza.com

DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

EAST ASH POND ADDITIONAL
SECTIONS OF 1989 EMBANKMENT RAISE

JOB NO.
01.0170142.30

FIGURE NO.
4

© 2011 GZA GeoEnvironmental, Inc.



REFERENCE

1. TOPOGRAPHIC SURVEY PERFORMED BY SURDEX CORPORATION, FLOWN ON OCTOBER 26, 2008.

Civil & Environmental Consultants, Inc.
5910 Harper Road, Suite 106 - Solon, OH 44139
440-287-0157 · 866-507-2324
www.cecinc.com

DYNEGY
HENNEPIN POWER STATION
PROPOSED POND 2 EAST
BASIS OF DESIGN

BORING LOCATION PLAN

DRAWN BY:	WRM	CHECKED BY:	MDJ	APPROVED BY:	PCC*	FIGURE NO.: 4
DATE:	MAY 19, 2009	DWG SCALE:	1"=200'	PROJECT NO:	082-255	

REV. NO.	DESCRIPTION	BY	DATE

PROJ MGR: DPS
DESIGNED BY: DPS
REVIEWED BY: PJH
OPERATOR: CLK
DATE: 12-12-11

NOTE:
IMAGE HAS BEEN REDUCED AND IS NO LONGER TO A SCALE

GZA
GeoEnvironmental, Inc.
20900 Swenson Drive, Suite 150
Waukesha, Wisconsin • 53186 • Phone
(262) 754-2560 • Fax (262) 754-9711
www.gza.com

DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

BORING LOCATION PLAN

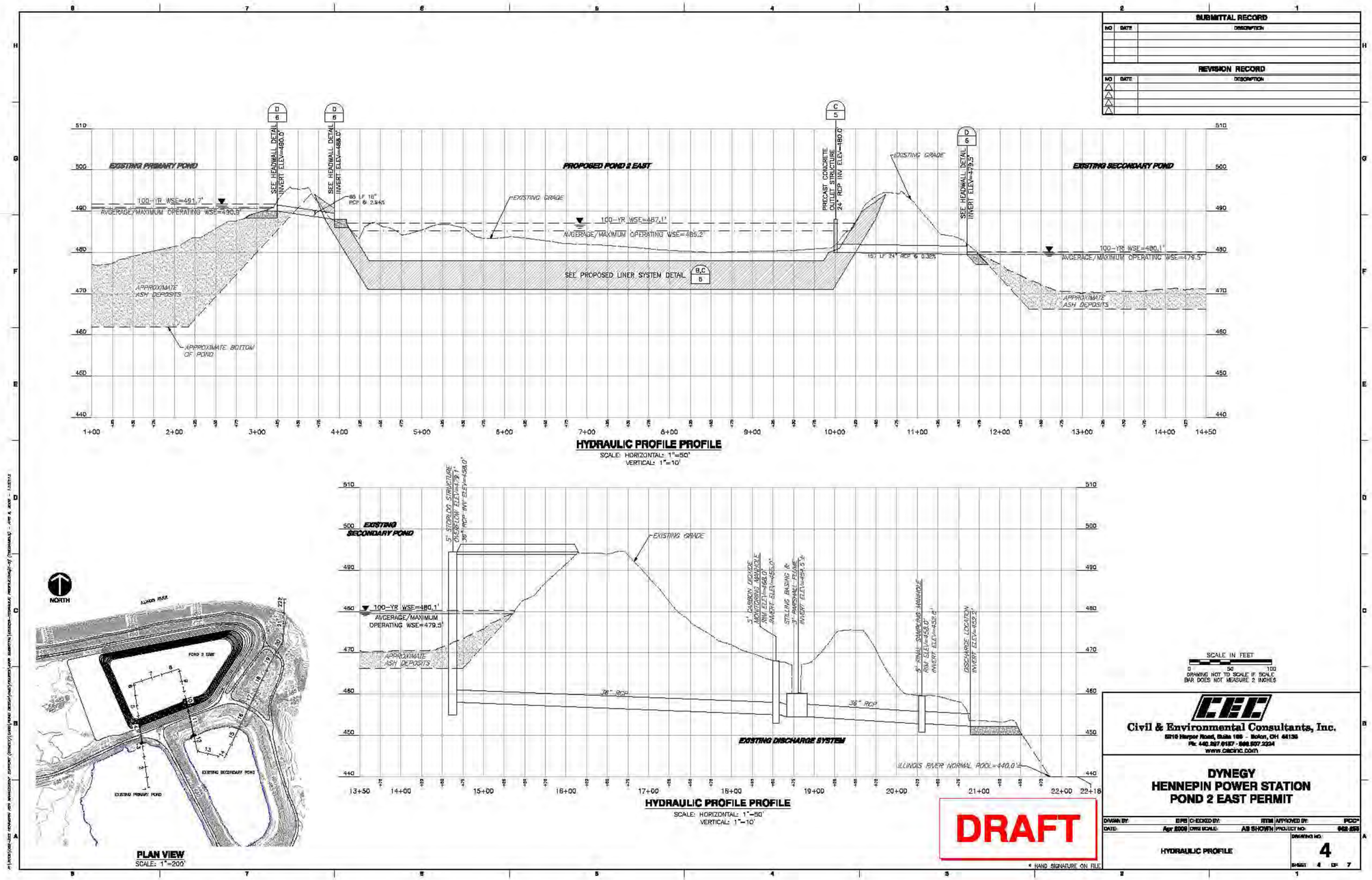
JOB NO.
01.0170142.30

FIGURE NO.
5

© 2011 GZA GeoEnvironmental, Inc.



GZA–J:\GZA_USA\#\01.0170142.30 Ash Imp. Round 10\01.0170142.30 Task 8 – Hennepin\Drawings\Autocad\SITE PLANS.dwg [fig 6] December 13, 2011 – 11:07am justin.hegarty



HYDRAULIC PROFILE PROFILE
SCALE: HORIZONTAL: 1"=50'
VERTICAL: 1"=10'

HYDRAULIC PROFILE PROFILE
SCALE: HORIZONTAL: 1"=50'
VERTICAL: 1"=10'

PLAN VIEW
SCALE: 1"=200'

SCALE IN FEET
0 50 100
DRAWING NOT TO SCALE IF SCALE BAR DOES NOT MEASURE 2 INCHES

DRAFT

* HAND SIGNATURE ON FILE

SUBMITTAL RECORD		
NO	DATE	DESCRIPTION

REVISION RECORD		
NO	DATE	DESCRIPTION
1		
2		
3		
4		

REV. NO.	DESCRIPTION	BY	DATE

NOTE:
IMAGE HAS BEEN REDUCED AND IS NO LONGER TO A SCALE

PROJ MGR: DPS
DESIGNED BY: DPS
REVIEWED BY: PJH

OPERATOR: CLK
DATE: 12-8-11

GZA
GeoEnvironmental, Inc.
20900 Swenson Drive, Suite 150
Waukesha, Wisconsin ◆ 53186 ◆ Phone
(262) 754-2560 ◆ Fax (262) 754-9711
www.gza.com

Civil & Environmental Consultants, Inc.
5210 Harper Road, Suite 100 - Solon, OH 44139
Ph: 440.287.0157 - 866.507.2234
www.cecinc.com

DYNEGY
HENNEPIN POWER STATION
POND 2 EAST PERMIT

DRAWN BY:	EPS	CHECKED BY:	RTM	APPROVED BY:	PCD*
DATE:	Apr 2008	DWG SCALE:	AS SHOWN	PROJECT NO:	852.852

HYDRAULIC PROFILE

DRAWING NO: 4
SHEET 4 OF 7

DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

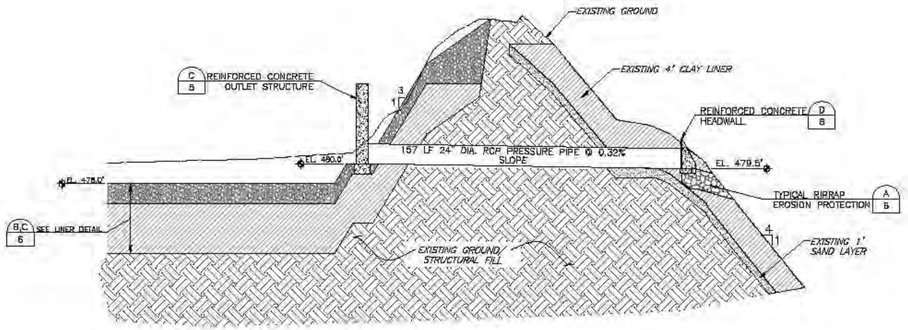
POND 2E PROFILES AND DETAILS

JOB NO.
01.0170142.30

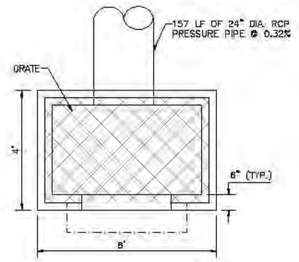
FIGURE NO.
7

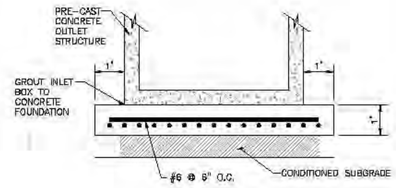
© 2011 GZA GeoEnvironmental, Inc.

PROPOSED CLARIFYING POND **EXISTING SECONDARY POND**

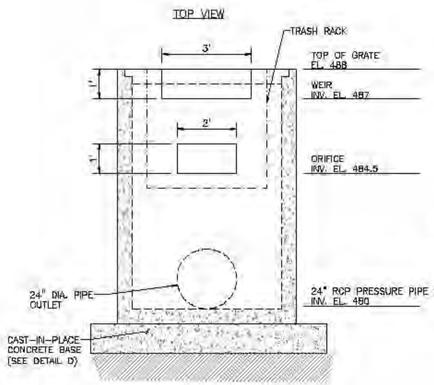


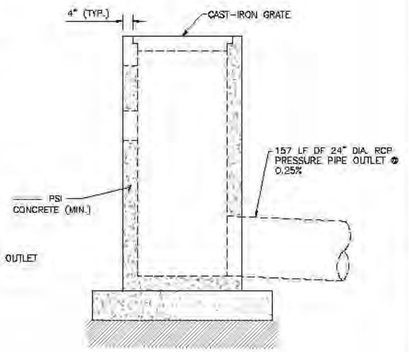
DETAIL A
PROPOSED CLARIFYING POND OUTLET STRUCTURE
N.T.S.
EXAGGERATED 5V:1H





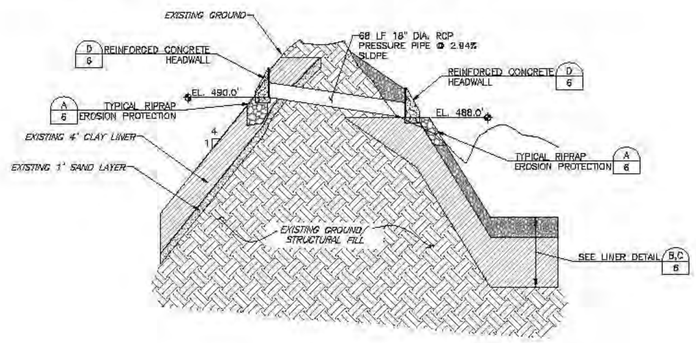
DETAIL D





DETAIL C
PRECAST CONCRETE OUTLET STRUCTURE
N.T.S.

EXISTING PRIMARY POND **PROPOSED CLARIFYING POND**



DETAIL B
PROPOSED PRIMARY POND OUTLET STRUCTURE
N.T.S.
EXAGGERATED 5V:1H

DRAFT

* HAND SIGNATURE ON FILE

SUBMITTAL RECORD

NO.	DATE	DESCRIPTION

REVISION RECORD

NO.	DATE	DESCRIPTION
1		
2		
3		
4		

REV. NO.	DESCRIPTION	DATE	BY

PROJ MGR: DPS OPERATOR: CLK
DESIGNED BY: DPS
REVIEWED BY: PJH DATE: 12-8-11

NOTE:
IMAGE HAS BEEN REDUCED AND IS NO LONGER TO A SCALE

GZA GeoEnvironmental, Inc.
20900 Swenson Drive, Suite 150
Waukesha, Wisconsin ◆ 53186 ◆ Phone (262) 754-2560 ◆ Fax (262) 754-9711
www.gza.com

Civil & Environmental Consultants, Inc.
6910 Hagar Road, Suite 100 - Solon, OH 44139
Ph: 330.318.6900 - 866.807.2324
www.cecinc.com

DYNEGY
HENNEPIN POWER STATION
POND 2 EAST PERMIT

DRAWN BY:	EPS	CHECKED BY:	RTM	APPROVED BY:	PCC*
DATE:	Apr 2009	DWG SCALE:	AS SHOWN	PROJECT NO:	668.358

POND INLET/OUTLET DETAILS

DRAWING NO. 5
SHEET 5 OF 7

DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

POND 2E STRUCTURE DETAILS

JOB NO.
01.0170142.30

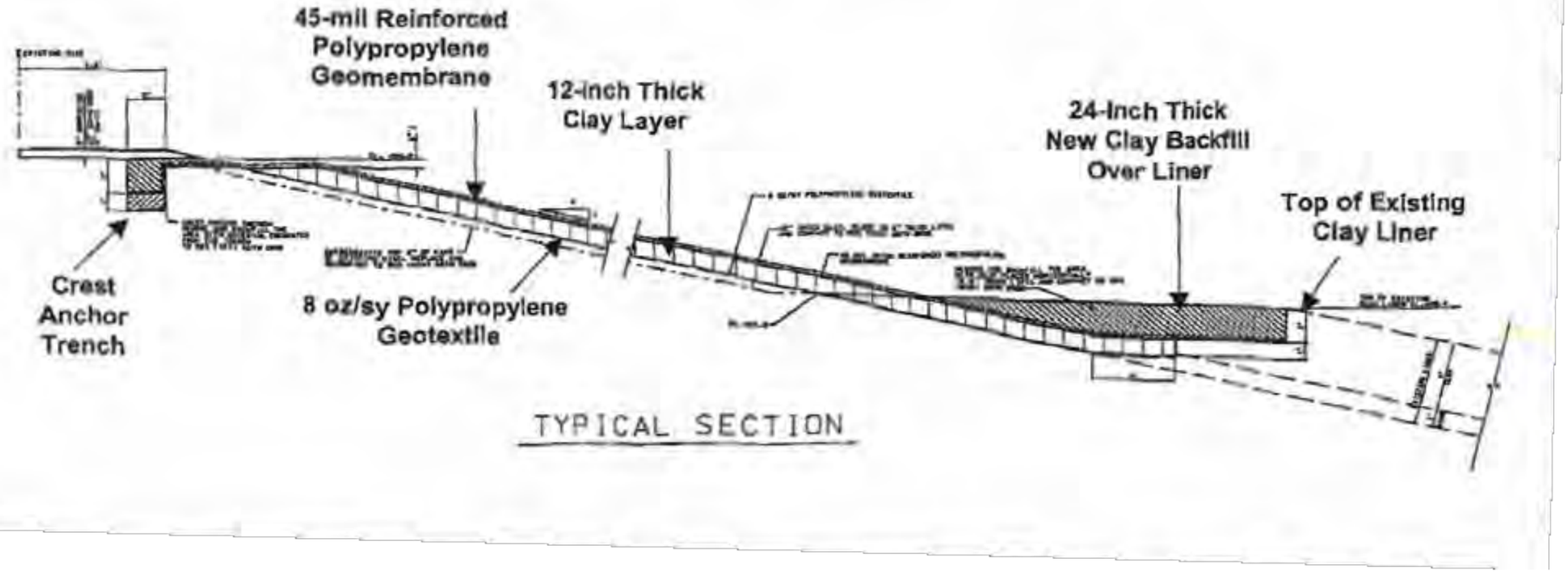
FIGURE NO.
8

© 2011 GZA GeoEnvironmental, Inc.

Hennepin Power Station
Hennepin, IL

East Ash Pond System

Raising of Interior Impermeable Liners in Primary and Secondary Cells



TYPICAL SECTION

REV. NO.	DESCRIPTION	BY	DATE

NOTE:
IMAGE HAS BEEN REDUCED AND IS NO LONGER TO A SCALE

PROJ MGR: DPS
DESIGNED BY: DPS
REVIEWED BY: PJH

OPERATOR: CLK
DATE: 12-12-11

GZA
GeoEnvironmental, Inc.
20900 Swenson Drive, Suite 150
Waukesha, Wisconsin • 53186 • Phone
(262) 754-2560 • Fax (262) 754-9711
www.gza.com

DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

TYPICAL SECTION OF LINER EXTENSION

JOB NO.
01.0170142.30

FIGURE NO.
9

© 2011 GZA GeoEnvironmental, Inc.

Drawing Name: J:\GZA_USA#\01.0170142.30 Ash Imp. Round 10\01.0170142.30 Task 8 – Hennepin\Drawings\Autocad\Scanned Figures – Hennepin.dwg Last Modified: Dec 13, 2011 – 10:53am Plotted on: De

SOURCE: DIGITAL ORTHOPHOTO/AERIAL IMAGERY PRODUCED BY THE UNITED STATES DEPARTMENT OF AGRICULTURE (USDA) AND RETRIEVED THROUGH USE OF A PROFESSIONAL LICENSE OF THE GOOGLE EARTH MAPPING PROGRAM.
DATA ACCESSED JULY 2011.

80 40 0 80 Feet

N W E S

NOTE

DISCHARGE PIPELINE DIAMETERS ESTIMATED BY GZA GEOENVIRONMENTAL, INC.

TREES ON SLOPE

APPROXIMATE LOCATION OF DISCHARGE STRUCTURE

APPROXIMATE LOCATION OF DECANT STRUCTURE

POTHOLES ALONG ROADWAY

WEST ASH POND

TREES ON SLOPE

TREES ON SLOPE

LEGEND

- APPROXIMATE IMPOUNDMENT BOUNDARY
- 12 GZA PHOTO LOCATION / DIRECTION
- 02 GROUNDWATER MONITORING WELL LOCATIONS

GZA GeoEnvironmental, Inc.
20900 Swenson Drive, Suite 150
Waukesha, Wisconsin 53186
Phone: (262) 754-2560 Fax: (262) 754-9711

DYNEGY MIDWEST GENERATION LLC
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

WEST ASH POND

PROJ. MGR.: DPS DESIGNED BY: DPS REVIEWED BY: PJH OPERATOR: CLK	DWG. Date: 12-13-2011 Job NO.: 01.0170143.30	FIGURE NO.: 10

G:\GZA_USA#\01.0170142.30 Ash Imp. Round 10\01.0170142.30 Task 8 - Hennepin\Drawings\Autocad\SITE PLANS.dwg [fig 10] December 13, 2011 - 10:40am justin.hegarty

APPENDIX A

LIMITATIONS

DAM ENGINEERING & VISUAL ASSESSMENT LIMITATIONS

1. The observations described in this report were made under the conditions stated herein. The conclusions presented in the report were based solely on the services described therein, and not on scientific tasks or procedures beyond the scope of described services or the time and budgetary constraints imposed by the United States Environmental Protection Agency (EPA).

2. In preparing this report, GZA GeoEnvironmental, Inc. (GZA) has relied on certain information provided by Dynegy Midwest Generation, LLC (Dynegy) (and their affiliates) as well as Federal, state, and local officials and other parties referenced therein. GZA has also relied on other parties which were available to GZA at the time of the assessment. Although there may have been some degree of overlap in the information provided by these various sources, GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this work.

3. In reviewing this Report, it should be noted that the reported condition of the Ash Ponds is based on observations of field conditions during the course of this study along with data made available to GZA. The observations of conditions at the Ash Ponds reflect only the situation present at the specific moment in time the observations were made, under the specific conditions present. It may be necessary to reevaluate the recommendations of this report when subsequent phases of evaluation or repair and improvement provide more data.

4. It is important to note that the condition of a dam or embankment depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam or embankment will continue to represent the condition of the dam or embankment at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions may be detected.

5. Water level readings have been reviewed and interpretations have been made in the text of this report. Fluctuations in the level of the groundwater and surface water may occur due to variations in rainfall, temperature, and other factors different than at the time measurements were made.

6. GZA's comments on the history, hydrology, hydraulics, and embankment stability for the Ash Ponds are based on a limited review of available design documentation for the Hennepin Power Station. Calculations and computer modeling used in these analyses were not available and were not independently reviewed by GZA.

7. This report has been prepared for the exclusive use of EPA for specific application to the existing dam facilities, in accordance with generally accepted dam engineering practices. No other warranty, express or implied, is made.

8. This dam inspection verification report has been prepared for this project by GZA. This report is for broad evaluation and management purposes only and is not sufficient, in and of itself, to prepare construction documents or an accurate bid.

9. The Phase I investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

APPENDIX B

DEFINITIONS

COMMON DAM SAFETY DEFINITIONS

For a comprehensive list of dam engineering terminology and definitions refer to references published by the U.S. Army Corps of Engineers, the Federal Energy Regulatory Commission, the Department of the Interior Bureau of Reclamation, or the Federal Emergency Management Agency.

Orientation

Upstream – Shall mean the side of the dam that borders the impoundment.

Downstream – Shall mean the high side of the dam, the side opposite the upstream side.

Right – Shall mean the area to the right when looking in the downstream direction.

Left – Shall mean the area to the left when looking in the downstream direction.

Dam Components

Dam – Shall mean any artificial barrier, including appurtenant works, which impounds or diverts water.

Embankment – Shall mean the fill material, usually earth or rock, placed with sloping sides, such that it forms a permanent barrier that impounds water.

Crest – Shall mean the top of the dam, usually provides a road or path across the dam.

Abutment – Shall mean that part of a valley side against which a dam is constructed. An artificial abutment is sometimes constructed as a concrete gravity section, to take the thrust of an arch dam where there is no suitable natural abutment.

Appurtenant Works – Shall mean structures, either in dams or separate there from, including but not be limited to, spillways; reservoirs and their rims; low level outlet works; and water conduits including tunnels, pipelines, or penstocks, either through the dams or their abutments.

Spillway – Shall mean a structure over or through which water flows are discharged. If the flow is controlled by gates or boards, it is a controlled spillway; if the fixed elevation of the spillway crest controls the level of the impoundment, it is an uncontrolled spillway.

General

EAP – Emergency Action Plan - Shall mean a predetermined plan of action to be taken to reduce the potential for property damage and/or loss of life in an area affected by an impending dam break.

O&M Manual – Operations and Maintenance Manual; Document identifying routine maintenance and operational procedures under normal and storm conditions.

Normal Pool – Shall mean the elevation of the impoundment during normal operating conditions.

Acre-foot – Shall mean a unit of volumetric measure that would cover one acre to a depth of one foot. It is equal to 43,560 cubic feet. One million U.S. gallons = 3.068 acre feet.

Height of Dam – Shall mean the vertical distance from the lowest portion of the natural ground, including any stream channel, along the downstream toe of the dam to the crest of the dam.

Spillway Design Flood (SDF) – Shall mean the flood used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works, and for determining maximum temporary storage and height of dam requirements.

Condition Rating

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

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

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

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

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.

APPENDIX C

INSPECTION CHECKLISTS

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name:	Hennepin Power Station	Date:	5/23/11
Unit Name:	East Ash Impoundment	Operator's Name:	Dynergy Midwest Generation, LLC
Unit I.D.:	NPDES IL 0001554	Hazard Potential Classification:	High / Significant ✓ / Low
Inspector's Name:	Patrick J. Harrison, P.E. and Doug P. Simon, P.E.		

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?	Quarterly		18. Sloughing or bulging on slopes?		✓
2. Pool elevation (operator records)? See Note Below			19. Major erosion or slope deterioration?		✓
3. Decant inlet elevation (operator records)? See Note Below			20. Decant Pipes: See Note Below		
4. Open channel spillway elevation (operator records)?			Is water entering inlet, but not exiting outlet?		
5. Lowest dam crest elevation (operator records)?	494.0		Is water exiting outlet, but not entering inlet?		
6. If instrumentation is present, are readings recorded (operator records)?	✓		Is water exiting outlet flowing clear?		
7. Is the embankment currently under construction?	✓		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)?	✓		From underdrain?		✓
9. Trees growing on embankment? (If so, indicate largest diameter below)	✓		At isolated points on embankment slopes?		✓
10. Cracks or scarps on crest?		✓	At natural hillside in the embankment area?		✓
11. Is there significant settlement along the crest?		✓	Over widespread areas?		✓
12. Are decant trashracks clear and in place? See Note Below			From downstream foundation area?		✓
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		✓	"Boils" beneath stream or ponded water?		✓
14. Clogged spillways, groin or diversion ditches? See Note Below			Around the outside of the decant pipe?		✓
15. Are spillway or ditch linings deteriorated?			22. Surface movements in valley bottom or on hillside?		✓
16. Are outlets of decant or underdrains blocked?		✓	23. Water against downstream toe?	✓	
17. Cracks or scarps on slopes?		✓	24. Were Photos taken during the dam inspection?	✓	

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.

Inspection Issue # Comments

2. No pool, decant, or open channel spillway is present in the East Ash Impoundment.

7. Dynegy has received a permit to construct a landfill over an inactive portion of Pond 2 and is referred to as the East Ash Impoundment.

8. Based on boring logs and observations.

9. Largest tree diameter noted was approximately 30 inches.

Items 12, 14, 15 and 20 do not apply to this impoundment.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # IL 0001554 INSPECTOR Patrick J. Harrison, P.E.
Doug P. Simon, P.E.
Date May 23, 2011

Impoundment Name East Ash Impoundment
Impoundment Company Dynergy Midwest Generation, LLC
EPA Region Region V
State Agency (Field Office) Addresss Illinois Department of Natural Resources
Springfield, Illinois
Name of Impoundment East Ash Impoundment
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New X Update _____

	Yes	No	
Is impoundment currently under construction?	X		Dynergy is building a land-fill on the impoundment.
Is water or ccw currently being pumped into the impoundment?		X	

IMPOUNDMENT FUNCTION: This impoundment has been inactive since 1995 and stores CCW from plant operations prior to 1995.

Nearest Downstream Town : Name Hennepin
Distance from the impoundment 4 miles
Impoundment Location: Longitude 89 Degrees 18 Minutes 28 Seconds
Latitude 41 Degrees 18 Minutes 10 Seconds
State IL County Putnam County

Does a state agency regulate this impoundment? YES X NO _____

If So Which State Agency? The Illinois Environmental Protection Agency regulates the environmental concerns associated with the impoundment through a Closure Protocol.

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.

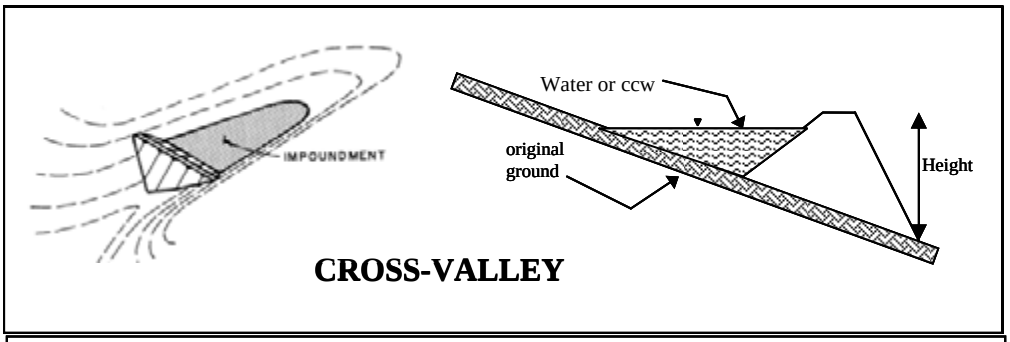
_X___ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. 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.

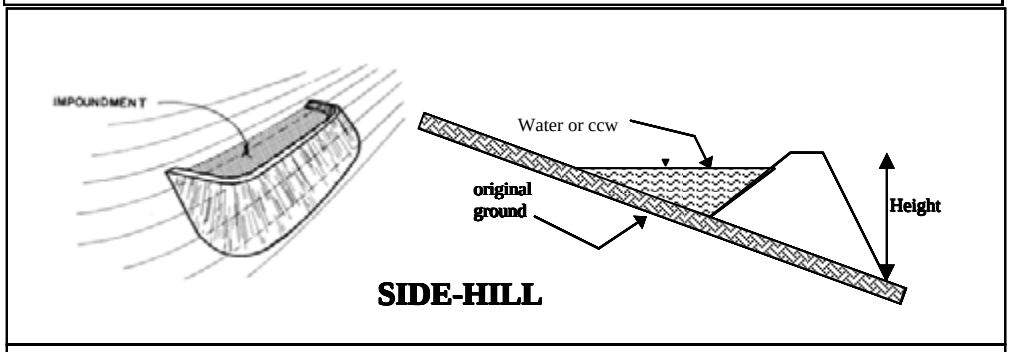
_____ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

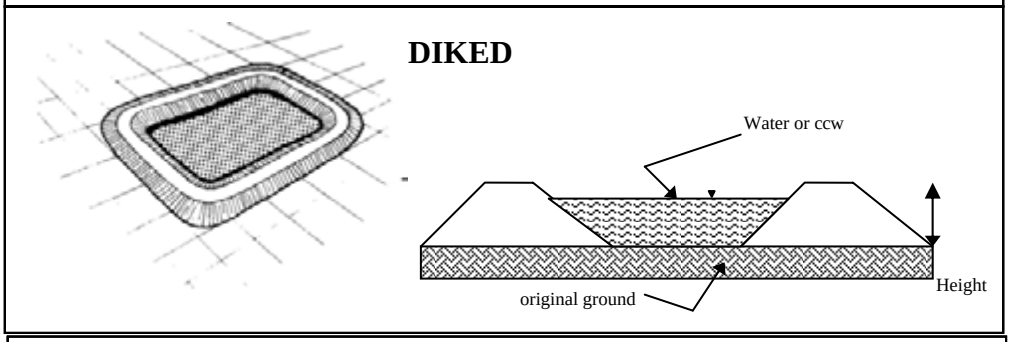
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

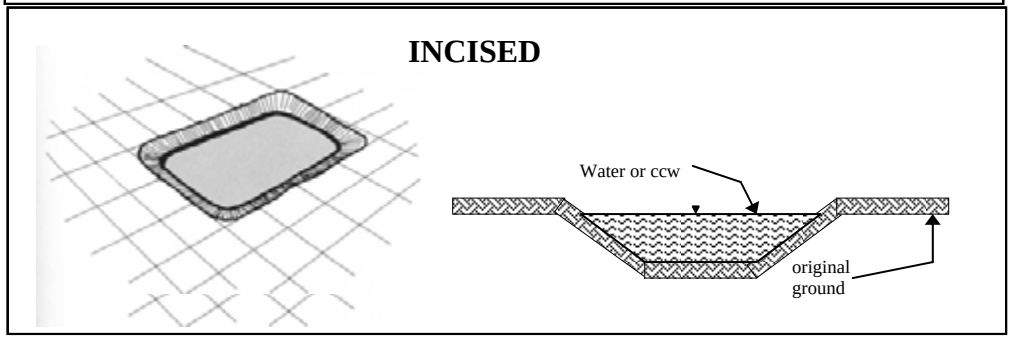
The Illinois River abuts the northern embankment of the East Ash Impoundment. Potential failure of the northern impoundment embankment could result in significant environmental impacts to areas outside of Utility owned property.

CONFIGURATION:









_____ Cross-Valley
_____ Side-Hill
_____ Diked
_____ Incised (form completion optional)
_X_ Combination Incised/Diked

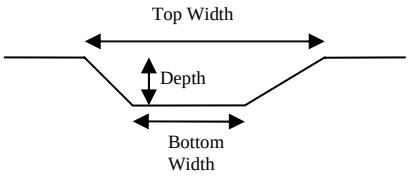
Embankment Height 52 feet
Pool Area No Pool acres
Current Freeboard NA feet

Embankment Material Compacted Native Fill
Liner None Present
Liner Permeability _____

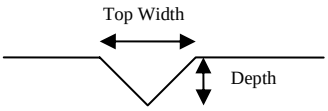
TYPE OF OUTLET (Mark all that apply)

_____ **Open Channel Spillway**
_____ Trapezoidal
_____ Triangular
_____ Rectangular
_____ Irregular

TRAPEZOIDAL

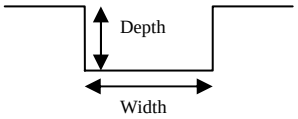


TRIANGULAR

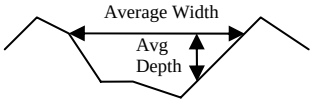


_____ depth
_____ bottom (or average) width
_____ top width

RECTANGULAR

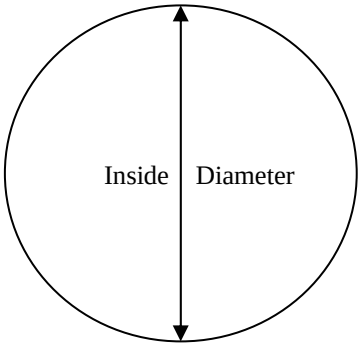


IRREGULAR



_____ **Outlet**

_____ inside diameter



Material
_____ corrugated metal
_____ welded steel
_____ concrete
_____ plastic (hdpe, pvc, etc.)
_____ other (specify) _____

Is water flowing through the outlet? YES _____ NO _____

_X_ **No Outlet**

_____ **Other Type of Outlet** (specify) _____

The Impoundment was Designed By Illinois Power Company

Has there ever been a failure at this site? YES _____ NO ___X_____

If So When? _____

If So Please Describe : _____

Has there ever been significant seepages at this site? YES _____ NO __X____

If So When? _____

IF So Please Describe: _____

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES _____ NO __X_____

If so, which method (e.g., piezometers, gw pumping,...)? _____

If so Please Describe : _____

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name:	Hennepin Power Station	Date:	5/23/11
Unit Name:	Active Ash Impoundment	Operator's Name:	Dynergy Midwest Generation, LLC
Unit I.D.:	IL50363	Hazard Potential Classification:	High / Significant ✓ / Low
Inspector's Name:	Patrick J. Harrison, P.E. and Doug P. Simon, P.E.		

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?	Quarterly		18. Sloughing or bulging on slopes?		✓
2. Pool elevation (operator records)? See Note Below	489.5		19. Major erosion or slope deterioration?		✓
3. Decant inlet elevation (operator records)?	489.5		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)? See Note Below			Is water entering inlet, but not exiting outlet?		✓
5. Lowest dam crest elevation (operator records)?	494.0		Is water exiting outlet, but not entering inlet?		✓
6. If instrumentation is present, are readings recorded (operator records)?	✓		Is water exiting outlet flowing clear?	✓	
7. Is the embankment currently under construction?		✓	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)?	✓		From underdrain?		✓
9. Trees growing on embankment? (If so, indicate largest diameter below)	✓		At isolated points on embankment slopes?		✓
10. Cracks or scarps on crest?		✓	At natural hillside in the embankment area?		✓
11. Is there significant settlement along the crest?		✓	Over widespread areas?		✓
12. Are decant trashracks clear and in place?	✓		From downstream foundation area?		✓
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		✓	"Boils" beneath stream or ponded water?		✓
14. Clogged spillways, groin or diversion ditches?		✓	Around the outside of the decant pipe?		✓
15. Are spillway or ditch linings deteriorated?		✓	22. Surface movements in valley bottom or on hillside?		✓
16. Are outlets of decant or underdrains blocked?		✓	23. Water against downstream toe?	✓	
17. Cracks or scarps on slopes?		✓	24. Were Photos taken during the dam inspection?	✓	

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.

Inspection Issue # Comments

2. There are three ponds that make up this impoundment. The elevation provided refers to that in the Primary pond which is also the highest elevation as referenced in the Operation and Maintenance Plan.
4. No open channel spillway was present.
8. Based on available soil borings.
9. Largest tree diameter noted was approximately 30 inches.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # IL 0001554 INSPECTOR Patrick J. Harrison, P.E.
Date May 23, 2011 Doug P. Simon, P.E.

Impoundment Name Active Ash Impoundment
Impoundment Company Dynergy Midwest Generation, LLC
EPA Region Region V
State Agency (Field Office) Addresss Illinois Department of Natural Resources
Springfield, Illinois
Name of Impoundment Active Ash Impoundment
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New X Update _____

	Yes	No
Is impoundment currently under construction?	_____	X
Is water or ccw currently being pumped into the impoundment?	X	_____

IMPOUNDMENT FUNCTION: Settlement of CCW that is sluiced into the impoundment.

Nearest Downstream Town : Name Hennepin
Distance from the impoundment 4 miles
Impoundment
Location: Longitude 41 Degrees 18 Minutes 00 Seconds
Latitude 89 Degrees 18 Minutes 13 Seconds
State IL County Putnam County

Does a state agency regulate this impoundment? YES X NO _____

If So Which State Agency? The Illinois Department of Natural Resources regulates discharge of water through NPDES permit and a portion of the Impoundment as a regulated dam.

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.

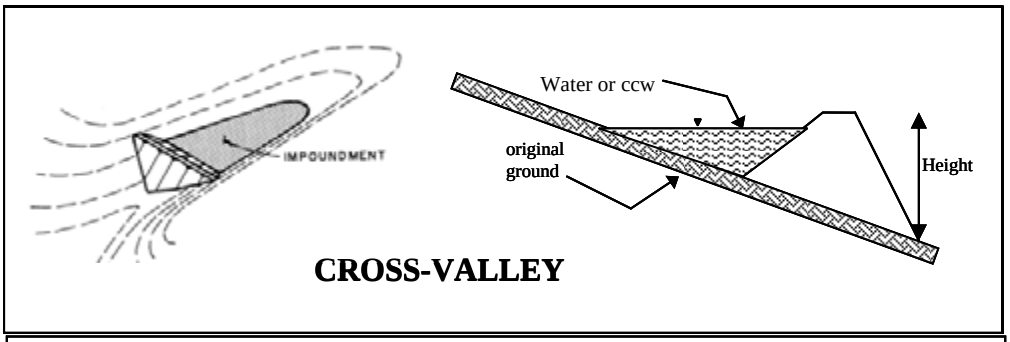
__X__ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. 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.

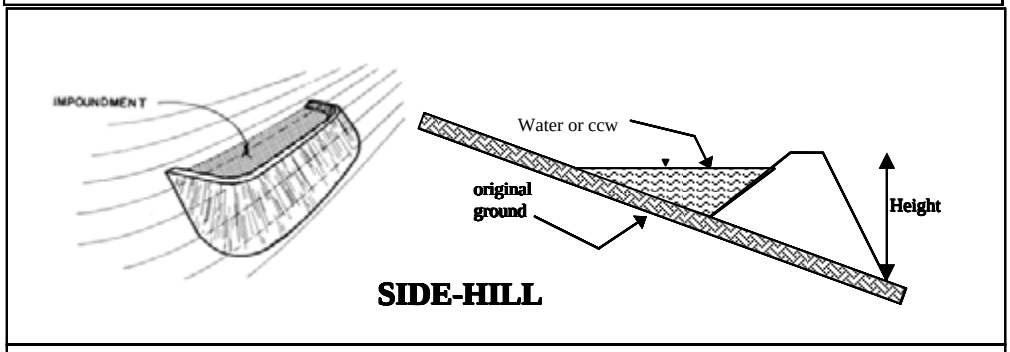
_____ **HIGH HAZARD POTENTIAL:** Dams assigned the high hazard potential classification are those where failure or misoperation will probably cause loss of human life.

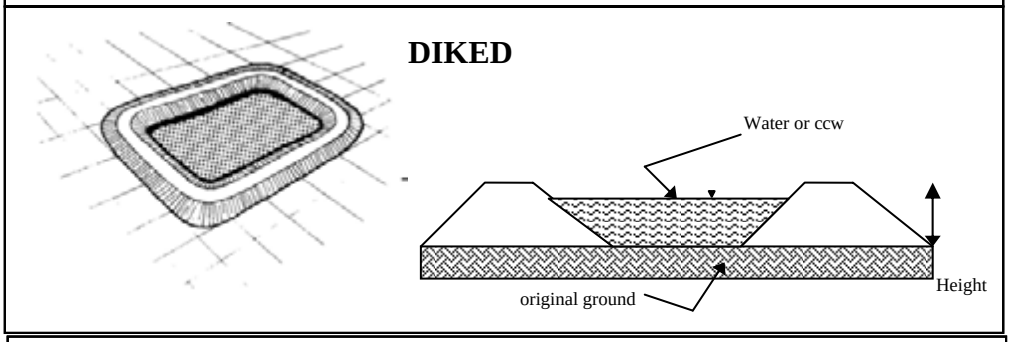
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

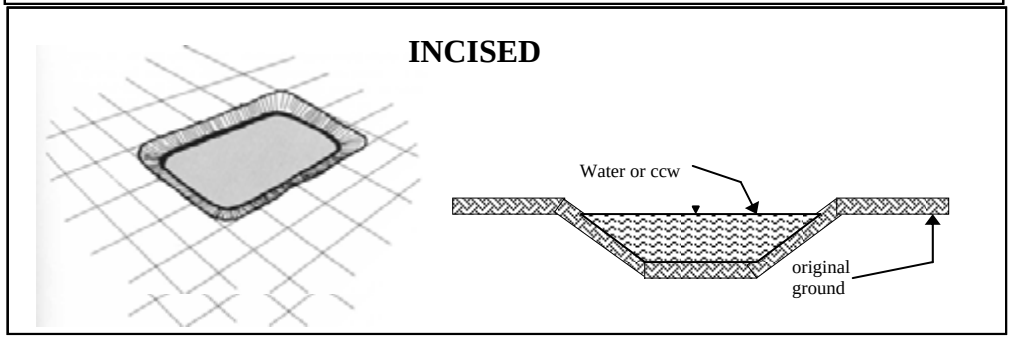
The Illinois River abuts the northern embankment of the Active Ash Impoundment. Potential failure of the northern impoundment embankment could result in significant environmental impacts to areas outside of Utility owned property.

CONFIGURATION:









_____ Cross-Valley
_____ Side-Hill
_____ Diked
_____ Incised (form completion optional)
_X_ Combination Incised/Diked

Embankment Height 52 feet
Pool Area 30 acres
Current Freeboard 3.5 feet

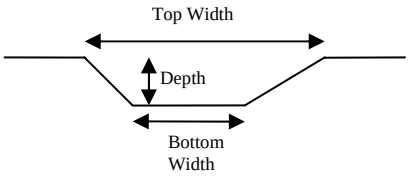
Embankment Material Compacted Native Fill
Liner Clay/HDPE
Liner Permeability _____

TYPE OF OUTLET (Mark all that apply)

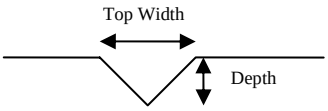
_____ **Open Channel Spillway**
_____ Trapezoidal
_____ Triangular
_____ Rectangular
_____ Irregular

_____ depth
_____ bottom (or average) width
_____ top width

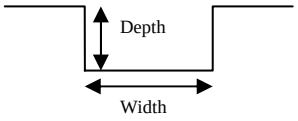
TRAPEZOIDAL



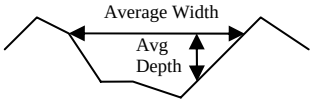
TRIANGULAR



RECTANGULAR



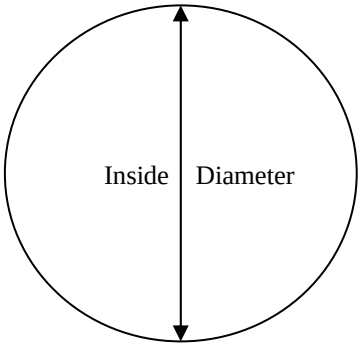
IRREGULAR



__X__ **Outlet**

_____ inside diameter
Varies: See Below.

Material
_____ corrugated metal
_____ welded steel
__X__ concrete
_____ plastic (hdpe, pvc, etc.)
_____ other (specify) _____



Is water flowing through the outlet? YES _____ NO __X__

There are three ponds that make up the active ash pond. The outlet diameters vary from approximately 12 inches to 30 inches.

_____ **No Outlet**

_____ **Other Type of Outlet** (specify) _____

The Impoundment was Designed By _____
_____

Has there ever been a failure at this site? YES _____ NO ___X_____

If So When? _____

If So Please Describe : _____

Has there ever been significant seepages at this site? YES _____ NO __X____

If So When? _____

IF So Please Describe: _____

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES _____ NO __X_____

If so, which method (e.g., piezometers, gw pumping,...)? _____

If so Please Describe : _____

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name:	Hennepin Power Station	Date:	5/23/11
Unit Name:	West Ash Impoundment	Operator's Name:	Dynergy Midwest Generation, LLC
Unit I.D.:	NPDES IL 0001554	Hazard Potential Classification:	High / Significant ✓ / Low
Inspector's Name:	Patrick J. Harrison, P.E. and Doug P. Simon, P.E.		

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?	Quarterly		18. Sloughing or bulging on slopes?		✓
2. Pool elevation (operator records)?	455.6		19. Major erosion or slope deterioration?		✓
3. Decant inlet elevation (operator records)?	455.6		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	See Note Below		Is water entering inlet, but not exiting outlet?		✓
5. Lowest dam crest elevation (operator records)?	460.0		Is water exiting outlet, but not entering inlet?		✓
6. If instrumentation is present, are readings recorded (operator records)?	✓		Is water exiting outlet flowing clear?	See Note Below	
7. Is the embankment currently under construction?		✓	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)?	✓		From underdrain?		✓
9. Trees growing on embankment? (If so, indicate largest diameter below)	✓		At isolated points on embankment slopes?		✓
10. Cracks or scarps on crest?		✓	At natural hillside in the embankment area?		✓
11. Is there significant settlement along the crest?		✓	Over widespread areas?		✓
12. Are decant trashracks clear and in place?		✓	From downstream foundation area?		✓
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		✓	"Boils" beneath stream or ponded water?		✓
14. Clogged spillways, groin or diversion ditches?		✓	Around the outside of the decant pipe?		✓
15. Are spillway or ditch linings deteriorated?		✓	22. Surface movements in valley bottom or on hillside?		✓
16. Are outlets of decant or underdrains blocked?		✓	23. Water against downstream toe?	✓	
17. Cracks or scarps on slopes?		✓	24. Were Photos taken during the dam inspection?	✓	

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.

Inspection Issue # Comments

4. No open channel spillway was present.
8. Based on boring logs and observations.
9. Largest tree diameter noted was approximately 30 inches.
20(c). No water was entering or exiting the impoundment.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # IL 0001554 INSPECTOR Patrick J. Harrison, P.E.
Date May 23, 2011 Doug P. Simon, P.E.

Impoundment Name West Ash Impoundment
Impoundment Company Dynergy Midwest Generation, LLC
EPA Region Region V
State Agency (Field Office) Addresss Illinois Department of Natural Resources
Springfield, Illinois
Name of Impoundment West Ash Impoundment
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New X Update _____

	Yes	No
Is impoundment currently under construction?	_____	X
Is water or ccw currently being pumped into the impoundment?	_____	X

IMPOUNDMENT FUNCTION: This impoundment has been inactive since 1995 and stores CCW from plant operations prior to 1995.

Nearest Downstream Town : Name Hennepin, Illinois
Distance from the impoundment 4 miles
Impoundment Location: Longitude 89 Degrees 19 Minutes 28 Seconds
Latitude 41 Degrees 18 Minutes 00 Seconds
State IL County Putnam

Does a state agency regulate this impoundment? YES X NO _____

If So Which State Agency? The Illinois Environmental Protection Agency regulates discharge from the impoundment through the NPDES permit.

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.

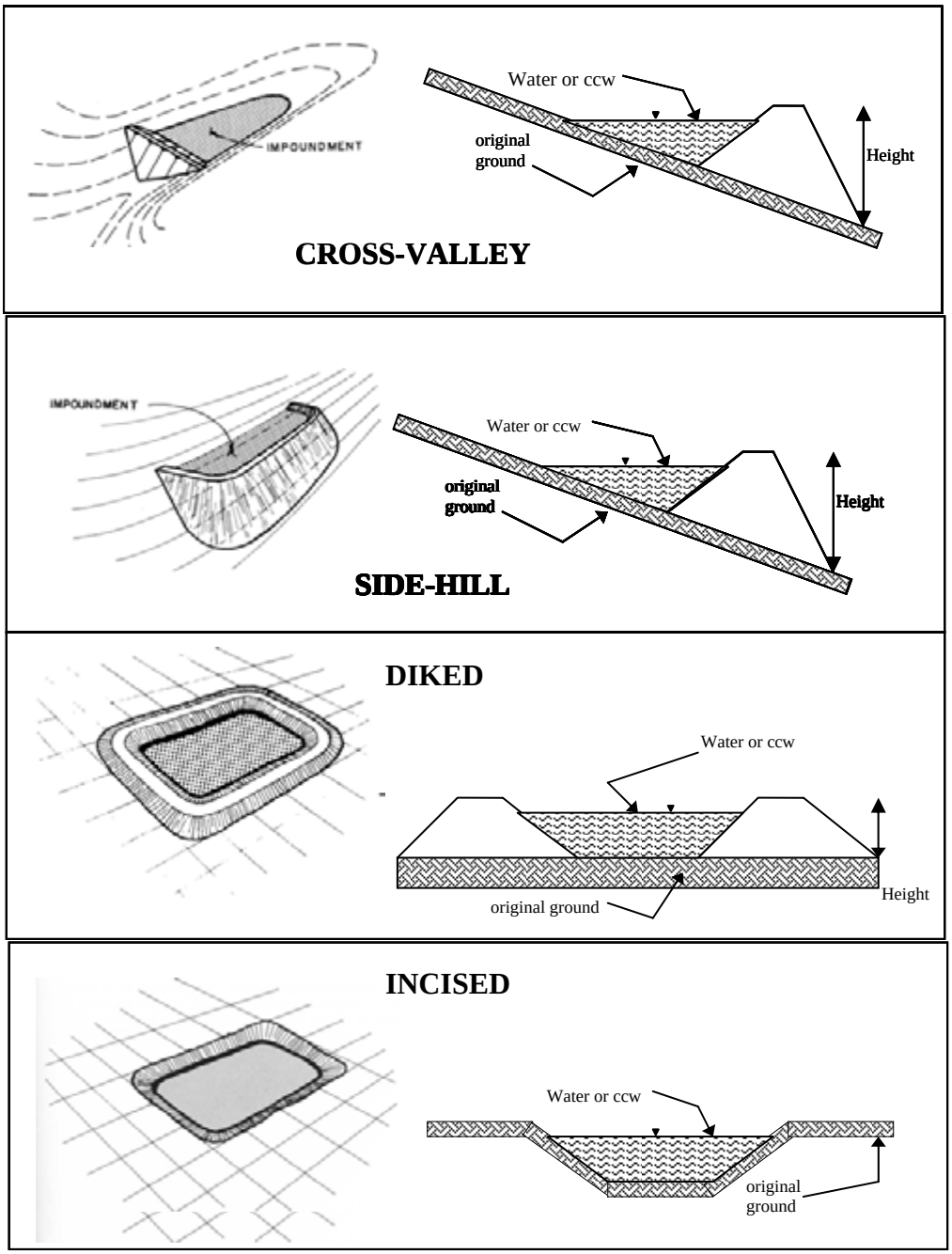
_X___ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. 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:

The Illinois River abuts the northern embankment of the West Ash Impoundment. Potential failure of the northern impoundment embankment could result in significant environmental impacts to areas outside of Utility owned property.

CONFIGURATION:



_____ Cross-Valley
_____ Side-Hill
_X_ Diked
_____ Incised (form completion optional)
_____ Combination Incised/Diked

Embankment Height 18 feet
Pool Area 2 acres
Current Freeboard 4.4 feet

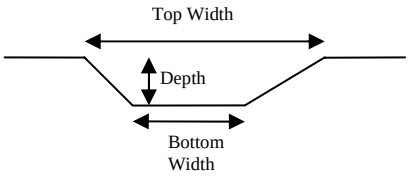
Embankment Material Compacted Native Fill
Liner None Present
Liner Permeability Unknown

TYPE OF OUTLET (Mark all that apply)

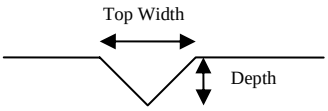
_____ **Open Channel Spillway**
_____ Trapezoidal
_____ Triangular
_____ Rectangular
_____ Irregular

_____ depth
_____ bottom (or average) width
_____ top width

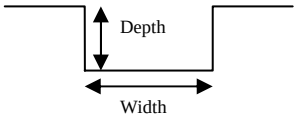
TRAPEZOIDAL



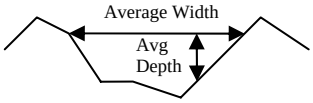
TRIANGULAR



RECTANGULAR

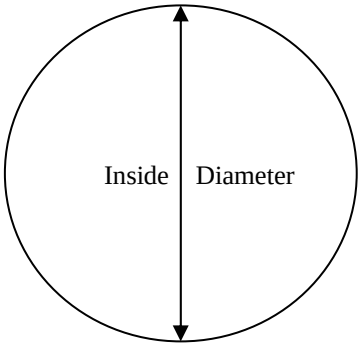


IRREGULAR



__X__ **Outlet**

12 in. inside diameter



Material
_____ corrugated metal
__X__ welded steel
_____ concrete
_____ plastic (hdpe, pvc, etc.)
_____ other (specify) _____

Is water flowing through the outlet? YES _____ NO __X__

_____ **No Outlet**

_____ **Other Type of Outlet** (specify) _____

The Impoundment was Designed By Sargent & Lundy

Has there ever been a failure at this site? YES _____ NO ___X_____

If So When? _____

If So Please Describe : _____

Has there ever been significant seepages at this site? YES _____ NO __X____

If So When? _____

IF So Please Describe: _____

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES _____ NO __X_____

If so, which method (e.g., piezometers, gw pumping,...)? _____

If so Please Describe : _____

APPENDIX D

PREVIOUS INSPECTION REPORTS

Dynegy Midwest Generation, Inc.
2828 North Monroe Street
Decatur, Illinois 62526-3269

December 31, 2001

Mr. Dennis L. Kennedy, P.E.
Senior Water Resources Engineer
Illinois Department of Natural Resources
Office of Water Resources
524 South Second Street
Springfield, IL 62701-1787

DYNEGY

Dear Mr. Kennedy:

Hennepin Power Station; East Ash Pond
Dam Safety Permit No. 21922
Dam I.D. No. IL50363

2001 Five-Year Inspection Report

Enclosed is a signed copy of the 2001 inspection report for the Hennepin Power Station's east ash pond dam. Mr. Jeffrey Lamb, professional civil engineer with Dynegy-Illinois Power's Engineering and Technical Services Department, conducted the professional engineer inspection on November 27, 2001. This inspection is required by Section 702.40(b)(5) of the Rules for the Construction and Maintenance of Dams and the conditions of IDNR Permit No. 21922.

The inspection report shows that the overall condition of the facility is good. The only minor maintenance that needs to be conducted is the continued removal of sapling trees on the embankments. This will be conducted as a part of routine maintenance during next year. Sapling tree removal was also conducted as a part of routine maintenance during the previous five years as recommended in the 1996 inspection report.

An Owner's Maintenance Statement, signed by Mr. James G. Dodson, Plant Manager, Hennepin Power Station, is also included.

If you have any questions regarding this report, please contact me at 217/872-2359.

Sincerely,
Dynegy Midwest Generation

Thomas L. Davis

Thomas L. Davis, P.E.
Senior Environmental Professional

bc: J.G.Dodson, w/att., S-10
J.P.Augspols w/att., S-10
B.J. Marshall/T.E. Tuttle/File: Hennepin PS Dam Inspection Reports, w/att., A-05

Illinois Power Company
500 South 27th Street
Decatur, IL 62521-2200

November 30, 2001

Mr. B. J. Marshall
Dynegy Midwest Generation
2828 N. Monroe St.
Decatur, IL 62526

ILLINOIS POWER
Part of the DYNEGY Performance Team

RE: Hennepin Power Station
Hennepin Ash Surface Impoundment
2001 Dam Inspection

Dear Brett:

Enclosed is the dam inspection report for the Hennepin Ash Improvement. The inspection was performed on Wednesday, November 27, 2001. John Augspol from the plant accompanied me on the inspection.

The following items need attention (Condition Code IM or MM).

Item	Issue	Remediation
Embankment	Scattered trees/saplings on or near the clay liner around perimeter of primary & final ponds	Spray to kill, cut down later

Please forward the inspection form to the plant for execution of the Owner's Maintenance Statement by the Plant Manager.

If you have any questions, please call me.

Sincerely,

J. R. Lamb, P.E.
Manager Civil Engineering

Enclosure

Cc: J. G. Dodson w/o attachments S-10
J. P. Augspol w/attachments S-10
CS 491417

Dam Inspection Report

Name of Dam Hennepin Ash Surface Impoundment Dam ID No. IL 50363

Permit Number 21922 Class of Dam III

Location NE ¼ Section 26 Township 33 N Range 2W of 3rd PM

Owner Dynegy Midwest Generation (Name) 815-339-9210 (Telephone Number (Day))

RR #1 Box 200 AA (Street) 815-339-9215 (Telephone Number (Night))

Hennepin (City) 61327-9737 (Zip Code) County Putnam

Type of Dam Homogeneous Earthen Dam @ 4' clay liner on upstream face

Type of Spillway Drop Structure @ Stop logs

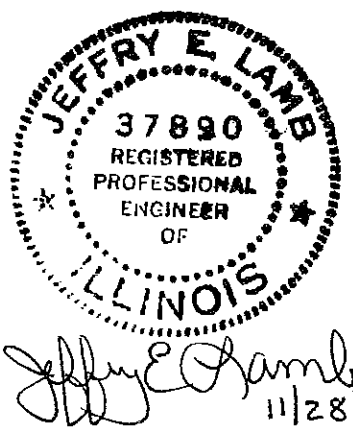
Date(s) Inspected November 28, 2001

Weather When Inspected Overcast & mild wind

Temperature When Inspected 39° F

Pool Elevation When Inspected Primary 481.51 Final 479.59

Tailwater Elevation When Inspected NA



Professional Engineer's Seal

Inspection Personnel:

Name	Title
Jeffry E Lamb	Manager Civil Engineering
John P. Avgspol	Chemist

The Department of Nautural Resources is requesting information that is necessary to accomplish the statutory purpose as outlined under the River, Lakes and Streams Act, 615 ILCS 5. Submittal of this information is REQUIRED. Failure to provide the required information could result in the initiation of non-compliance procedures as outlined in Section 3702.160 of the "Rules for Construction and Maintenance of Dams".

EARTH EMBANKMENT

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Surface Cracks	GC	NE	
Vertical and Horizontal Alignment of Crest	GC	NE	
Unusual Movement or Cracking At or Beyond Toe	GC	NE	
Sloughing or Erosion of Embankment and Abutment Slopes	GC	OB	Small erosion rills @ SEc of primary pond upstream & @ SWc of final pond upstream face
Upstream Face Slope Protection	GC	NE	
Seepage	GC	NE	
Filter and Filter Drains	NA		

EARTH EMBANKMENT
(Continued)

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Animal Damage	GC	NE	
Embankment Drainage Ditches	GC	NE	
Vegetative Cover	GC	MM	Scattered small trees + saplings on liner - Spray to kill and remove after dead.
Other (Name)			
Other			
Other			
Other			

CONCRETE OR MASONRY DAMS

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Seepage			
Structure to Abutment/ Embankment Junctions			
Water Passages			
Foundation		NA	
Surface Cracks in Concrete Surfaces			
Structural Cracking			
Vertical and Horizontal Alignment			

CONCRETE OR MASONRY DAMS
(CONTINUED)

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Monolith Joints			
Contruction Joints			
Spalling of Concrete			
Filters, Drains, etc.			
Riprap			
Other (Name)			

NA

IF THE DAM IS GATED - Fill out the portion of the Principal Spillway Form related to Gated Spillways

PRINCIPAL SPILLWAY
APPROACH CHANNEL

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Debris			
Side Slope Stability			
Slope Protection			
Other (Name)			N/A
Other			
Other			
Other			

PRINCIPAL SPILLWAY

☒ Drop Inlet Spillway Ponds 1+2 ☐ Overflow Spillway Structure ☐ Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	GC	OB	Beam Seats for walkway at drop structures have spalled or cracked surface concrete. Observe for any further spalling/cracking of concrete support.
Structure to Embankment Junction	NI underwater	NE	
Drains		NA	
Seepage Around or Into Structure			
Surface Cracks	GC	NE	
Structural Cracks	GC	NE	

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY
(Continued)

☐ Drop Inlet Spillway ☐ Overflow Spillway Structure ☐ Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Alignment of Abutment Walls	GC	NE	
Construction Joints	GC	NE	
Filter and Filter Drains			
Trash Racks	NA		
Bridge and Piers	GC	OB	Surface rust beginning to appear on beams & bolts.
Differential Settlement	GC	NE	
Other (Name)			

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY
(Continued)

☒ Conduit ☐ Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	GC	NE	
Joint Separation	NI buried & underwater	NE	
Seepage Around of Into Conduit	NI buried & underwater	NE	
Surface Cracks	NI buried & underwater	NE	
Structural Cracks	NI buried & underwater	NE	
Trash Racks	NA		
Differential Settlement	GC	NE	
Alignment	GC	NE	
Other (Name)			

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY
(Continued)

☐ Chute

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation			
Structure to Embankment Junction			
Construction Joints			
Expansion and Contraction Joints			NA
Differential Settlement			
Surface Cracks			
Structural Cracks			
Wall Alignment			
Other (Name)			

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY

☒ Principal Spillway Ponds 1 & 2 Stop Logs ☐ Dewatering ☐ Other:

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Gate Sill	NI underwater	NE	
Gate Seals	NI underwater	NE	
Gate and Frame	GC	NE	
Operating Machinery	NA		
Emergency Operating Machinery	NA		
Other (Name)			
Other			

OUTLET WORKS
IF SEPARATE FROM PRINCIPAL SPILLWAY STRUCTURE

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation			
Joint Separation			
Seepage Around or Into Conduit			
Intake Structure			NA
Outlet Structure			
Outlet Channel			
Riprap			
Other (Name)			
Other			

ENERGY DISSIPATOR

☐ Principal Spillway Type: 36" ϕ RCC Pipe Discharges into a ripraped basin. ☐ Outlet Works

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NA		
Structure to Embankment Junction	GC	NE	
Construction Joints	NA		
Surface Cracks	NA		
Structural Cracks	NA		
Differential Alignment	NA		
Expansion and Contraction Joints	NA		

ENERGY DISSIPATOR
(Continued)

☐ Principal Spillway ☐ Outlet Works

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Riprap	GC	NE	
Outlet Channel	NA		
Debris	NA		
Other (Name)			
Other			
Other			
Other			

EMERGENCY SPILLWAY

☐ Earth

Other:Name _____

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion			
Weeds, Logs, Other Obstructions			
Side Slope Sloughing			
Vegetation			
Sedimentation			
Riprap			
Settlement of Crest			
Downstream Channel			
Other (Name)			

NA

SUMMARY OF MAINTENANCE DONE AND/OR

REPAIRS MADE SINCE THE LAST INSPECTION

DATE OF PRESENT INSPECTION November 28, 2001

DATE OF LAST INSPECTION November 12, 1996

1. EARTH EMBANKMENT DAMS

Repaired gate latch on primary pond outlet structure noted in last inspection.

2. CONCRETE MASONRY DAMS

3. PRINCIPAL SPILLWAY

4. OUTLET WORKS

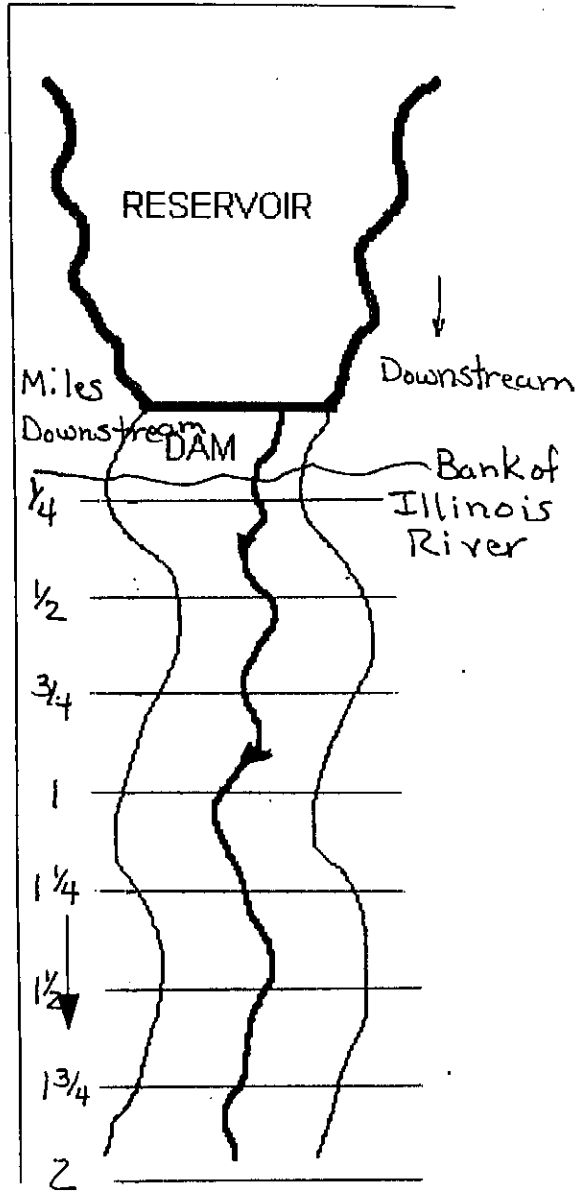
5. EMERGENCY SPILLWAY

DOWNSTREAM DEVELOPMENT
APPROXIMATE WIDTH OF AFFECTED FLOODPLAIN < 1/4 MILES

MILES DOWNSTREAM FROM DAM	DOWNSTREAM DEVELOPMENT												Loss of Life Potential			Economic Loss Potential		
	OCCUPIED HOMES	UNOCCUPIED HOMES	AGRICULTURAL BUILDINGS	INDUSTRIAL BUILDINGS	COMMERCIAL BUILDINGS	SCHOOLS	HOSPITALS	ROADS & BRIDGES	DAMS	OVERHEAD UTILITIES	OTHER DEVELOPMENT (Name)	OTHER DEVELOPMENT (Name)	NONE	1 TO 10	OVER 10	MINIMAL EXPECTED	APPRECIABLE EXPECTED	EXCESSIVE EXPECTED
0 to 1/4													X			X		
1/4 to 1/2																		
1/2 to 3/4																		
3/4 to 1																		
1 to 1-1/4					N/A													
1-1/4 to 1-1/2																		
1-1/2 to 1-3/4																		
1-3/4 to 2																		
OVER 2																		

The number of homes, buildings, or other items in the floodplain downstream of the dam should be placed in the appropriate row and column to designate their location.

SKETCH IN DEVELOPMENTS DOWNSTREAM OF THE DAM



Owner's Maintenance Statement

I, _____, owner of Hennepin Ash Impoundment dam,

Dam Identification Number IL50363, in Putnam County,

am maintaining the dam in accordance with the accepted maintenance plan which is part of

Permit Number 21922.

James G Dodson
Signature

12/27/01
Date

Owner's Operation and Maintenance Plan Statement

I, _____, owner of Hennepin Ash Impoundment dam,

Dam Identification Number IL50363, in Putnam County,

have reviewed the operation and maintenance plan including the Emergency Action Plan (EAP),

which is part of, Permit Number 21922.

I ( ) have enclosed the appropriate revisions or

(✓) have determined that no revisions to the plan are necessary.

James G Dodson
Signature

12/27/01
Date

The Department of Nautural Resources is requesting information that is necessary to accomplish the statutory purpose as outlined under the River, Lakes and Streams Act, 615 ILCS 5. Submittal of this information is REQUIRED. Failure to provide the required information could result in the initiation of non-compliance procedures as outlined in Section 3702.160 of the "Rules for Construction and Maintenance of Dams".

Dynegy Midwest Generation, Inc
2828 North Monroe Street
Decatur, IL 62526-3269
Phone 217.876.3900 Fax 217.876.7475
www.dynegy.com

December 11, 2006

DYNEGY

Mr. Mike Diedrichsen, Acting Manager
Downstate Regulatory Programs
Division of Water Resources Management
Office of Water Resources
Illinois Department of Natural Resources
One Natural Resources Way
Springfield, IL 62702-1271

Dear Mr. Diedrichsen:

Hennepin Power Station; East Ash Pond
Dam Safety Permit No. DS2004119
Dam I.D. No. IL50363

2006 Five-Year Inspection Report

Enclosed is a signed copy of the 2006 inspection report for the Hennepin Power Station's east ash pond dam. Mr. Joseph P. Kimlinger, and Illinois-registered professional civil engineer (no. 062-049181) with Dynegy Midwest Generation's Construction and Maintenance Department, conducted the professional engineer inspection of the embankments and outlet structures on November 20, 2006. This inspection is required by Section 3702.40(b)(5) of the Rules for the Construction and Maintenance of Dams and the conditions of IDNR Permit No. DS2004119.

The inspection report shows that the overall condition of the east ash pond system is good. The only minor maintenance that needs to be conducted is the continued removal of sapling trees on the embankments. This will be conducted as a part of routine maintenance during 2007. Sapling tree removal was also conducted as a part of the routine maintenance performed during the previous five years as recommended in the 2001 inspection report. Some spalling of concrete and rusting of steel walkway beams was also noted.

An Owner's Maintenance Statement, signed by Mr. James G. Dodson, Plant Manager, Hennepin Power Station, is also included.

If you have any questions regarding this report, please contact me at 217/872-2354 or Tom Davis at 217-872-2315.

Sincerely,
Dynegy Midwest Generation, Inc.

Rick D. Diericx
Sr. Director – Operations Environmental Compliance
Environmental Health and Safety

Dam Inspection Report

Name of Dam Hennepin PS, Ash Surface Impoundment Dam ID No. IL 50363

Permit Number DS2004119 Class of Dam III

Location NE 1/4 Section 26 Township 33N Range 2W of 3rd PM

Owner Dynegy Midwest Generation — 815-339-9210

Name — Telephone Number (Day)

RR1, Box 200 AA — 815-339-9215

Street — Telephone Number (Night)

Hennepin, IL 61327 County Putnam

City Zip Code

Type of Dam Homogeneous Earthen Dam with clay and geosynthetic/clay liner

Type of Spillway Drop structure and stop logs

Date(s) Inspected November 20, 2006

Weather When Inspected Sunny and Breezy

Temperature When Inspected 36 deg. F

Pool Elevation When Inspected Primary 481.5; Secondary 479.6

Tailwater Elevation When Inspected NA

JOSEPH P. KIMLINGER
062-049161
REGISTERED
PROFESSIONAL
ENGINEER
STATE OF ILLINOIS

12/7/06

LIC EXPIRES 11/30/07

Professional Engineer's Seal

Inspection Personnel:

Name	Title
Joseph P. Kimlinger P.E.	Construction Manager
John Augspols	Sr. Env & Chem. Engineer

The Department of Natural Resources is requesting information that is necessary to accomplish the statutory purpose as outlined under the River, Lakes and Streams Act, 615 ILCS 5. Submittal of this information is REQUIRED. Failure to provide the required information could result in the initiation of non-compliance procedures as outlined in Section 3702.160 of the "Rules for Construction and Maintenance of Dams".

CONDITION CODES

NE - No evidence of a problem

GC - Good condition

MM - Item needing minor maintenance and/or repairs within the year, the safety or integrity of the item is not yet imperiled

IM - Item needing immediate maintenance to restore or ensure its safety or integrity

EC - Emergency condition which if not immediately repaired or other appropriate measures taken could lead to failure of the dam

OB - Condition requires regular observation to ensure that the condition does not become worse

NA - Not applicable to this dam

NI - Not inspected - list the reason for non-inspection under deficiencies

---

All Condition Codes will be listed with the following abbreviations:

P = Primary Cell
S = Secondary (polishing) Cell

EARTH EMBANKMENT

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Surface Cracks	NE	NA	
Vertical and Horizontal Alignment of Crest	GC	NA	
Unusual Movement or Cracking At or Beyond Toe	NE	NA	
Sloughing or Erosion of Embankment and Abutment Slopes	GC	NA	
Upstream Face Slope Protection	GC	NA	
Seepage	NE	NA	
Filter and Filter Drains	NA		

EARTH EMBANKMENT
(Continued)

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Animal Damage	NE	NA	
Embankment Drainage Ditches	GC	NA	
Vegetative Cover	OB	Some small trees and saplings near the embankment	Observe the small trees and saplings and spray to kill or remove as time allows. No issue at this time.
Other (Name)	NA		
Other	NA		
Other	NA		
Other	NA		

CONCRETE OR MASONRY DAMS

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Seepage	NA		
Structure to Abutment/ Embankment Junctions	NA		
Water Passages	NA		
Foundation	NA		
Surface Cracks in Concrete Surfaces	NA		
Structural Cracking	NA		
Vertical and Horizontal Alignment	NA		

CONCRETE OR MASONRY DAMS
(CONTINUED)

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Monolith Joints	NA		
Contruction Joints	NA		
Spalling of Concrete	NA		
Filters; Drains, etc.	NA		
Riprap	NA		
Other (Name)	NA		

IF THE DAM IS GATED - Fill out the portion of the Principal Spillway Form related to Gated Spillways

PRINCIPAL SPILLWAY
APPROACH CHANNEL

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Debris	NA		
Side Slope Stability	NA		
Slope Protection	NA		
Other (Name)	NA		
Other	NA		
Other	NA		
Other	NA		

PRINCIPAL SPILLWAY

[X] Drop Inlet Spillway [ ] Overflow Spillway Structure [ ] Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	OB	Some spalling of concrete near walkway beam supports.	Observe the concrete condition in the outfall structures, primarily near the beam seats. Contact a certified engineer if condition worsens.
Structure to Embankment Junction	NI	Underwater	
Drains	NA		
Seepage Around or Into Structure	NI	Underwater	
Surface Cracks	NE	NA	
Structural Cracks	NE	NA	

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY
(Continued)

[x] Drop Inlet Spillway [ ] Overflow Spillway Structure [ ] Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Alignment of Abutment Walls	NA	NA	
Construction Joints	GC	NA	
Filter and Filter Drains	NA		
Trash Racks	NA		
Bridge and Piers	OB	Rust forming on bridge beams and connections.	Observe and contact a certified engineer if condition worsens.
Differential Settlement	NE	NA	
Other (Name)	NA		

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY
(Continued)

[X] Conduit

[ ] Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NE	NA	
Joint Separation	NE	NA	
Seepage Around of Into Conduit	NI	Underwater	
Surface Cracks	NI	Underwater	
Structural Cracks	NI	Underwater	
Trash Racks	NA		
Differential Settlement	NE	NA	
Alignment	GC	NA	
Other (Name)	NA		

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY
(Continued)

☐ Chute

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NA		
Structure to Embankment Junction	NA		
Construction Joints	NA		
Expansion and Contraction Joints	NA		
Differential Settlement	NA		
Surface Cracks	NA		
Structural Cracks	NA		
Wall Alignment	NA		
Other (Name)	NA		

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY

[x] Principal Spillway [ ] Dewatering [ ] Other:

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Gate Sill	NI	Underwater	The sill and seals are located under stop logs and could not be inspected.
Gate Seals	NI	Underwater	
Gate and Frame	GC	NE	Stop logs and guides were in good condition.
Operating Machinery	NA		
Emergency Operating Machinery	NA		
Other (Name)	NA		
Other	NA		

OUTLET WORKS
IF SEPARATE FROM PRINCIPAL SPILLWAY STRUCTURE

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NA		
Joint Separation	NA		
Seepage Around or Into Conduit	NA		
Intake Structure	NA		
Outlet Structure	NA		
Outlet Channel	NA		
Riprap	NA		
Other (Name)	NA		
Other	NA		

ENERGY DISSIPATOR

☐ Principal Spillway Type:

☒ Outlet Works

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NE	NA	
Structure to Embankment Junction	GC	NA	
Construction Joints	GC	NA	
Surface Cracks	NE	NA	
Structural Cracks	NE	NA	
Differential Alignment	NE	NA	
Expansion and Contraction Joints	NA		

ENERGY DISSIPATOR
(Continued)

☐ Principal Spillway ☒ Outlet Works

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Riprap	GC	NA	
Outlet Channel	GC	NA	
Debris	NE	NA	
Other (Name)	NA		
Other	NA		
Other	NA		
Other	NA		

EMERGENCY SPILLWAY

☐ Earth

Other:Name _____

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion	NA		
Weeds, Logs, Other Obstructions	NA		
Side Slope Sloughing	NA		
Vegetation	NA		
Sedimentation	NA		
Riprap	NA		
Settlement of Crest	NA		
Downstream Channel	NA		
Other (Name)	NA		

SUMMARY OF MAINTENANCE DONE AND/OR

REPAIRS MADE SINCE THE LAST INSPECTION

DATE OF PRESENT INSPECTION November 20, 2006

DATE OF LAST INSPECTION November 28, 2001

1. EARTH EMBANKMENT DAMS

The pond level was raised in 2004 with the extension of the liner. The liner extension consisted of one foot of clay overlain with a polypropylene liner.
Minor erosion repairs, mowing and general maintenance have been performed during the last five years.

2. CONCRETE MASONRY DAMS

NA

3. PRINCIPAL SPILLWAY

NA

4. OUTLET WORKS

NA

5. EMERGENCY SPILLWAY

NA

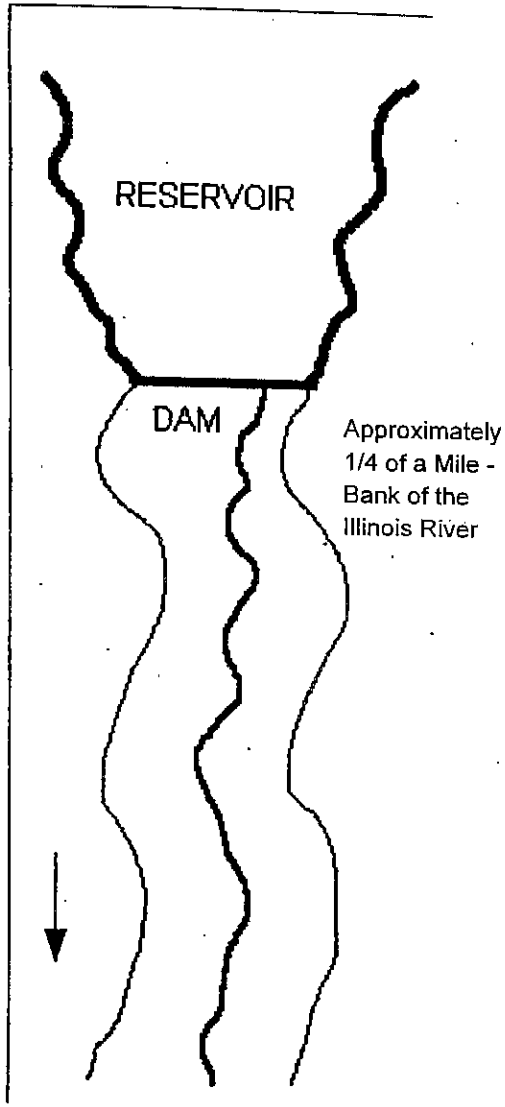
DOWNSTREAM DEVELOPMENT

APPROXIMATE WIDTH OF AFFECTED FLOODPLAIN 0.25 MILES

MILES DOWNSTREAM FROM DAM	DOWNSTREAM DEVELOPMENT												Loss of Life Potential			Economic Loss Potential		
	OCCUPIED HOMES	UNOCCUPIED HOMES	AGRICULTURAL BUILDINGS	INDUSTRIAL BUILDINGS	COMMERCIAL BUILDINGS	SCHOOLS	HOSPITALS	ROADS & BRIDGES	DAMS	OVERHEAD UTILITIES	OTHER DEVELOPMENT (Name)	OTHER DEVELOPMENT (Name)	NONE	1 TO 10	OVER 10	MINIMAL EXPECTED	APPRECIABLE EXPECTED	EXCESSIVE EXPECTED
0 to 1/4	0	0	0	0	0	0	0	0	0	0	0	0	X			X		
1/4 to 1/2																		
1/2 to 3/4																		
3/4 to 1																		
1 to 1-1/4																		
1-1/4 to 1-1/2																		
1-1/2 to 1-3/4																		
1-3/4 to 2																		
OVER 2																		

The number of homes, buildings, or other items in the floodplain downstream of the dam should be placed in the appropriate row and column to designate their location.

SKETCH IN DEVELOPMENTS DOWNSTREAM OF THE DAM



Owner's Maintenance Statement

I, James G. Dodson, owner of Hennepin PS Ash Surface Impoundment dam,

Dam Identification Number IL 50363, in Putnam County,

am maintaining the dam in accordance with the accepted maintenance plan which is part of

Permit Number DS2004119.

Signature

Dec. 7, 2006
Date

Owner's Operation and Maintenance Plan Statement

I, James G. Dodson, owner of Hennepin PS Ash Surface Impoundment dam,

Dam Identification Number IL 50363, in Putnam County,

have reviewed the operation and maintenance plan including the Emergency Action Plan (EAP),

which is part of, Permit Number DS2004119.

[ ] have enclosed the appropriate revisions or,

[X] have determined that no revisions to the plan are necessary.

Signature

Dec. 7, 2006
Date

The Department of Natural Resources is requesting information that is necessary to accomplish the statutory purpose as outlined under the River, Lakes and Streams Act, 615 ILCS 5. Submittal of this information is REQUIRED. Failure to provide the required information could result in the initiation of non-compliance procedures as outlined in Section 3702.150 of the "Rules for Construction and Maintenance of Dams".

Close Window

Tracking Detail

Your package has been delivered.

Tracking Number:	1Z V9W 975 03 4525 747 6
Type:	Package
Status:	**Delivered**
Delivered on:	12/13/2006 9:51 A.M.
Signed by:	PATTERSON
Location:	MAIL ROOM
Delivered to:	US
Shipped or Billed on:	12/12/2006
Service Type:	GROUND
Weight:	1.00 lb

Package Progress

Location	Date	Local Time	Description
SPRINGFIELD, IL, US	12/13/2006	9:51 A.M.	DELIVERY
	12/13/2006	5:01 A.M.	OUT FOR DELIVERY
	12/13/2006	4:05 A.M.	ARRIVAL SCAN
DECATUR, IL, US	12/13/2006	1:26 A.M.	DEPARTURE SCAN
DECATUR, IL, US	12/12/2006	10:08 P.M.	ARRIVAL SCAN
	12/12/2006	8:30 P.M.	DEPARTURE SCAN
	12/12/2006	6:58 P.M.	ORIGIN SCAN
US	12/12/2006	2:52 P.M.	BILLING INFORMATION RECEIVED

Tracking results provided by UPS: 12/13/2006 3:26 P.M. EST (USA)

NOTICE: UPS authorizes you to use UPS tracking systems solely to track shipments tendered by or for you to UPS for delivery and for no other purpose. Any other use of UPS tracking systems and information is strictly prohibited.

Close Window

Copyright © 1994-2006 United Parcel Service of America, Inc. All rights reserved.

Dynegy Midwest Generation
DAILY SHIPMENT DETAIL REPORT
12/12/06 01:52 PM

Pickup Date: 12/12/06
Pickup Record No.: 2819375 39 2

UPS Account No.: V9W975
Sorted By: Order of Shipment

Name/Address	Shipment Detail		Options	Reference Rate Charges
Ship To: James Eiseman Bluegrass Generation 3095 Commerce Parkway LA GRANGE KY 40031-8799	Service Type: Total Packages: Hundredweight: Billable Wt.: Billing Option:	UPS NEXT DAY AIR 1 No LTR Prepaid	Shipment Service Charge:	$ 17.28
	Tracking No.: Package Type:	1ZV9W9750145360045 UPS Letter	Package Service Charge: **Shipper Amt:** **UPS Total Charge*:**	$ 17.28 **$ 17.28** **$ 17.28**
Ship To: Deirdre K. Hirner IL Environmental Regulatory Group 3150 Roland Ave. SPRINGFIELD IL 62703	Service Type: Total Packages: Hundredweight: Billable Wt.: Billing Option:	UPS GROUND 1 No 1.0 Prepaid	Shipment Service Charge:	$ 3.93
	Tracking No.: Package Type: Weight:	1ZV9W9750343581655 Package 1.0	Package Service Charge: **Shipper Amt:** **UPS Total Charge*:**	$ 3.93 **$ 3.93** **$ 3.93**
Ship To: Julie Armitage IL Environmental Protection Agency Bureau of Air 1021 North Grand Ave., East SPRINGFIELD IL 62794-9276	Service Type: Total Packages: Hundredweight: Billable Wt.: Billing Option:	UPS GROUND 1 No 1.0 Prepaid	Shipment Service Charge:	$ 3.93
	Tracking No.: Package Type: Weight:	1ZV9W9750344879467 Package 1.0	Package Service Charge: **Shipper Amt:** **UPS Total Charge*:**	$ 3.93 **$ 3.93** **$ 3.93**
Ship To: Mr. Mike Diedrichsen Illinois Dept. of Natural Resources Office of Water Resources Division of Water Resources Mgtmnt One Natural Resources Way SPRINGFIELD IL 62702-1270	Service Type: Total Packages: Hundredweight: Billable Wt.: Billing Option:	UPS GROUND 1 No 1.0 Prepaid	Shipment Service Charge:	$ 3.93
	Tracking No.: Package Type: Weight:	1ZV9W9750345257476 Package 1.0	Package Service Charge: **Shipper Amt:** **UPS Total Charge*:**	$ 3.93 **$ 3.93** **$ 3.93**
Ship To: Fiscal Svcs Section, Receipts #2 IL Environmental Protection Agency 1021 North Grand Ave., East SPRINGFIELD IL 62794-9276	Service Type: Total Packages: Hundredweight: Billable Wt.: Billing Option:	UPS GROUND 1 No 1.0 Prepaid	Shipment Service Charge:	$ 3.93
	Tracking No.: Package Type: Weight:	1ZV9W9750345399680 Package 1.0	Package Service Charge: **Shipper Amt:** **UPS Total Charge*:**	$ 3.93 **$ 3.93** **$ 3.93**
Ship To: Dynegy Midwest Generation 22228 Network Place CHICAGO IL 60673-1222	Service Type: Total Packages: Hundredweight: Billable Wt.: Billing Option:	UPS GROUND 1 No 1.0 Prepaid	Shipment Service Charge:	$ 4.02
	Tracking No.: Package Type: Weight:	1ZV9W9750345270095 Package 1.0	Package Service Charge: **Shipper Amt:** **UPS Total Charge*:**	$ 4.02 **$ 4.02** **$ 4.02**

bc: J.G.Dodson, w/o att – Hennepin Station
J.P.Augspols w/att. - Hennepin Station
T.L.Davis/Hennepin PS Dam Inspection Reports, w/att., Decatur
Rick Diericx Reading File - Decatur

Dam Inspection Report

Name of Dam Hennepin PS, East Ash Surface Impoundment **Dam ID No.** IL 50363

Permit Number DS2004119 **Class of Dam** III

Location NE 1/4 **Section** 26 **Township** 33N **Range** 2W of 3rd PM

Owner Dynegy Midwest Generation
Name

815-339-9210
Telephone Number (Day)

RR1, Box 200 AA
Street

815-339-9215
Telephone Number (Night)

Hennepin, IL 61327
City **Zip Code**

County Putnam

Type of Dam Homogeneous Earth Dam with clay and geosynthetic/clay liner

Type of Spillway Drop structure and stop logs

Date(s) Inspected March 29, 2010

Weather When Inspected Sunny

Temperature When Inspected 60 degrees F

Pool Elevation When Inspected Primary 481.5, Secondary 479.6

Tailwater Elevation When Inspected NA



Professional Engineer's Seal

Inspection Personnel:

Name	Title
Kenneth M Berry, P.E.	Sr Proj Engr (URS)
Phil L. Morris, P.E.	Environmental Professional
John Augspols	Plant Engineer

The Department of Natural Resources is requesting information that is necessary to accomplish the statutory purpose as outlined under the River, Lakes and Streams Act, 615 ILCS 5. Submittal of this information is REQUIRED. Failure to provide the required information could result in the initiation of non-compliance procedures as outlined in Section 3702.160 of the "Rules for Construction and Maintenance of Dams.

CONDITION CODES

NE - No evidence of a problem

GC - Good condition

MM - Item needing minor maintenance and/or repairs within the year, the safety or integrity of the item is not yet imperiled

IM - Item needing immediate maintenance to restore or ensure its safety or integrity

EC - Emergency condition which if not immediately repaired or other appropriate measures taken could lead to failure of the dam

OB - Condition requires regular observation to ensure that the condition does not become worse

NA - Not applicable to this dam

NI - Not inspected -list the reason for non-inspection under deficiencies

---

All Condition Codes will be listed with the following abbreviations:

P = Primary Cell

S = Secondary (polishing) Cell

EARTH EMBANKMENT

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Surface Cracks	NE	NA	
Vertical and Horizontal Alignment of Crest	GC	NA	
Unusual Movement or Cracking' At or Beyond Toe	NE	NA	
Sloughing or Erosion of Embankment and Abutment Slopes	NE	NA	
Upstream Face Slope Protection	NA	NA	No slope protection
Seepage	NE	NA	
Filter and Filter Drains	NA	NA	No evidence of internal filters or drains

EARTH EMBANKMENT
(Continued)

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Animal Damage	NE	NA	
Embankment Drainage Ditches	GC	NA	
Vegetative Cover	NE	NA	
Other (Name)	NA		
Other –	NA		
Other -	NA		
Other	NA		

CONCRETE OR MASONRY DAMS

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Seepage	NA		
Structure to Abutment! Embankment Junctions	NA		
Water Passages	NA		
Foundation	NA		
Surface Cracks in Concrete Surfaces	NA		
Structural Cracking	NA		
Vertical and Horizontal Alignment	NA		

CONCRETE OR MASONARY DAMS
(CONTINUED)

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Monolith Joints	NA		
Contruction Joints	NA		
Spalling of Concrete	NA		
Filters; Drains, etc.	NA		
Riprap	NA		
Other (Name)	NA		

IF THE DAM IS GATED – Fill out the portion of the Principal Spillway Form related to Gated Spillways

PRINCIPAL SPILLWAY
APPROACH CHANNEL

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Debris	NA		
Side Slope Stability	NA		
Slope Protection	NA		
Other (Name)	NA		
Other	NA		
Other	NA		
Other	NA		

PRINCIPAL SPILLWAY

x Drop Inlet Spillway ☐ Overflow Spillway Structure ☐ Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NE	NA	
Structure to Embankment Junction	NI	Underwater	
Drains	NA	NA	
Seepage Around or Into Structure	NI	Underwater	
Surface Cracks	NI	Underwater	
Structural Cracks	NI	Underwater	

IF THE SPILLWAY IS GATED FILL OUT THE SPILLWAY SECTION

PRINCIPAL SPILLWAY
(Continued)

x Drop Inlet Spillway ☐ Overflow Spillway Structure ☐ Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Alignment of Abutment Walls	NA	NA	
Construction Joints	NA	NA	
Filter and Filter Drains	NA	NA	
Trash Racks	NA	NA	
Bridge and Piers	NE	NA	
Differential Settlement	NE	NA	
Other (Name)	NA	NA	

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY
(Continued)

x Conduit ☐ Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NE	NA	
Joint Separation	NI	NA	
Seepage Around of Into Conduit	NI	Underwater	
Surface Cracks	NI	Underwater	
Structural Cracks	NI	Underwater	
Trash Racks	NA	NA	
Differential Settlement	NI	Underwater	
Alignment	NI	Underwater	
Other (Name)	NA	NA	

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY
(Continued)

☐ Chute

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NA		
Structure to Embankment Junction	NA		
Construction Joints	NA		
Expansion and Contraction Joints	NA		
Differential Settlement	NA		
Surface Cracks	NA		
Structural Cracks	NA		
Wall Alignment	NA		
Other (Name)	NA		

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY

x Principal Spillway ☐ Dewatering ☐ Other:

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Gate Sill (Stoplogs)	NI	Underwater	
Gate Seals (Stoplogs)	NI	Underwater	
Gate and Frame (Stoplogs)	GC	NA	
Operating Machinery	NA		
Emergency Operating Machinery	NA		
Other (Name)	NA		
Other	NA		

OUTLET WORKS
IF SEPARATE FROM PRINCIPAL SPILLWAY STRUCTURE

ITEM	CONDITION CODE'	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion. Spalling, Cavitation	NA		
Joint Separation	NA		
Seepage Around or Into Conduit	NA		
Intake Structure	NA		
Outlet Structure	NA		
Outlet Channel	NA		
Riprap	NA		
Other (Name)	NA		
Other	NA		

ENERGY DISSIPATOR

☐ Principal Spillway
Type:

x Outlet Works

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NE	NA	
Structure to Embankment Junction	NE	NA	
Construction Joints	NE	NA	
Surface Cracks	NE	NA	
Structural Cracks	NI	Underwater	
Differential Alignment	NE	NA	
Expansion and Contraction Joints	NI	Underwater	

ENERGY DISSIPATOR
(Continued)

☐ Principal Spillway ☐ Outlet Works

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Riprap	NE	NA	
Outlet Channel	NE	NA	
Debris	NE	NA	
Other (Name)	NA		
Other	NA		
Other	NA		
Other	NA		

EMERGENCY SPILLWAY

☐ Earth ☐ Other: Name _____

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion	NA		
Weeds, Logs, Other Obstructions	NA		
Side Slope Sloughing	NA		
Vegetation	NA		
Sedimentation	NA		
Riprap	NA		
Settlement of Crest	NA		
Downstream Channel	NA		
Other (Name)	NA		

SUMMARY OF MAINTENANCE DONE AND/OR

REPAIRS MADE SINCE THE LAST INSPECTION

DATE OF PRESENT INSPECTION March 29, 2010

DATE OF LAST INSPECTION March 19, 2009

1. EARTH EMBANKMENT DAMS

Minor erosion repairs, mowing, tree cutting, and general maintenance have been performed.

2. CONCRETE MASONARY DAMS

3. PRINCIPAL SPILLWAY

4. OUTLET WORKS

5. EMERGENCY SPILLWAY

DOWNSTREAM DEVELOPMENT
APPROXIMATE WIDTH OF AFFECTED FLOODPLAIN 0.25 MILES.

MILES DOWNSTREAM FROM DAM	DOWNSTREAM DEVELOPMENT												Loss Of Life Potential			Economic Loss Potential			SKETCH IN DEVELOPMENTS DOWNSTREAM OF THE DAM
	OCCUPIED HOMES	UNOCCUPIED HOMES	AGRICULTURAL BUILDINGS	INDUSTRIAL BUILDINGS	COMMERCIAL BUILDINGS	SCHOOLS	HOSPITALS	ROADS & BRIDGES	DAMS	OVERHEAD UTILITIES	OTHER DEVELOPMENT (Name)	OTHER DEVELOPMENT (Name)	NONE	1 TO 10	OVER 10	MINIMAL EXPECTED	APPRECIABLE EXPECTED	EXCESSIVE EXPRECTED	
0 to ¼		0	0	0	0	0	0	0	0	0	0	0	x			x			
¼ to ½																			
½ to ¾																			
¾ to 1																			
1 to 1 ¼																			
1 ¼ to 1 ½																			
1 ½ to 1 ¾																			
1 ¾ to 2																			
OVER 2																			

The number of homes, buildings, or other items in the floodplain downstream of the dam should be placed in the appropriate row and column to designate their location.

Owner's Maintenance Statement

I, Ted Lindenbusch, owner of Hennepin PS East Ash Surface Impoundment dam, Dam Identification Number IL 50363, in Putnam County, am maintaining the dam in accordance with the accepted maintenance plan which is part of Permit Number DS2004119.

_____
Signature

_____
Date

Owner's Operation and Maintenance Plan Statement

I, Ted Lindenbusch, owner of Hennepin PS East Ash Surface Impoundment dam, Dam Identification Number IL 50363, in Putnam County, have reviewed the operation and maintenance plan including the Emergency Action Plan (EAP), which is part of Permit Number DS2004119.

I ☐ have enclosed the appropriate revisions or

☐ have determined that no revisions to the plan are necessary.

_____
Signature

_____
Date

The Department of Natural Resources is requesting information that is necessary to accomplish the statutory purposes as outlined under the River, Lakes and Streams Act, 615 IL CS 5. Submittal of this information is REQUIRED. Failure to provide the required information could result in the initiation on non-compliance procedures as outlined in Section 3702.160 of the "Rules for Construction and Maintenance of Dams."

Dam Inspection Report

Name of Dam Hennepin PS, West Ash Surface Impoundment **Dam ID No.** N/A

Permit Number N/A **Class of Dam** N/A

Location NE _ **Section** _ **Township** ___ **Range** ____

Owner Dynegy Midwest Generation — **Name**

815-339-9210 — **Telephone Number (Day)**

RR1, Box 200 AA — **Street**

815-339-9215 — **Telephone Number (Night)**

Hennepin, IL — **City** 61327 — **Zip Code**

County Putnam

Type of Dam Homogeneous Earth Dam

Type of Spillway Drop structure

Date(s) Inspected March 29, 2010

Weather When Inspected Sunny

Temperature When Inspected 60 degrees F

Pool Elevation When Inspected Unknown

Tailwater Elevation When Inspected NA

KENNETH MONROE BERRY
062-051918
REGISTERED PROFESSIONAL ENGINEER
STATE OF ILLINOIS
5/26/2010

Professional Engineer's Seal

Inspection Personnel:

Name	Title
Kenneth M Berry, P.E.	Sr Proj Engr (URS)
Phil L. Morris, P.E.	Environmental Professional
John Augspols	Plant Engineer

The Department of Natural Resources is requesting information that is necessary to accomplish the statutory purpose as outlined under the River, Lakes and Streams Act. 615 ILCS 5. Submittal of this information is REQUIRED. Failure to provide the required information could result in the initiation of non.-compliance procedures as outlined in Section 3702.160 of the "Rules for Construction and Maintenance of Dams.

CONDITION CODES

NE - No evidence of a problem

GC - Good condition

MM - Item needing minor maintenance and/or repairs within the year, the safety or integrity of the item is not yet imperiled

IM - Item needing immediate maintenance to restore or ensure its safety or integrity

EC - Emergency condition which if not immediately repaired or other appropriate measures taken could lead to failure of the dam

OB - Condition requires regular observation to ensure that the condition does not become worse

NA - Not applicable to this dam

NI - Not inspected -list the reason for non-inspection under deficiencies

EARTH EMBANKMENT

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Surface Cracks	NE	NA	
Vertical and Horizontal Alignment of Crest	GC	NA	
Unusual Movement or Cracking' At or Beyond Toe	NI	Underwater	
Sloughing or Erosion of Embankment and Abutment Slopes	OB/MM	Vegetation was high and thick – limited ability to observe.	Sporadic riverbank erosion observed towards the south. Recommend placement of rip rap to repair.
Upstream Face Slope Protection	OB	Vegetation was high and thick, so not able to observe.	Cut vegetation and observe.
Seepage	NE	Mostly underwater	
Filter and Filter Drains	NA	NA	

EARTH EMBANKMENT
(Continued)

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Animal Damage	NE	NA	
Embankment Drainage Ditches	NE	NA	
Vegetative Cover	MM	High vegetation and Sporadic trees	Cut vegetation on interior to facilitate inspection and limit roots. Do not cut trees on river bank since they provide erosion protection from the river.
Other (Name)	NA		
Other --	NA		
Other -	NA		
Other	NA		

CONCRETE OR MASONRY DAMS

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Seepage	NA		
Structure to Abutment! Embankment Junctions	NA		
Water Passages	NA		
Foundation	NA		
Surface Cracks in Concrete Surfaces	NA		
Structural Cracking	NA		
Vertical and Horizontal Alignment	NA		

CONCRETE OR MASONARY DAMS
(CONTINUED)

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Monolith Joints	NA		
Contruction Joints	NA		
Spalling of Concrete	NA		
Filters; Drains, etc.	NA		
Riprap	NA		
Other (Name)	NA		

IF THE DAM IS GATED – Fill out the portion of the Principal Spillway Form related to Gated Spillways

PRINCIPAL SPILLWAY
APPROACH CHANNEL

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Debris	NA		
Side Slope Stability	NA		
Slope Protection	NA		
Other (Name)	NA		
Other	NA		
Other	NA		
Other	NA		

PRINCIPAL SPILLWAY

x Drop Inlet Spillway ☐ Overflow Spillway Structure ☐ Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NI	High vegetation	
Structure to Embankment Junction	NI	High vegetation	
Drains	NA	NA	
Seepage Around or Into Structure	NI	High vegetation	
Surface Cracks	NI	High vegetation	
Structural Cracks	NI	High vegetation	

IF THE SPILLWAY IS GATED FILL OUT THE SPILLWAY SECTION

PRINCIPAL SPILLWAY
(Continued)

x Drop Inlet Spillway ☐ Overflow Spillway Structure ☐ Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Alignment of Abutment Walls	NA	NA	
Construction Joints	NA	NA	
Filter and Filter Drains	NA	NA	
Trash Racks	NA	NA	
Bridge and Piers	NA	NA	
Differential Settlement	NA	NA	
Other (Name)	NA	NA	

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY
(Continued)

x Conduit ☐ Gated

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NI	Inaccessible	
Joint Separation	NI	Inaccessible	
Seepage Around of Into Conduit	NI	Inaccessible	
Surface Cracks	NI	Inaccessible	
Structural Cracks	NI	Inaccessible	
Trash Racks	NA	NA	
Differential Settlement	NI	Inaccessible	
Alignment	NI	Inaccessible	
Other (Name)	NA	NA	

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY
(Continued)

☐ Chute

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NA		
Structure to Embankment Junction	NA		
Construction Joints	NA		
Expansion and Contraction Joints	NA		
Differential Settlement	NA		
Surface Cracks	NA		
Structural Cracks	NA		
Wall Alignment	NA		
Other (Name)	NA		

IF THE SPILLWAY IS GATED FILL OUT THE GATES SECTION

PRINCIPAL SPILLWAY

☐ Principal Spillway ☐ Dewatering ☐ Other:

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Gate Sill	NA		
Gate Seals	NA		
Gate and Frame	NA		
Operating Machinery	NA		
Emergency Operating Machinery	NA		
Other (Name)	NA		
Other	NA		

OUTLET WORKS
IF SEPARATE FROM PRINCIPAL SPILLWAY STRUCTURE

ITEM	CONDITION CODE'	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion. Spalling, Cavitation	NA		
Joint Separation	NA		
Seepage Around or Into Conduit	NA		
Intake Structure	NA		
Outlet Structure	NA		
Outlet Channel	NA		
Riprap	NA		
Other (Name)	NA		
Other	NA		

ENERGY DISSIPATOR

☐ Principal Spillway
Type:

☐ Outlet Works

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion, Spalling, Cavitation	NA		
Structure to Embankment Junction	NA		
Construction Joints	NA		
Surface Cracks	NA		
Structural Cracks	NA		
Differential Alignment	NA		
Expansion and Contraction Joints	NA		

ENERGY DISSIPATOR
(Continued)

☐ Principal Spillway ☐ Outlet Works

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Riprap	NA		
Outlet Channel	NA		
Debris	NA		
Other (Name)	NA		
Other	NA		
Other	NA		
Other	NA		

EMERGENCY SPILLWAY

☐ Earth ☐ Other: Name _____

ITEM	CONDITION CODE	DEFICIENCIES	RECOMMENDED REMEDIAL MEASURES AND IMPLEMENTATION SCHEDULE
Erosion	NA		
Weeds, Logs. Other Obstructions	NA		
Side Slope Sloughing	NA		
Vegetation	NA		
Sedimentation	NA		
Riprap	NA		
Settlement of Crest	NA		
Downstream Channel	NA		
Other (Name)	NA		

SUMMARY OF MAINTENANCE DONE AND/OR

REPAIRS MADE SINCE THE LAST INSPECTION

DATE OF PRESENT INSPECTION March 29, 2010

DATE OF LAST INSPECTION March 19, 2009

1. EARTH EMBANKMENT DAMS

Unknown.

2. CONCRETE MASONARY DAMS

3. PRINCIPAL SPILLWAY

4. OUTLET WORKS

5. EMERGENCY SPILLWAY

DOWNSTREAM DEVELOPMENT
APPROXIMATE WIDTH OF AFFECTED FLOODPLAIN 0.25 MILES.

MILES DOWNSTREAM FROM DAM	DOWNSTREAM DEVELOPMENT												Loss Of Life Potential			Economic Loss Potential			SKETCH IN DEVELOPMENTS DOWNSTREAM OF THE DAM
	OCCUPIED HOMES	UNOCCUPIED HOMES	AGRICULTURAL BUILDINGS	INDUSTRIAL BUILDINGS	COMMERCIAL BUILDINGS	SCHOOLS	HOSPITALS	ROADS & BRIDGES	DAMS	OVERHEAD UTILITIES	OTHER DEVELOPMENT (Name)	OTHER DEVELOPMENT (Name)	NONE	1 TO 10	OVER 10	MINIMAL EXPECTED	APPRECIABLE EXPECTED	EXCESSIVE EXPRECTED	
0 to ¼		0	0	0	0	0	0	0	0	0	0	0	x			x			
¼ to ½																			
½ to ¾																			
¾ to 1																			
1 to 1 ¼																			
1 ¼ to 1 ½																			
1 ½ to 1 ¾																			
1 ¾ to 2																			
OVER 2																			

The number of homes, buildings, or other items in the floodplain downstream of the dam should be placed in the appropriate row and column to designate their location.

Owner's Maintenance Statement

I, Ted Lindenbusch, owner of Hennepin PS West Ash Surface Impoundment dam,

Dam Identification Number _____, in Putnam County,

am maintaining the dam in accordance with the accepted maintenance plan

which is part of Permit Number_____.

_____

Signature

_____

Date

Owner's Operation and Maintenance Plan Statement

I, Ted Lindenbusch, owner of Hennepin PS West Ash Surface Impoundment dam,

Dam Identification Number _____, in Putnam County,

have reviewed the operation and maintenance plan including the Emergency

Action Plan (EAP), which is part of Permit Number_____.

I ☐ have enclosed the appropriate revisions or

☐ have determined that no revisions to the plan are necessary.

_____

Signature

_____

Date

The Department of Natural Resources is requesting information that is necessary to accomplish the statutory purposes as outlined under the River, Lakes and Streams Act, 615 IL CS 5. Submittal of this information is REQUIRED. Failure to provide the required information could result in the initiation on non-compliance procedures as outlined in Section 3702.160 of the "Rules for Construction and Maintenance of Dams."

APPENDIX E

PHOTOGRAPHS

GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 1	Date: 5/23/11

Direction Photo Taken:
Northeast

Description:
Downstream slope of the West Ash Pond System (WAPS) Impoundment.



Photo No. 2	Date: 5/23/11

Direction Photo Taken:
South

Description:
Downstream slope of the WAPS.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 3	Date: 5/23/11

Direction Photo Taken:
North

Description:
Downstream slope of the WAPS.



Photo No. 4	Date: 5/23/11

Direction Photo Taken:
East

Description:
Downstream slope of the WAPS.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
5	5/23/11

Direction Photo Taken:
East

Description:
Downstream slope of the WAPS.



Photo No.	Date:
6	5/23/11

Direction Photo Taken:
North

Description:
Crest and downstream slope of the WAPS.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
7	5/23/11

Direction Photo Taken:
North

Description:
Crest and downstream slope of the WAPS.



Photo No.	Date:
8	5/23/11

Direction Photo Taken:
West

Description:
Crest and downstream slope of the WAPS.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
9	5/23/11

Direction Photo Taken:
Southwest

Description:
Downstream slope of the WAPS.



Photo No.	Date:
10	5/23/11

Direction Photo Taken:
Southwest

Description:
Downstream slope of the WAPS.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
11	5/23/11

Direction Photo Taken:
Southwest

Description:
Downstream slope of the WAPS.



Photo No.	Date:
12	5/23/11

Direction Photo Taken:
Southeast

Description:
Downstream slope of the WAPS.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
13	5/23/11

Direction Photo Taken:
Southwest

Description:
Downstream slope of the WAPS.



Photo No.	Date:
14	5/23/11

Direction Photo Taken:
North

Description:
Toe access road along the eastern portion of the WAPS.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 15	Date: 5/23/11

Direction Photo Taken:
Southwest

Description:
Crest of the WAPS.



Photo No. 16	Date: 5/23/11

Direction Photo Taken:
Northeast

Description:
Crest of the WAPS.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
17	5/23/11

Direction Photo Taken:
West

Description:
Crest of the WAPS.



Photo No.	Date:
18	5/23/11

Direction Photo Taken:
East

Description:
Crest and upstream slope of the WAPS.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
19	5/23/11

Direction Photo Taken:
West

Description:
Crest and upstream slope of the WAPS.



Photo No.	Date:
20	5/23/11

Direction Photo Taken:
Northeast

Description:
Crest and upstream slope of the WAPS.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
21	5/23/11

Direction Photo Taken:
South

Description:
Decant structure in the WAPS.



Photo No.	Date:
22	5/23/11

Direction Photo Taken:
Southeast

Description:
Decant structure in the WAPS.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
23	5/23/11

Direction Photo Taken:
Northeast

Description:
Discharge pipe from the WAPS into the Illinois River.



Photo No.	Date:
24	5/23/11

Direction Photo Taken:
West

Description:
Upstream slope and ponded water in the WAPS.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 25	Date: 5/23/11

Direction Photo Taken:
Northeast

Description:
Downstream slope of the EAPS.



Photo No. 26	Date: 5/23/11

Direction Photo Taken:
Northeast

Description:
Downstream slope of the EAPS.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
27	5/23/11

Direction Photo Taken:
Northeast

Description:
Crest of the 1978 embankment and downstream slope of the 1995 embankment along the EAPS.



Photo No.	Date:
28	5/23/11

Direction Photo Taken:
Northeast

Description:
Crest of the 1978 embankment and downstream slope of the 1995 embankment along the EAPS.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
29	5/23/11

Direction Photo Taken:
East

Description:
Crest of the 1978 embankment and downstream slope of the 1995 embankment near Pond 2E.



Photo No.	Date:
30	5/23/11

Direction Photo Taken:
North

Description:
Downstream slope of Pond 2E.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 31	Date: 5/23/11

Direction Photo Taken:
Northwest

Description:
Downstream slope of Pond 2E along crest of the 1978 embankment.



Photo No. 32	Date: 5/23/11

Direction Photo Taken:
Southwest

Description:
Crest of the EAPS.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
33	5/23/11

Direction Photo Taken:
Northeast

Description:
Crest and upstream slope of the EAPS.



Photo No.	Date:
34	5/23/11

Direction Photo Taken:
Northeast

Description:
Crest and upstream slope of the EAPS.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 35	Date: 5/23/11

Direction Photo Taken:
South

Description:
Crest of embankment between the EAPS and Pond 2E.



Photo No. 36	Date: 5/23/11

Direction Photo Taken:
East

Description:
Crest and upstream slope of Pond 2E.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
37	5/23/11

Direction Photo Taken:
Southeast

Description:
Crest and upstream slope of Pond 2E.



Photo No.	Date:
38	5/23/11

Direction Photo Taken:
West

Description:
Crest of the embankment between Pond 2E and Secondary Cell.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 39	Date: 5/23/11

Direction Photo Taken:
Southeast

Description:
Crest and upstream slope of the Secondary Cell.



Photo No. 40	Date: 5/23/11

Direction Photo Taken:
Southwest

Description:
Crest and upstream slope of the Secondary Cell.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 41	Date: 5/23/11

Direction Photo Taken:
Northwest

Description:
Crest and upstream slope of the Secondary Cell.



Photo No. 42	Date: 5/23/11

Direction Photo Taken:
Northwest

Description:
Crest and upstream slope of the Secondary Cell.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
43	5/23/11

Direction Photo Taken:
Southwest

Description:
Crest of the embankment between Pond 2E and the Secondary Cell.



Photo No.	Date:
44	5/23/11

Direction Photo Taken:
Northwest

Description:
Upstream slope of the EAPS.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 45	Date: 5/23/11

Direction Photo Taken:
Southwest

Description:
Crest and upstream slope of the Primary Cell.



Photo No. 46	Date: 5/23/11

Direction Photo Taken:
East

Description:
Upstream slope of the Primary Cell.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
47	5/23/11

Direction Photo Taken:
Southwest

Description:
Upstream slope of the Primary Cell.



Photo No.	Date:
48	5/23/11

Direction Photo Taken:
Northwest

Description:
Upstream slope of the Primary Cell near the decant structure.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
49	5/23/11

Direction Photo Taken:
Southwest

Description:
Crest and upstream slope of the Primary Cell.



Photo No.	Date:
50	5/23/11

Direction Photo Taken:
Southwest

Description:
Crest and upstream slope of the Primary Cell.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
51	5/23/11

Direction Photo Taken:
Southwest

Description:
Upstream slope of the Primary Cell.



Photo No.	Date:
52	5/23/11

Direction Photo Taken:
Northwest

Description:
Crest and upstream slope of the Primary Cell.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 53	Date: 5/23/11

Direction Photo Taken:
Northwest

Description:
Crest and upstream slope of the Primary Cell.



Photo No. 54	Date: 5/23/11

Direction Photo Taken:
West

Description:
Downstream slope of the EAPS.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 55	Date: 5/23/11

Direction Photo Taken:
West

Description:
Crest and downstream slope of the EAPS.



Photo No. 56	Date: 5/23/11

Direction Photo Taken:
West

Description:
Downstream slope of the EAPS.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
57	5/23/11

Direction Photo Taken:
Northwest

Description:
Downstream slope of the EAPS.



Photo No.	Date:
58	5/23/11

Direction Photo Taken:
North

Description:
Discharge pipe into the northwest portion of the Primary Cell.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
59	5/23/11

Direction Photo Taken:
East

Description:
Old decant structure in the Primary Cell.



Photo No.	Date:
60	5/23/11

Direction Photo Taken:
East

Description:
Discharge pipe into the Primary Cell near the northeast corner.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
61	5/23/11

Direction Photo Taken:
East

Description:
Decant structure in the Primary Cell.



Photo No.	Date:
62	5/23/11

Direction Photo Taken:
Southeast

Description:
Discharge pipe from the Primary Cell to Pond 2E.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
63	5/23/11

Direction Photo Taken:
South

Description:
Decant structure in the Secondary Cell.



Photo No.	Date:
64	5/23/11

Direction Photo Taken:
Down

Description:
Decant structure in the Secondary Cell.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No. 65	Date: 5/23/11

Direction Photo Taken:
Southwest

Description:
Surface features of the flume structure in the discharge line from the Secondary Cell to the Illinois River.



Photo No. 66	Date: 5/23/11

Direction Photo Taken:
Down

Description:
Flume structure in the discharge line from the Secondary Cell to the Illinois River.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
67	5/23/11

Direction Photo Taken:
West

Description:
Crest of the interior embankment in the AEAPS with the Pond 2E decant structure shown.



Photo No.	Date:
68	5/23/11

Direction Photo Taken:
Southwest

Description:
Outfall at the Illinois River.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
69	5/23/11

Direction Photo Taken:
Southeast

Description:
Downstream slope of EAPS near Pond 4.



Photo No.	Date:
70	5/23/11

Direction Photo Taken:
South

Description:
Downstream slope of the EAPS near Pond 4.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
71	5/23/11

Direction Photo Taken:
Southeast

Description:
Crest of the EAPS near Pond 4.



Photo No.	Date:
72	5/23/11

Direction Photo Taken:
Northeast

Description:
Crest of the EAPS near Pond 4.



GZA GeoEnvironmental, Inc.

PHOTOGRAPHIC LOG

Client Name: U.S. EPA	Site Location: Hennepin Power Station Hennepin, Illinois	Project No. 01.0170142.30

Photo No.	Date:
73	5/23/11

Direction Photo Taken:
Northeast

Description:
Crest of the EAPS looking over the Primary Cell.



Photo No.	Date:
74	5/23/11

Direction Photo Taken:
Northeast

Description:
Crest of the EAPS near Pond 4.



APPENDIX F

REFERENCES

REFERENCE LIST HENNEPIN POWER STATION

Civil & Environmental Consultants, Inc. "Application for a Permit to Construct a New Leachate and Storm Water Runoff Collection Pond, Dynegy-Hennepin Power Station Hennepin, Illinois". Date July 2009.

Civil & Environmental Consultants, Inc. "Pond 2 East Construction Completion Report, Hennepin Power Station, Hennepin, Putnam County, Illinois". Date December 2010.

Sargent & Lundy Engineers. "Roadways at Plant Site, General Location Plan, Hennepin, Power Station, Illinois Power Company, Hennepin, Illinois," Drawing No.B-9. Dated March 27, 1953.

Sargent & Lundy Engineers. "Roadways at Plant Site, General Location Plan, Hennepin, Power Station, Illinois Power Company, Hennepin, Illinois," Drawing No.B-11. Dated March 27, 1953.

Illinois Power Company. "Hennepin Power Station Ash Surface Impoundment Hydrologic/Hydraulic Analysis" Dated September 1994.

Illinois Power Company. "Hennepin Power Station Ash Surface Impoundment Geotechnical/Structural Design" Dated September 1994.

Illinois Power Company, Decatur. "West Ash Pond Topographic Survey, Hennepin Power Station." Drawing No. E-HEN1-B451. Dated September 29, 1987.

Illinois Power Company, Decatur. "Cross Sections of Ash Pond Berm Extension" Hennepin Station." Drawing No. E-HEN1-B452. Dated December 30, 1987.

Illinois Power Company, Decatur. "Cross Sections of Ash Pond Berm Extension" Hennepin Station." Drawing No. E-HENI-B453. Dated December 30, 1987.

Illinois Power Company, Decatur. "Cross Sections of Ash Pond Berm Extension" Hennepin Station." Drawing No. E-HEN1-B454. Dated December 30, 1987.

Illinois Power Company, Decatur. "Cross Sections of Ash Pond Berm Extension" Hennepin Station." Drawing No. E-HEN1-B455. Dated December 30, 1987.

Illinois Power Company, Decatur. "Cross Sections of Ash Pond Berm Extension" Hennepin Station." Drawing No. E-HEN1-B456. Dated December 30, 1987.

Illinois Power Company, Decatur. "Cross Sections of Ash Pond Berm Extension" Hennepin Station." Drawing No. E-HEN1-B457. Dated December 30, 1987.

Illinois Power Company, Decatur. "Cross Sections, East Ash Pond Extension" Hennepin Station." Drawing No. CE-HEN1-B458-1. Dated January 11, 1989.

Illinois Power Company, Decatur. “Cross Sections, East Ash Pond Extension” Hennepin Station.” Drawing No. CE-HEN1-B458-2. Dated January 12, 1989.

Illinois Power Company, Decatur. “Cross Sections, East Ash Pond Extension” Hennepin Station.” Drawing No. CE-HEN1-B458-3. Dated January 12, 1989.

Illinois Power Company, Decatur. “Cross Sections, East Ash Pond Extension” Hennepin Station.” Drawing No. CE-HEN1-B458-4. Dated January 12, 1989.

Illinois Power Company, Decatur. “Cross Sections, East Ash Pond Extension” Hennepin Station.” Drawing No. CE-HEN1-B458-5. Dated January 12, 1989.

Illinois Power Company, Decatur. “Cross Sections, East Ash Pond Extension” Hennepin Station.” Drawing No. CE-HEN1-B458-6. Dated January 12, 1989.

Illinois Power Company, Decatur. “Cross Sections, East Ash Pond Extension” Hennepin Station.” Drawing No. CE-HEN1-B458-7. Dated January 12, 1989.

Illinois Power Company, Decatur. “East Ash Pond Topographic Survey, Hennepin Power Station.” Drawing No. E-HEN1-B450. Dated September 27. 1987.

Illinois Power Company, Decatur. “Area Site Plan, Hennepin Power Station.” Drawing No. CE-HEN1-C4. Dated January 10, 1994.

Illinois Power Company, Decatur. “Survey Plan Ash Impoundment”, Hennepin Station.” Drawing No. CE-HEN1-C5.1. Dated September 20 1994.

Illinois Power Company, Decatur. “Survey Plan Ash Impoundment”, Hennepin Station.” Drawing No. CE-HEN1-C5.2. Dated September 20 1994.

Illinois Power Company, Decatur. “Survey Plan Ash Impoundment”, Hennepin Station.” Drawing No. CE-HEN1-C5.3. Dated September 20 1994.

Illinois Power Company, Decatur. “Cross Sections, 1995 Ash Facility”, Hennepin Station.” Drawing No. CE-HEN1-C7-1. Dated October 12, 1993.

Illinois Power Company, Decatur. “Plan and Ash Pond Cross Section, Proposed Ash Facility”, Hennepin Station.” Drawing No. CE-HEN1-C7.9. Dated October 5, 1994.

Illinois Power Company, Decatur. “Plan and Ash Pond Cross Section, Proposed Ash Facility”, Hennepin Station.” Drawing No. CE-HEN1-C7.10. Dated October 5, 1994.

Illinois Power Company, Decatur. “Plan and Ash Pond Cross Section, Proposed Ash Facility”, Hennepin Station.” Drawing No. CE-HEN1-C7.12. Dated July 21, 1994.

Illinois Power Company, Decatur. “Plan and Ash Pond Cross Section, Proposed Ash Facility”, Hennepin Station.” Drawing No. CE-HEN1-C7.12A. Dated July 24, 1994.

Illinois Power Company, Decatur. “Plan and Ash Pond Cross Section, Proposed Ash Facility”, Hennepin Station.” Drawing No. CE-HEN1-C7.12B. Dated July 24, 1994.

Illinois Power Company, Decatur. “Plan and Ash Pond Cross Section, Proposed Ash Facility”, Hennepin Station.” Drawing No. CE-HEN1-C7.15. Dated October 10, 1993.

Illinois Power Company, Decatur. “Plan and Ash Pond Cross Section, Proposed Ash Facility”, Hennepin Station.” Drawing No. CE-HEN1-C7.16. Dated October 12, 1993.

Illinois Power Company, Decatur. “Plan and Ash Pond Cross Section, Proposed Ash Facility”, Hennepin Station.” Drawing No. CE-HEN1-C7.17. Dated October 12, 1993.

Illinois Power Company, Decatur. “Plan and Ash Pond Cross Section, Proposed Ash Facility”, Hennepin Station.” Drawing No. CE-HEN1-C7.18. Dated October 12, 1993.

Dynegy Midwest Generation, LLC . “Hennepin Revised Stability Analysis for Section P2-1”; Email correspondence from Mr. Phil Morris. Dated October 22, 2012.

PREFACE

The assessment of the general condition of the dams/impoundment structures reported herein was based upon available data and visual inspections. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations were beyond the scope of this report.

In reviewing this report, it should be realized that the reported condition of the dams and/or impoundment structures was based on observations of field conditions at the time of inspection, along with data available to the inspection team. In cases where an impoundment is lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions, which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is critical to note that the condition of the dam and/or impoundment structures depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the reported condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Prepared by:

GZA GeoEnvironmental, Inc.



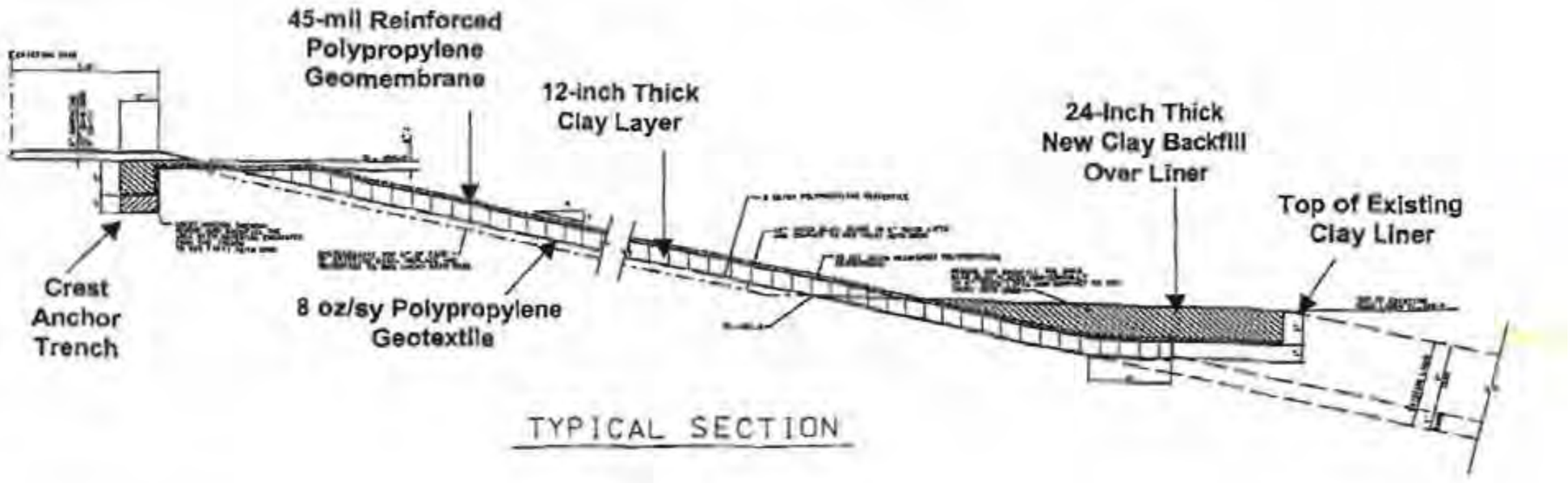
Patrick Harrison, P.E.

License No.: 062.034946
Senior Geotechnical Consultant
GZA GeoEnvironmental, Inc.

Hennepin Power Station
Hennepin, IL

East Ash Pond System

Raising of Interior Impermeable Liners in Primary and Secondary Cells



TYPICAL SECTION

REV. NO.	DESCRIPTION	BY	DATE

PROJ MGR: DPS
DESIGNED BY: DPS
REVIEWED BY: PJH
OPERATOR: CLK
DATE: 12-12-11

GZA
GeoEnvironmental, Inc.
2590 Swenson Drive, Suite 150
Waukesha, Wisconsin ◆ 53186 ◆ Phone
(262) 754-2560 ◆ Fax (262) 754-9711
www.gza.com

NOTE:
IMAGE HAS BEEN REDUCED AND IS NO LONGER TO A SCALE

DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

TYPICAL SECTION OF LINER EXTENSION

JOB NO.
01.0170142.30

FIGURE NO.
9

© 2011 GZA GeoEnvironmental, Inc.

The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 10a

AECOM

October 2016

Dynegy Midwest Generation, LLC
13498 E 800th St.
Hennepin, IL 61327

RE: History of Construction
USEPA Final CCR Rule, 40 CFR § 257.73(c)
Hennepin Power Station
Hennepin, Illinois

On behalf of Dynegy Midwest Generation, LLC, AECOM has prepared the following history of construction for the Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and East Ash Pond at the Hennepin Power Station in accordance with 40 CFR § 257.73(c).

BACKGROUND

40 CFR § 257.73(c)(1) requires the owner or operator of an existing coal combustion residual (CCR) surface impoundment that either (1) has a height of five feet or more and a storage volume of 20 acre-feet or more, or (2) has a height of 20 feet or more to compile a history of construction by October 17, 2016 that contains, to the extent feasible, the information specified in 40 CFR § 257.73(c)(1)(i)–(xii).

The history of construction presented herein was compiled based on existing documentation, to the extent that it is reasonably and readily available (see 80 Fed. Reg. 21302, 21380 [April 17, 2015]), and AECOM's site experience. AECOM's document review included construction drawings, geotechnical investigations, operation and maintenance information, etc. for Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and East Ash Pond at the Hennepin Power Station.

AECOM

HISTORY OF CONSTRUCTION

§ 257.73(c)(1)(i): The name and address of the person(s) owning or operating the CCR unit; the name associated with the CCR unit; and the identification number of the CCR unit if one has been assigned by the state.

Owner: Dynegy Midwest Generation, LLC

Address: 1500 Eastport Plaza Drive
Collinsville, IL 62234

CCR Units: Old West Polishing Pond
Old West Ash Pond (Pond No. 1 and Pond No. 3)
Ash Pond No. 2
East Ash Pond, IDNR Dam ID No. IL50363

The Old West Polishing Pond, Old West Ash Pond, and Ash Pond No. 2 do not have a state assigned identification number.

§ 257.73(c)(1)(ii): The location of the CCR unit identified on the most recent USGS $7^1/_2$ or 15 minute topographic quadrangle map or a topographic map of equivalent scale if a USGS map is not available.

The locations of the Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and East Ash Pond have been identified on an USGS 7-1/2 minute topographic quadrangle map in **Appendix A**.

§ 257.73(c)(1)(iii): A statement of the purpose for which the CCR unit is being used.

The following captures the purpose of each CCR unit:

- The Old West Polishing Pond (inactive) was used to store and dispose fly ash and bottom ash and is currently being used to clarify stormwater runoff from the Old West Ash Pond prior to discharge in accordance with the station's NPDES permit.
- The Old West Ash Pond (inactive) was used to store and dispose fly ash and bottom ash.
- The Ash Pond No. 2 (inactive) was used to store and dispose fly ash, bottom ash, and other non-CCR waste streams including coal pile runoff.
- The East Ash Pond is being used to store and dispose bottom ash, fly ash, and other non-CCR waste and to clarify process water prior to discharge in accordance with the station's NPDES permit.

Notice of intent to close the Old West Polishing Pond, Old West Ash Pond, and Ash Pond No. 2 was provided in November 2015.[1]

[1] This history of construction report was prepared on a facility-wide basis for CCR surface impoundments at the Hennepin Power Station. The inclusion of the Old West Polishing Pond, Old West Ash Pond, and Ash Pond No. 2 in this history of construction report does not concede and should not be construed to concede that the Old

§ 257.73(c)(1)(iv): The name and size in acres of the watershed where the CCR unit is located.

The Hennepin Power Station and the above-referenced CCR units are located at the western edge of the Depue Lake-Illinois River Watershed with a 12-digit Hydrologic Unit Code (HUC) of 071300010804 and a drainage area of 44,525 acres (USGS 2016).

§ 257.73(c)(1)(v): A description of the physical and engineering properties of the foundation and abutment materials on which the CCR unit is constructed.

Physical properties of the foundation materials for the Old West Polishing Pond and Old West Ash Pond are described as cohesive material underlain by granular material. The cohesive material consists of lean clay, gravelly clay, silt, clayey silt, and sandy silt. The consistency of the cohesive material varies from very soft to medium stiff. The granular material consists of silty sand and clayey gravel. The relative density of the granular materials varies from loose to very dense and generally increases with depth. An available summary of the engineering properties of the foundation materials for the Old West Polishing Pond and Old West Ash Pond is presented in **Table 1** below. The engineering properties are based on previous geotechnical explorations and laboratory testing.

Table 1. Summary of Material Engineering Properties for the Old West Polishing Pond and Old West Ash Pond

Layer	Unit Weight (pcf)	Total (undrained) Shear Strength Parameters		Effective (drained) Shear Strength Parameters	
		ϕ (deg)	*c (psf)*	*ϕ′ (deg)*	*c′ (psf)*
CL (soft)	120	0	500	28	0
CL (medium stiff gravely clay)	120	28	0	28	0
ML (soft to medium stiff)	125	28	0	28	0
CL-ML (very soft)	120	0	400	26	0
SM (very loose)	125	28	0	28	0
GC (dense)	130	34	0	34	0
GC (very dense)	130	36	0	36	0
Fill: GC (very dense)	130	34	50	34	0

West Polishing Pond, Old West Ash Pond, and Ash Pond No. 2 are subject to the Design Criteria or all Operating Criteria in the CCR Rule.

The Old West Polishing Pond and Old West Ash Pond are enclosed impoundments with dikes and do not have abutments.

Physical properties of the foundation and abutment materials for Ash Pond No. 2 and the East Ash Pond are described as gravel materials with varying amounts of silt and clay. The relative density of the gravel is medium dense to very dense. An available summary of the engineering properties of the foundation materials for Ash Pond No. 2 and the East Ash Pond is presented in **Table 2** below. The engineering properties are based on previous geotechnical explorations and laboratory testing.

Table 2. Summary of Foundation and Abutment Material Engineering Properties for the Ash Pond No. 2 and East Ash Pond

Material	Unit Weight (pcf)	Effective (drained) Shear Strength Parameters		Total (undrained) Shear Strength Parameters	
		c' (psf)	Φ' (°)	c (psf)	Φ (°)
Alluvial Foundation	135	0	38	0	38

§ 257.73(c)(1)(vi): A statement of the type, size, range, and physical and engineering properties of the materials used in constructing each zone or stage of the CCR unit; the method of site preparation and construction of each zone of the CCR unit; and the approximate dates of construction of each successive stage of construction of the CCR unit.

Physical properties of the embankment materials for the Old West Polishing Pond and Old West Ash Pond are described as gravel with occasional zones of clayey sand and lean clay. The gravel has a general relative density of very dense. An available summary of the engineering properties of the embankment materials for the Old West Polishing Pond and Old West Ash Pond is presented in **Table 1** above. The engineering properties are based on previous geotechnical explorations and laboratory testing.

The physical properties of Ash Pond No. 2 embankment construction materials are described in this paragraph. The original embankments are constructed of sand with varying amounts of coal pieces and gravel. The initial embankment raise is constructed of silty clay, clayey sand, sand, and gravel and the later embankment raise is constructed with layers of lean clay, silty clay, clayey silt, clayey, and gravel. An available summary of the engineering properties of the embankment materials for Ash Pond No. 2 is presented in **Table 3** below. The engineering properties are based on previous geotechnical explorations and laboratory testing.

Table 3. Summary of Construction Material Engineering Properties for Ash Pond No. 2

Material	Unit Weight (pcf)	Effective (drained) Shear Strength Parameters		Total (undrained) Shear Strength Parameters	
		c' (psf)	Φ' (°)	c (psf)	Φ (°)
Fill: GP-GM (medium dense)	125	0	32	0	32
Fill: CL (hard)	120	0	32	4000	0
Fill: ML (hard)	120	0	32	4500	0
Fill: SC (medium dense)	120	0	28	0	28

Physical properties of the embankment materials for the East Ash Pond are described as clayey silt and clay. The consistency of both the clayey silt and clay ranges from stiff to hard. The original pond surface is lined with a 4-foot thick compacted clay layer of 1.0×10^{-7} cm/s underlain by a 1-foot thick sand layer. The liner system of the embankment raise consists of a (from top to bottom) 45 mil reinforced polyethylene geomembrane, a 1-foot thick clay layer, and an 8 oz/sy polypropylene geotextile. A typical cross section profile of the liner system is shown on drawing C-56 presented in **Appendix B**. An available summary of the construction material engineering properties for the East Ash Pond is presented in **Table 4** below. The engineering properties are based on previous geotechnical explorations and laboratory testing.

Table 4. Summary of Construction Material Engineering Properties for the East Ash Pond

Material	Unit Weight (pcf)	Effective (drained) Shear Strength Parameters		Total (undrained) Shear Strength Parameters	
		c' (psf)	Φ' (°)	c (psf)	Φ (°)
Embankment Fill	105	30	32	2500	0
Liner System	120	60	30	2500	0

The method of site preparation and construction of the Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and the original East Ash Pond are not reasonably and readily available. Site preparation and construction of the 2003 East Ash Pond liner raise were completed in accordance with the applicable construction specification (see § 257.73(c)(1)(xi) below).

Reasonably and readily available approximate dates of construction of each successive stage of construction of the Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and East Ash Pond are provided in **Table 5** below.

Table 5. Approximate dates of construction of each successive stage of construction.

Date	Event
1951 to 1952	Construction of historical Ash Pond No. 1
1958	Construction of Ash Pond No. 2
Late 1960's	Construction of historical Ash Pond No. 3
1978	Embankment raise of Ash Pond No. 2
1985	Embankment raise of Ash Pond No. 2 to elevation 484 feet and Ash Pond No. 3 (Old West Ash Pond) to elevation 460 feet
1988 to 1989	Embankment raise of Old West Ash Pond to elevation 465 feet that merged historical Ash Pond No. 1 and Ash Pond No. 3 into one single pond and created the Old West Polishing Pond
1989	Embankment raise of Ash Pond No. 2 to elevation 494 feet
1995 to 1996	Construction of East Ash Pond
2003	Embankment liner raise of East Ash Pond
2009 to 2010	Eastern portion of Ash Pond No. 2 was removed to facilitate construction of the Leachate Pond
2011	Landfill Cell 1 was constructed over placed CCR in Ash Pond No. 2 adjacent to the Leachate Pond
2014	North Embankment tree removal, grading, and vegetation re-establishment of Ash Pond No. 2

§ 257.73(c)(1)(vii): At a scale that details engineering structures and appurtenances relevant to the design, construction, operation, and maintenance of the CCR unit, detailed dimensional drawings of the CCR unit, including a plan view and cross sections of the length and width of the CCR unit, showing all zones, foundation improvements, drainage provisions, spillways, diversion ditches, outlets, instrument locations, and slope protection, in addition to the normal operating pool surface elevation and the maximum pool surface elevation following peak discharge from the inflow design flood, the expected maximum depth of CCR within the CCR surface impoundment, and any identifiable natural or manmade features that could adversely affect operation of the CCR unit due to malfunction or mis-operation.

Drawings that contain items pertaining to the requested information for the Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and East Ash Pond are listed in **Table 6** below. Items marked as "Not Available" are items not found during a review of the reasonably and readily available record documentation.

Table 6. List of drawings containing items pertaining to the information requested in § 257.73(c)(1)(vii).

	Old West Polishing Pond	Old West Ash Pond	Ash Pond No. 2	East Ash Pond
Dimensional plan view (all zones)	HEN1-B460-2	HEN1-B460-1 to 2	HEN1-B461, HEN1-C117	HEN1-C55
Dimensional cross sections	HEN1-B452 to B457	HEN1-B452 to B457	HEN1-B458-1 to 7, Berm Modification Drawings 7 to 9	HEN1-C56 to C59
Foundation Improvements	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Drainage Provisions	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Spillways and Outlets	Not Available	Not Available	Not Applicable	HEN1-C8 to C9, HEN1-C109, HEN1-C113
Diversion Ditches	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Instrument Locations	Figure 2D	Figure 2C	Figure 2A	Figure 2B
Slope Protection	Not Available	Not Available	Berm Modification Drawings 3 to 9	HEN1-C56 to C59
Normal Operating Pool Elevation	Not Available	Not Available	Not Available	Not Available
Maximum Pool Elevation	Not Available	Not Available	Not Available	Not Available
Approximate Maximum Depth of CCR in 2016	11 feet	15 feet	46 feet	35 feet

All drawings referenced in **Table 6** above can be found in **Appendix B** and **Appendix C**.

Based on the review of the drawings listed above, no natural or manmade features that could adversely affect operation of these CCR units due to malfunction or mis-operation were identified.

§ 257.73(c)(1)(viii): A description of the type, purpose, and location of existing instrumentation.

Existing instrumentation consists of open-standpipe piezometers installed in 2015. The purpose of the piezometers is to measure the pore water pressures within the embankments of the Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and East Ash Pond. There are seven (7) existing piezometers within the Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and East Ash Pond. A location map of the existing instrumentation is presented in **Appendix C**.

§ 257.73(c)(1)(ix): Area-capacity curves for the CCR unit.

Area-capacity curves for the Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and East Ash Pond are not reasonably and readily available.

§ 257.73(c)(1)(x): A description of each spillway and diversion design features and capacities and calculations used in their determination.

The Old West Polishing Pond contains a 24-inch diameter corrugated metal pipe (CMP) outlet that discharges stormwater to the Illinois River in accordance with the station's NPDES permit. Current capacity and calculation information for the Old West Polishing Pond's discharge capability is not reasonably and readily available.

The Old West Ash Pond contains a 24-inch dia. pipe culvert. Stormwater collected within the CCR unit drains via surface flow and through the pipe culvert into the Old West Polishing Pond. Current capacity and calculation information for the Old West Ash Pond's discharge capability is not reasonably and readily available.

The Ash Pond No. 2 does not contain a spillway or diversion feature. Stormwater collected within the CCR unit drains via surface flow into the East Ash Pond. Current capacity and calculation information for the Ash Pond No. 2's discharge capability is not reasonably and readily available.

The East Ash Pond contains two outlet structures. The southeast outlet is a 5-foot wide stop-log structure that is connected to a 36-inch diameter reinforced concrete pipe (RCP). The 36-inch diameter RCP discharges into the East Polishing Pond. The northeast outlet, located on the northeast corner of the East Ash Pond, is a headwall structure connected to an 18-inch diameter RCP. The 18-inch diameter RCP discharges into the East Leachate Pond. In 2016, the discharge capacity of the East Ash Pond was evaluated using HydroCAD 10 software modeling a 1,000-year, 24-hour rainfall event. The model results indicate that the East Ash Pond has enough storage capacity and will not overtop the embankment during the 1,000-year, 24-hour storm event. The results of the HydroCAD 10 analysis are presented below in **Table 7**.

Table 7. Results of HydroCAD 10 analysis

	East Ash Pond
Approximate Minimum Berm Elevation[1] (ft)	493.0
Approximate Emergency Spillway Elevation[1] (ft)	Not Applicable
Starting Pool Elevation[1] (ft)	490.4
Peak Elevation[1] (ft)	492..2
Time to Peak (hr)	12.5
Surface Area (ac)	6.5
Storage[2] (ac-ft)	8.4

Note: 1. Elevations are based on NAVD88 datum
2. Storage given is from Starting Pool Elevation to Peak Elevation.

§ 257.73(c)(1)(xi): The construction specifications and provisions for surveillance, maintenance, and repair of the CCR unit.

The construction specifications for Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and the original East Ash Pond are not reasonably and readily available. The construction specification for the 2003 East Ash Pond liner raise is located in *Specification J-2616, Rev. A* (presented in **Appendix D**).

The provisions for surveillance, maintenance, and repair of the Old West Polishing Pond and Old West Ash Pond are located in *Hennepin Power Station; West Ash Disposal Pond Maintenance Plan* (2013) (presented in **Appendix E**). The provisions for surveillance, maintenance, and repair of Ash Pond No. 2 are located in *Hennepin Power Station; Old East Ash Disposal Pond Maintenance Plan* (2013) (presented in **Appendix F**). The provisions for surveillance, maintenance, and repair of the East Ash Pond are located in *Hennepin Power Station; East Ash Disposal Pond Maintenance Plan* (2014) (presented in **Appendix G**).

The operations and maintenance plans for the Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and East Ash Pond are currently being revised by Dynegy Midwest Generation, LLC.

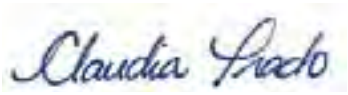
§ 257.73(c)(1)(xii): Any record or knowledge of structural instability of the CCR unit.

There is no record or knowledge of structural instability of the Old West Polishing Pond, Old West Ash Pond, Ash Pond No. 2, and East Ash Pond at the Hennepin Power Station.

LIMITATIONS

The signature of AECOM's authorized representative on this document represents that to the best of AECOM's knowledge, information and belief in the exercise of its professional judgment, it is AECOM's professional opinion that the aforementioned information is accurate as of the date of such signature. Any recommendation, opinion or decisions by AECOM are made on the basis of AECOM's experience, qualifications and professional judgment and are not to be construed as warranties or guaranties. In addition, opinions relating to environmental, geologic, and geotechnical conditions or other estimates are based on available data and that actual conditions may vary from those encountered at the times and locations where data are obtained, despite the use of due care.

Sincerely,



Claudia Prado
Project Manager



Victor Modeer, P.E., D.GE
Senior Project Manager

REFERENCES

United States Environmental Protection Agency (USEPA). (2015). *Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities; Final Rule.* 40 CFR Parts 257 and 261, 80 Fed. Reg. 21302, 21380 April 17, 2015.

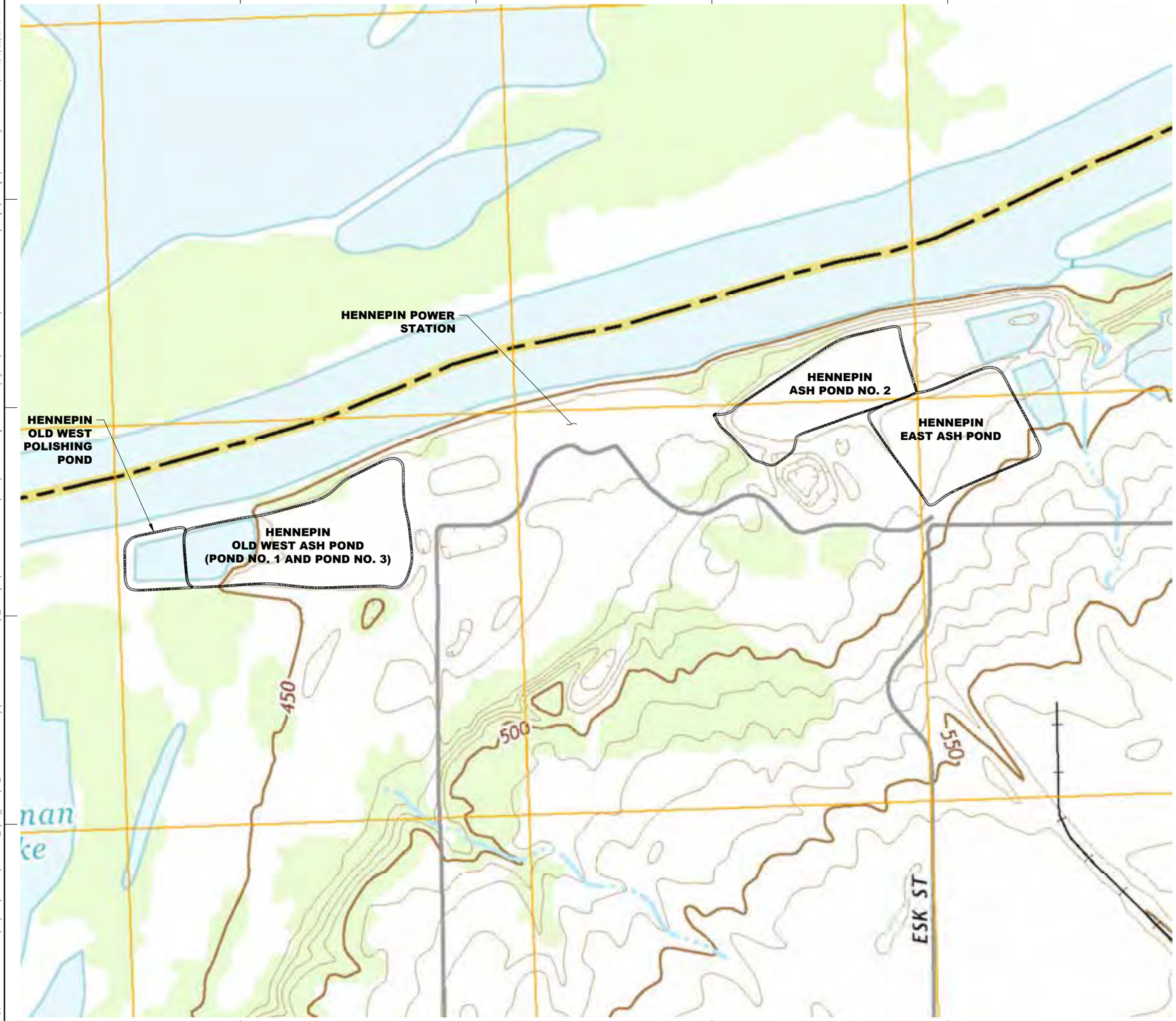
United States Geological Survey (USGS). (2016). The National Map Viewer. http://viewer.nationalmap.gov/viewer/. USGS data first accessed in March of 2016.

APPENDICES

Appendix A: History of Construction Vicinity Map
Appendix B: Hennepin Power Station Drawings
Appendix C: Hennepin Power Station Piezometer Locations
Appendix D: Specification J-2616, Rev. A, Primary Ash Pond Modifications
Appendix E: Hennepin Power Station; West Ash Disposal Pond Maintenance Plan (2013)
Appendix F: Hennepin Power Station; Old East Ash Disposal Pond Maintenance Plan (2013)
Appendix G: Hennepin Power Station; East Ash Disposal Pond Maintenance Plan (2014)

AECOM

Appendix A: History of Construction Vicinity Map



LEGEND

CCR UNITS

SOURCE:
MAP PROVIDED FROM ELECTRONIC USGS DIGITAL RASTER GRAPHIC 7.5 MINUTE TOPOGRAPHIC MAP OF DEPUE ILLINOIS, REVISED 2015.



QUADRANGLE LOCATION

N

0 400 800 1200

SCALE IN FEET

AECOM
1001 Highlands Plaza Drive, Suite 300
St. Louis, Mo. 63110
314 429-0100 (phone)
314-429-0462 (fax)

DYNEGY MIDWEST GENERATION, L.L.C.
13498 East 800th Street
Hennepin, IL 61327

HISTORY OF CONSTRUCTION

HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

ISSUED FOR BIDDING DATE BY

ISSUED FOR CONSTRUCTION DATE BY

REVISIONS

NO.	DESCRIPTION	DATE
△		
△		
△		
△		
△		

AECOM PROJECT NO:	60489731
DRAWN BY:	DJD
DESIGNED BY:	DJD
CHECKED BY:	MN
DATE CREATED:	2016-04-13
PLOT DATE:	
SCALE:	1" = 400'
ACAD VER:	2014

SHEET TITLE

HISTORY OF CONSTRUCTION VICINITY MAP

01

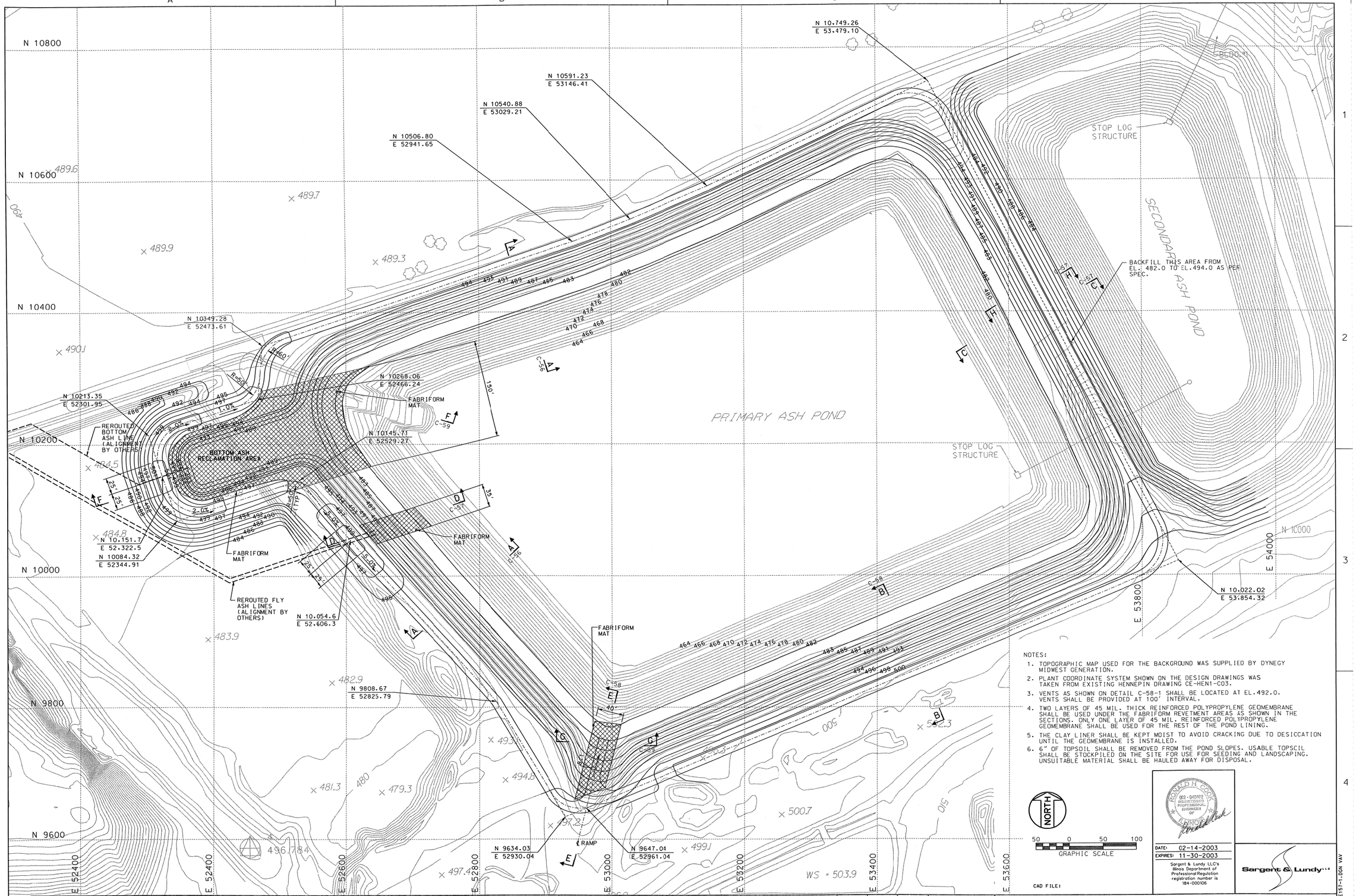
AECOM DRAWING PATH: P:\Projects\Geotech\60428794_DynegyCCR\13_Construction History\04 Technical Production\4_Hennepin\Reference Documents\Vicinity Location Map References\Figures\C-01 History of Construction Vicinity Map (Hennepin) - MAP.dwg NAWAK, MATT, 9/28/2016 4:11 PM

Appendix B: Hennepin Power Station Drawings

1. “Plan of Primary Ash Pond, Modification to Primary Ash Pond”, Drawing No. C-55, Revision 0.1, 14 February, 2003, Sargent & Lundy, LLC.
2. “Sections and Details – Sheet 1, Modification to Primary Ash Pond”, Drawing No. C-56, Revision 0.1, 14 February, 2003, Sargent & Lundy, LLC.
3. “Sections and Details – Sheet 2, Modification to Primary Ash Pond”, Drawing No. C-57, Revision 0.1, 14 February, 2003, Sargent & Lundy, LLC.
4. “Sections and Details – Sheet 3, Modification to Primary Ash Pond”, Drawing No. C-58, Revision 0.1, 14 February, 2003, Sargent & Lundy, LLC.
5. “Sections and Details – Sheet 4, Modification to Primary Ash Pond”, Drawing No. C-59, Revision 0.1, 14 February, 2003, Sargent & Lundy, LLC.
6. “Cross Sections of Ash Pond Berm Extension, Sta 1+00, 5+00 & 9+50”, Drawing No. E-HEN1-B452, Revision 0, 4 November, 1997, Illinois Power Company.
7. “Cross Sections of Ash Pond Berm Extension, Sta 14+25, 20+80 & 26+00”, Drawing No. E-HEN1-B453, Revision 0, 4 November, 1997, Illinois Power Company.
8. “Cross Sections of Ash Pond Berm Extension, Sta 30+00, 35+00 & 39+00”, Drawing No. E-HEN1-B454, Revision 0, 4 November, 1997, Illinois Power Company.
9. “Cross Sections of Ash Pond Berm Extension, Sta 40+00, 42+00, 44+90”, Drawing No. E-HEN1-B455, Revision 0, 4 November, 1997, Illinois Power Company.
10. “Cross Sections of Ash Pond Berm Extension, Sta 47+00, 51+00 & 56+00”, Drawing No. E-HEN1-B456, Revision 0, 4 November, 1997, Illinois Power Company.
11. “Cross Sections of Ash Pond Berm Extension, Sta 61+50”, Drawing No. E-HEN1-B457, Revision 0, 4 November, 1997, Illinois Power Company.
12. “Cross Sections, East Ash Pond Extension”, Drawing No. E-HEN1-B458-1, Revision 0, 8 March, 1990, Illinois Power Company.
13. “Cross Sections, East Ash Pond Extension”, Drawing No. E-HEN1-B458-2, Revision 0, 8 March, 1990, Illinois Power Company.
14. “Cross Sections, East Ash Pond Extension”, Drawing No. E-HEN1-B458-3, Revision 0, 8 March, 1990, Illinois Power Company.
15. “Cross Sections, East Ash Pond Extension”, Drawing No. E-HEN1-B458-4, Revision 0, 8 March, 1990, Illinois Power Company.
16. “Cross Sections, East Ash Pond Extension”, Drawing No. E-HEN1-B458-5, Revision 0, 8 March, 1990, Illinois Power Company.
17. “Cross Sections, East Ash Pond Extension”, Drawing No. E-HEN1-B458-6, Revision 0, 8 March, 1990, Illinois Power Company.
18. “Cross Sections, East Ash Pond Extension”, Drawing No. E-HEN1-B458-7, Revision 0, 8 March, 1990, Illinois Power Company.
19. “Plan-Unit #1 Ash Pond Extension, Sheet #1”, Drawing No. E-HEN1-B460-1, 2 February, 1988, Illinois Power Company.
20. “Plan-Unit #1 Ash Pond Extension, Sheet #2”, Drawing No. E-HEN1-B460-2, 2 February, 1988, Illinois Power Company.

Appendix B: Hennepin Power Station Drawings (continued)

21. “Contour and Grading Plan, Unit #2 Ash Pond Extension”, Drawing No. CE-HEN1-B461, Revision 0, 8 March, 1990, Illinois Power Company.
22. “Pond 2 East, Flexible Membrane Liner and Structures”, Drawing No. HEN1-C109, Revision 0, 28 July, 2010, Civil & Environmental Consultants, Inc.
23. “Pond 2 East, Details”, Drawing No. HEN1-C113, Revision 0, 28 July, 2010, Civil & Environmental Consultants, Inc.
24. “Landfill Phase 1 Construction, Existing Conditions”, Drawing No. HEN1-C117, Revision 0, 28 November, 2010, Civil & Environmental Consultants, Inc.
25. “Layout-Pond Discharge Structures, 1995 Ash Facility”, Drawing No. CE-HEN1-C8, Revision 0, 17 September, 1996, Illinois Power Company.
26. “Details: Pond Discharge Structure, 1995 Ash Facility”, Drawing No. CE-HEN1-C9, Revision 0, 17 September, 1996, Illinois Power Company.
27. “East Berm Modification, Existing Site Conditions”, Drawing No. 3, Revision 3, 4 February, 2015, Civil & Environmental Consultants, Inc.
28. “East Berm Modification, Proposed Site Plan”, Drawing No. 4, Revision 3, 4 February, 2015, Civil & Environmental Consultants, Inc.
29. “East Berm Modification, Proposed Grading Plan 1 of 2”, Drawing No. 5, Revision 3, 4 February, 2015, Civil & Environmental Consultants, Inc.
30. “East Berm Modification, Proposed Grading Plan 2 of 2”, Drawing No. 6, Revision 3, 4 February, 2015, Civil & Environmental Consultants, Inc.
31. “East Berm Modification, Proposed Sections Sta 1+00 to 15+00”, Drawing No. 7, Revision 3, 4 February, 2015, Civil & Environmental Consultants, Inc.
32. “East Berm Modification, Proposed Sections Sta 16+00 to 23+50”, Drawing No. 8, Revision 3, 4 February, 2015, Civil & Environmental Consultants, Inc.
33. “East Berm Modification, Berm and Erosion Control Details”, Drawing No. 9, Revision 3, 4 February, 2015, Civil & Environmental Consultants, Inc.



NOTES:

1. TOPOGRAPHIC MAP USED FOR THE BACKGROUND WAS SUPPLIED BY DYNEGY MIDWEST GENERATION.
2. PLANT COORDINATE SYSTEM SHOWN ON THE DESIGN DRAWINGS WAS TAKEN FROM EXISTING HENNEPIN DRAWING CE-HEN1-C03.
3. VENTS AS SHOWN ON DETAIL C-58-1 SHALL BE LOCATED AT EL.492.0. VENTS SHALL BE PROVIDED AT 100' INTERVAL.
4. TWO LAYERS OF 45 MIL. THICK REINFORCED POLYPROPYLENE GEOMEMBRANE SHALL BE USED UNDER THE FABRIFORM REVETMENT AREAS AS SHOWN IN THE SECTIONS. ONLY ONE LAYER OF 45 MIL. REINFORCED POLYPROPYLENE GEOMEMBRANE SHALL BE USED FOR THE REST OF THE POND LINING.
5. THE CLAY LINER SHALL BE KEPT MOIST TO AVOID CRACKING DUE TO DESICCATION UNTIL THE GEOMEMBRANE IS INSTALLED.
6. 6" OF TOPSOIL SHALL BE REMOVED FROM THE POND SLOPES. USABLE TOPSCIL SHALL BE STOCKPILED ON THE SITE FOR USE FOR SEEDING AND LANDSCAPING. UNSUITABLE MATERIAL SHALL BE HAULED AWAY FOR DISPOSAL.

NORTH

50 0 50 100
GRAPHIC SCALE

CAD FILE:

RONALD H. COOK 062-040902 REGISTERED PROFESSIONAL ENGINEER OF ILLINOIS

DATE: 02-14-2003
EXPIRES: 11-30-2003

Sargent & Lundy LLC's Illinois Department of Professional Regulation registration number is 184-000106

Sargent & Lundy LLC

DYNEGY CONFIDENTIAL
This drawing is the property of DYNEGY INC. Neither this drawing, nor reproductions of it, nor information derived from it, shall be given to others without the expressed written consent of DYNEGY INC. No use is to be made of it which is, or may be, injurious to DYNEGY INC.

REFERENCE DRAWINGS

NO.	DATE	REVISION	PREP'D	REV'D	APPR'D
0.1	02-14-2003	FOR PERMIT	MED	VP	

NO.	DATE	REVISION	PREP'D	REV'D	APPR'D

SCALE:	1"=50'	
DWN. M.DOWNS	DATE	02-12-03
CHK. V.PATEL	DATE	02-14-03
APPV.	DATE	

DYNEGY

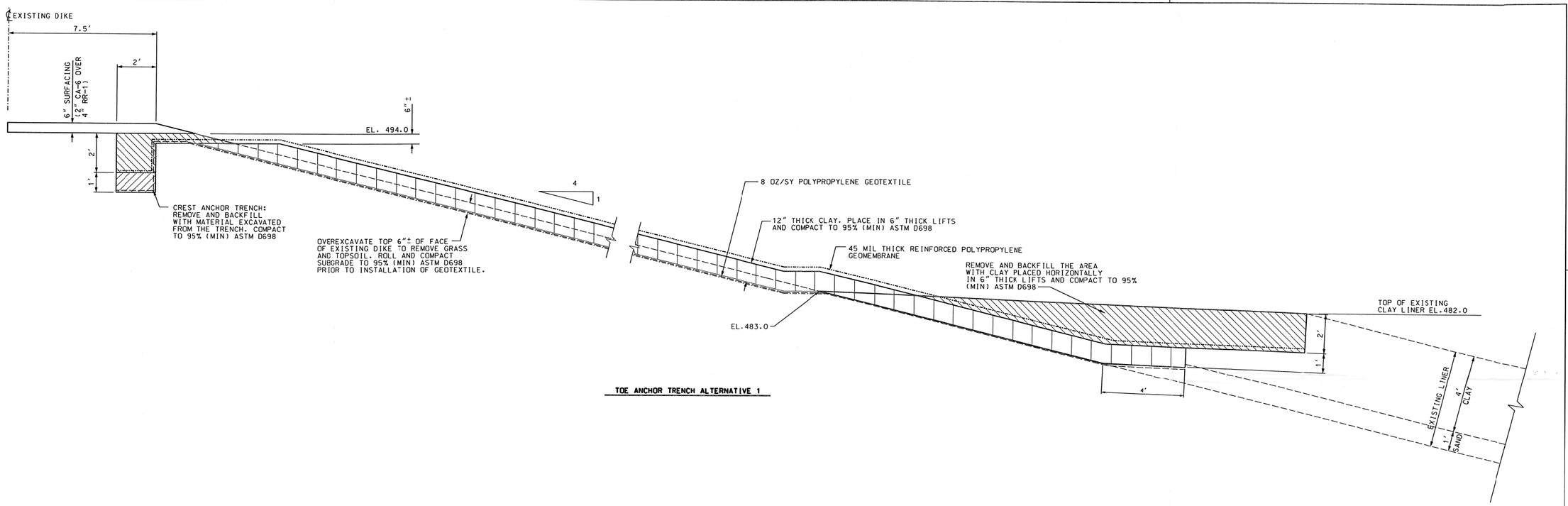
PLAN OF PRIMARY ASH POND

MODIFICATION TO PRIMARY ASH POND
HENNEPIN POWER STATION

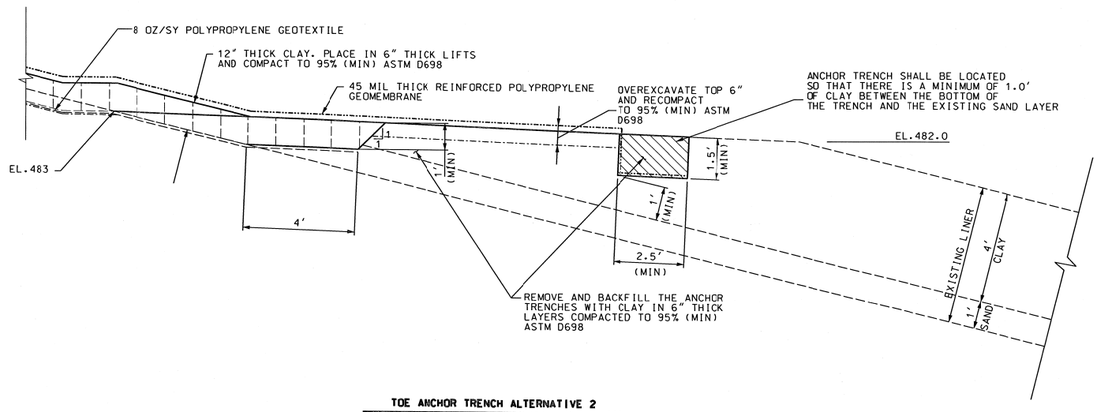
PROJECT NO.: 08820-331
CLIENT: DYNEGY MIDWEST GENERATION
DWG. NO.: C-55
REV.: 0.1

E-WDRT-E157-1.DGN VAY
07-10-2001

02-13-03 ALS



TOE ANCHOR TRENCH ALTERNATIVE 1



TOE ANCHOR TRENCH ALTERNATIVE 2

SECTION A
SEE DWG C-55

2 0 2 4
GRAPHIC SCALE
HOR 1/2"=1'-0"

2 0 2 4
GRAPHIC SCALE
VER 1/2"=1'-0"

NOTES:

1. CONTRACTOR SHALL BE RESPONSIBLE FOR CHECKING EXISTING ELEVATIONS AND DIMENSIONS PRIOR TO FABRICATION OF THE GEOMEMBRANE LINER.
2. CONTRACTOR MAY USE EITHER ALTENATIVE 1 OR ALTERNATIVE 2 AS APPROVED BY THE BUYER FOR ALL TOE ANCHOR TRENCH DETAILS.
3. DIMENSIONS WERE TAKEN FROM TYPICAL SECTION ON DRAWING CH-HEN1-C6.1 DATED 12-9-93.

DYNEGY CONFIDENTIAL
This drawing is the property of DYNEGY INC. Neither this drawing, nor reproductions of it, nor information derived from it, shall be given to others without the expressed written consent of DYNEGY INC. No use is to be made of it which is, or may be, injurious to DYNEGY INC.

REFERENCE DRAWINGS

NO.	DATE	REVISION	PREP'D	REV'D	APPR'D
0.1	02-14-2003	FOR PERMIT	MED	VP	

CAD FILE:

DATE: 02-14-2003
EXPIRES: 11-30-2003
Sargent & Lundy LLC's Illinois Department of Professional Regulation registration number is 184-000106

Sargent & Lundy LLC

SCALE:
DWN. M.DOWNS DATE 02-12-02
CHK. V.PATEL DATE 02-14-03
APPV. DATE

DYNEGY

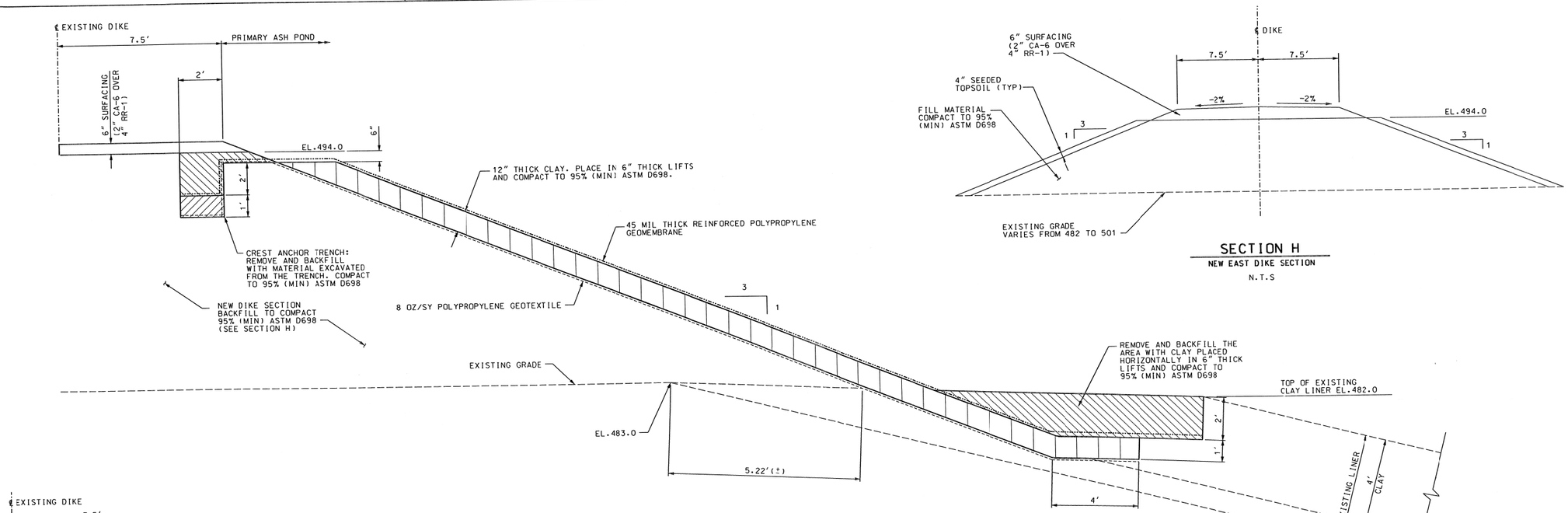
SECTIONS AND DETAILS - SHEET 1

MODIFICATION TO PRIMARY ASH POND
HENNEPIN POWER STATION

PROJECT NO.: 08820-331
CLIENT: DYNEGY MIDWEST GENERATION
DWG. NO.: C-56 REV. 0.1

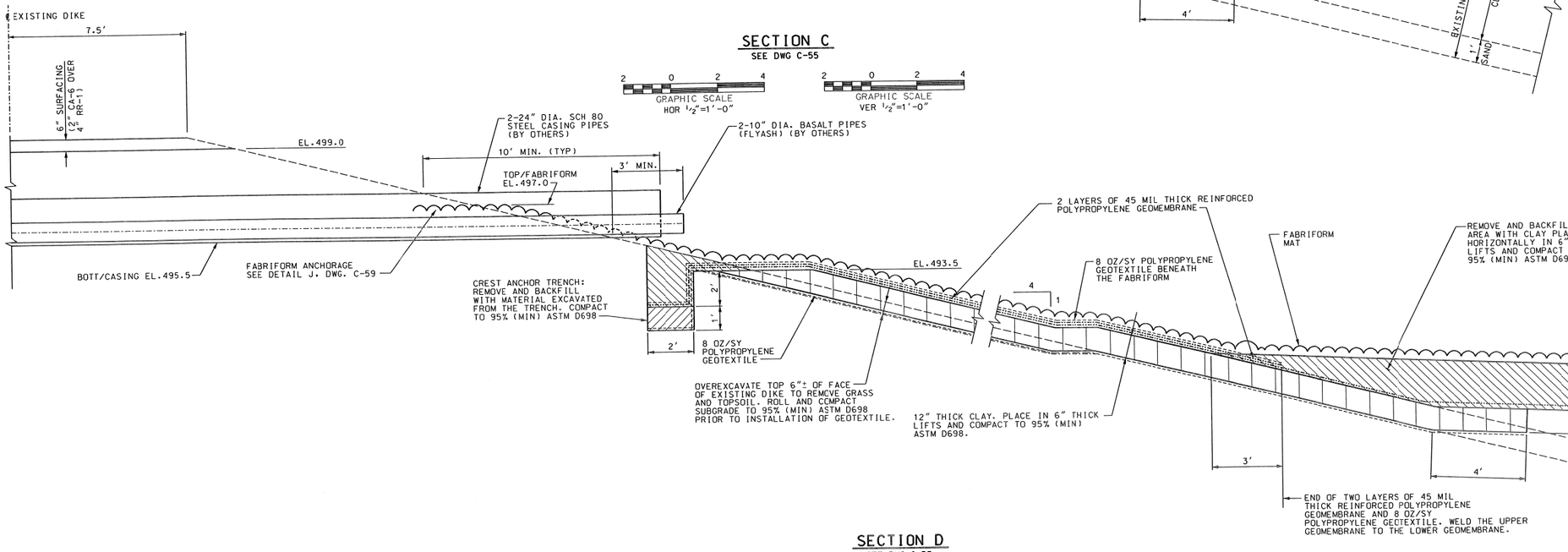
E-MGN-4157-1.DGN VAN 07-10-2001

02-13-03 ALS



SECTION C
SEE DWG C-55

SECTION H
NEW EAST DIKE SECTION
N.T.S



SECTION D
SEE DWG C-55







DATE: 02-14-2003
EXPIRES: 11-30-2003

Sargent & Lundy LLC's Illinois Department of Professional Regulation registration number is 184-000106

Sargent & Lundy LLC

CAD FILE: E-MDR1-E157-1.DGN VAV

DYNEGY CONFIDENTIAL
This drawing is the property of DYNEGY INC. Neither this drawing, nor reproductions of it, nor information derived from it, shall be given to others without the expressed written consent of DYNEGY INC. No use is to be made of it which is, or may be, injurious to DYNEGY INC.

REFERENCE DRAWINGS

NO.	DATE	REVISION	PREP'D	REV'D	APPR'D
0.1	02-14-2003	FOR PERMIT	MED	VP	———

NO.	DATE	REVISION	PREP'D	REV'D	APPR'D

SCALE: 1/2"=1'-0"
DWN. M.DOWNS DATE 02-12-02
CHK. V.PATEL DATE 02-14-03
APPV. DATE

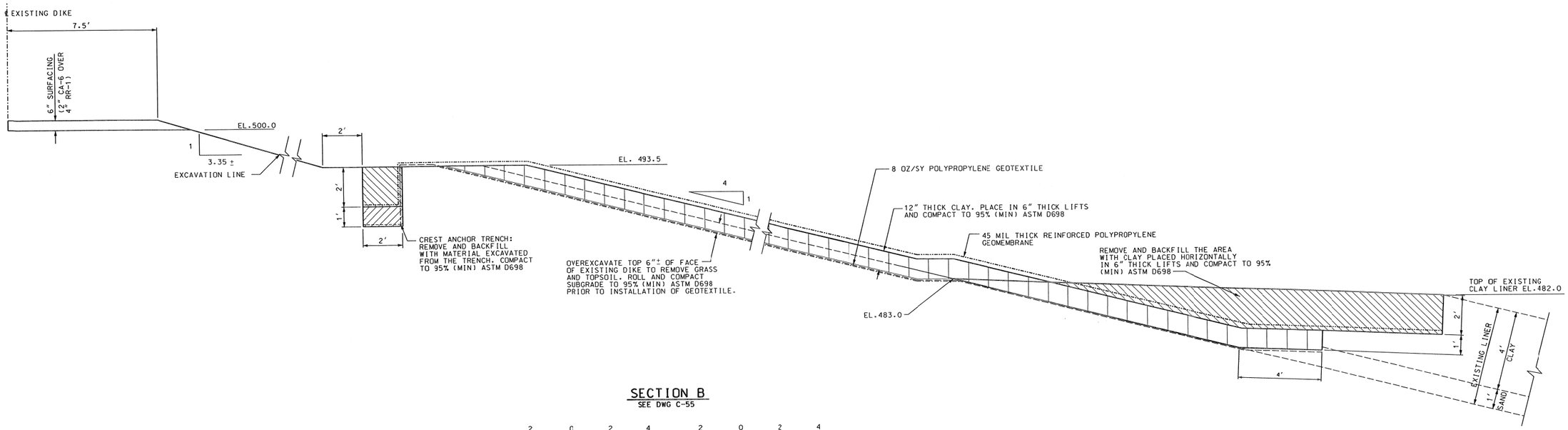
DYNEGY

SECTIONS AND DETAILS - SHEET 2

MODIFICATION TO PRIMARY ASH POND
HENNEPIN POWER STATION

PROJECT NO.: 08820-331
CLIENT: DYNEGY MIDWEST GENERATION
DWG. NO.: C-57
REV.: 0.1

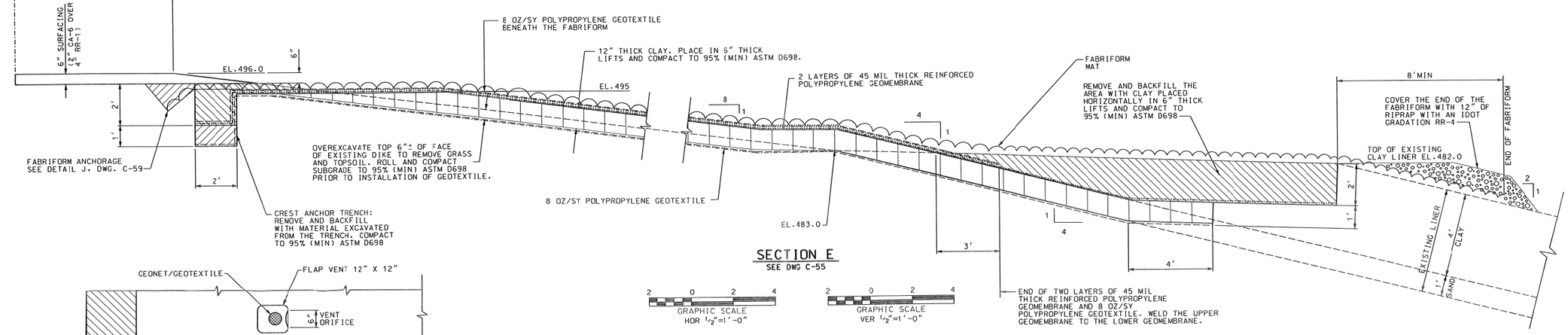
07-10-2001
02-13-03 ALS



SECTION B
SEE DWG C-55

2 0 2 4
GRAPHIC SCALE
HOR 1/2"=1'-0"

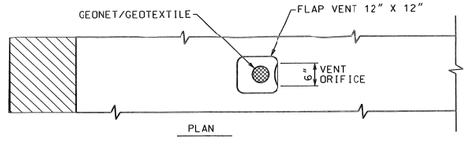
2 0 2 4
GRAPHIC SCALE
VER 1/2"=1'-0"



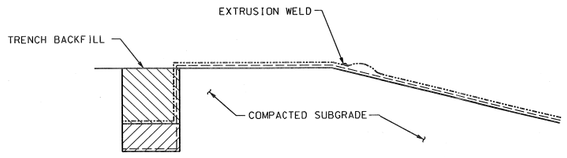
SECTION E
SEE DWG C-55

2 0 2 4
GRAPHIC SCALE
HOR 1/2"=1'-0"

2 0 2 4
GRAPHIC SCALE
VER 1/2"=1'-0"



PLAN



SECTION

DETAIL C-58-1
MAXIMUM INTERVAL SHALL BE 100'

RONALD H. SCOTT
062-048012
REGISTERED
PROFESSIONAL
ENGINEER
OF
ILLINOIS

DATE: 02-14-2003
EXPIRES: 11-30-2003

Sargent & Lundy LLC's Illinois Department of Professional Regulation registration number is 184-000106

Sargent & Lundy LLC

CAD FILE:

DYNEGY CONFIDENTIAL
This drawing is the property of DYNEGY INC. Neither this drawing, nor reproductions of it, nor information derived from it, shall be given to others without the expressed written consent of DYNEGY INC. No use is to be made of it which is, or may be, injurious to DYNEGY INC.

REFERENCE DRAWINGS

NO.	DATE	REVISION	PREP'D	REV'D	APPR'D
0.1	02-14-2003	FOR PERMIT	MED	VP	———

NO.	DATE	REVISION	PREP'D	REV'D	APPR'D

SCALE	1/2"=1'-0"	
DWN.	M.DOWNS	DATE 02-14-03
CHK.	V.PATEL	DATE 02-14-03
APPV.		DATE

DYNEGY

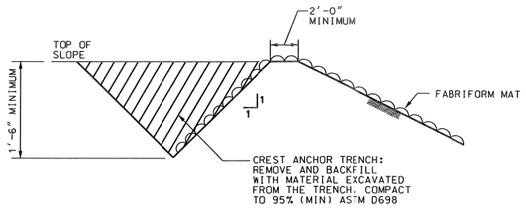
SECTIONS AND DETAILS - SHEET 3

MODIFICATION TO PRIMARY ASH POND
HENNEPIN POWER STATION

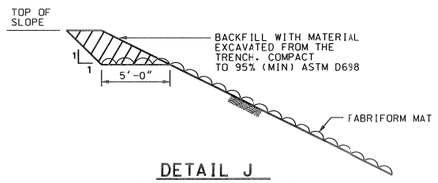
PROJECT NO.: 08820-331
CLIENT: DYNEGY MIDWEST GENERATION
DWG. NO.: C-58
REV.: 0.1

02-12-03 ALS

E-MDR1-E157-1.DGN VAV
07-10-2001

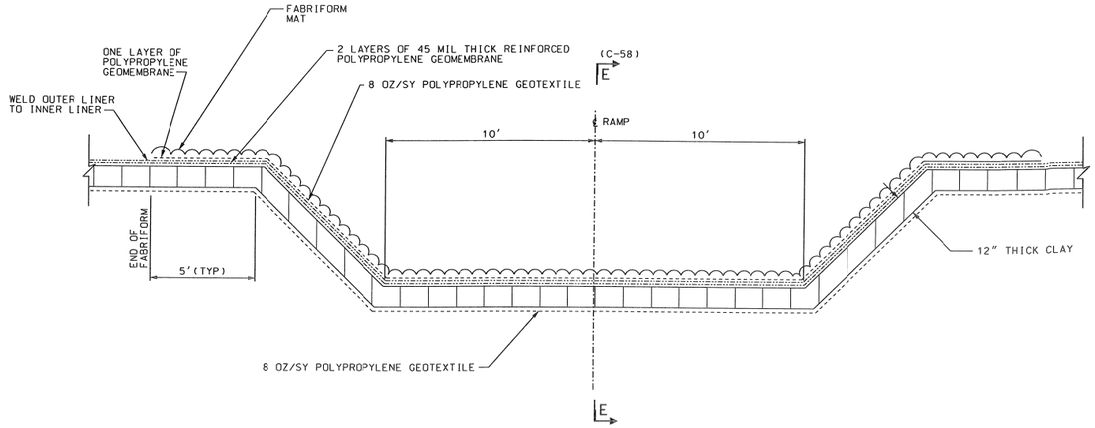


ANCHORAGE IF PROTECTION IS PROVIDED TO THE TOP OF THE SLOPE



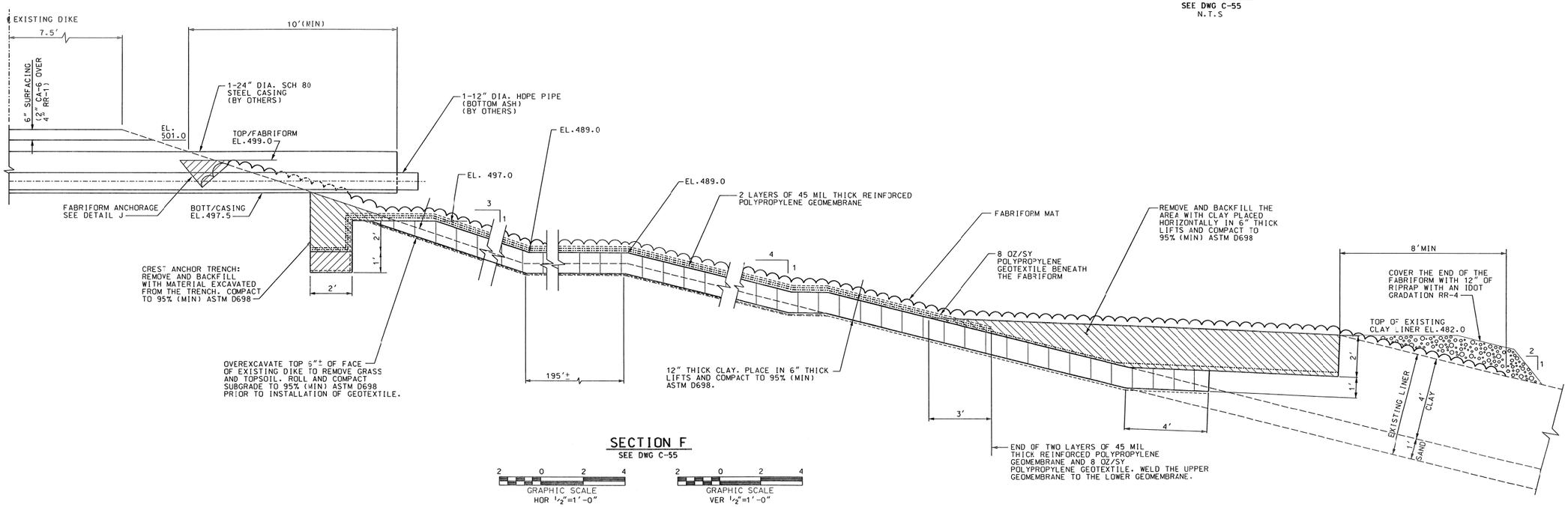
DETAIL J

ANCHORAGE FOR FABRIFORM MAT
N.T.S.



SECTION G

SEE DWG C-55
N.T.S



SECTION F

SEE DWG C-55

2 0 2 4
GRAPHIC SCALE
HOR 1/2"=1'-0"

2 0 2 4
GRAPHIC SCALE
VER 1/2"=1'-0"

RONALD H. COOK
023-048322
REGISTERED PROFESSIONAL ENGINEER OF ILLINOIS

DATE: 02-14-2003
EXPIRES: 11-30-2003

Sargent & Lundy LLC's Illinois Department of Professional Regulation registration number is 184-000106

Sargent & Lundy LLC

CAD FILE:

DYNEGY CONFIDENTIAL
This drawing is the property of DYNEGY INC. Neither this drawing, nor reproductions of it, nor information derived from it, shall be given to others without the expressed written consent of DYNEGY INC. No use is to be made of it which is, or may be, injurious to DYNEGY INC.

REFERENCE DRAWINGS

NO.	DATE	REVISION	PREP'D	REV'D	APPR'D
0.1	02-14-2003	FOR PERMIT	MED	VP	———

NO.	DATE	REVISION	PREP'D	REV'D	APPR'D

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

DWN.	M.DOWNS	DATE 02-12-02
CHK.	V.PATEL	DATE 02-14-03
APPV.		DATE

DYNEGY

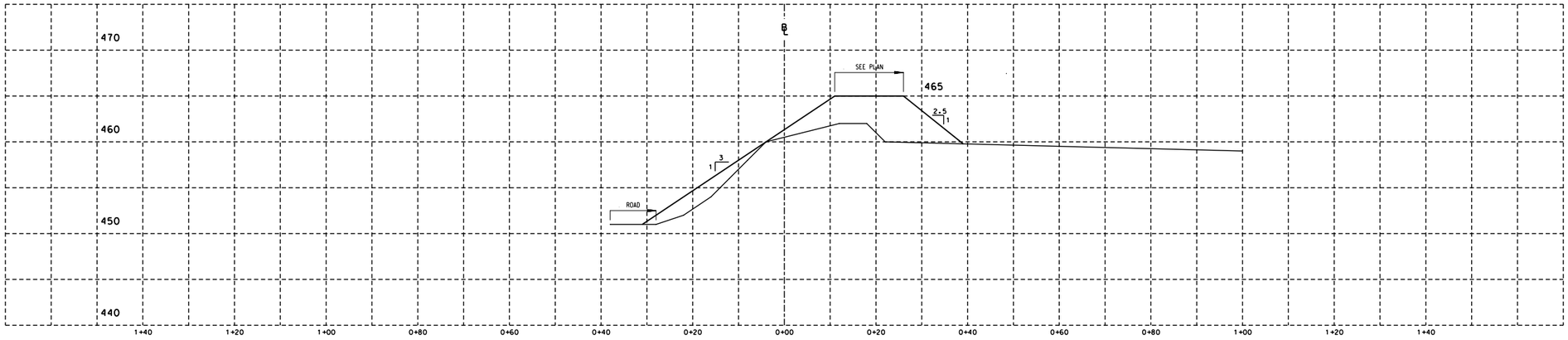
SECTIONS AND DETAILS - SHEET 4

MODIFICATION TO PRIMARY ASH POND
HENNEPIN POWER STATION

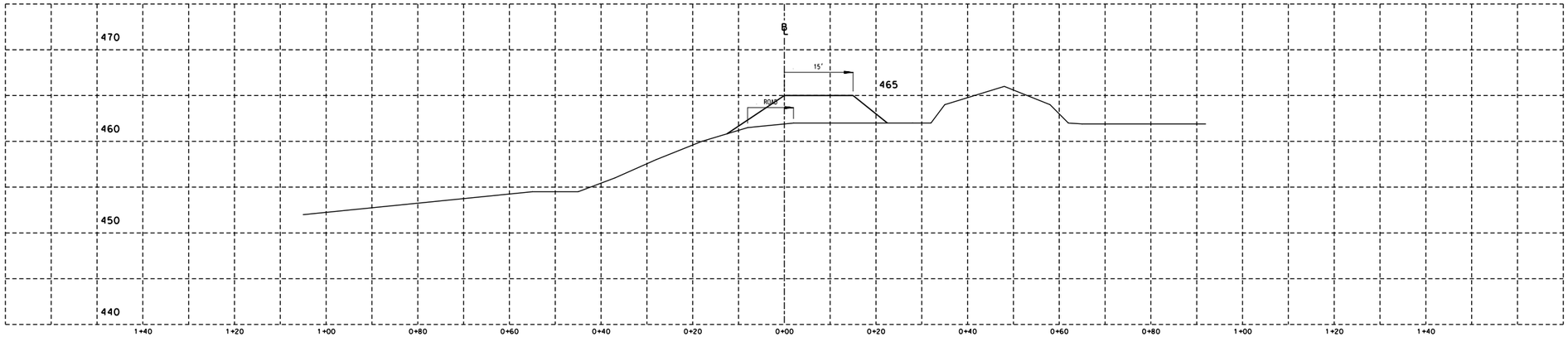
PROJECT NO.: 08820-331
CLIENT: DYNEGY MIDWEST GENERATION
DWG. NO.: C-59
REV.: 0.1

02-13-03 ALS

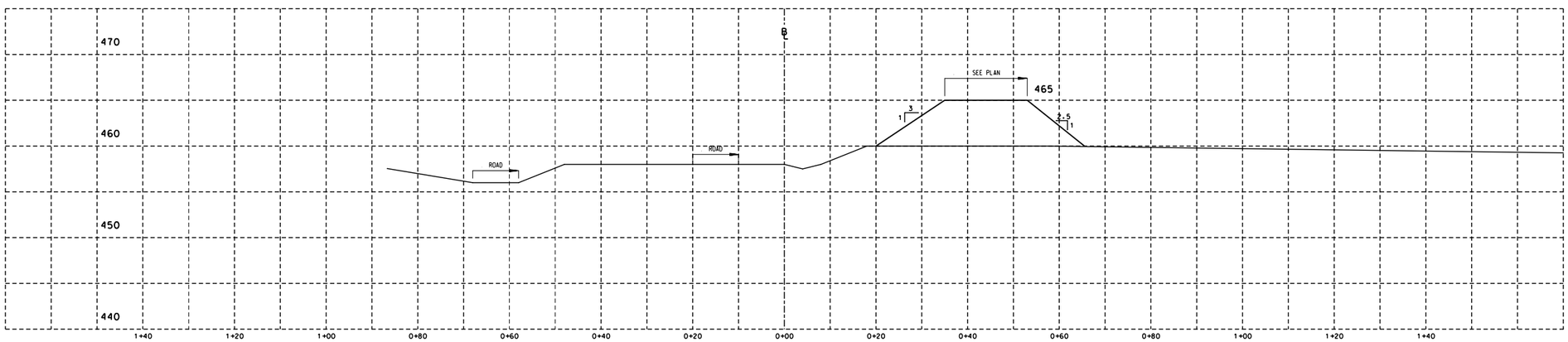
E-MAIL-5151-1.DGN V4A
01-10-2001



STATION 9+50



STATION 5+00



STATION 1+00

LEDGEND

- ℄ REFERENCE BASE LINE SHOWN ON PLAN
- OLD BERM
- NEW BERM
- ▽ WATER LINE
- ✳ ESTIMATED ELEVATION

NO	DATE	DRF	DESCRIPTION	E	C	A
0						

NOTES

REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD
(0)

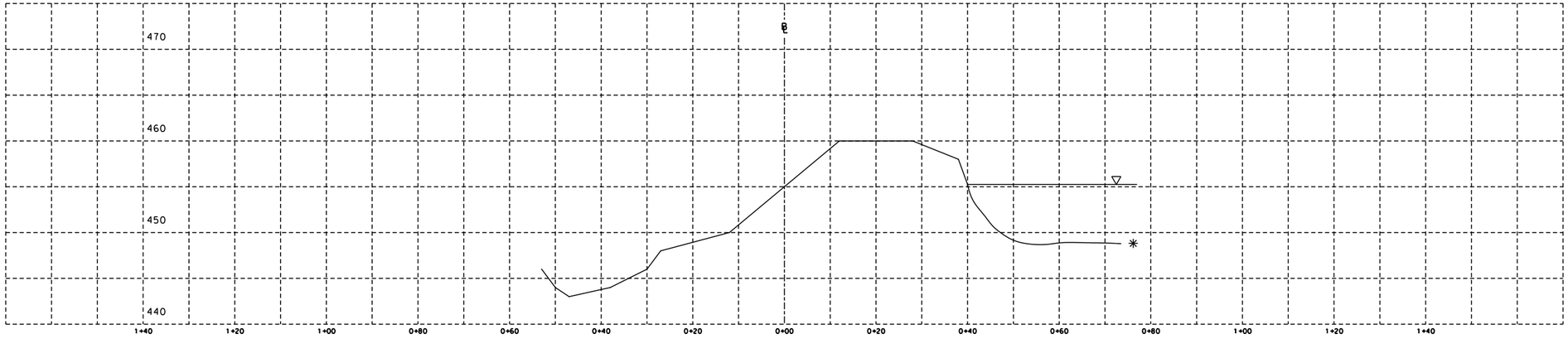
ILLINOIS POWER COMPANY
DECATUR

CROSS SECTIONS OF
ASH POND BERM EXTENSION
STA 1+00, 5+00 & 9+50
HENNEPIN POWER STATION

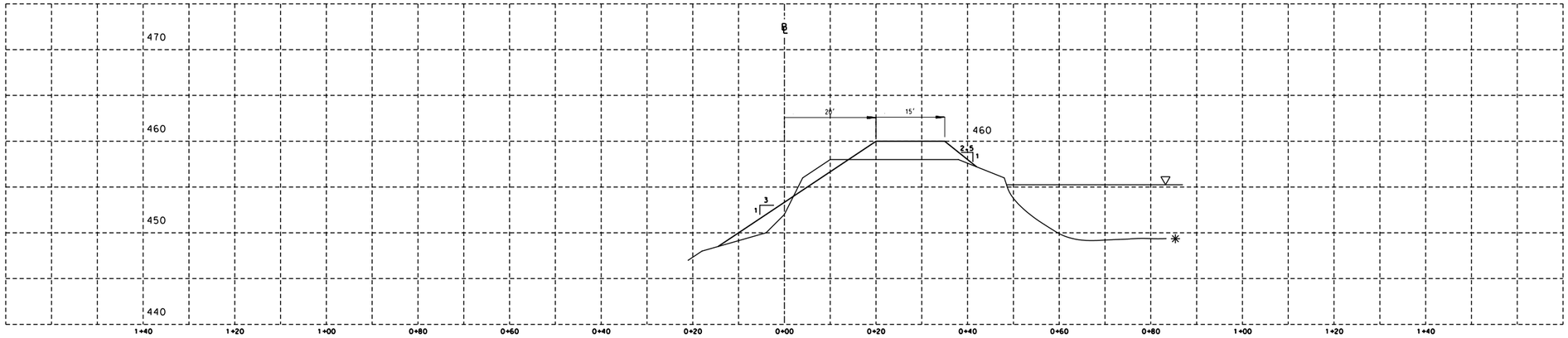
DR GRH	CAD EM	DATE 12-30-87
OK	CKD	SCALE 1"=10'H,1"=5'V
APP	PLOTTED 11-4-97	E-HEN1-B452
APP		

COMPUTER DNG. - DO NOT REVISE MANUALLY

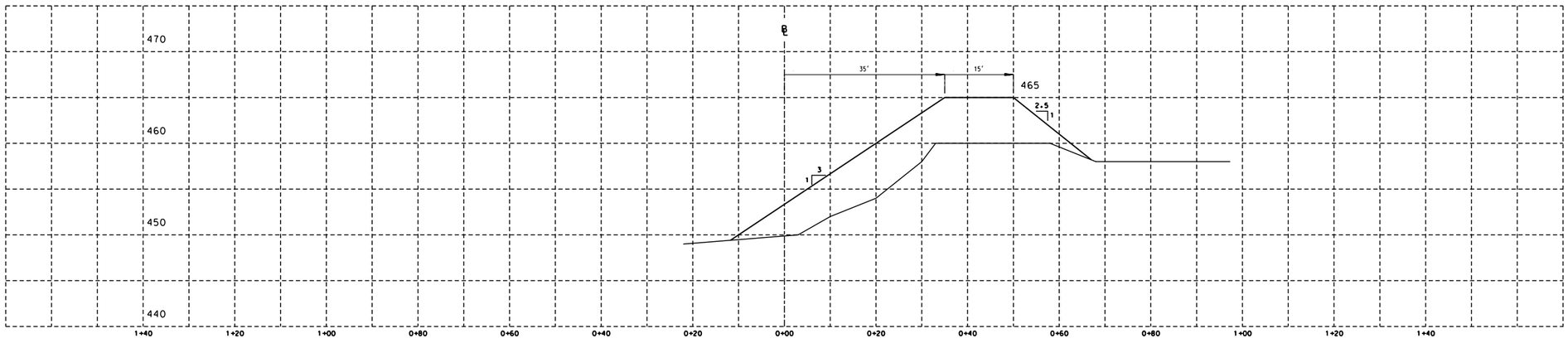
E-HEN1-B452



STATION 26+00



STATION 20+80



STATION 14+25

LEGEND

- ℄ REFERENCE BASE LINE SHOWN ON PLAN
- OLD BERM
- NEW BERM
- ▽ WATER LINE
- ✳ ESTIMATED ELEVATION

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
(0)													

NOTES

REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD
(0)

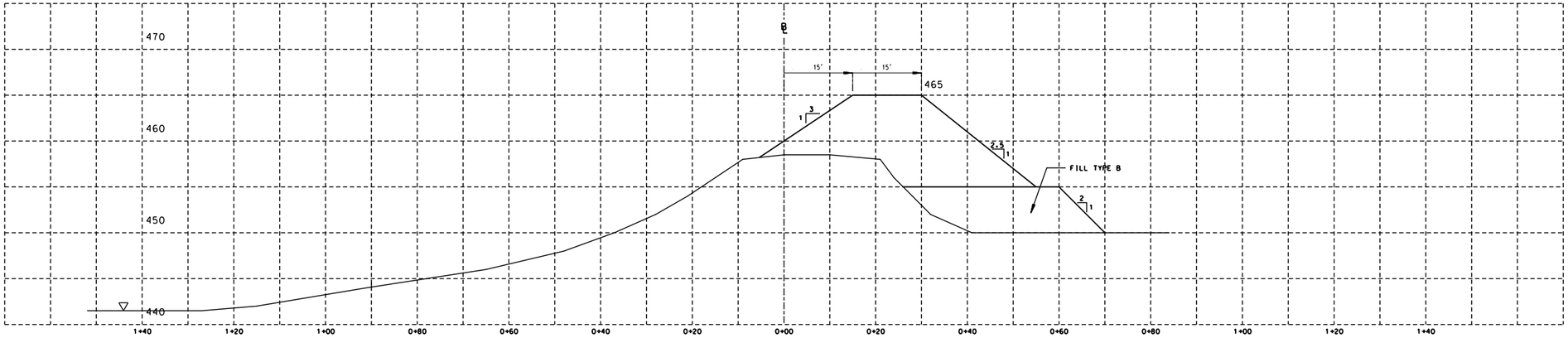
ILLINOIS POWER COMPANY
DECATUR

CROSS SECTIONS OF
ASH POND BERM EXTENSION
STA 14+25, 20+80 & 26+00
HENNEPIN POWER STATION

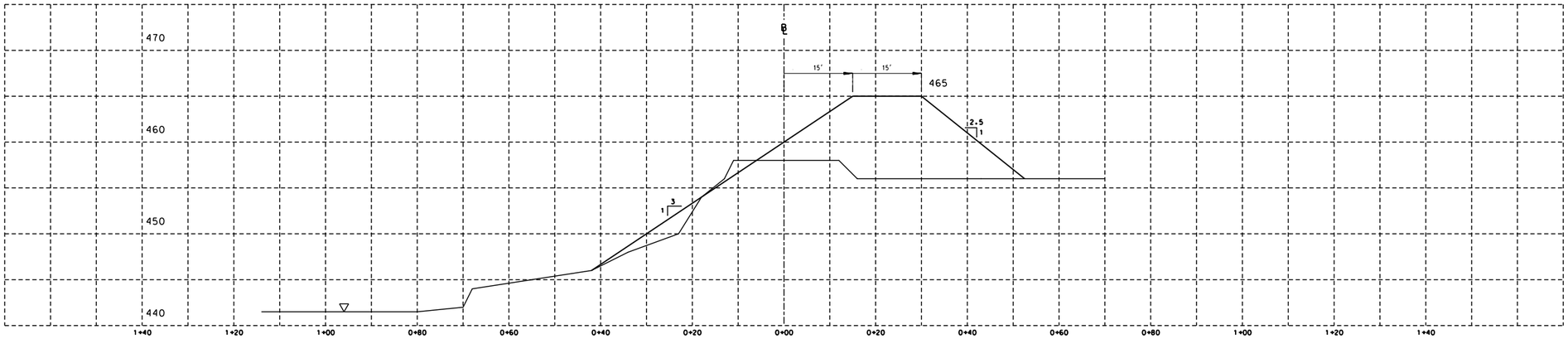
DR GRH	CAD EM	DATE 12-30-87
CK	CKD	SCALE 1"=10' H. 1"=5' V
APP	PLOTTED 11-4-97	E-HEN1-B453
APP		

COMPUTER DNG. - DO NOT REVISE MANUALLY

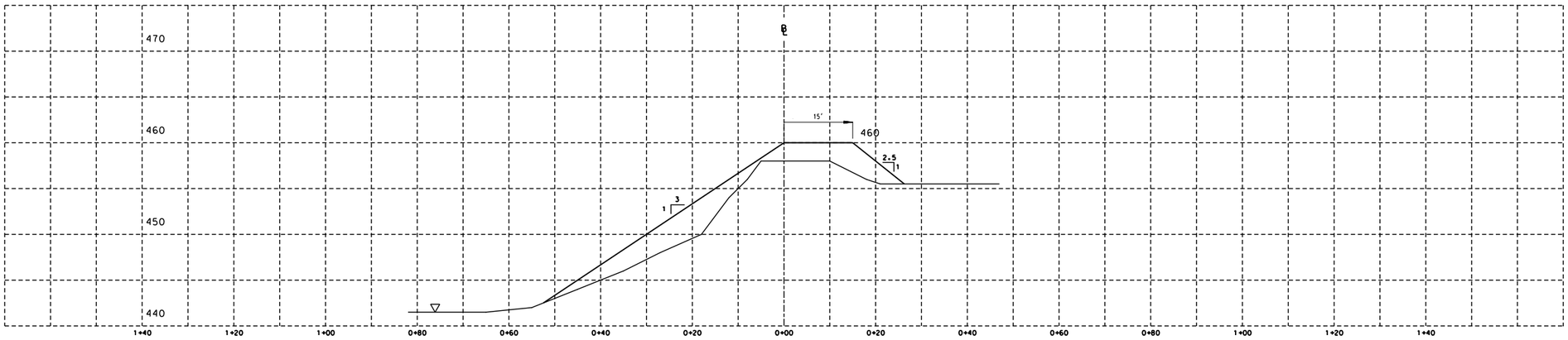
E-HEN1-B453



STATION 39+00



STATION 35+00



STATION 30+00

LEDGEND

- ℄ REFERENCE BASE LINE SHOWN ON PLAN
- OLD BERM
- NEW BERM
- ▽ WATER LINE
- ✳ ESTIMATED ELEVATION

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
⓪													

NOTES

REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD
⓪

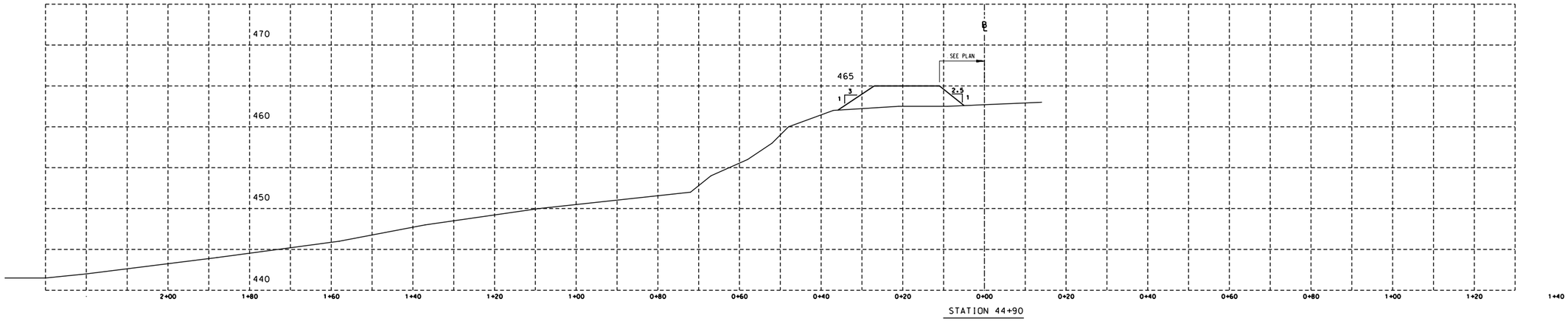
ILLINOIS POWER COMPANY
DECATUR

CROSS SECTIONS OF
ASH POND BERM EXTENSION
STA 30+00, 35+00 & 39+00
HENNEPIN POWER STATION

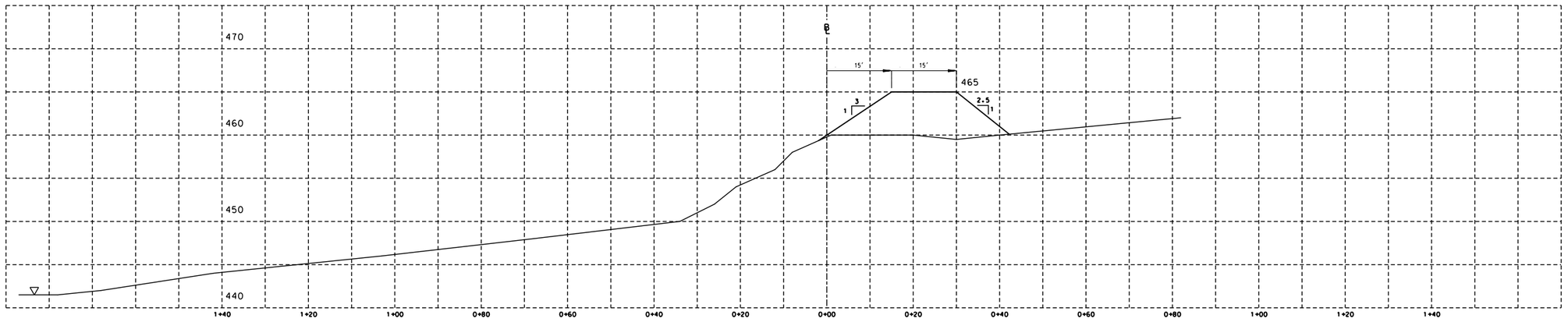
DR GRH	CAD EM	DATE 12-30-87
DK	CKD	SCALE 1"=10'H, 1"=5'V
APP	PLOTTED 11-4-97	E-HEN1-B454
APP		

E-HEN1-B454

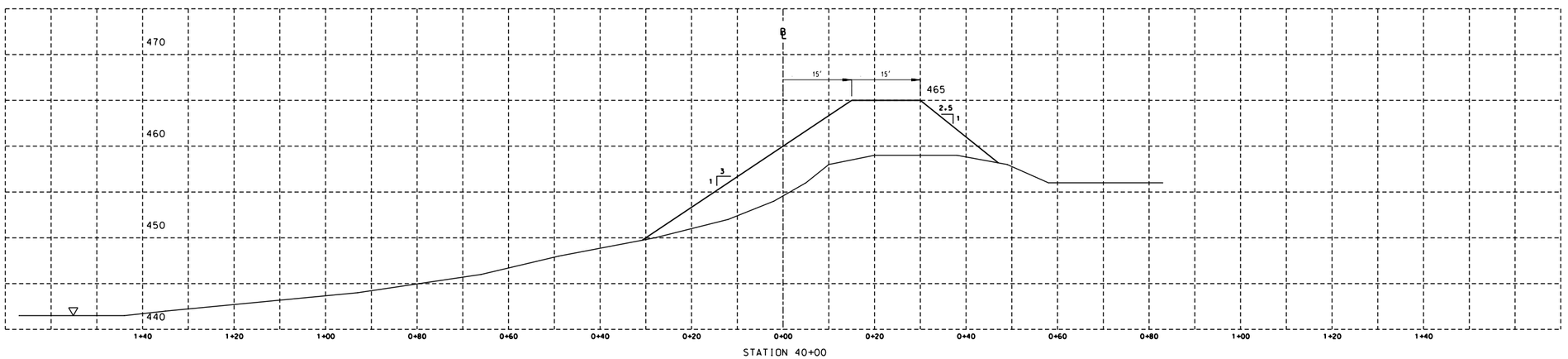
COMPUTER DWG. - DO NOT REVISE MANUALLY



STATION 44+90



STATION 42+00



STATION 40+00

LEDGEND

- ℄ REFERENCE BASE LINE SHOWN ON PLAN
- OLD BERM
- NEW BERM
- ▽ WATER LINE
- ✳ ESTIMATED ELEVATION

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
(0)													

NOTES

REFERENCES

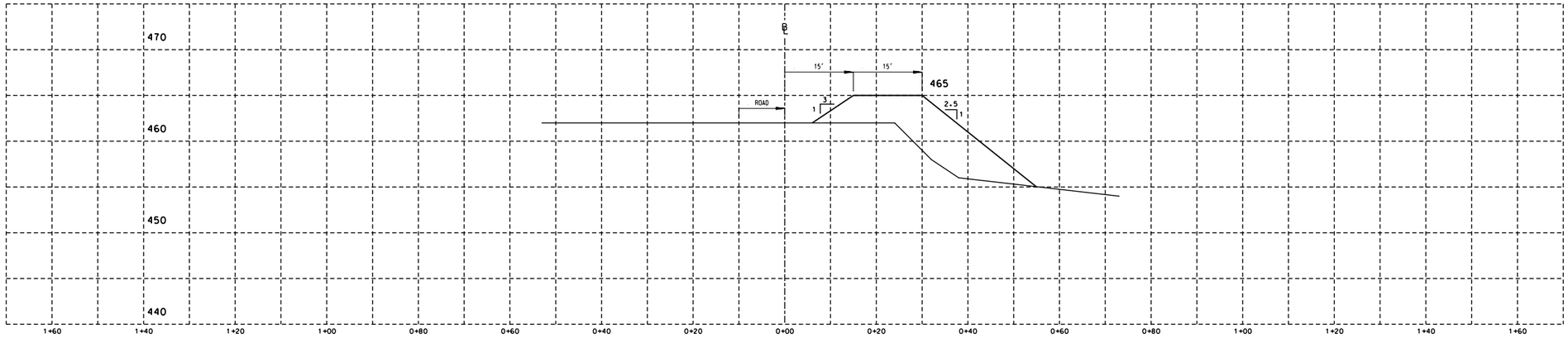
REVISION STATUS
□ -CONSTRUCTION
○ -RECORD
(0)

ILLINOIS POWER COMPANY
DECATUR
CROSS SECTIONS OF
ASH POND BERM EXTENSION
STA 40+00, 42+00 & 44+90
HENNEPIN POWER STATION

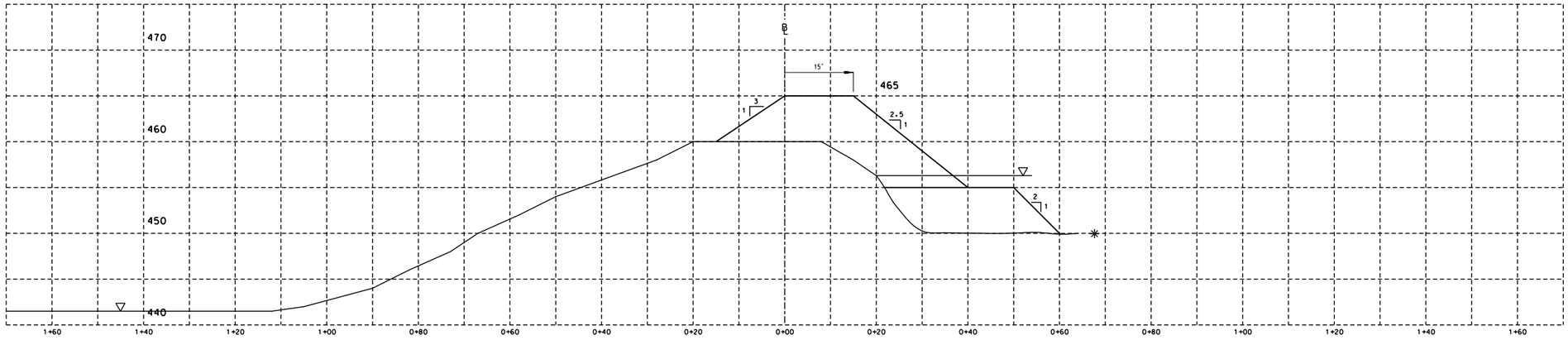
DR GRH	CAD EM	DATE 12-30-87
DK	CKD	SCALE 1"=10'H.1"=5'V
APP	PLOTTED 11-4-97	E-HEN1-B455
APP		

COMPUTER DWG. - DO NOT REVISE MANUALLY

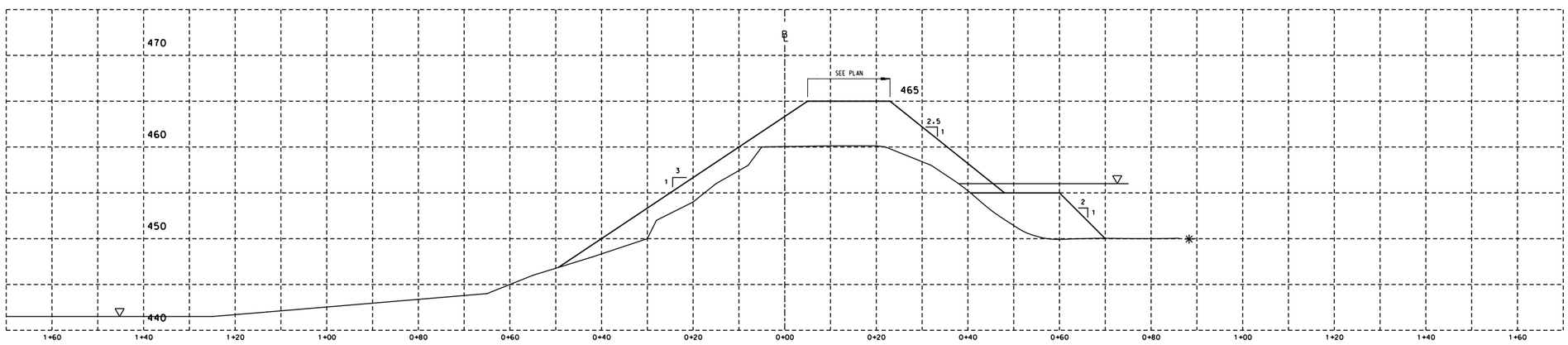
E-HEN1-B455



STATION 56+00



STATION 51+00



STATION 47+00

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD
(0)

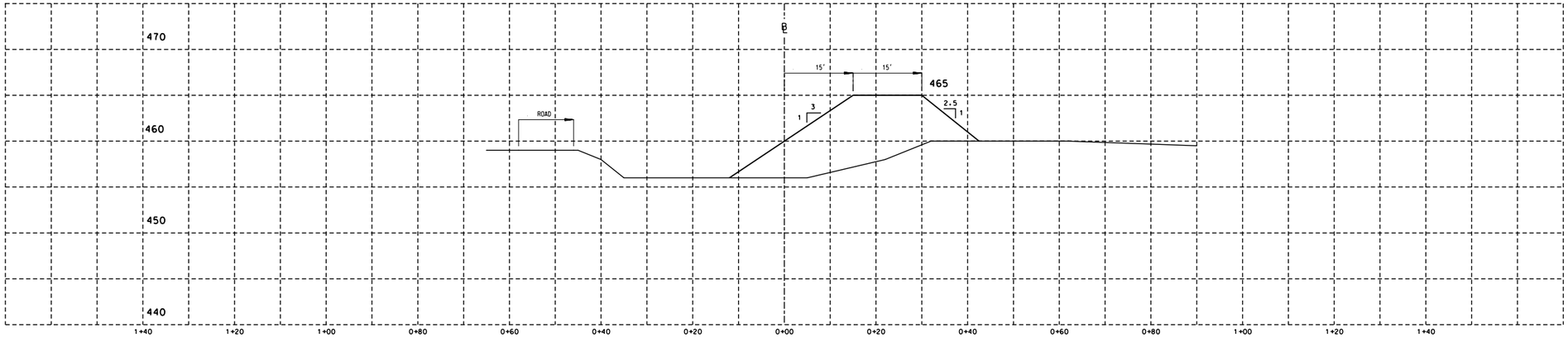
ILLINOIS POWER COMPANY
DECATUR

CROSS SECTIONS OF
ASH POND BERM EXTENSION
STA 47+00, 51+00 & 56+00
HENNEPIN POWER STATION

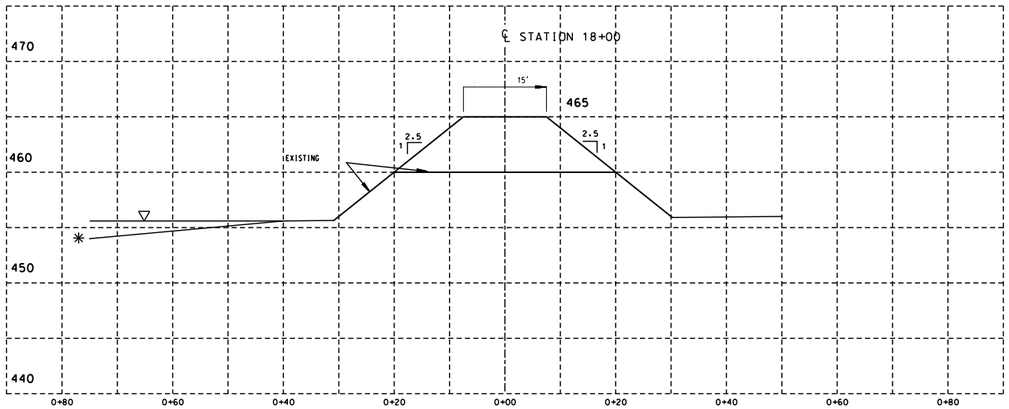
DR CRH	CAD EM	DATE 12-30-87
DR	CKD	SCALE 1"=10' H, 1"=5' V
APP	PLOTTED 11-4-97	E-HEN1-B456
APP		

E-HEN1-B456

COMPUTER DWG. - DO NOT REVISE MANUALLY



STATION 61+50



SECTION A-A

LEDGEND

- ℄ REFERENCE BASE LINE SHOWN ON PLAN
- OLD BERM
- NEW BERM
- ▽ WATER LINE
- ✳ ESTIMATED ELEVATION

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

REFERENCES

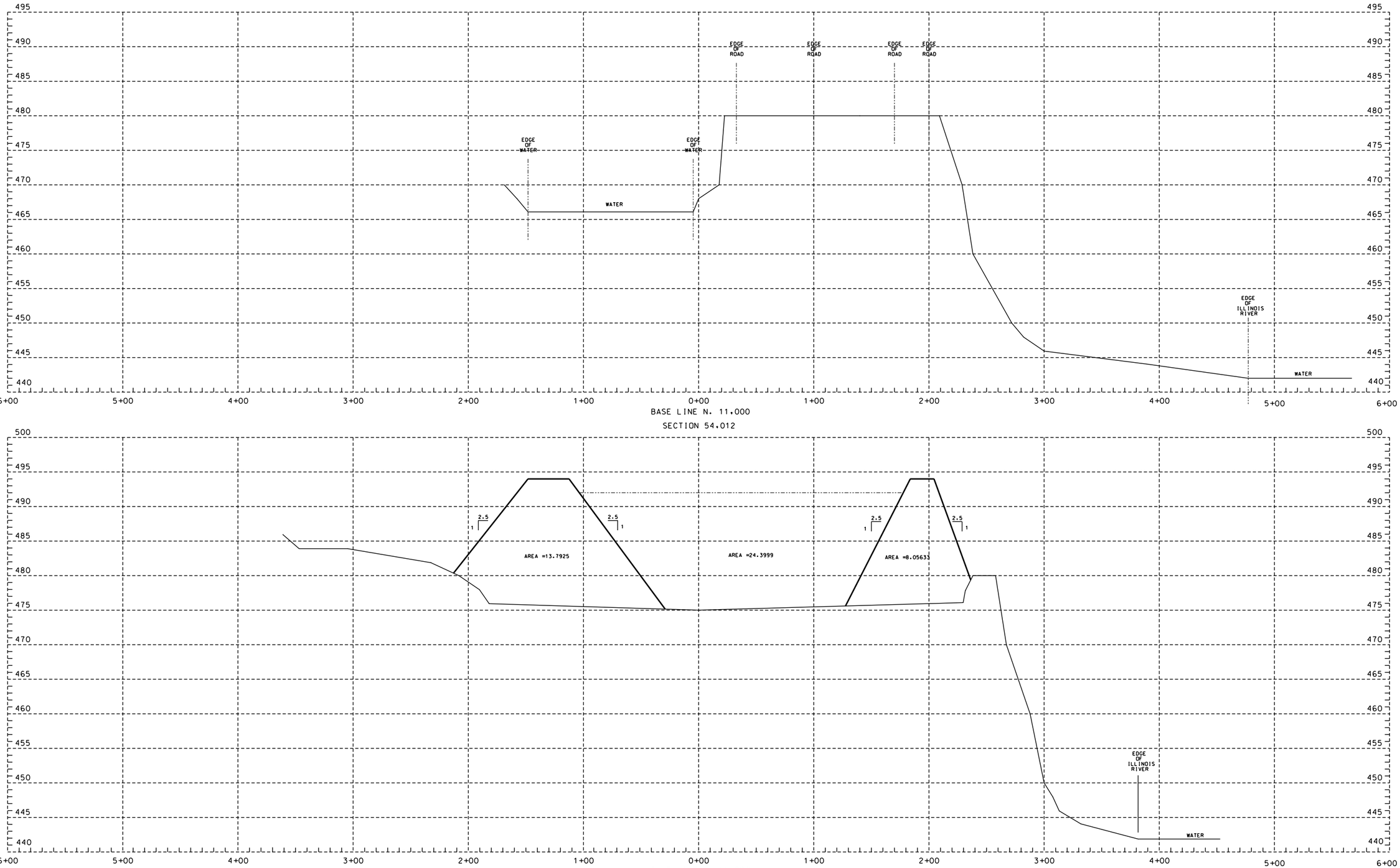
REVISION STATUS
D-CONSTRUCTION
R-RECORD
D: 0

ILLINOIS POWER COMPANY
DECATUR
CROSS SECTIONS OF
ASH POND BERM EXTENSION
STA 61+50
HENNEPIN POWER STATION

DR GRH	CAD EM	DATE 12-30-87
CK	CKD	SCALE 1"=10'H, 1"=5'V
APP	PLOTTED 11-4-97	E-HEN1-B457
APP		

E-HEN1-B457

COMPUTER DWG. - DO NOT REVISE MANUALLY



NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

1. DATA COLLECTED FROM TOPO ON DWG. CE-HEN1-B-450 DATED NOV. 4, 1987, REV. 0
2. COORDINATES WERE SUPPLIED BY G. DECKARD FIELD INFORMATION TIEING TO J.L. FISHER'S PANELS.

REFERENCES

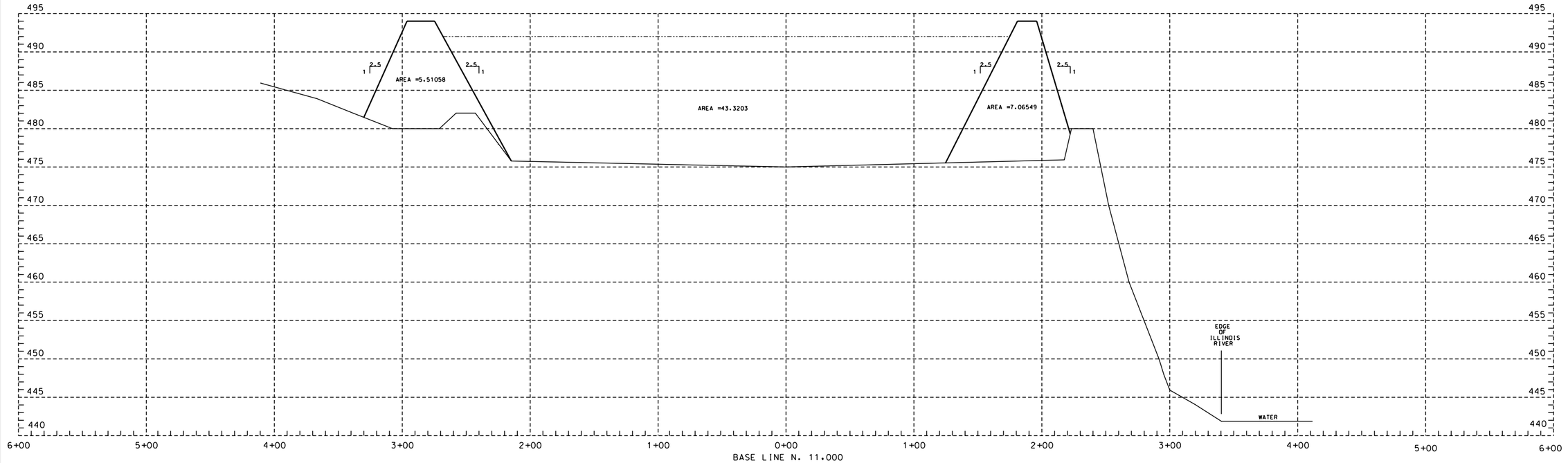
REVISION STATUS
O -CONSTRUCTION
O -RECORD

0

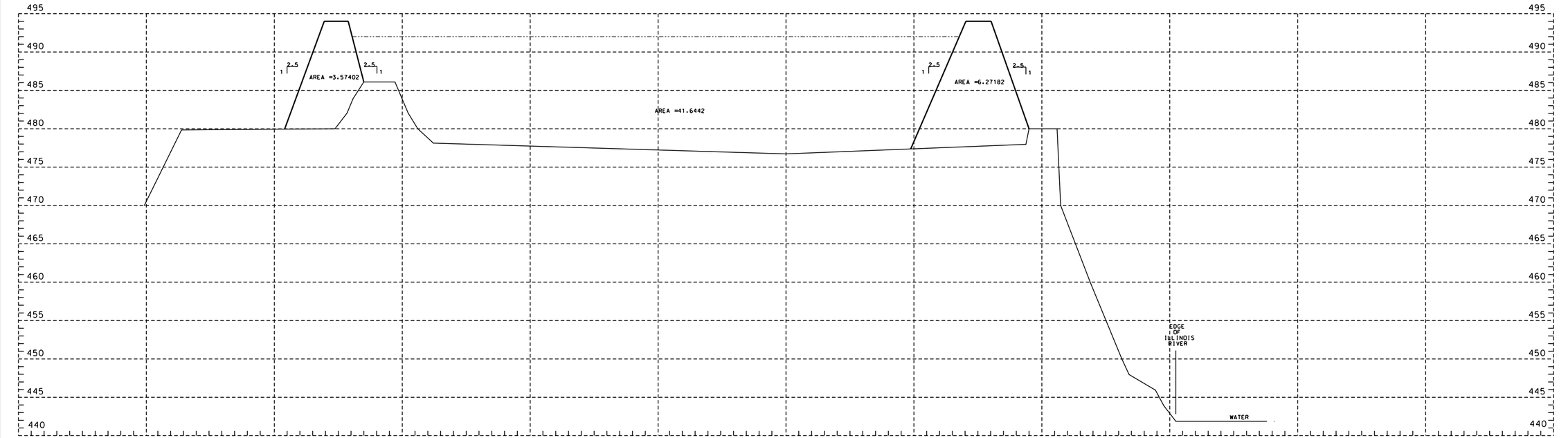
ILLINOIS POWER COMPANY
DECATUR

CROSS SECTIONS
EAST ASH POND EXTENSION
HENNEPIN POWER STATION

DR	WJM	CAD WJM	DATE 1-11-89
DK		CKD	SCALE 1"=5' V. 1"=30' H.
APP		PLOTTED 03-08-90	CE-HEN1-B458-1
APP			



BASE LINE N. 11.000
SECTION E. 53.692



BASE LINE N. 11.000
SECTION E. 53.492

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

1. DATA COLLECTED FROM TOPO ON DWG. CE-HEN1-B-450 DATED NOV. 4, 1987, REV. 0
2. COORDINATES WERE SUPPLIED BY G. DECKARD FIELD INFORMATION TIEING TO J.L. FISHER'S PANELS.

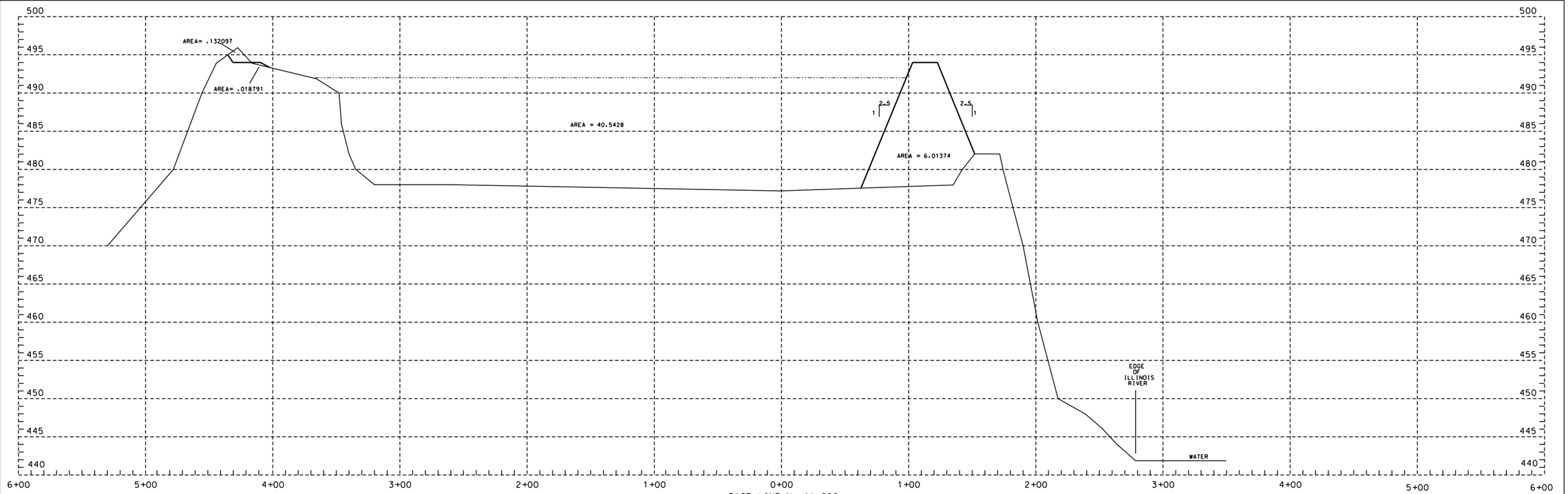
REFERENCES

REVISION STATUS
C -CONSTRUCTION
R -RECORD
0

ILLINOIS POWER COMPANY
DECATUR

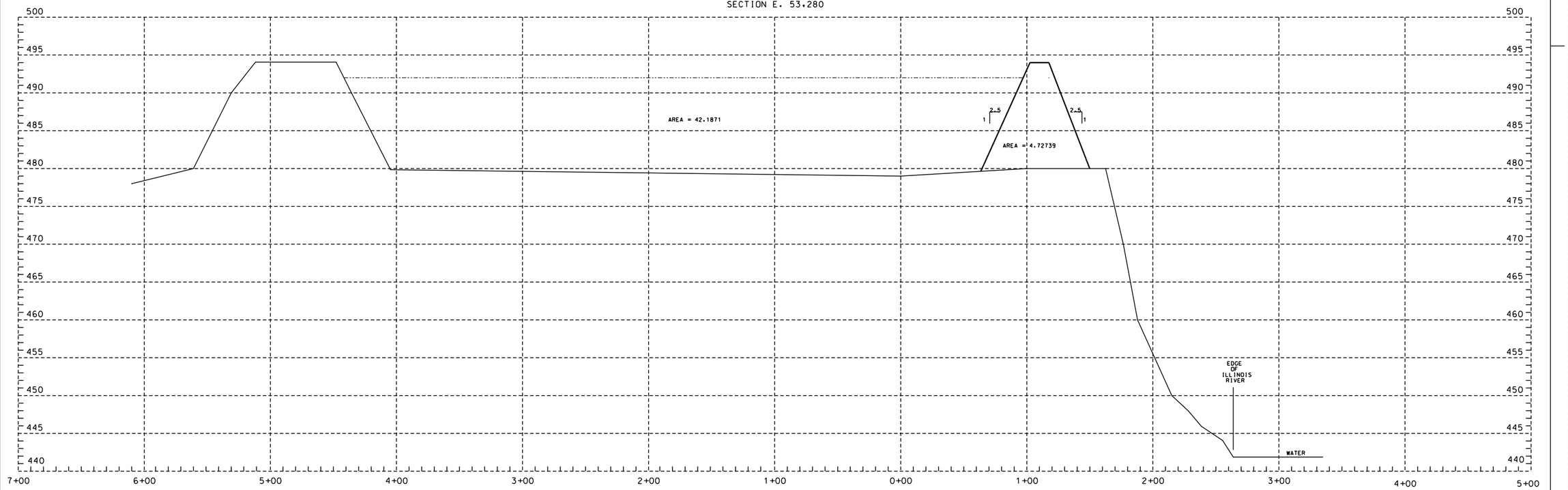
CROSS SECTIONS
EAST ASH POND EXTENSION
HENNEPIN POWER STATION

DR WJM	CAD WJM	DATE 1-12-89	
OK	CKD	SCALE 1"=5' V. 1"=30' H.	
APP	PLOTTED 03-08-90	CE-HEN1-B458-2	
APP			



BASE LINE N. 11.000

SECTION E. 53.280



BASE LINE N. 11.000

SECTION E. 53.080

NO	DATE	DRF	DESCRIPTION	E	C	A
0						

NOTES

1. DATA COLLECTED FROM TOPO ON DWG. CE-HEN1-B-450 DATED NOV. 4. 1987. REV. 0
2. COORDINATES WERE SUPPLIED BY G. DECKARD FIELD INFORMATION TIEING TO J.L. FISHER'S PANELS.

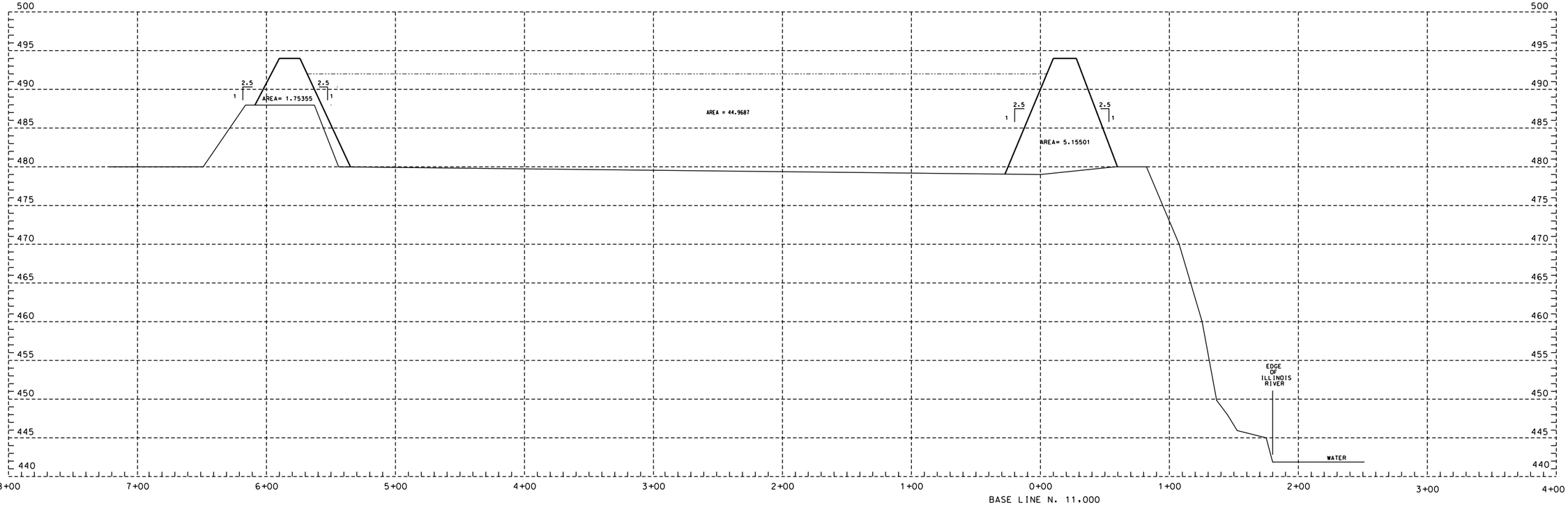
REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD

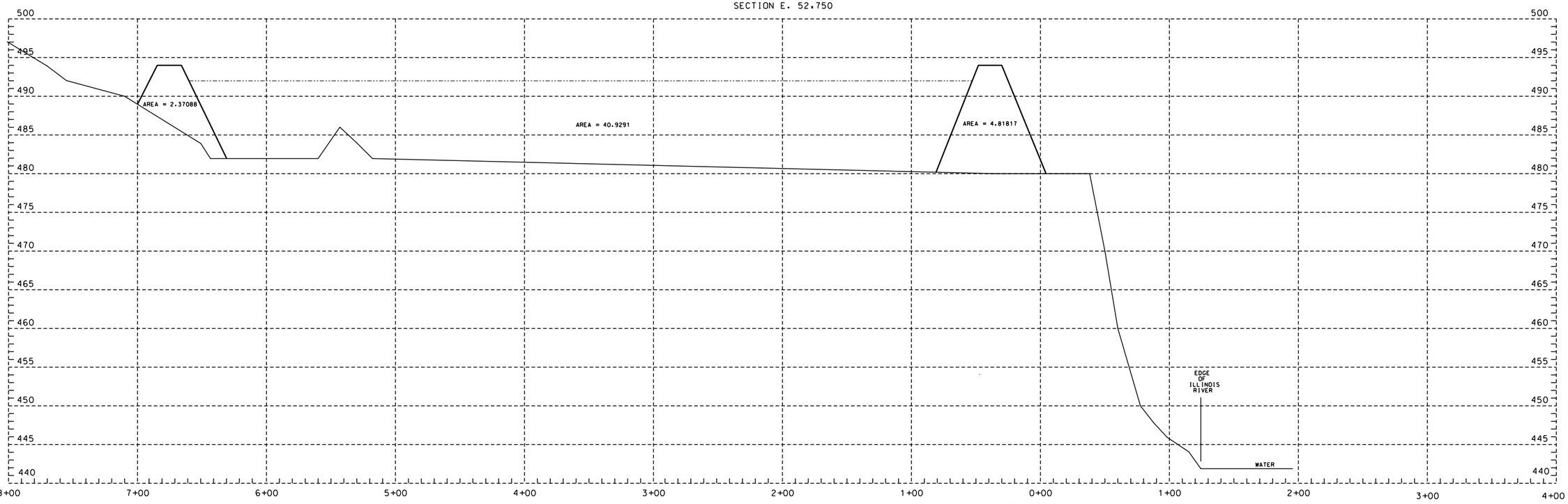
ILLINOIS POWER COMPANY
DECATUR

CROSS SECTIONS
EAST ASH POND EXTENSION
HENNEPIN POWER STATION

DR WJM	CAD WJM	DATE 1-12-89	
DK	CKD	SCALE 1"=5' V. 1"=30' H.	
APP	PLOTTED 03-08-90	CE-HEN1-B458-3	
APP			



SECTION E. 52.750



SECTION E. 52.448

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

1. DATA COLLECTED FROM TOPO ON DWG. CE-HEN1-B-450 DATED NOV. 4, 1987, REV. 0
2. COORDINATES WERE SUPPLIED BY G. DECKARD FIELD INFORMATION TIEING TO J.L. FISHER'S PANELS.

REFERENCES

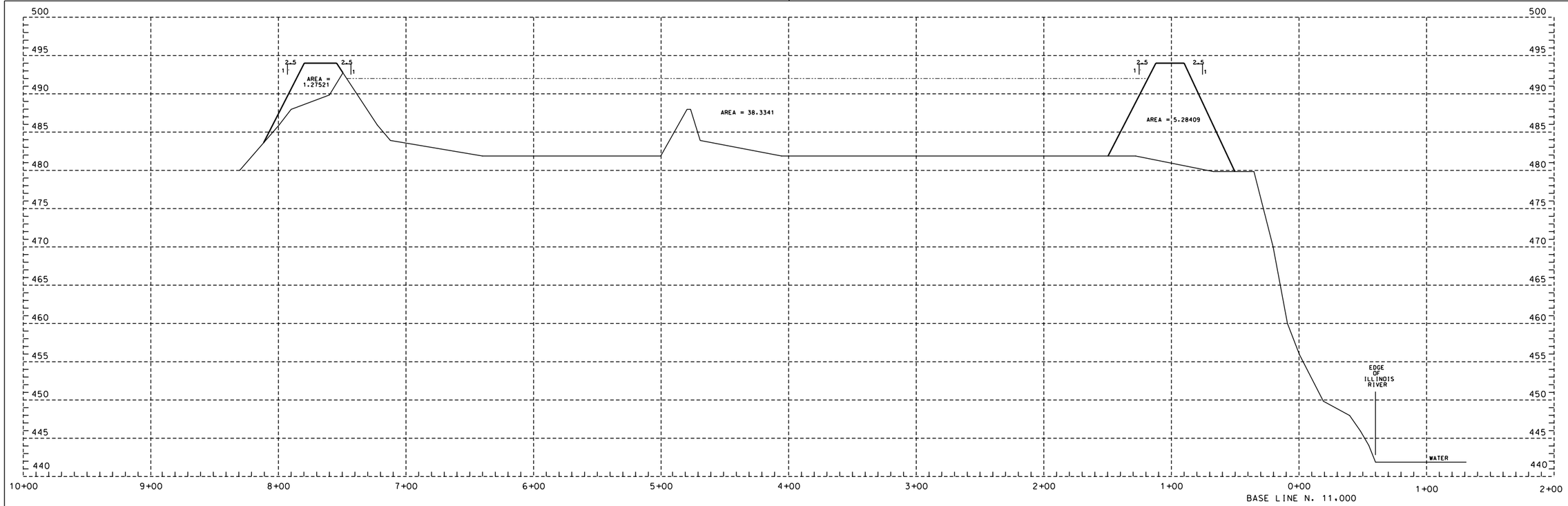
REVISION STATUS
□ -CONSTRUCTION
○ -RECORD

0

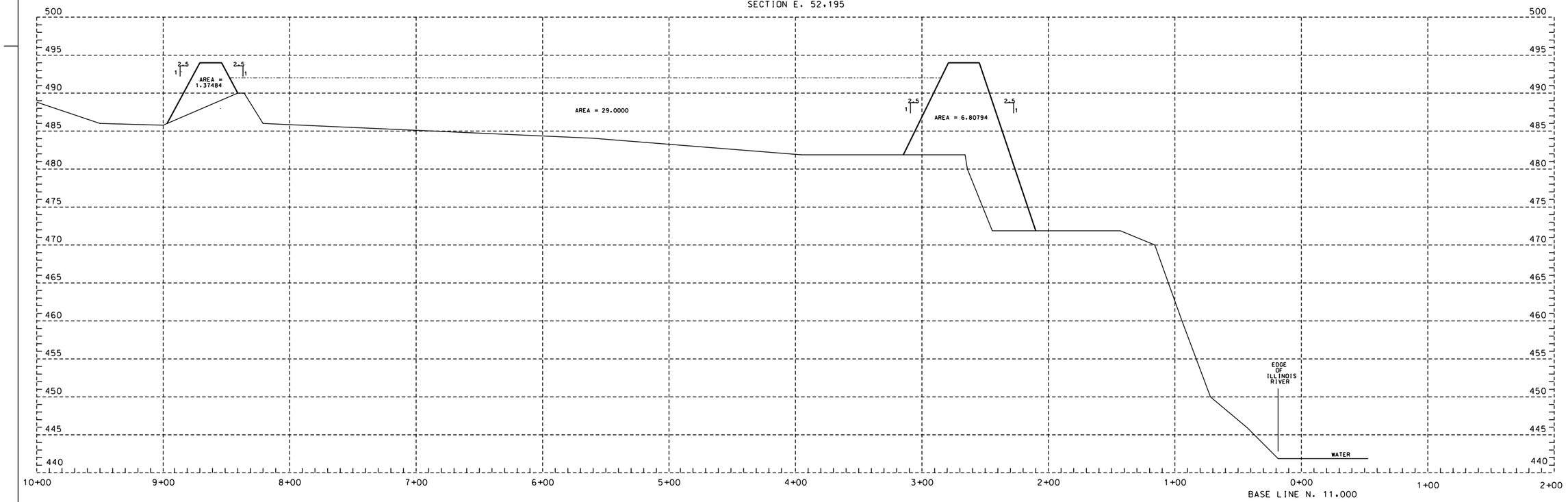
ILLINOIS POWER COMPANY
DECATUR

CROSS SECTIONS EAST ASH POND EXTENSION HENNEPIN POWER STATION

DR WJM	CAD WJM	DATE 1-12-89	
DK	CKD	SCALE 1"=5' V. 1"=30' H.	
APP	PLOTTED 03-08-90	CE-HEN1-B458-4	
APP			



SECTION E. 52.195



SECTION E. 51.920

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

1. DATA COLLECTED FROM TOPO ON DWG. CE-HEN1-B-450 DATED NOV. 4. 1987. REV. 0
2. COORDINATES WERE SUPPLIED BY G. DECKARD FIELD INFORMATION TIEING TO J.L. FISHER'S PANELS.

REFERENCES

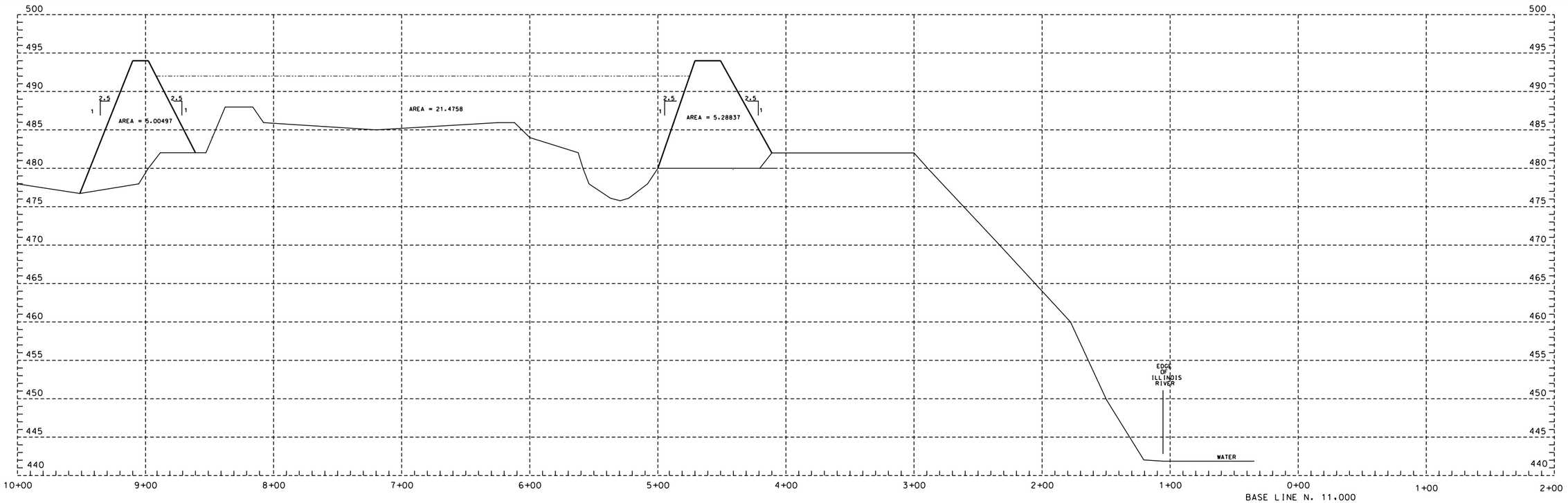
REVISION STATUS
O -CONSTRUCTION
O -RECORD

0

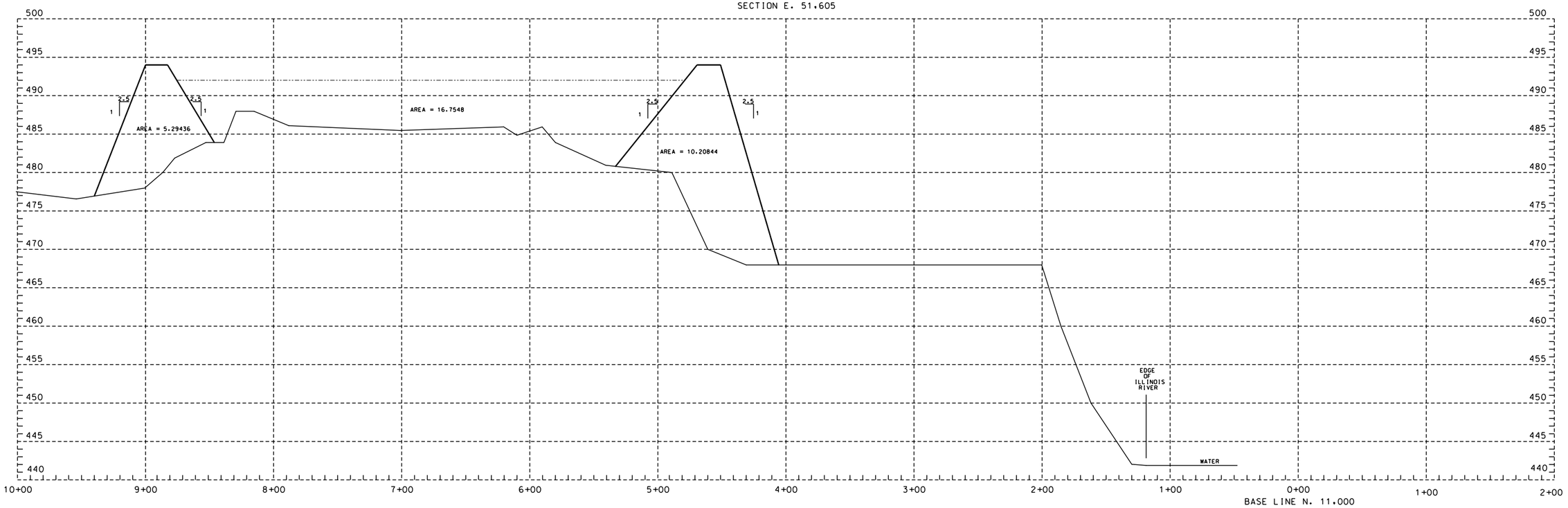
ILLINOIS POWER COMPANY
DECATUR

CROSS SECTIONS
EAST ASH POND EXTENSION
HENNEPIN POWER STATION

DR	WJM	CAD WJM	DATE 1-12-89
DK		CKD	SCALE 1"=5' V. 1"=30' H.
APP		PLOTTED 03-08-90	CE-HEN1-B458-5
APP			



SECTION E. 51.605



SECTION E. 51.552

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

1. DATA COLLECTED FROM TOPO ON DWG. CE-HEN1-B-450 DATED NOV. 4, 1987, REV. 0
2. COORDINATES WERE SUPPLIED BY G. DECKARD FIELD INFORMATION TIEING TO J.L. FISHER'S PANELS.

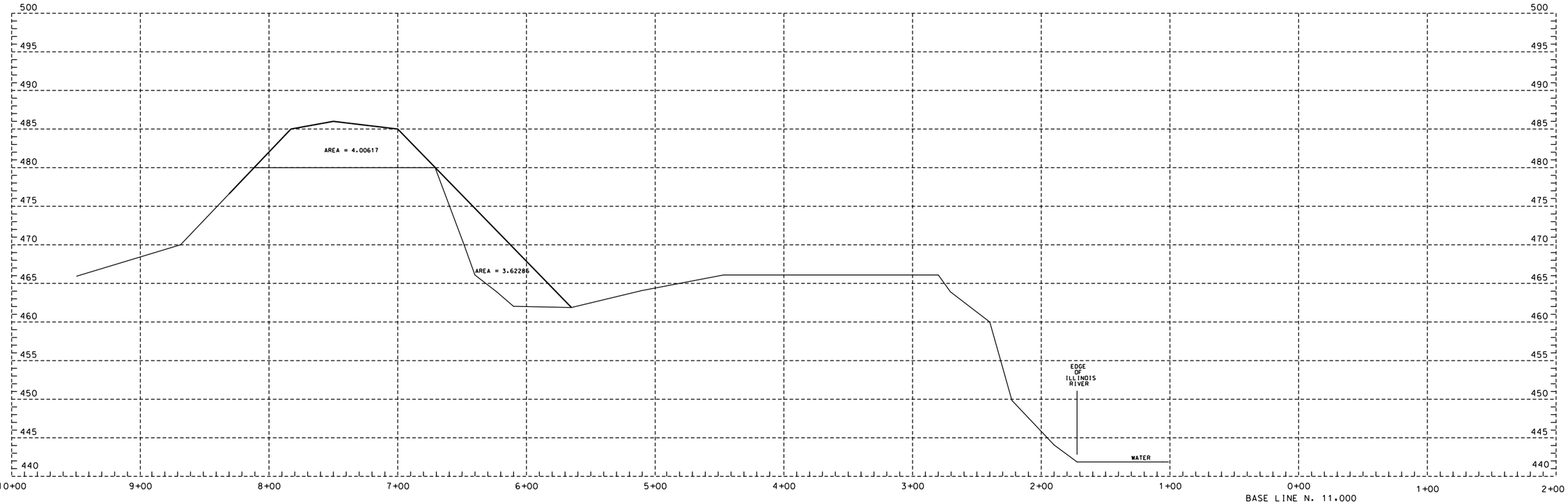
REFERENCES

REVISION STATUS
○ -CONSTRUCTION
○ -RECORD
0

ILLINOIS POWER COMPANY
DECATUR

CROSS SECTIONS
EAST ASH POND EXTENSION
HENNEPIN POWER STATION

DR	WJM	CAD WJM	DATE 1-12-89
DK		CKD	SCALE 1"=5' V. 1"=30' H.
APP		PLOTTED 03-08-90	CE-HEN1-B458-6
APP			



SECTION E. 51.285

NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

1. DATA COLLECTED FROM TOPO ON DWG. CE-HEN1-B-450 DATED NOV. 4. 1987. REV. 0
2. COORDINATES WERE SUPPLIED BY G. DECKARD FIELD INFORMATION TIEING TO J.L. FISHER'S PANELS.

REFERENCES

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD

0

ILLINOIS POWER COMPANY
DECATUR

CROSS SECTIONS
EAST ASH POND EXTENSION
HENNEPIN POWER STATION

DR	WJM	CAD WJM	DATE 1-12-89
DK		CKD	SCALE 1"=5' V. 1"=30' H.
APP		PLOTTED 03-08-90	CE-HEN1-B458-7
APP			

E-HEN1-B460-1

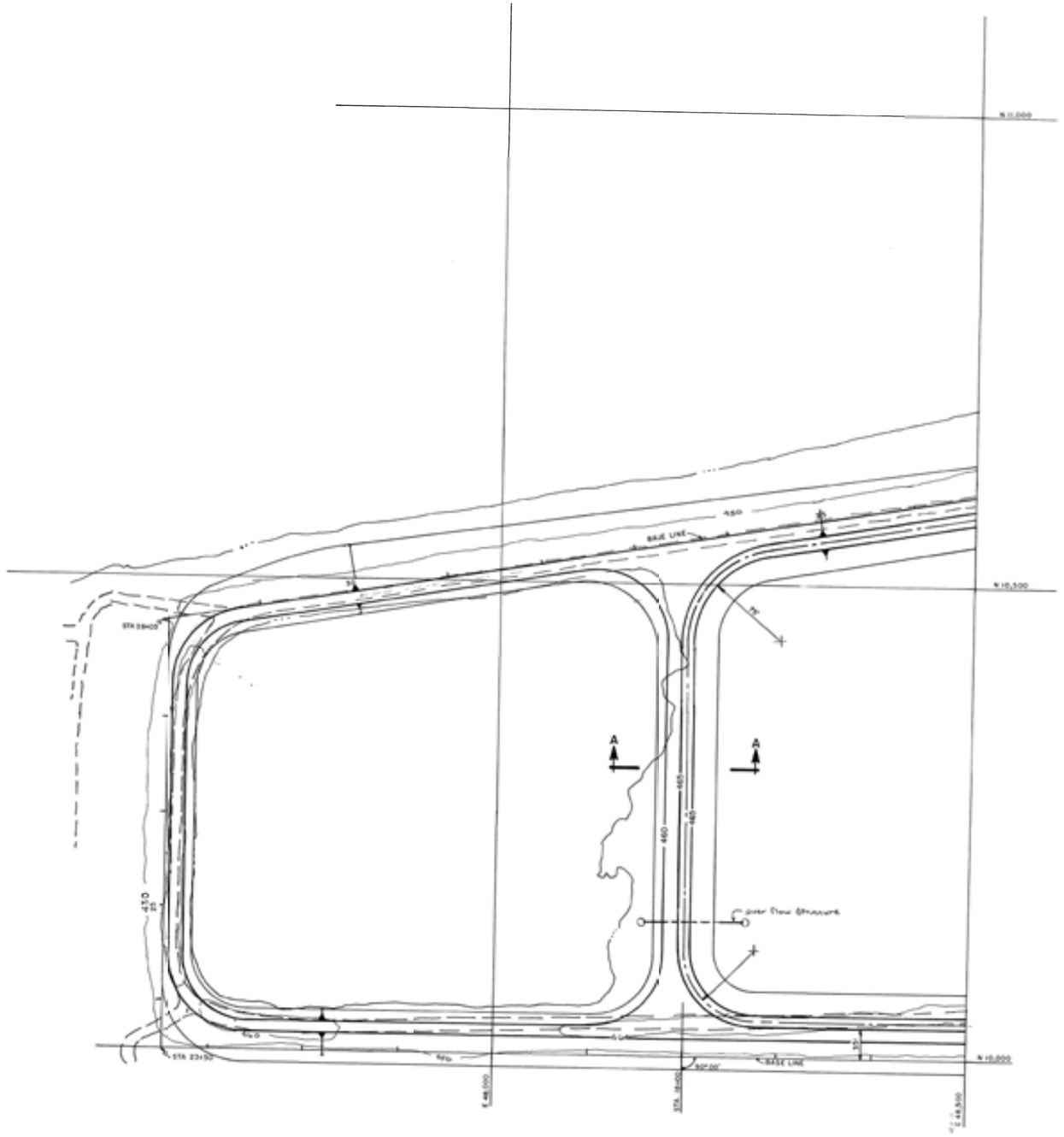


REVISION STATUS: C = CONSTRUCTION, R = RECORD	ILLINOIS POWER COMPANY, DECATUR	
	PLAN-UNITS ASH POND EXTENSION, HENNEPIN POWER STATION, SHEET 4 of 1	
DR. G.R.H.	TR.	CHK.
DES. JDO	DATE 2-2-88	SCALE 1"=50'
APP.	PROJECTED	E-HEN1-B460-1
APP.		

PLATE NO. 1

Scanned by Illinois Power Company

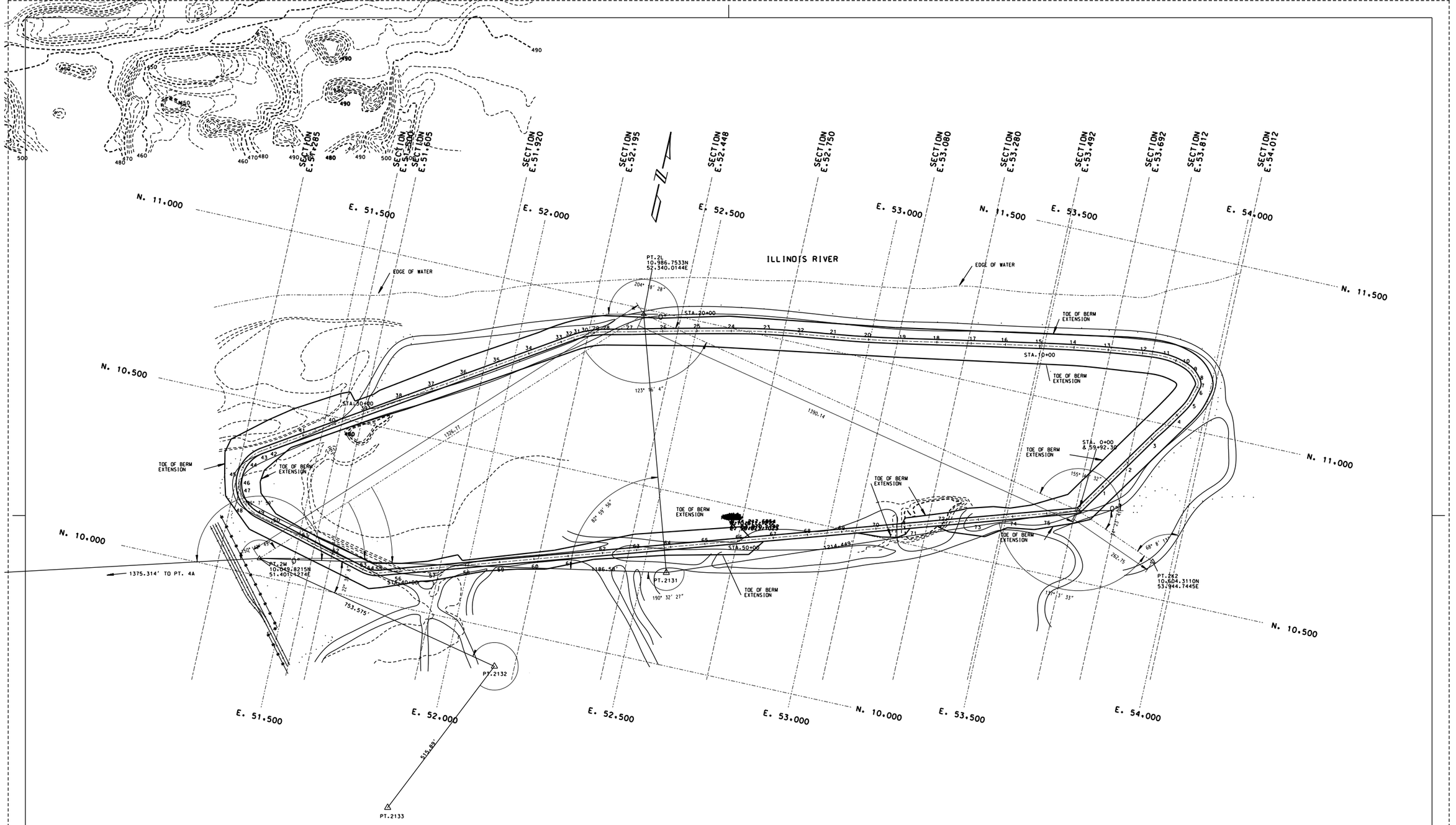
E-HEN1-B460-2



REVISION STATUS 1 CONSTRUCTION 2 RECORD	ILLINOIS POWER COMPANY DECATUR	
	PLAN - UNITH ASH POND EXTENSION HENNEPIN POWER STATION SHEET #2	
DR. G. H. H.	DES.	
CH. JWD	DATE 2-2-88	SCALE 1"=50'
APP.	PRINTED	E-HEN1-B460-2

PLATE NO. 1

Scanned by Illinois Power Company



NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

NOTES

REFERENCES

NOTE: TOPO WAS DIGITIZED FROM DWG. CE-HEN1-B-450 DATED 11-4-87

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD

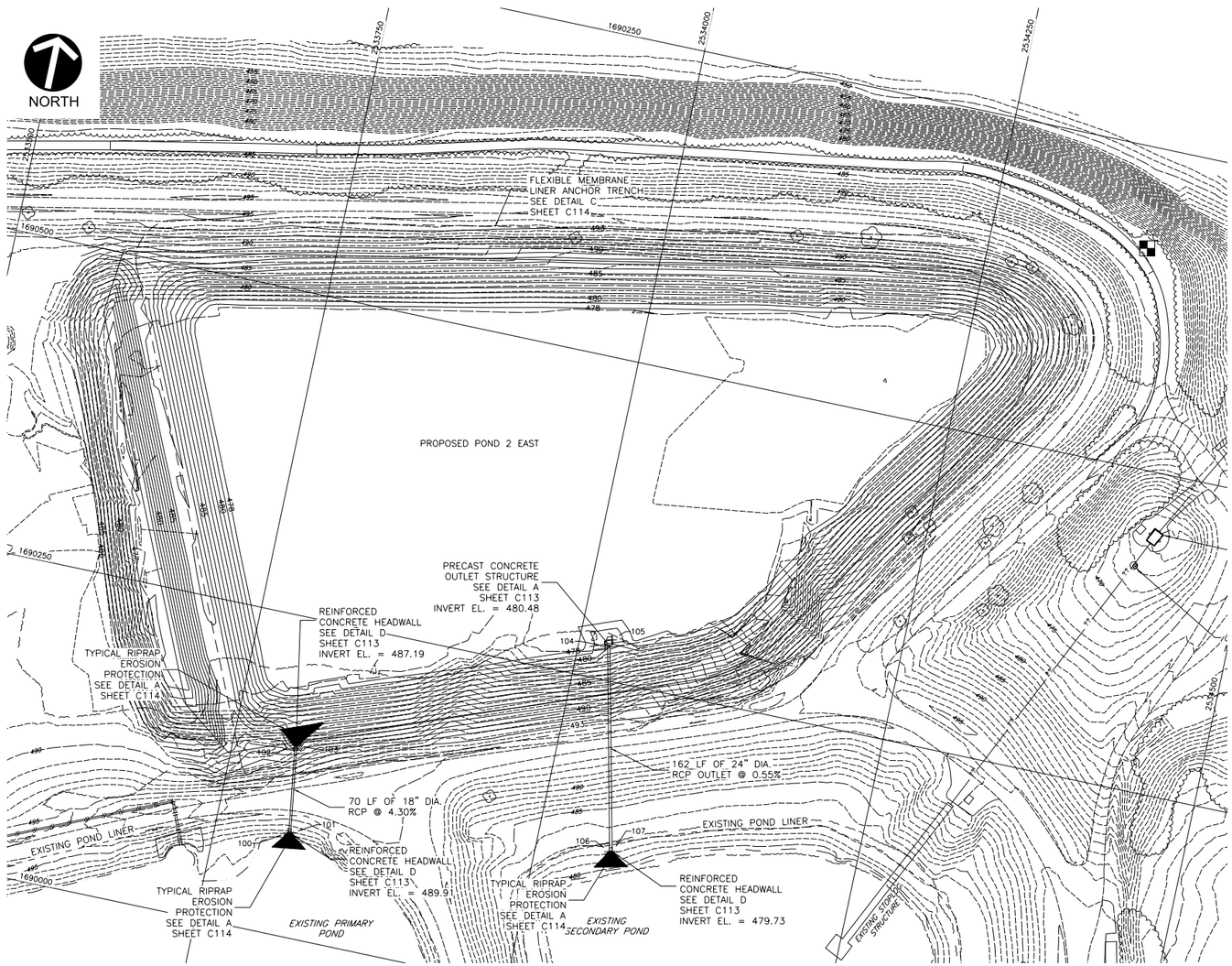
0

ILLINOIS POWER COMPANY
DECATUR

CONTOUR AND GRADING PLAN
UNIT #2 ASH POND EXTENSION
HENNEPIN POWER STATION

DR WJM	CAD WJM	DATE 1-11-89	
DR	CKD	SCALE 1"=100'	
APP	PLOTTED 03-08-90	CE-HEN1-B461	
APP			

DVO.1.2.3.4.5



SCALE IN FEET
0 40 80
DRAWING NOT TO SCALE IF SCALE BAR DOES NOT MEASURE 2 INCHES

REFERENCE

1. TOPOGRAPHIC INFORMATION BASED UPON AERIAL SURVEY CONDUCTED BY SURDEX CORPORATION FLOWN ON OCTOBER 26, 2008.

STRUCTURE TABLE		
Point #	Northing	Easting
100	1690080.864	2533807.450
101	1690081.207	2533809.928
102	1690149.246	2533797.977
103	1690149.589	2533800.456
104	1690276.331	2534020.790
105	1690282.205	2534024.973
106	1690118.909	2534057.560
107	1690119.451	2534060.003

NOTE

THE LOCATION OF THE ABOVE AND BELOW GRADE STRUCTURES SHOWN ON THESE DRAWINGS ARE APPROXIMATE. PRIOR TO PERFORMING EXCAVATIONS, THE CONTRACTOR SHALL FIELD LOCATE STRUCTURES THAT MAY BE WITHIN THE LIMITS OF WORK AND PROTECT THEM ACCORDINGLY.

LEGEND

- 495 PROPOSED INDEX CONTOURS
- 495 PROPOSED INTERMEDIATE CONTOURS
- 495 EXISTING INDEX CONTOURS
- 495 EXISTING INTERMEDIATE CONTOURS
- ?? EXISTING STORM WATER DRAINS
- EXISTING ACCESS ROAD

Civil & Environmental Consultants, Inc.
5910 Haper Road, Suite 106 • Solon, OH 44139
Ph: 330.310.6800 • 866.507.2324
www.cecinc.com

DYNEGY CONFIDENTIAL
This drawing is the property of DYNEGY INC. Neither this drawing, nor reproductions of it, nor information derived from it, shall be given to others without the expressed written consent of DYNEGY INC. No use is to be made of it which is, or may be, injurious to DYNEGY INC.

REFERENCE DRAWINGS

NO.	DATE	REVISION	BY	APPROVED

NO.	DATE	REVISION	BY	APPROVED
0	7/28/10	RECORD REVISION - 082-255	DFB	SFP

SCALE: AS_NOTED

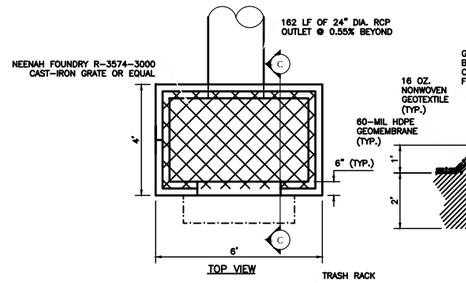
DWN DFB	DATE 07/05/2010
CHK RTM	DATE 07/12/2010
APPV SFP	DATE 07/12/2010

DYNEGY

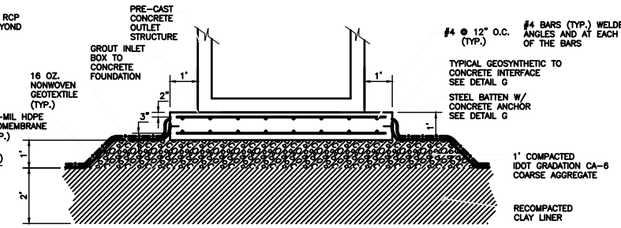
DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
POND 2 EAST
FLEXIBLE MEMBRANE LINER AND STRUCTURES

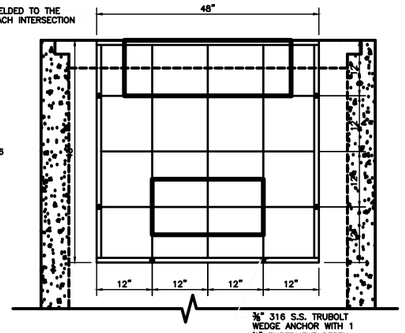
PROJECT NO: 082-255
CLIENT: DYNEGY
DWG NO: HEN1-C109
REV: 0

HEN1-C109 HENNEPIN DFB 07/05/2010

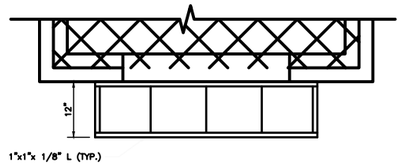


TOP VIEW

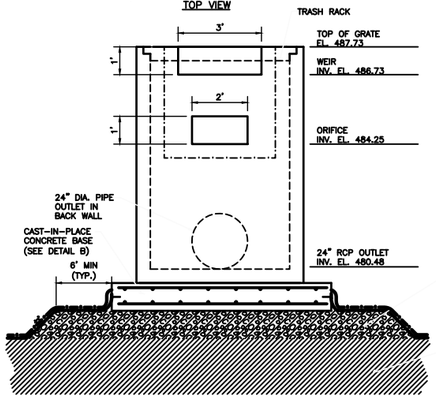




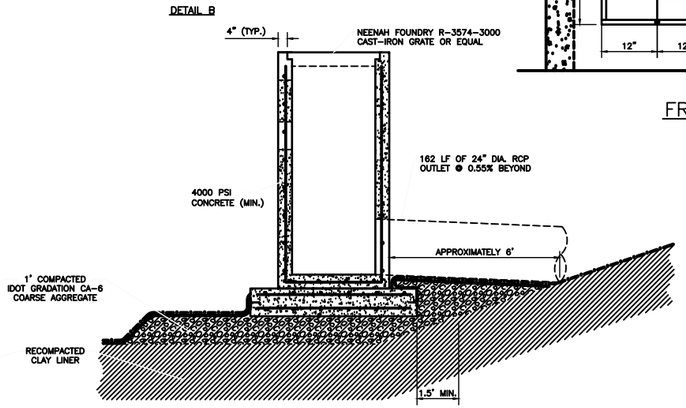
FRONT



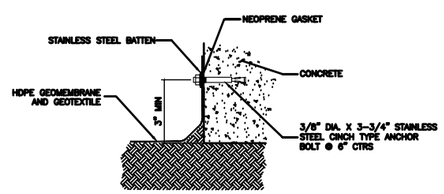
TOP



DETAIL B



DETAIL F
TRASH RACK
N.T.S.



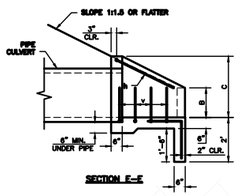
STEEL BATTEN W/ CONCRETE ANCHOR

DETAIL A
PRECAST CONCRETE OUTLET STRUCTURE
N.T.S.

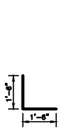
NOTES

1. REFER TO ILLINOIS DEPARTMENT OF TRANSPORTATION (IDOT) STANDARD FOR OUTLET REINFORING.

FRONT VIEW

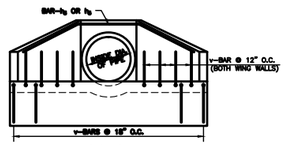


SECTION E-E



BAR v

SECTION C-C



END VIEW

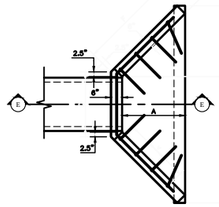


DETAIL D
REINFORCED CONCRETE HEADWALL
N.T.S.

NOTES

1. REFER TO IDOT STANDARD 542101-02 REINFORCED CONCRETE HEADWALL DETAIL FOR FINAL DESIGN.

DIMENSIONS OF BARS-h_3 AND h_5		
BAR	a	b
h_3	2'-1"	3'-3.00"
h_5	2'-8"	4'-1.00"



PLAN

DIMENSIONS AND QUANTITIES													
DESIGN NO.	NOMINAL INSIDE DIA. OF PIPE	SLOPE OF WING WALLS	DIMENSIONS (A)	DIMENSIONS (B)	DIMENSIONS (C)	DIMENSIONS (D)	DIMENSIONS (E)	DIMENSIONS (F)	CONCRETE 2 END SECS. CU. YDS.	NO.4 REBAR h-BARS (BAR)	NO.4 REBAR h-BARS (LENGTH)	NO.4 REBAR v-BARS NO.	NO.4 REBAR TOTAL WT. 2 END SECS. LBS.
D18-2	1'-6"	1 TO 2	2'-2"	1'-1"	2'-2"	2'-3"	6'-10.20"	3'-3.25"	1.30	h_3	8'-6"	22	60
D24-2	2'-0"	1 TO 2	2'-10"	1'-4"	2'-8"	2'-11"	8'-10.20"	4'-3.00"	2.00	h_5	11'-0"	28	70

DETAIL G
TYPICAL GEOSYNTHETIC TO CONCRETE INTERFACE
N.T.S.

NOTES

1. EARTH ADJACENT TO CONCRETE TO BE WELL COMPACTED TO PREVENT FUTURE DIFFERENTIAL SETTLEMENT.
2. ALL CONCRETE COLLARS TO BE CHAMFERED A MINIMUM OF 1" (TYP.) @ ALL CORNERS IN CONTACT WITH LINER

Civil & Environmental Consultants, Inc.
5910 Haper Road, Suite 106 - Solon, OH 44139
Ph: 330.310.6800 · 866.507.2324
www.cecinc.com

DYNEGY CONFIDENTIAL
This drawing is the property of DYNEGY INC. Neither this drawing, nor reproductions of it, nor information derived from it, shall be given to others without the expressed written consent of DYNEGY INC. No use is to be made of it which is, or may be, injurious to DYNEGY INC.

REFERENCE DRAWINGS

NO.	DATE	REVISION	BY	APPROVED	
0	7/28/10	RECORD REVISION - 082-255	DFB	SFP	

SCALE: AS_NOTED

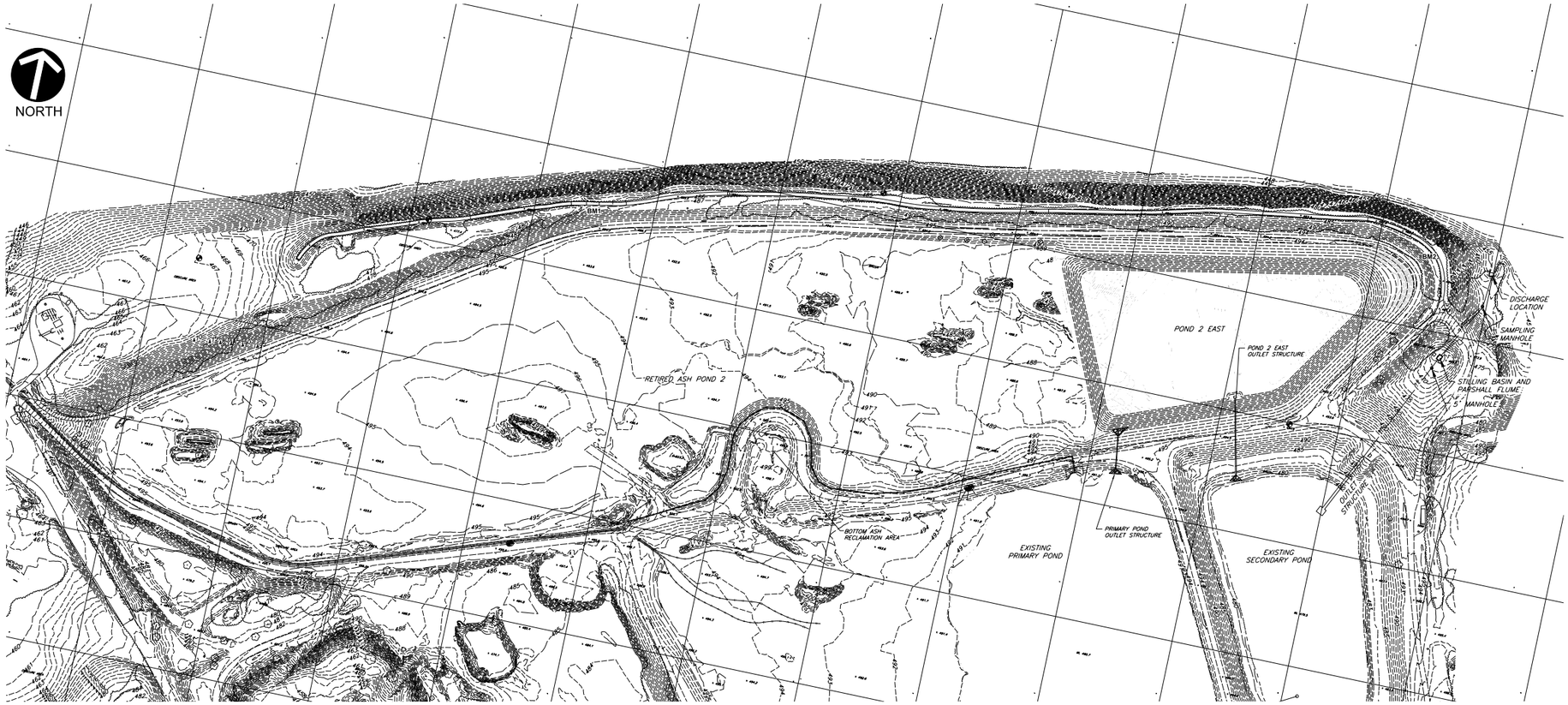
DWN. DFB	DATE 07/05/2010
CHK. RTH	DATE 07/12/2010
APPV. SFP	DATE 07/12/2010

DYNEGY

DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
POND 2 EAST
DETAILS

PROJECT NO. 082-255
CLIENT: DYNEGY
DWG. NO. HEN1-C113
REV. 0

07/05/2010 DFB HEN-C113 HENNEPIN



BENCHMARK LOCATIONS			
NUMBER	NORTHING	EASTING	ELEVATION
1	1690395.43	2532618.60	482.19
2	1690670.86	2534372.87	484.08
3*	1689478.87	2534643.99	506.80
4*	1688458.82	2533256.76	499.45
5*	1688781.84	2531352.15	468.27
6*	1689875.08	2531310.12	463.75

* BENCHMARKS BEYOND DRAWING BOUNDARY.

SCALE IN FEET
0 100 200
DRAWING NOT TO SCALE IF SCALE BAR DOES NOT MEASURE 2 INCHES

REFERENCE:

1. TOPOGRAPHIC INFORMATION BASED UPON AERIAL SURVEY CONDUCTED BY SURDEX CORPORATION FLOWN ON SEPTEMBER 10, 2008.

   DUE TO CONSTRUCTION ACTIVITIES, ACTUAL FIELD TOPOGRAPHY MAY VARY.

2. POND 2 EAST CONTOURS FROM CONSTRUCTION DRAWINGS SUBMITTED AUGUST 2009.

LEGEND

- MISCELLANEOUS FLOW PIPING
- EXISTING STORMWATER DRAINS
- EXISTING TREELINE
- EXISTING PIPING
- EXISTING ACCESS ROAD
- EXISTING PONDS/STREAMS
- EXISTING FENCE
- EXISTING BENCHMARK
- EXISTING INDEX CONTOUR
- EXISTING INTERMEDIATE CONTOUR
- EXISTING ROCK CHANNEL PROTECTION
- EXISTING MONITORING WELL

Civil & Environmental Consultants, Inc.
5910 Roper Road, Suite 106 • Solon, OH 44139
Ph: 330.310.6800 • 866.507.2324
www.ceciinc.com

DYNEGY CONFIDENTIAL
This drawing is the property of DYNEGY INC. Neither this drawing, nor reproductions of it, nor information derived from it, shall be given to others without the expressed written consent of DYNEGY INC. No use is to be made of it which is, or may be, injurious to DYNEGY INC.

REFERENCE DRAWINGS

NO.	DATE	REVISION	BY	APPROVED	
0	11/28/10	RECORD REVISION - 082-255	DFB	SFP	

SCALE: AS_NOTED

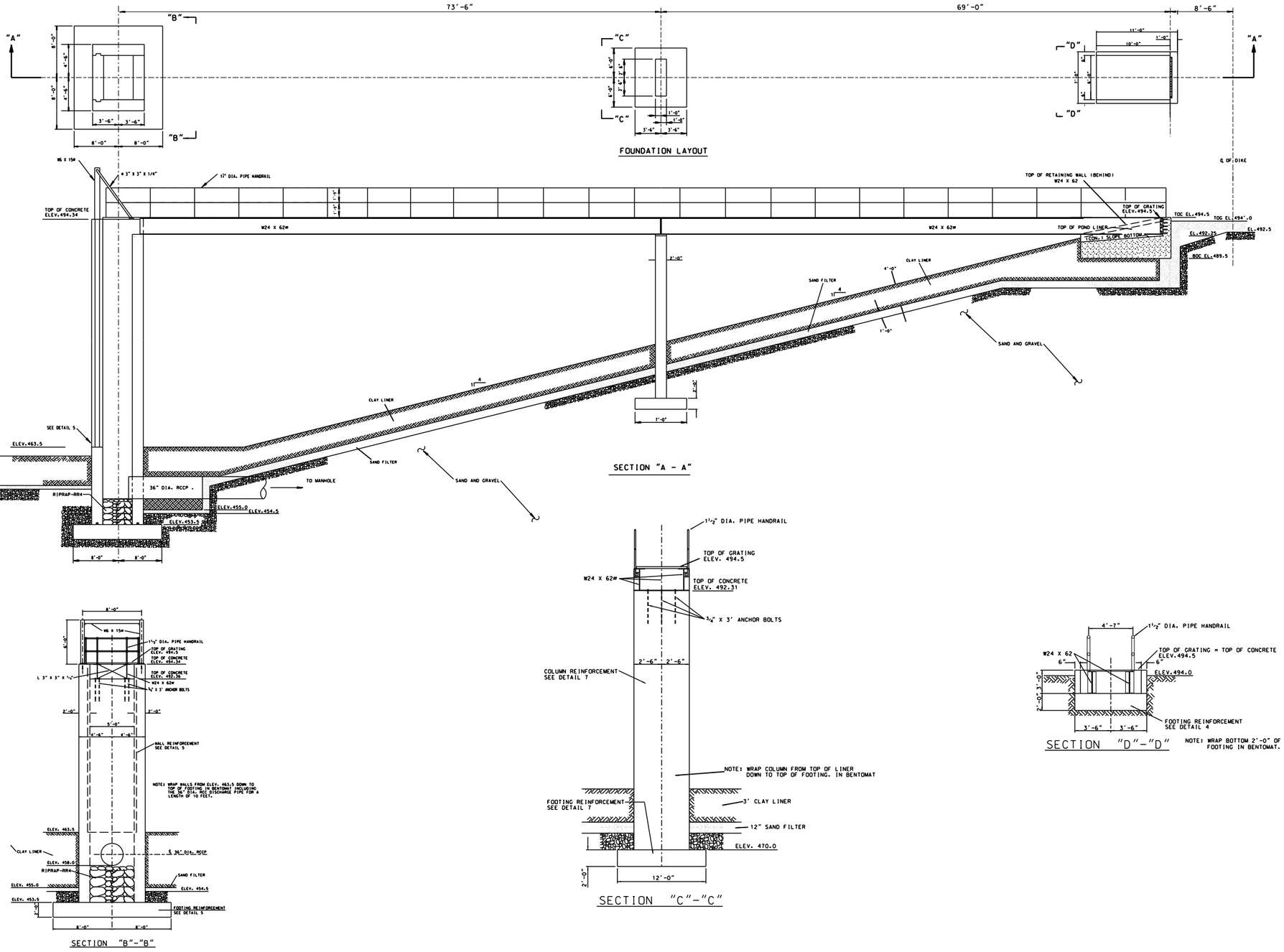
DWN. DFB	DATE 11/05/2010
CHK. RTM	DATE 11/12/2010
APPV. SFP	DATE 11/12/2010
EAPP_BY	EABD
FEAPP_BY	FEABD

DYNEGY

DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
LANDFILL PHASE 1 CONSTRUCTION
EXISTING CONDITIONS

PROJECT NO.: 082-255
CLIENT: DYNEGY
DWG. NO.: HEN1-C117
REV.: 0

HENNEPIN
HEN1-C117
DFB
07/05/2010



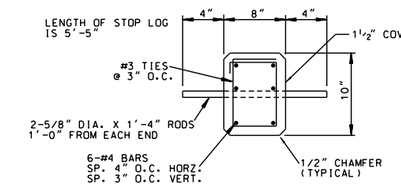
NO	DATE	DRF	DESCRIPTION	E	C	A	NO	DATE	DRF	DESCRIPTION	E	C	A
0													

REVISION STATUS
□ -CONSTRUCTION
○ -RECORD
0
p0019275.dgn

ILLINOIS POWER COMPANY
DECATUR

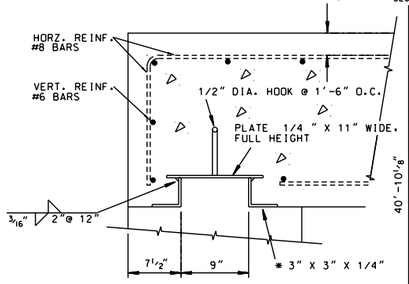
LAYOUT-POND DISCHARGE STRUCTURES
1995 ASH FACILITY
HENNEPIN POWER STATION

DR G.R.H.	CAD G.R.H.	DATE 1/5/94	
OK	CKD	SCALE NO SCALE	
APP	PLOTTED 9/17/96	CE-HEN1-C8	
APP			

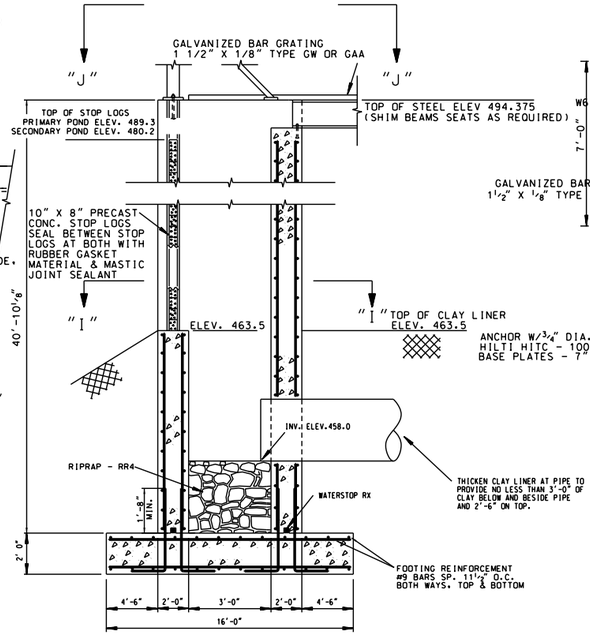


STOP LOG DETAIL

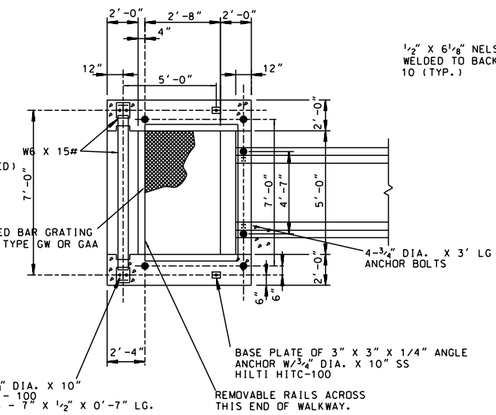
(51 REQUIRED INITIALLY, PROVIDE COMPANY WITH 10 EXTRA)
PRIMARY POND - 31
SECONDARY POND - 20



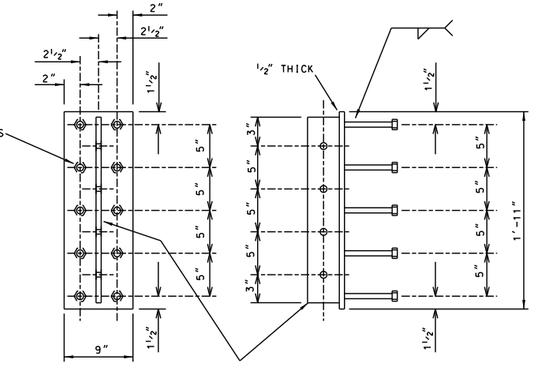
DETAIL 6



DETAIL 5

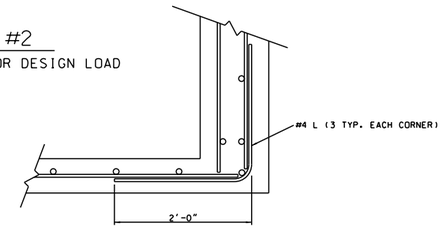


SECTION J-J

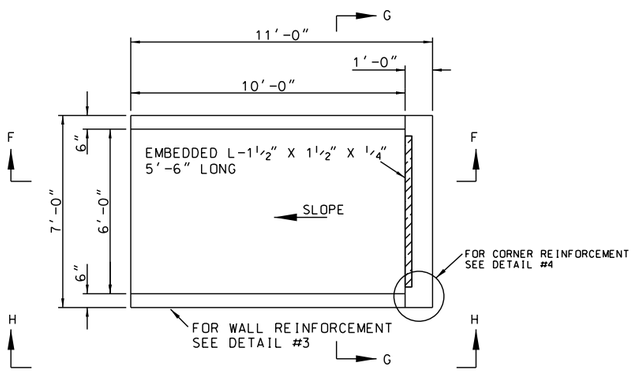


DETAIL #2

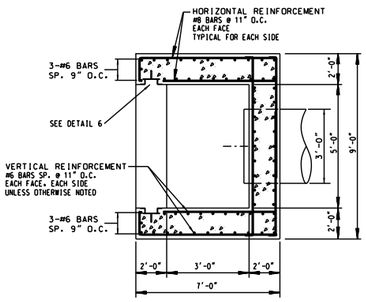
SEE CATWALK PLAN FOR DESIGN LOAD



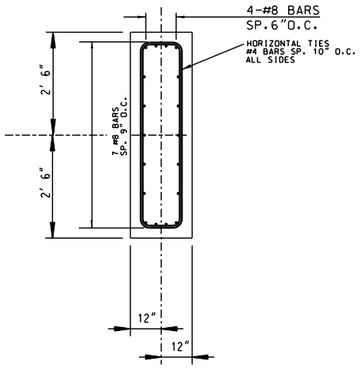
DETAIL #4



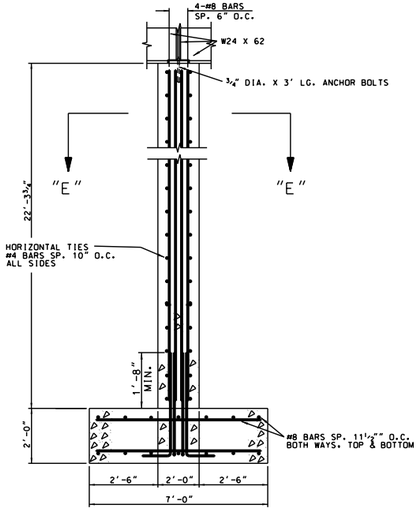
PLAN: CATWALK FOUNDATION



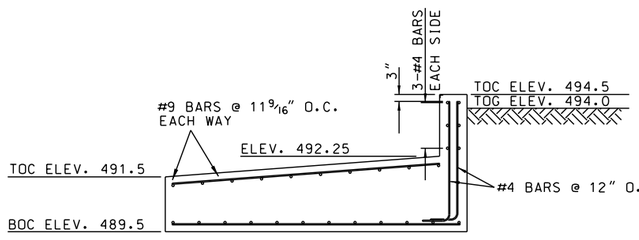
SECTION "I - I"



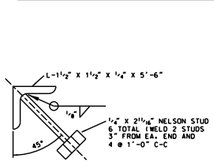
SECTION E-E



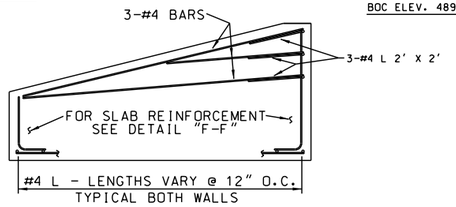
DETAIL 7



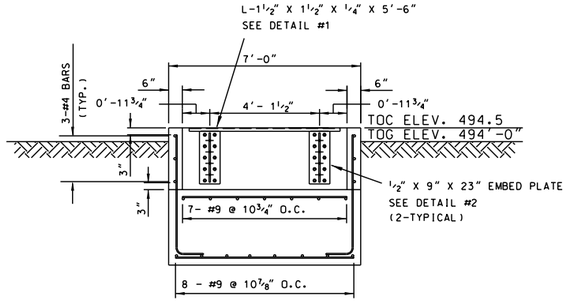
SECTION "F-F"



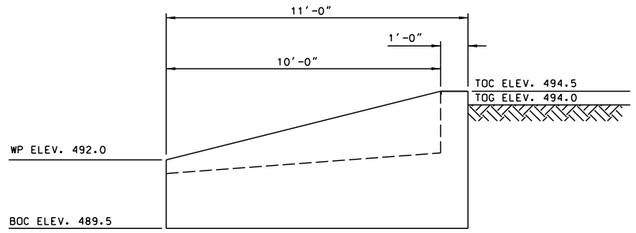
DETAIL #1



DETAIL #3



SECTION "G-G"



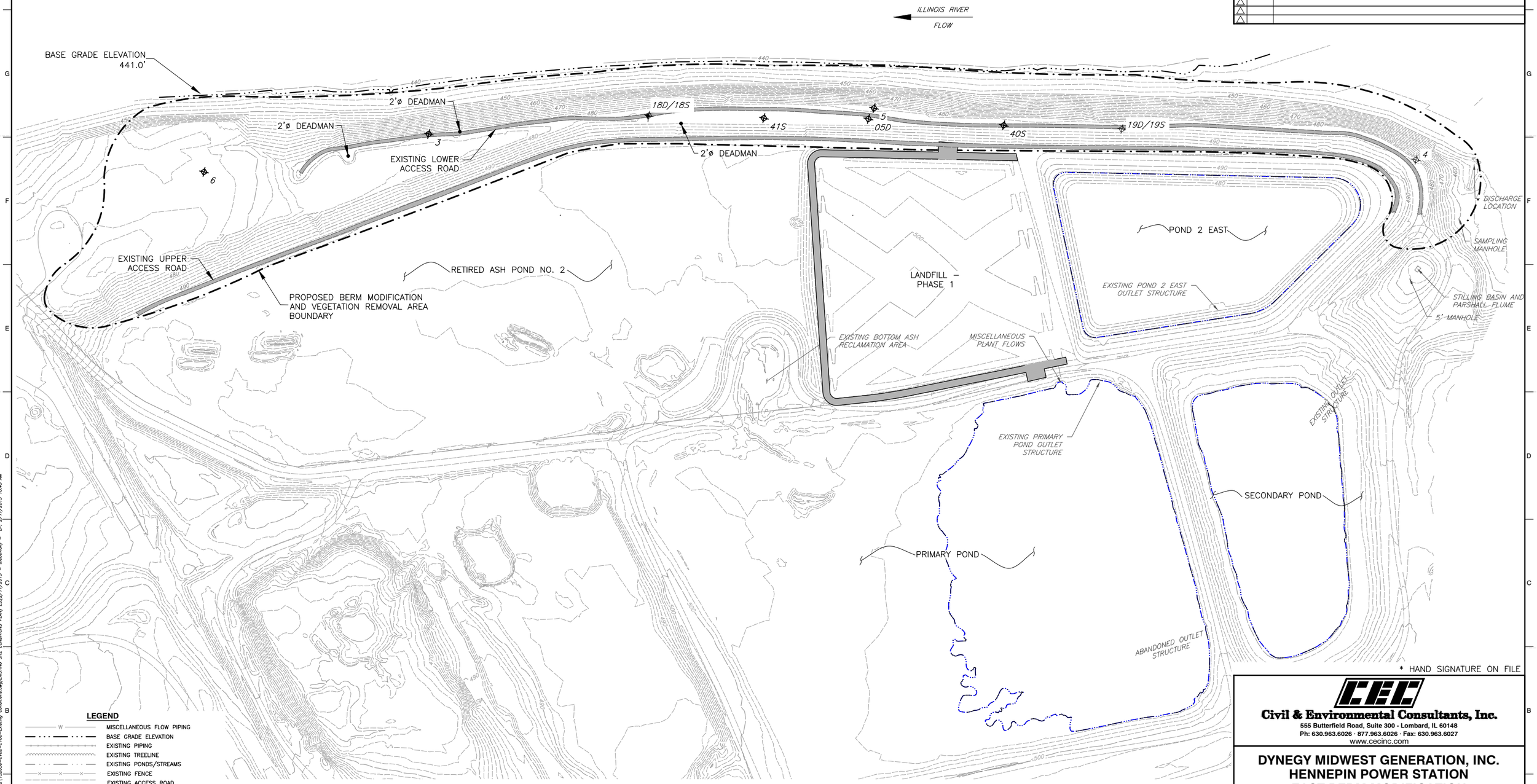
SECTION "H-H"

REVISION STATUS	ILLINOIS POWER COMPANY	
O -CONSTRUCTION O -RECORD	DECATUR	
0	DETAILS: POND DISCHARGE STRUCTURE 1995 ASH FACILITY HENNEPIN POWER STATION	
DR G.R.H.	CAD G.R.H.	DATE 1/5/94
OK	CKD	SCALE AS NOTED
APP	PLOTTED 9/17/96	CE-HEN1-C9
APP		
p0019276.dgn		

NORTH

SUBMITTAL RECORD		
NO	DATE	DESCRIPTION
1	5/2013	IDNR DAM MODIFICATION PERMIT
2	6/9/2014	ISSUED FOR CONSTRUCTION
3	2/4/2015	AS-BUILT CONSTRUCTION DRAWINGS

REVISION RECORD		
NO	DATE	DESCRIPTION
△		
△		
△		
△		



LEGEND

- MISCELLANEOUS FLOW PIPING
- BASE GRADE ELEVATION
- EXISTING PIPING
- EXISTING TREELINE
- EXISTING PONDS/STREAMS
- EXISTING FENCE
- EXISTING ACCESS ROAD
- EXISTING STORM WATER PIPING
- EXISTING UNDERGROUND PLANT FLOW PIPING
- EXISTING PLANT FLOW PIPING
- EXISTING INDEX CONTOURS
- EXISTING INTERMEDIATE CONTOURS
- EXISTING MONITORING WELL LOCATIONS
- EXISTING ACCESS ROAD
- PROPOSED EAST BERM MODIFICATIONS AREA BOUNDARY

REFERENCE:

1. TOPOGRAPHIC INFORMATION BASED UPON AERIAL SURVEY CONDUCTED BY SURDEX CORPORATION FLOWN ON SEPTEMBER 10, 2008.
2. EMBANKMENT AREA SURVEY RECEIVED BY CEC FROM DLZ ON MARCH 4, 2013 AND JANUARY 10, 2014.
3. IL DNR PERMIT NO. DS2014017–DAM I.D. NO. 50663
4. AS–BUILT SURVEY RECEIVED BY CEC FROM DLZ, DECEMBER 12, 2014.

AS-BUILT CONSTRUCTION PLANS

SCALE IN FEET
0 100 200

* HAND SIGNATURE ON FILE

Civil & Environmental Consultants, Inc.
555 Butterfield Road, Suite 300 - Lombard, IL 60148
Ph: 630.963.6026 · 877.963.6026 · Fax: 630.963.6027
www.cecinc.com

DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
EAST BERM MODIFICATION
HENNEPIN, ILLINOIS

DRAWN BY:	DFB	CHECKED BY:	MDJ	APPROVED BY:	*MDJ
DATE:	FEBRUARY 2015	DWG SCALE:	AS NOTED	PROJECT NO:	132-650

EXISTING SITE CONDITIONS PLAN

DRAWING NO.: **3**
SHEET 3 OF 9

p:\2013\1_132-650\2200\1-CAD\Dwg\C102\132650-C102-C100-Existing Conditions.dwg[EXISTING SITE CONDITIONS PLAN] LS:[2/11/2015 - lhostman] - LP: 2/11/2015 10:43 AM

The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 10b

SUBMITTAL RECORD		
NO	DATE	DESCRIPTION
1	5/2013	IDNR DAM MODIFICATION PERMIT
2	2/2014	ISSUED FOR CONSTRUCTION
3	2/4/2015	AS-BUILT CONSTRUCTION DRAWINGS

REVISION RECORD		
NO	DATE	DESCRIPTION
△		
△		
△		
△		

NORTH

TYPICAL BERM DETAIL 3/9

30" SILT FENCE DETAIL 1/4

TYPICAL BERM DETAIL 2/9

PROPOSED GRADING NOT SHOWN FOR CLARITY

ILLINOIS RIVER FLOW

4/9 TYPICAL BERM DETAIL WITH UNSUITABLE SOIL REMOVAL

BASE GRADE ELEVATION 441.0'

PROPOSED TEMPORARY SILT FENCE

2'ø DEADMAN

18D/18S

41S

5

05D

40S

19D/19S

ACCESS RAMP AND HAUL ROAD

ACCESS RAMP AND HAUL ROAD

6

3

2'ø DEADMAN

2'ø DEADMAN

4

DISCHARGE LOCATION

SAMPLING MANHOLE

TREE AND ROOT BALL REMOVAL AS WELL AS BERM RECONFIGURATION

POND 2 EAST

TREE AND ROOT BALL REMOVAL ONLY ON THIS SLOPE

UPPER ACCESS ROAD

LOWER ACCESS ROAD

LANDFILL – PHASE 1

EXISTING POND 2 EAST OUTLET STRUCTURE

RETIRED ASH POND NO. 2

STILLING BASIN AND PARSHALL FLUME

5' MANHOLE

TREE AND ROOT BALL REMOVAL ONLY ON THIS SLOPE

EXISTING BOTTOM ASH RECLAMATION AREA

MISCELLANEOUS PLANT FLOWS

EXISTING OUTLET STRUCTURE

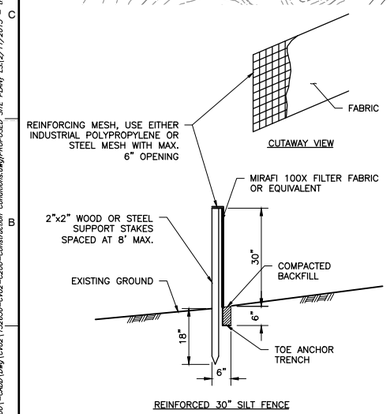
EXISTING PRIMARY POND OUTLET STRUCTURE

SECONDARY POND

PRIMARY POND

ABANDONED OUTLET STRUCTURE

SITE PLAN
SCALE: 1" = 100'



DETAIL 1
30" SILT FENCE DETAIL
N.T.S.

SILT FENCE NOTES:

1. SILT FENCE SHALL BE PLACED ON LEVEL GRADE, WHERE POSSIBLE, AND BOTH ENDS OF THE SILT FENCE SHALL BE EXTENDED UP THE SLOPE.
2. SILT FENCE SHALL NOT BE PLACED IN ANY AREA OF CONCENTRATED FLOW NOR IN AREAS WHERE ROCK OR ROCKY SOILS PREVENT THE FULL AND UNIFORM ANCHORING OF THE FENCE TOE.
3. THE CONTRACTOR SHALL INSPECT THE SILT FENCE AFTER EVERY PRECIPITATION EVENT AND IMMEDIATELY REPAIR ANY DEFICIENCIES.
4. THE CONTRACTOR SHALL REMOVE ACCUMULATED SEDIMENTS AS REQUIRED TO KEEP THE FENCE FUNCTIONAL. IN ALL CASES, THE CONTRACTOR SHALL REMOVE DEPOSITS WHERE ACCUMULATIONS REACH ONE-HALF THE ABOVE GROUND HEIGHT OF THE FENCE.
5. THE CONTRACTOR SHALL IMMEDIATELY REPAIR ALL UNDERCUTTING OR EROSION OF THE ANCHOR TOE WITH A ROCK FILTER OUTLET.
6. THE CONTRACTOR SHALL CONFORM TO ANY RECOMMENDATIONS BY THE MANUFACTURER FOR REPLACING FILTER FABRIC FENCE DUE TO WEATHERING.

LEGEND

W	MISCELLANEOUS FLOW PIPING
	BASE GRADE ELEVATION
	EXISTING PIPING
	EXISTING TREELINE
	EXISTING PONDS/STREAMS
X X X	EXISTING FENCE
	EXISTING ACCESS ROAD
ST	EXISTING STORM WATER PIPING
P	EXISTING UNDERGROUND PLANT FLOW PIPING
	EXISTING PLANT FLOW PIPING
495	EXISTING INDEX CONTOURS
	EXISTING INTERMEDIATE CONTOURS
18D	EXISTING MONITORING WELL LOCATIONS
	PROPOSED CONSTRUCTION ACCESS ROAD
	PROPOSED EAST BERM MODIFICATIONS AREA BOUNDARY
SF	PROPOSED SILT FENCE
	PROPOSED GRADING LIMITS

AS-BUILT CONSTRUCTION PLANS

NOTE:
MONITORING WELLS EXIST WITHIN THE PROPOSED BERM MODIFICATION AREA. CONTRACTOR SHALL PROTECT EXISTING MONITORING WELLS WHILE PERFORMING BERM MODIFICATION ACTIVITIES.

REFERENCE:

1. TOPOGRAPHIC INFORMATION BASED UPON AERIAL SURVEY CONDUCTED BY SURDEX CORPORATION FLOWN ON SEPTEMBER 10, 2008.
2. EMBANKMENT AREA SURVEY RECEIVED BY CEC FROM DLZ ON MARCH 4, 2013 AND JANUARY 10, 2014.
3. IL DNR PERMIT NO. DS2014017-DAM I.D. NO. 50663
4. AS-BUILT SURVEY RECEIVED BY CEC FROM DLZ, DECEMBER 12, 2014.

SCALE IN FEET
0 100 200

* HAND SIGNATURE ON FILE

Civil & Environmental Consultants, Inc.
555 Butterfield Road, Suite 300 · Lombard, IL 60148
Ph: 630.963.6026 · 877.963.6026 · Fax: 630.963.6027
www.cecinc.com

DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
EAST BERM MODIFICATION
HENNEPIN, ILLINOIS

DRAWN BY:	DFB	CHECKED BY:	MDJ	APPROVED BY:	*MDJ
DATE:	FEBRUARY 2015	DWG SCALE:	AS NOTED	PROJECT NO:	132-650

PROPOSED SITE PLAN

DRAWING NO.: **4**
SHEET 4 OF 9

A:\2013\132-650.02001-CAD\Dwg\CIVIL\132650-CIV02-C200-Construction Conditions.dwg[PROPOSED SITE PLAN] LS(2/11/2015 - thoolman) - LP: 2/11/2015 10:43 AM

SUBMITTAL RECORD		
NO	DATE	DESCRIPTION
1	5/2013	IDNR DAM MODIFICATION PERMIT
2	6/9/2014	ISSUED FOR CONSTRUCTION
3	2/4/2015	AS-BUILT CONSTRUCTION DRAWINGS

REVISION RECORD		
NO	DATE	DESCRIPTION
△		
△		
△		
△		

NORTH

PROPOSED SECTIONS (TYP.)
SEE SHEETS 7 & 8

TYPICAL BERM DETAIL 3/9

TYPICAL BERM DETAIL 2/9

ILLINOIS RIVER FLOW

SAFETY BENCH

BASE GRADE ELEVATION
441.0'

WEST ACCESS RAMP

0+00 1+00 2+00 3+00 4+00 5+00 6+00 7+00 8+00 9+00 10+00 11+00

MATCHLINE – SEE SHEET 6

18D/18S

41S

2' ø DEADMAN

LOWER ACCESS ROAD

2'ø DEADMAN (REMOVED)

TREE AND ROOT BALL REMOVAL AS
WELL AS BERM RECONFIGURATION

UPPER ACCESS ROAD

TREE AND ROOT
BALL REMOVAL ONLY

RETIRED ASH POND

LEGEND

- MISCELLANEOUS FLOW PIPING
- BASE GRADE ELEVATION
- EXISTING TREELINE
- EXISTING PONDS/STREAMS
- EXISTING FENCE
- EXISTING ACCESS ROAD
- EXISTING STORM WATER PIPING
- EXISTING UNDERGROUND PLANT FLOW PIPING
- EXISTING PLANT FLOW PIPING
- EXISTING INDEX CONTOURS
- EXISTING INTERMEDIATE CONTOURS
- EXISTING MONITORING WELL LOCATIONS
- EXISTING ACCESS ROAD
- PROPOSED EAST BERM MODIFICATIONS AREA BOUNDARY
- PROPOSED INDEX CONTOUR
- PROPOSED INTERMEDIATE CONTOUR
- PROPOSED SAFETY BENCH
- TREE/ROOT BALL REMOVAL ONLY
- TREE/ROOT BALL REMOVAL WITH BERM RECONFIGURATION

AS-BUILT CONSTRUCTION PLANS

REFERENCE:

1. TOPOGRAPHIC INFORMATION BASED UPON AERIAL SURVEY CONDUCTED BY SURDEX CORPORATION FLOWN ON SEPTEMBER 10, 2008.
2. EMBANKMENT AREA SURVEY RECEIVED BY CEC FROM DLZ ON MARCH 4, 2013 AND JANUARY 10, 2014.
3. IL DNR PERMIT NO. DS2014017–DAM I.D. NO. 50663
4. AS–BUILT SURVEY RECEIVED BY CEC FROM DLZ, DECEMBER 12, 2014.

SCALE IN FEET
0 50 100

* HAND SIGNATURE ON FILE

Civil & Environmental Consultants, Inc.
555 Butterfield Road, Suite 300 · Lombard, IL 60148
Ph: 630.963.6026 · 877.963.6026 · Fax: 630.963.6027
www.cecinc.com

DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
EAST BERM MODIFICATION
HENNEPIN, ILLINOIS

DRAWN BY:	DFB	CHECKED BY:	MDJ	APPROVED BY:	*MDJ
DATE:	FEBRUARY 2015	DWG SCALE:	AS NOTED	PROJECT NO:	132-650

PROPOSED GRADING PLAN
1 OF 2

DRAWING NO.: **5**
SHEET 5 OF 9

A:\2013\132-650.02001-CAD\Dwg\CAD21\132650-CV02-C300-Proposed Grading Plan.dwg[PROPOSED GRADING PLAN - 1 OF 2] LS(2/17/2015 - dbvencik) - LP: 2/17/2015 10:43 AM

SUBMITTAL RECORD		
NO	DATE	DESCRIPTION
1	5/2013	IDNR DAM MODIFICATION PERMIT
2	6/9/2014	ISSUED FOR CONSTRUCTION
3	2/4/2015	AS-BUILT CONSTRUCTION DRAWINGS

REVISION RECORD		
NO	DATE	DESCRIPTION
△		
△		
△		
△		

NORTH

MATCHLINE – SEE SHEET 5

PROPOSED SECTIONS (TYP.)
SEE SHEETS 7 & 8

ILLINOIS RIVER FLOW

BASE GRADE ELEVATION
441.0'

SAFETY BENCH

LIMITS OF UNSUITABLE
SOIL REMOVAL

TYPICAL BERM SECTION WITH
UNSUITABLE SOIL REMOVAL 4/9

11+00 12+00 13+00 14+00 15+00 16+00 17+00 18+00 19+00 20+00 21+00 22+00 23+00 23+50

05D 5 40S 19D/19S 4

TREE AND ROOT BALL REMOVAL AS
WELL AS BERM RECONFIGURATION

TREE AND ROOT
BALL REMOVAL ONLY

DISCHARGE
LOCATION

SAMPLING MANHOLE

POND 2 EAST

LANDFILL - PHASE 1

EXISTING POND 2 EAST OUTLET STRUCTURE

STILLING BASIN AND
PARSHALL FLUME

5' MANHOLE

COAL PILE RUNOFF

MISCELLANEOUS PLANT FLOWS

LEGEND

- MISCELLANEOUS FLOW PIPING
- BASE GRADE ELEVATION
- EXISTING TREELINE
- EXISTING PONDS/STREAMS
- EXISTING FENCE
- EXISTING ACCESS ROAD
- EXISTING STORM WATER PIPING
- EXISTING UNDERGROUND PLANT FLOW PIPING
- EXISTING PLANT FLOW PIPING
- EXISTING INDEX CONTOURS
- EXISTING INTERMEDIATE CONTOURS
- EXISTING MONITORING WELL LOCATIONS
- EXISTING ACCESS ROAD
- PROPOSED EAST BERM MODIFICATIONS AREA BOUNDARY
- PROPOSED INDEX CONTOUR
- PROPOSED INTERMEDIATE CONTOUR
- PROPOSED SAFETY BENCH

- TREE/ROOT BALL REMOVAL ONLY
- TREE/ROOT BALL REMOVAL WITH BERM RECONFIGURATION

AS-BUILT CONSTRUCTION PLANS

REFERENCE:

1. TOPOGRAPHIC INFORMATION BASED UPON AERIAL SURVEY CONDUCTED BY SURDEX CORPORATION FLOWN ON SEPTEMBER 10, 2008.
2. EMBANKMENT AREA SURVEY RECEIVED BY CEC FROM DLZ ON MARCH 4, 2013 AND JANUARY 10, 2014.
3. IL DNR PERMIT NO. DS2014017–DAM I.D. NO. 50663
4. AS–BUILT SURVEY RECEIVED BY CEC FROM DLZ, DECEMBER 12, 2014.

SCALE IN FEET
0 50 100

* HAND SIGNATURE ON FILE

Civil & Environmental Consultants, Inc.
555 Butterfield Road, Suite 300 - Lombard, IL 60148
Ph: 630.963.6026 · 877.963.6026 · Fax: 630.963.6027
www.cecinc.com

DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
EAST BERM MODIFICATION
HENNEPIN, ILLINOIS

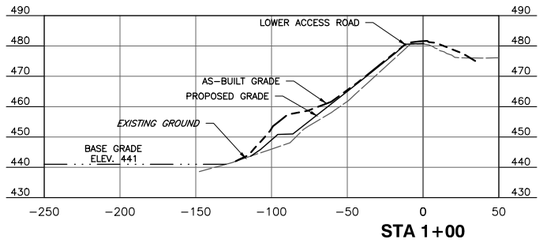
DRAWN BY:	DFB	CHECKED BY:	MDJ	APPROVED BY:	*MDJ
DATE:	FEBRUARY 2015	DWG SCALE:	AS NOTED	PROJECT NO:	132-650

PROPOSED GRADING PLAN
2 OF 2

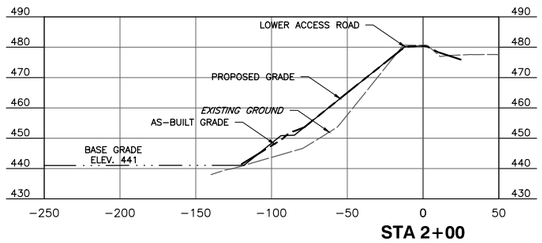
DRAWING NO.: 6

SHEET 6 OF 9

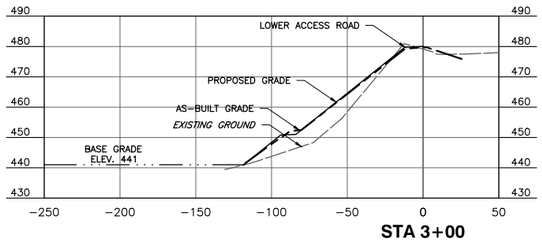
A:\2013\132-650.02001\–CADD\Dwg\Civil\132650-Civil2–C302–Proposed Grading Plan.dwg(PROPOSED GRADING PLAN – 2 OF 2) LS(2/17/2015 – dtvincelli) – LP, 2/17/2015 10:43 AM



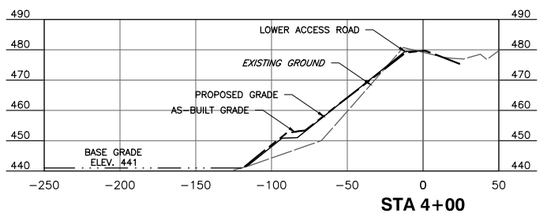
STA 1+00



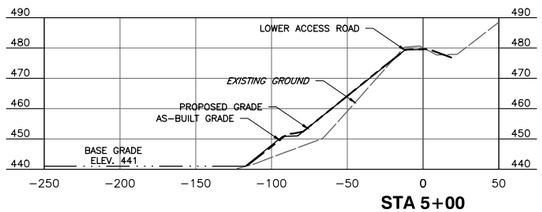
STA 2+00



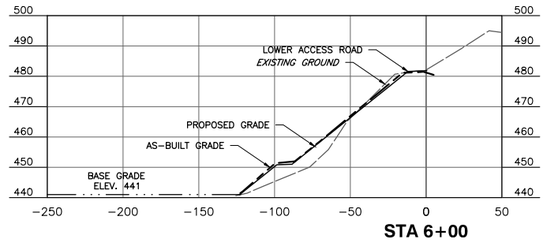
STA 3+00



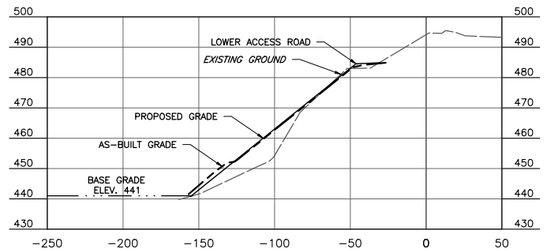
STA 4+00



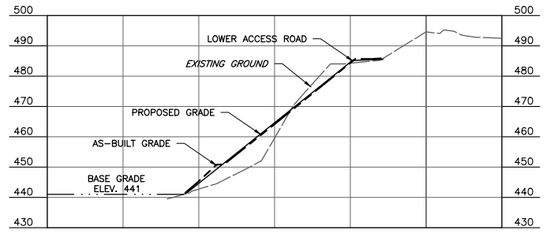
STA 5+00



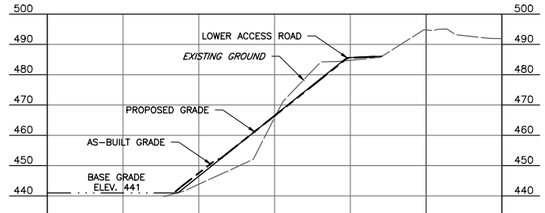
STA 6+00



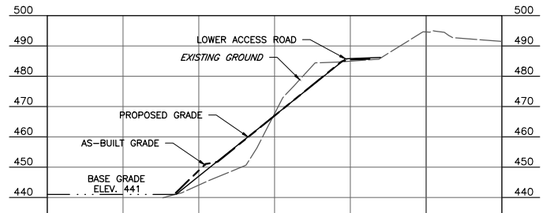
STA 7+00



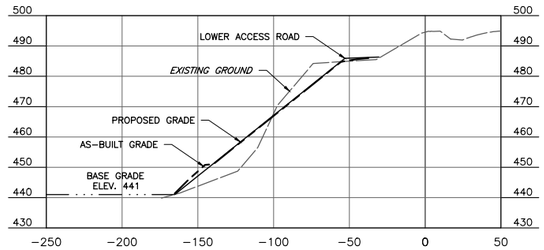
STA 8+00



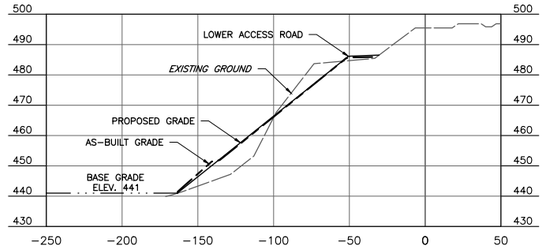
STA 9+00



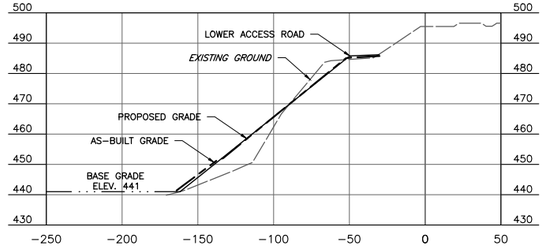
STA 10+00



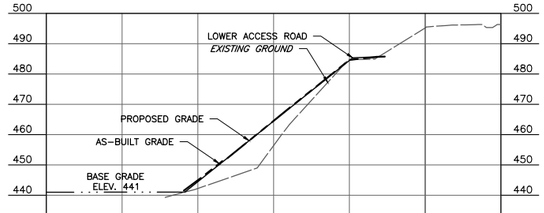
STA 11+00



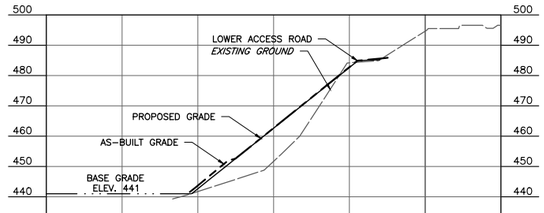
STA 12+00



STA 13+00



STA 14+00



STA 15+00

SUBMITTAL RECORD

NO	DATE	DESCRIPTION
1	5/2013	IDNR DAM MODIFICATION PERMIT
2	6/9/2014	ISSUED FOR CONSTRUCTION
3	2/4/2015	AS-BUILT CONSTRUCTION DRAWINGS

REVISION RECORD

NO	DATE	DESCRIPTION
△		
△		
△		
△		

REFERENCE:

1. TOPOGRAPHIC INFORMATION BASED UPON AERIAL SURVEY CONDUCTED BY SURDEX CORPORATION FLOWN ON SEPTEMBER 10, 2008.
2. EMBANKMENT AREA SURVEY RECEIVED BY CEC FROM DLZ ON MARCH 4, 2013 AND JANUARY 10, 2014.
3. IL DNR PERMIT NO. DS2014017–DAM I.D. NO. 50663
4. AS–BUILT SURVEY RECEIVED BY CEC FROM DLZ, DECEMBER 12, 2014.

AS-BUILT CONSTRUCTION PLANS

HORIZONTAL
SCALE IN FEET
0 50 100

VERTICAL
SCALE IN FEET
0 25 50

* HAND SIGNATURE ON FILE

Civil & Environmental Consultants, Inc.
555 Butterfield Road, Suite 300 - Lombard, IL 60148
Ph: 630.963.6026 · 877.963.6026 · Fax: 630.963.6027
www.cecinc.com

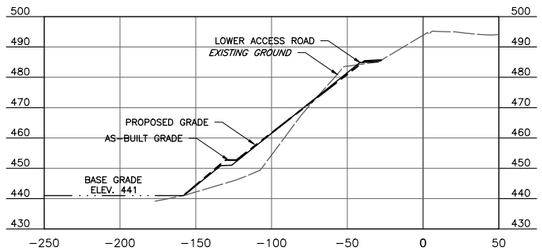
DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
EAST BERM MODIFICATION
HENNEPIN, ILLINOIS

DRAWN BY:	DFB	CHECKED BY:	MDJ	APPROVED BY:	*MDJ
DATE:	FEBRUARY 2015	DWG SCALE:	AS NOTED	PROJECT NO:	132-650

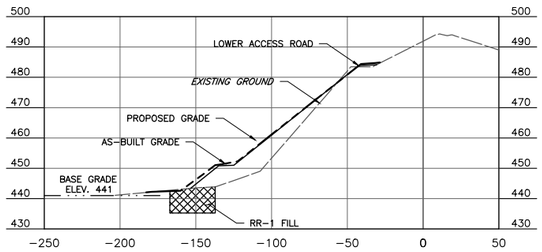
PROPOSED SECTIONS
STA 1+00 TO 15+00

DRAWING NO.: **7**
SHEET 7 OF 9

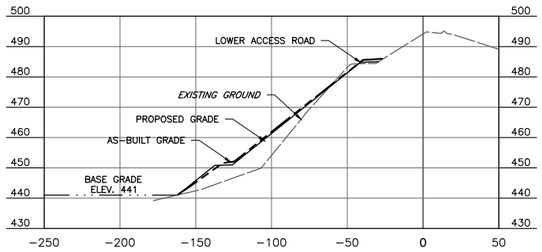
I:\2013\132-650.0200\-CADD\Dwg\Civil\132650-Civil-C300-Proposed Grading Plan.dwg(CROSS SECTIONS (1)) LS(2/17/2015 - dbrondvik) - LP: 2/17/2015 10:43 AM



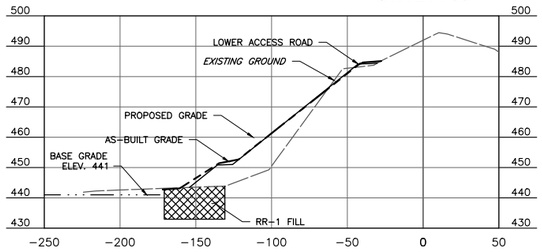
STA 16+00



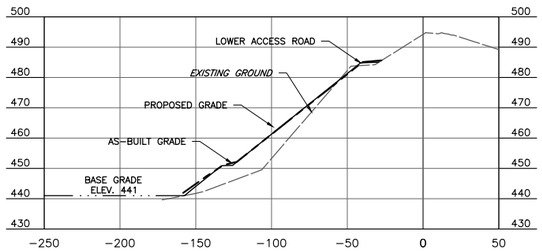
STA 21+00



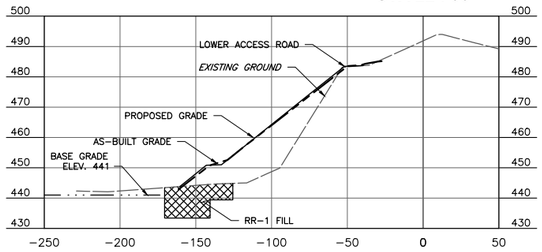
STA 17+00



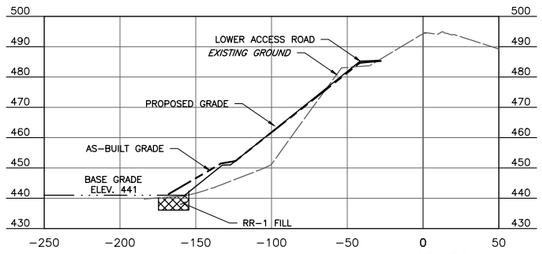
STA 22+00



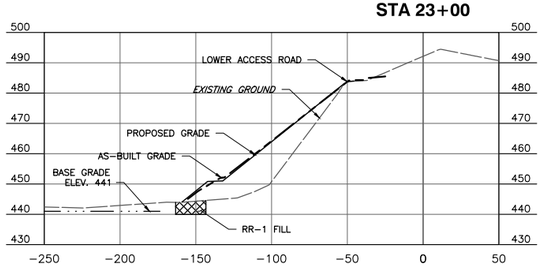
STA 18+00



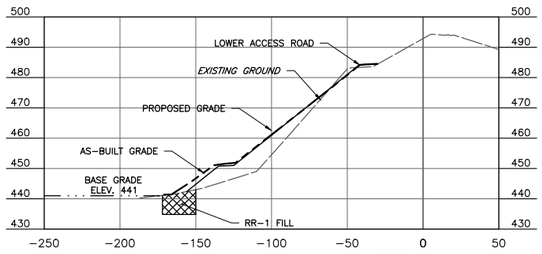
STA 23+00



STA 19+00



STA 23+50



STA 20+00

SUBMITTAL RECORD		
NO	DATE	DESCRIPTION
1	5/2013	IDNR DAM MODIFICATION PERMIT
2	6/9/2014	ISSUED FOR CONSTRUCTION
3	2/4/2015	AS-BUILT CONSTRUCTION DRAWINGS

REVISION RECORD		
NO	DATE	DESCRIPTION
1		
2		
3		
4		

REFERENCE:

1. TOPOGRAPHIC INFORMATION BASED UPON AERIAL SURVEY CONDUCTED BY SURDEX CORPORATION FLOWN ON SEPTEMBER 10, 2008.
2. EMBANKMENT AREA SURVEY RECEIVED BY CEC FROM DLZ ON MARCH 4, 2013 AND JANUARY 10, 2014.
3. IL DNR PERMIT NO. DS2014017–DAM I.D. NO. 50663
4. AS–BUILT SURVEY RECEIVED BY CEC FROM DLZ, DECEMBER 12, 2014.

AS-BUILT CONSTRUCTION PLANS

HORIZONTAL SCALE IN FEET
0 50 100

VERTICAL SCALE IN FEET
0 25 50

* HAND SIGNATURE ON FILE

Civil & Environmental Consultants, Inc.
555 Butterfield Road, Suite 300 - Lombard, IL 60148
Ph: 630.963.6026 · 877.963.6026 · Fax: 630.963.6027
www.cecinc.com

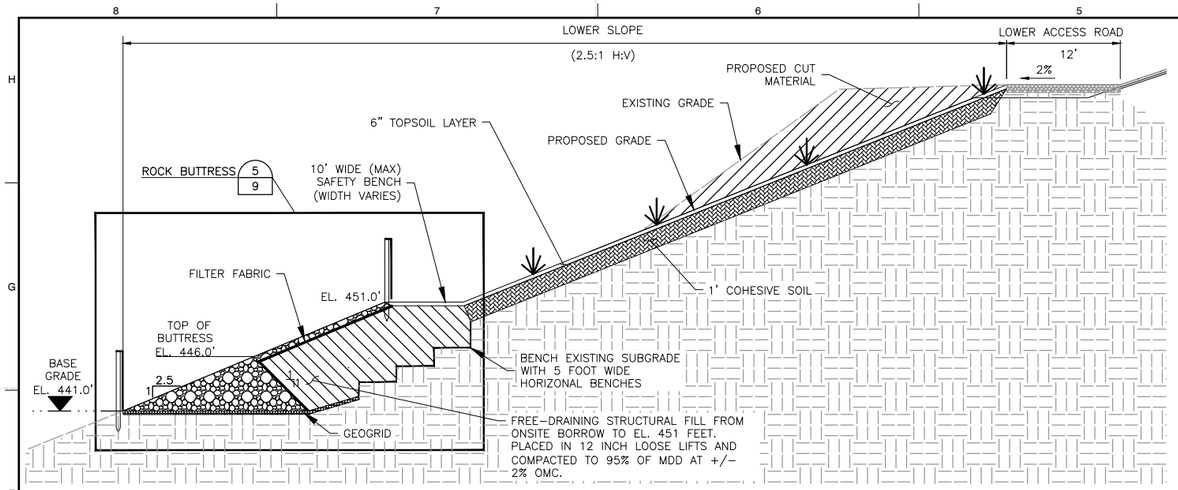
DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
EAST BERM MODIFICATION
HENNEPIN, ILLINOIS

DRAWN BY:	DFB	CHECKED BY:	MDJ	APPROVED BY:	*MDJ
DATE:	FEBRUARY 2015	DWG SCALE:	AS NOTED	PROJECT NO:	132-650

PROPOSED SECTIONS
STA 16+00 TO 23+50

DRAWING NO.: **8**
SHEET **8** OF **9**

A:\2013\132-650\02001\-CADD\Dwg\Civil\132650-Civil2-C300-Proposed Grading Plan.dwg(CROSS SECTIONS (2)) LS(2/17/2015 - dbrondyk) - LP: 2/17/2015 10:43 AM



DETAIL 2
TYPICAL BERM DETAIL
SCALE: NTS

LEGEND

- PROPOSED CUT MATERIAL
- PROPOSED STRUCTURAL FILL
- UNSUITABLES/RR1 FILL
- RIPRAP
- DRAINAGE LAYER
- PROPOSED GRADELINE
- EXISTING GRADELINE
- WATER SURFACE ELEVATION
- VEGETATION

SUBMITTAL RECORD

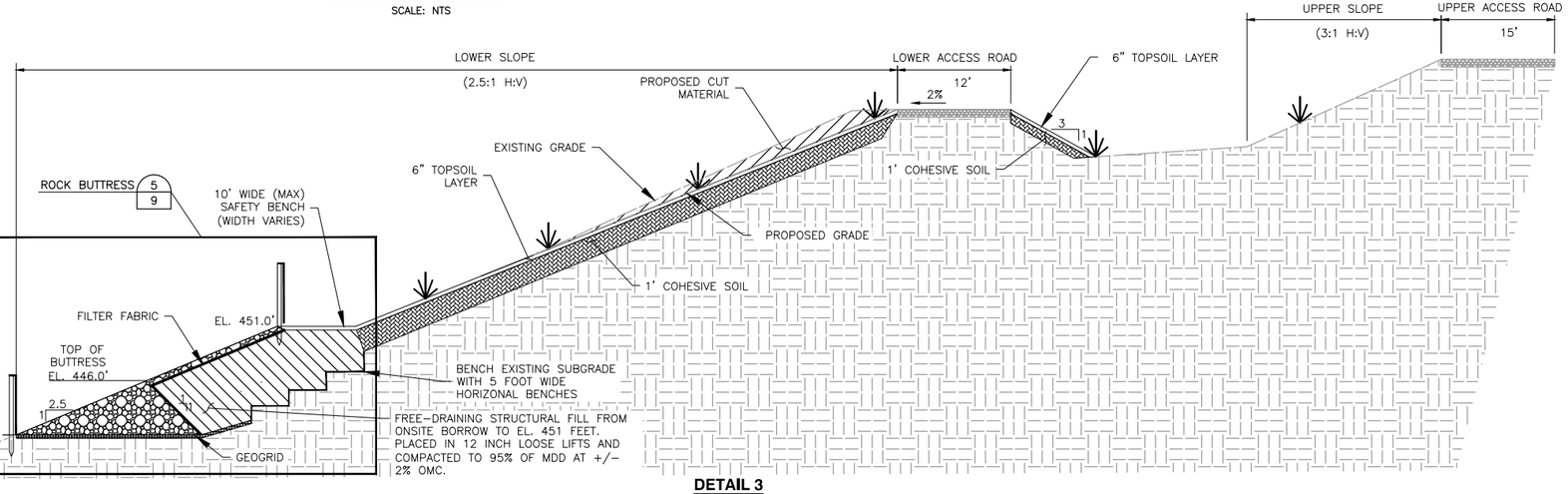
NO	DATE	DESCRIPTION
1	5/2013	IDNR DAM MODIFICATION PERMIT
2	6/9/2014	ISSUED FOR CONSTRUCTION
3	2/4/2015	AS-BUILT CONSTRUCTION DRAWINGS

REVISION RECORD

NO	DATE	DESCRIPTION
△		
△		
△		
△		

REFERENCE:

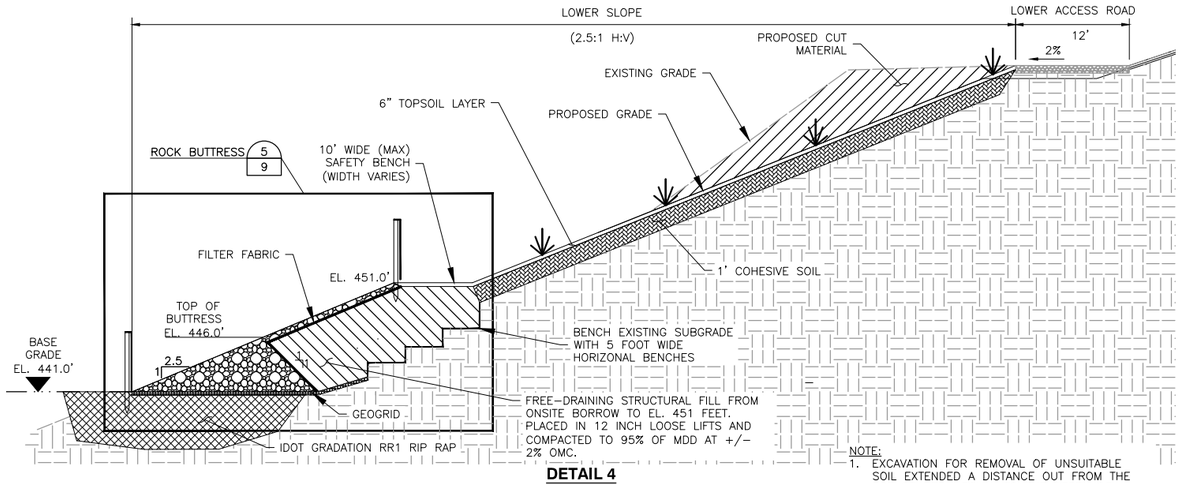
1. TOPOGRAPHIC INFORMATION BASED UPON AERIAL SURVEY CONDUCTED BY SURDEX CORPORATION FLOWN ON SEPTEMBER 10, 2008.
2. EMBANKMENT AREA SURVEY RECEIVED BY CEC FROM DLZ ON MARCH 4, 2013 AND JANUARY 10, 2014.
3. IL DNR PERMIT NO. DS2014017-DAM I.D. NO. 50663
4. AS-BUILT SURVEY RECEIVED BY CEC FROM DLZ, DECEMBER 12, 2014.



DETAIL 3
TYPICAL BERM DETAIL
SCALE: NTS

NOTE:

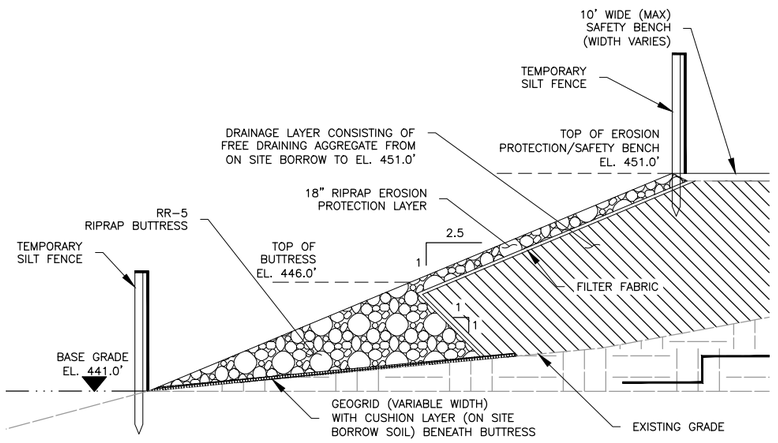
1. TEMPORARY SILT FENCE WAS INSTALLED PRIOR TO ROCK BUTTRESS INSTALLATION. UPON COMPLETION OF ROCK BUTTRESS. SILT FENCE WAS INSTALLED UP SLOPE OF ROCK BUTTRESS AND TEMPORARY SILT FENCE REMOVED.
2. AFTER PLACING TOPSOIL AND SEEDING, EROSION CONTROL BLANKETS WERE INSTALLED ON ALL SLOPES STEEPER THAN 3:1 FOR EROSION PROTECTION AND SEED ESTABLISHMENT. STRAW WATTLES WERE PLACED AT MID-HEIGHT OF BERM FOR ADDITIONAL EROSION PROTECTION.



DETAIL 4
TYPICAL BERM WITH UNSUTABLE SOIL REMOVAL DETAIL
SCALE: NTS

NOTE:

1. EXCAVATION FOR REMOVAL OF UNSUITABLE SOIL EXTENDED A DISTANCE OUT FROM THE TOE OF BERM EQUAL TO THE DEPTH OF EXCAVATION.



DETAIL 5
ROCK BUTRESS AND EROSION PROTECTION LAYER DETAIL
SCALE: NTS

AS-BUILT CONSTRUCTION PLANS

* HAND SIGNATURE ON FILE

Civil & Environmental Consultants, Inc.
555 Butterfield Road, Suite 300 - Lombard, IL 60148
Ph: 630.963.6026 · 877.963.6026 · Fax: 630.963.6027
www.cecinc.com

DYNEGY MIDWEST GENERATION, INC.
HENNEPIN POWER STATION
EAST BERM MODIFICATION
HENNEPIN, ILLINOIS

DRAWN BY:	DFB	CHECKED BY:	MDJ	APPROVED BY:	*MDJ
DATE:	FEBRUARY 2015	DWG SCALE:	AS NOTED	PROJECT NO:	132-650

BERM AND EROSION CONTROL DETAILS

DRAWING NO.: 9
SHEET 9 OF 9

I:\2013\132-650.02001\-CADD\Dwg\Civil\132650-Civil2-C900-Erosion Control Details.dwg[DETAILS 2][4] LS(2/17/2015 - 8:44:43 AM) - LP: 2/17/2015 10:43 AM

Appendix C: Hennepin Power Station Piezometer Locations



EXPLORATION METHOD (B=BORING, C=CPT, P=PIEZOMETER)

XXX–X###

ID NUMBER

STATION ABBREVIATION

SOURCE:
MAP PROVIDED BY GOOGLE EARTH PRO 2015

LEGEND

PIEZOMETER LOCATION

CCR UNIT BERM ALIGNMENT

0 200

APPROXIMATE SCALE FEET

DYNEGY MIDWEST GENERATION, LLC

PROJECT NO. 60439752

AECOM

DRN. BY: djd October 2015
DSGN. BY: eg
CHKD. BY: eg

Hennepin Ash Pond No. 2
Piezometer Locations

FIG. NO. 2A

File: P:\PROJECTS\GEOTECH\60439794_DYNEGY\CCR\04TASKS\00 PROGRAM TASKS\1.0 TASK 1 INITIAL UNIT ASSESSMENT\CCR FACT SHEETS\SITE MAPS\FIGURE 2A–2D PIEZOMETER LOCATION PLAN (HENNEPIN).DWG Last edited: NOV. 03, 15 @ 3:11 p.m. by: david_deguire



EXPLORATION METHOD (B=BORING, C=CPT, P=PIEZOMETER)

XXX-X###

ID NUMBER

STATION ABBREVIATION

SOURCE:
MAP PROVIDED BY GOOGLE EARTH PRO 2015

LEGEND

PIEZOMETER LOCATION

CCR UNIT BERM ALIGNMENT

0 200

APPROXIMATE SCALE FEET

DYNEGY MIDWEST GENERATION, LLC	PROJECT NO. 60439752
AECOM	
DRN. BY: djd October 2015 DSGN. BY: eg CHKD. BY: eg	Hennepin East Ash Pond Piezometer Locations
	FIG. NO. 2B

File: P:\PROJECTS\GEOTECH\60439794_DYNEGYCCR\04TASKS\00 PROGRAM TASKS\1.0 TASK 1 INITIAL UNIT ASSESSMENT\CCR FACT SHEETS\SITE MAPS\FIGURE 2A-2D PIEZOMETER LOCATION PLAN (HENNEPIN).DWG Last edited: NOV. 03, 15 @ 3:11 p.m. by: david_deguire



EXPLORATION METHOD (B=BORING, C=CPT, P=PIEZOMETER)

XXX-X###

ID NUMBER

STATION ABBREVIATION

SOURCE:
MAP PROVIDED BY GOOGLE EARTH PRO 2015

LEGEND

PIEZOMETER LOCATION

CCR UNIT BERM ALIGNMENT

0 200

APPROXIMATE SCALE FEET

DYNEGY MIDWEST GENERATION, LLC

PROJECT NO. 60439752

AECOM

DRN. BY: djd October 2015
DSGN. BY: eg
CHKD. BY: eg

Hennepin Old West Ash Pond (Pond No. 1 and Pond No. 3) Piezometer Locations

FIG. NO. 2C

File: P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\04TASKS\00 PROGRAM TASKS\1.0 TASK 1 INITIAL UNIT ASSESSMENT\CCR FACT SHEETS\SITE MAPS\FIGURE 2A-2D PIEZOMETER LOCATION PLAN (HENNEPIN).DWG Last edited: NOV. 03, 15 @ 3:11 p.m. by: david_deguire



EXPLORATION METHOD (B=BORING, C=CPT, P=PIEZOMETER)

XXX-X###

ID NUMBER

STATION ABBREVIATION

SOURCE:
MAP PROVIDED BY GOOGLE EARTH PRO 2015

LEGEND

PIEZOMETER LOCATION

CCR UNIT BERM ALIGNMENT

0 100

APPROXIMATE SCALE FEET

DYNEGY MIDWEST GENERATION, LLC		PROJECT NO. 60439752
AECOM		
DRN. BY: djd October 2015 DSGN. BY: eg CHKD. BY: eg	Hennepin Old West Polishing Pond Piezometer Locations	FIG. NO. 2D

File: P:\PROJECTS\GEOTECH\60428794_DYNEGYCCR\04TASKS\00 PROGRAM TASKS\1.0 TASK 1 INITIAL UNIT ASSESSMENT\CCR FACT SHEETS\SITE MAPS\FIGURE 2A-2D PIEZOMETER LOCATION PLAN (HENNEPIN).DWG Last edited: NOV. 03, 15 @ 3:11 p.m. by: david_deguire

Appendix D: Specification J-2616, Rev. A, Primary Ash Pond Modifications

Sargent & Lundy

DYNEGY MIDWEST GENERATION
HENNEPIN POWER STATION

SPECIFICATION J-2616, REV. A
PERMIT APPLICATION

PRIMARY ASH POND MODIFICATIONS

Prepared By:
Sargent & Lundy, LLC
55 East Monroe Street
Chicago, Illinois 60603

PRIMARY ASH POND MODIFICATIONS

ISSUE SUMMARY

Rev.	Purpose of Issue	Date	Sections Affected
A	Spec No. J-2616 Released for Permit Application	02/14/03	All

CERTIFICATION OF SPECIFICATION

FOR

PRIMARY ASH POND MODIFICATION

I certify that this Specification was prepared by me or under my supervision and that I am a registered professional engineer under the laws of the State of Illinois.

Sargent & Lundy LLC's Illinois Department of Professional Regulation registration number is 184-000106

Certified By: Ronald Cook Date: Feb 14, 2003

RONALD H. COOK
062 - 048602
REGISTERED
PROFESSIONAL
ENGINEER
OF
ILLINOIS

EXP. 11-30-03

Seal

Revision: _____ Certified By: _____ Date: _____

PRIMARY ASH POND MODIFICATIONS

TABLE OF CONTENTS

Notes:

(1) Where Division and/or Sections are not included, work under the unlisted headings is not part of the Work.

(2) This Table of Contents will indicate the date of issue for the latest complete issue or revision issue of each section and any subsequent revision issue thereto.

(3) The numbering and subsequent Revisions to the Specification are in sequence with the previously issued Revision mark number.

SECTION		DATE OF ISSUE	LATEST ISSUE/REVISION
PCTC 08003	Fabric Formed Concrete Mats	02/14/03	A
PCTC 12001	Temporary and Permanent Seeding (Illinois)	02/14/03	A
PCTC 36007	Crushed Stone Surfacing for Unpaved Roads, Parking Lots, and Laydown Areas (IDOT)	02/14/03	A
PCTC 54005	Earthwork and Clay Lining for a Clay/Geomembrane Lined Ash Pond	02/14/03	A
PCTC 56008	Polypropylene Geomembrane Liner for a Pond	02/14/03	A
PCTC 57001	Geotextile for Lined Ponds	02/14/03	A
PCTC 60008	Quality Assurance for Installation of Earthwork and Clay Lining for the Ash Pond	02/14/03	A

FABRIC FORMED CONCRETE MATS

ISSUE SUMMARY

Rev.	Purpose of Issue	Date	Sections Affected	Prepared By	Reviewed By	Approved By
A	Permit Application	02/14/03	ALL	Ronald Cook	Daniel C. Kunk	Ronald Cook

FABRIC FORMED CONCRETE MATS

TABLE OF CONTENTS

Notes:

(1) This Table of Contents will indicate the date of issue for the latest complete issue or revision issue of each section and any subsequent revision issue thereto.

(2) The numbering and subsequent Revisions to the Specification are in sequence with the previously issued Revision mark number.

		Page
1.0	Scope of Work	1
1.1	Work Included	1
2.0	Codes and Standards	1
2.1	ASTM – American Society for Testing and Materials	1
3.0	Supplier's Drawings and Data Submittals	2
3.1	Submittals Prior to Installation	2
3.2	Submittals During and After Installation	3
4.0	Construction Quality Assurance	3
4.1	Testing	4
4.1.1	Independent Testing Service	4
4.1.2	Concrete Grout Testing	4
5.0	Materials	5
5.1	Fabric Design	5
5.2	Fiber and Fabric Material	5
5.3	Fabric Assembly	7
5.4	Concrete Grout	7
5.5	Acceptable Materials	7
6.0	Execution	7

6.1 Acceptance and Storage at the Project Site 7

6.1.1 Handling of Rolls 7

6.1.2 Storage at the Field Site 8

6.2 Inspection upon Delivery 8

6.3 Fabric Placement 8

6.4 Concrete Injection 8

Fabric Formed Concrete Mats - Technical Specification and Optional Features/Accessories

1.0 Scope of Work

The intent of this specification is to define the material and installation requirements for fabric formed concrete mats installed in accordance with the Design Drawings, technical data and as specified herein.

1.1 Work Included

The work shall include, but not be limited to, the following items as indicated:

A. Preparation and grading of surfaces to receive fabric mats.

B. Placing fabric mats and filling them with a pumpable sand/cement slurry to form a stable erosion protection system.

C. Offsite disposal of excess or unsuitable materials and debris.

2.0 Codes and Standards

A. Standards, specifications, manuals, codes and other publications of nationally recognized organizations and associations are referenced herein. Methods, equipment and materials specified herein shall comply with the specified and applicable portions of the referenced documents, in addition to federal, state or local codes having jurisdiction.

B. References to these documents are to the latest issue date of each document, unless otherwise indicated, together with the latest additions, addenda, amendments, supplements, etc., thereto, in effect as of the date of contract for the work.

C. Abbreviations listed indicate the form used to identify the reference documents in the specification text.

2.1 ASTM – American Society for Testing and Materials

A. ASTM C 31 – Standard Practice for Making and Curing Concrete Test Specimens in the Field.

B. ASTM C 39 – Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

C. ASTM C 143 – Standard Test Method for Slump of Hydraulic Cement Concrete.

D. ASTM C 172 – Standard Practice for Sampling Freshly Mixed Concrete.

E. ASTM C 173 – Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their contractors, subcontractors, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2000 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

F. ASTM C 231 – Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.

G. ASTM C1064 – Standard Test Method for Temperature of Freshly Mixed Portland-Cement Concrete.

H. ASTM D 543 – Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents.

I. ASTM D 751 – Standard Test Methods for Coated Fabrics.

J. ASTM D 792 – Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.

K. ASTM D1777 – Standard Test Method for Thickness of Textile Materials.

L. ASTM D2101 – Standard Test Method for Tensile Properties of Single Man-Made Textile Fibers Taken From Yarns and Tows.

M. ASTM D3776 – Standard Test Methods for Mass Per Unit Area (Weight) of Fabric.

N. ASTM D3786 – Standard Test Method for Hydraulic Bursting Strength of Knitted Goods and Nonwoven Fabrics (Mullen Burst).

O. ASTM D3787 – Standard Test Method for Bursting Strength of Knitted Goods: Constant-Rate-of Traverse (CRT) Ball Burst Test.

P. ASTM D3885 – Standard Test Method for Abrasion Resistance of Textile Fabrics.

Q. ASTM D4355 – Standard Test Methods for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.

R. ASTM D4491 – Standard Test Methods for Water Permeability of Geotextiles by Permittivity.

S. ASTM D4533 – Standard Test Method for Trapezoid Tearing Strength of Geotextiles.

T. ASTM D4632 – Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.

U. ASTM D5034 – Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test).

V. ASTM D5035 – Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Strip Method).

3.0
Supplier's Drawings and Data Submittals

A. Supplier shall submit drawings and data as specified. Supplier's drawings and data shall be submitted via electronic medium in a format compatible for importing into the Buyer's information systems specified by the Buyer.

3.1
Submittals Prior to Installation

The Supplier shall submit the following items at least 30 days prior to scheduled delivery of materials:

A. Manufacturer's literature providing specifications on the fabric mats that will be supplied.

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their contractors, subcontractors, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2000 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

B Manufacturer's certification that the fabric mats to be supplied comply with the requirements of this Technical Specification.

C Manufacturer's Quality Control and Construction Quality Control Plans. The MQC Plan shall state the frequency that index tests are performed on the fabric mat during manufacturing.

D If requested by the Buyer, four samples of each fabric mat suitable for testing.

E. Required concrete grout slurry mix design, including requirements for compressive strength, slump, air content and maximum temperature.

3.2 Submittals During and After Installation

The Supplier shall submit the following items on a daily basis during installation and a complete set of data within 30 days of the completion of the work:

A Results of tests performed on the concrete grout fill.

4.0 Construction Quality Assurance

A The Supplier shall examine the areas and conditions under which the work is to be installed and notify Buyer in writing of conditions detrimental to the proper and timely completion of the work that have changed from the time of the bidder's walkdown.

B Material and installation procedures are subject to inspection and tests conducted by an Independent Testing Service employed by the Buyer. Such inspections and tests will not relieve the Supplier of responsibility for providing material and installation procedures in compliance with specified requirements. The Buyer reserves the right, at any time before final acceptance, to reject material not complying with the specified requirements.

C The Supplier shall correct deficiencies in the work which inspections and laboratory test reports have indicated to be not in compliance with requirements. The Supplier shall perform additional tests, at his expense, as may be necessary to reconfirm any noncompliance of the original work, and as may be necessary to show compliance of corrected work.

D The Supplier shall promptly correct errors or flaws in material or placement of the protection mats identified during construction. The Supplier shall make immediate substitution of non-complying component or make field changes to make the non-complying component acceptable. Whether the correction is made by substitution or field correction, it shall be performed without cost to the Buyer.

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their contractors, subcontractors, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2000 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

4.1
Testing

4.1.1
Independent Testing Service

An Independent Testing Service shall perform the following:

A. Test material for the concrete slurry fill and prepare initial test cylinders in accordance with the requirements specified herein.

B. Prepare test cylinders and determine the compressive strength of job concrete fill test cylinders.

4.1.2
Concrete Grout Testing

A. Obtaining and testing concrete grout shall be by the Independent Testing Service in accordance with the following specifications:

- Sampling freshly mixed grout shall be done in accordance with ASTM C172.
- Making and curing concrete test specimens shall be in accordance with ASTM C31.
- Slump test shall be in accordance with ASTM C143.
- Air Content tests shall be in accordance with ASTM C173 or ASTM C231.
- Tests for the temperature of the freshly mixed grout shall be in accordance with ASTM C1064.
- Compressive strength test shall be in accordance with ASTM C39.

B. The frequency of testing shall be as directed by Buyer as follows:

- At least one test shall be made for each day's placement of grout, but not less than once for each 100 cubic yards or part thereof placed.
- A test shall consist of a minimum of four cylinders taken from the same truck. One 7-day and two 28-day tests shall be performed by the laboratory with results submitted to the Buyer as soon as possible. One spare cylinder shall be made and used as directed by the Buyer.
- A slump test and air content test shall be performed on every 100 cubic yards of concrete grout.
- The temperature of each 100 cubic yards shall be recorded in the field prior to placement. If the concrete grout temperature is in excess of 100°F, the concrete shall be rejected.

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their contractors, subcontractors, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2000 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

5.0
Materials

5.1
Fabric Design

A. Fabric-forming material shall consist of double-layer, open-selvage fabric joined in a mat configuration. The fabric shall be woven of 100% continuous multi-filament nylon fiber of which 50% by weight shall be bulk textured fiber. The use of staple yarns will not be permitted.

B. The fabric shall be woven in such a manner as to provide interwoven points of attachment on spaced centers. These points of attachment shall serve to control the thickness of the finished product and to also act as a filter point to provide relief of hydrostatic uplift pressure beneath the completed revetment. The fabric shall be woven in a basket or other open pattern to provide permeability at the filter points and the main fabric field.

C. The spacing of the filter points is indicated on the Design Drawings. This spacing will result in an average revetment thickness that is consistent with the average thickness published by the manufacturer for the designated style specified.

5.2
Fiber and Fabric Material

A. The warp fiber shall be 1260 Denier Nylon, 18.5 ends/inch per single layer and the fill fiber shall be 1900 Denier Nylon, 14 picks/inch per single layer. The fiber and fabric material shall meet the minimum requirements listed in Table 1.

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their contractors, subcontractors, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2000 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

TABLE 1
MATERIAL PROPERTIES

PROPERTY	ASTM TEST METHOD	MINIMUM TEST VALUE
Fiber count	-	0.164 g/m
Trapezoidal tear breaking force on the warp fiber at 70% elongation	D 4533	80 lbs/in
Trapezoidal tear breaking force on the fill fiber at 70% elongation	D 4533	40 lbs/in
Density	D 792	1.00 g/cm^3
Fiber dry breaking strength at 48% elongation	D 2101	20 lbs
Fiber wet breaking strength at 53% elongation (soaked in water for 2 hours)	D 2101	19 lbs
Tensile strength in the warp direction after exposure to 300 hours of Ca (OH) at a pH of 10	D 543	180 lbs/in
Tensile strength in the warp direction after exposure to 300 hours of H_2SO_4	D 543	170 lbs/in
Tensile breaking strength in the warp direction on a strip of the fabric at 39% elongation (1)	D 5034, D 5035	160 lbs/in
Tensile breaking strength in the fill direction on a strip of the fabric at 34% elongation (1)	D 5034, D 5035	190 lbs/in
Mass/unit area for a single layer of fabric	D 3776	7.8 oz/sq yd
Thickness of a single layer of fabric	D 1777	31 mils
Falling head permittivity of two layers of fabric woven together	D 4491	0.28 s^{-1} 0.04 cm/s (2)
Falling head permittivity of a single layer of fabric	D 4491	1.3 s^{-1} 0.12 cm/s
Seam strength (2)	D 751	35 lbs/in
Abrasion resistance in the warp direction	D 3885	160 lbs/in
Grab strength in the warp direction at 31% elongation	D 4632	350 lbs
Grab strength in the fill direction at 41% elongation	D 4632	275 lbs
Breaking strength in the warp direction after exposure to 500 hours of UV light	D 4355	190 lbs/in
Mullen burst test	D 3786	750 psi
Puncture test	D 3787	80 lbs

Notes for Table 1:

(1) 3" x 8" sample gripped along full width of the specimen with 3" of separation between grips. Strip test to be performed on single layer of fabric at cross-head speed of 5 inches per minute.

(2) Seam centered between grips 3" apart and gripped the full width of the specimen.

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their contractors, subcontractors, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2000 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

(3) Applies to Filter Points only

5.3
Fabric Assembly

A. Adjacent fabric panels shall be connected by sewing or by means of zipper.

B. The two top layers of fabric and the two bottom layers of fabric shall be joined separately permitting full mat thickness between the two parallel seams. A single seam in which all four layers of the fabric are joined at one point will not be permitted.

C. If required, grout stops may be installed parallel to and in between individual mill widths at predetermined intervals to regulate the flow of the concrete fill. Grout stops shall be so designed as to produce full mat thickness along the full length of the grout stop.

5.4
Concrete Grout

A. The concrete grout shall consist of a mixture of Portland cement, fine aggregate and water so proportioned and mixed as to provide a readily pumpable slurry.

B. Admixtures and/or a pozzolan may be used with the approval of the Buyer. The use of superplasticizers and/or silica fume require special precautions and the approval of the Buyer.

C. The hardened concrete shall exhibit a minimum compressive strength of 2,500 psi at 28 days when specimens are made and tested in accordance with the provisions of ASTM C 31 and ASTM C 39.

5.5
Acceptable Materials

The following companies manufacture products that meet the requirements of the specification:

A. Fabriform Filter Point Fabric as manufactured by Construction Techniques, Inc., Cleveland, Ohio, 440-572-8300.

B. Other approved by Buyer.

6.0
Execution

6.1
Acceptance and Storage at the Project Site

6.1.1
Handling of Rolls

A. The method of off-loading the fabric at the project site shall not cause any damage to the fabric, its core, nor its protective covering.

B. Any protective covering that is accidentally damaged or stripped off of a pallet or roll shall be immediately repaired or the pallet or roll shall be moved to an enclosed facility until the repair can be made.

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their contractors, subcontractors, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2000 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

6.1.2
Storage at the Field Site

A. The Buyer shall provide on-site storage space in a location near where the fabric will be placed such that on-site transportation and handling are minimized. The Supplier shall be responsible for protecting the stored material from theft and vandalism.

B. Rolls or pallets of fabric shall be stored in such a manner that cores are not crushed, the fabric damaged, and as required to provide protection from exposure to ultraviolet light, inundation, mud, dirt, dust, puncture, cutting or any other damaging or deleterious condition.

C. Outdoor storage of rolls or pallets shall not exceed the manufacturer's recommendations or longer than six months, whichever is less.

6.2
Inspection upon Delivery

A. Upon delivery of the materials to the site, the Supplier shall conduct a visual inspection of all rolls of fabric for damage or defects. This inspection shall be done without unrolling any rolls unless damage to the inside of a roll is found or suspected.

B. Any damage or defects shall be noted and immediately reported to the Buyer, the manufacturer and the carrier that transported the material. Any roll, or portion thereof, which, in the judgement of the Buyer, is seriously damaged, shall be removed from the project site and replaced with complying material at no additional cost to the Buyer.

6.3
Fabric Placement

A. Prior to concrete injection, the fabric shall be positioned over a geotextile on the grade as indicated on the Design Drawings making appropriate allowances for contraction of the fabric mats as a result of injecting the concrete grout.

B. Anchoring of fabric shall be as shown on the Design Drawings.

C. Fabric panels may be factory assembled in predetermined sizes and joined together side-by-side at the project site by field sewing or by means of zipper closures attached to the upper and lower layers of the fabric. In no case will simple unattached butt joints between panels be allowed. Overlapping shall be allowed only if approved by the Buyer.

6.4
Concrete Injection

A. Following placement of the fabric mats the specified concrete grout shall be injected between the top and bottom layers of the fabric through small slits cut in the upper layer of the fabric. The injection pipe shall be wrapped tightly at the point of injection with a strip of burlap, or similar material, during pumping to seal the joint between the injection pipe and the slit. After pumping, the burlap shall be pushed into the slit as the injection pipe is withdrawn in order to minimize spillage of the concrete slurry onto the surface of the revetment.

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their contractors, subcontractors, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2000 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

B. The sequence of concrete slurry injection shall be such as to insure complete filling of the revetment-forming fabric to average thickness indicated by the manufacturer for the designated style specified on the Design Drawings.

C. Foot traffic will not be permitted on the freshly pumped mat since such traffic will cause permanent indentations in the mat surface. Walk boards shall be used where necessary.

D. Excess concrete slurry which has been inadvertently spilled on the mat surface shall be cleaned up with a broom and shovel. The use of a water hose to remove spillage from the surface of a freshly pumped mat will not be permitted.

E. During concrete slurry injection, the mat thickness shall be measured by inserting a short piece of stiff wire through the crowns of the mats midway between the filter points at several locations from the crest to the toe of the slope. Any mat measurements less than 90% of the average of all thickness measurements shall be re-injected until the average thickness indicated for the style specified has been attained.

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L, for use by S&L, its clients, their contractors, subcontractors, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2000 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

TEMPORARY AND PERMANENT SEEDING (ILLINOIS)

ISSUE SUMMARY

Rev.	Purpose of Issue	Date	Sections Affected	Prepared By	Reviewed By	Approved By
A	Permit Application	02/14/03	ALL	Ronald Cook	David C. Kunk	Ronald Cook

TEMPORARY AND PERMANENT SEEDING (ILLINOIS)

TABLE OF CONTENTS

Notes:

(1) This Table of Contents will indicate the date of issue for the latest complete issue or revision issue of each section and any subsequent revision issue thereto.

(2) The numbering and subsequent Revisions to the Specification are in sequence with the previously issued Revision mark number.

		Page
1.0	Scope of Work	1
1.1	Purpose and Use	1
1.2	Method of Seed and Mulch Application	1
1.3	Work Included	1
2.0	Codes and Standards	2
2.1	USDA-United States Department of Agriculture, Soil Conservation Service	2
2.2	ASTM-American Society for Testing and Materials	2
3.0	Supplier's Drawings and Data Submittals	2
3.1	Topsoil	2
3.2	Seed	3
3.3	Data on Materials as Applied	3
3.4	Binder Spray	3
3.5	Matting	3
3.6	Samples	3
4.0	Products	4
4.1	Top Soil	4
4.2	Seed	4
4.2.1	General Requirements	4

4.2.2 Seed Storage 5
4.2.3 Seed Mixture 5
4.3 Lime (Agricultural Ground Limestone) 8
4.4 Fertilizer 8
4.5 Mulch 8
4.5.1 Straw Mulch 8
4.5.2 Wood Cellulose Fiber Mulch 8
4.5.3 Binder Sprays 9
4.6 Tackifier (Synthetic Binder) 9
4.7 Inoculant 9
4.8 Matting for Erosion Control 9
5.0 Execution 10
5.1 Site Preparation 10
5.2 Limestone for pH Adjustment 10
5.3 Fertilizer 10
5.4 Tilling of Subsoil 10
5.5 Placing Topsoil 11
5.6 Seeding (Conventional Method) 11
5.7 Mulching (Conventional Method) 11
5.7.1 Straw Mulching 11
5.7.2 Anchoring Mulch Using a Mulch Anchoring Tool 12
5.7.3 Anchoring Mulch Using a Sprayed Liquid Binder 12
5.7.4 Repairing and Reseeding 12
5.8 Hydro seeding 13
5.9 Laying and Securing Matting 13
5.9.1 Laying and Securing Jute Matting 13

5.9.2 Laying and Securing Excelsior Matting 14

5.10 Construction Completed after Acceptable Seeding Dates 14

6.0 Protection 14

7.0 Maintenance 14

Temporary and Permanent Seeding (Illinois) – Technical Specification and Optional Features/Accessories

1.0 Scope of Work

The intent of this specification is to define the minimum requirements for material and work for establishing a vegetative cover by planting grass seed.

1.1 Purpose and Use

A. All graded areas, slopes, and ditches which will not be paved or otherwise surfaced shall be provided with permanent seeding.

B. Graded areas subject to erosion shall not remain unprotected for longer than 30 days. Temporary seeding shall be provided by the Supplier to protect graded areas from erosion where permanent protection is not scheduled to be installed for 2 to 12 months after grading is completed.

1.2 Method of Seed and Mulch Application

Seed may be spread by a conventional method of application such as broadcasting, grass drill, or cultipacker followed by an application of mulch or by a hydro seeding procedure consisting of spraying a slurry mixture of water, seed, mulch, fertilizer, and tackifier onto the prepared seedbed.

1.3 Work Included

A. Furnish all materials.

B. Subgrade preparation.

C. Seedbed preparation, including placing topsoil and the addition of lime and fertilizer.

D. Seeding using broadcast, grass drill, or the cultipacker method and mulching, or hydro seeding with a mixture that contains seed, mulch and a tackifier.

E. Installation of matting where specified for erosion control.

F. Protection.

G. Maintenance.

H. Repairing and reseeding.

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their Suppliers, subSuppliers, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2001 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

2.0
Codes and Standards

A. Standards, specifications, manuals, codes and other publications of nationally recognized organizations and associations are referenced herein. Methods, equipment and materials specified herein shall comply with the specified and applicable portions of the referenced documents, in addition to federal, state or local codes having jurisdiction.

B. References to these documents are to the latest issue date of each document, unless otherwise indicated, together with the latest additions, addenda, amendments, supplements, etc., thereto, in effect as of the date of Contract for the Work.

C. Abbreviations listed indicate the form used to identify the reference documents in the Specification text.

2.1
USDA - United States Department of Agriculture, Soil Conservation Service

A. USDA-SCS Soil Classification Supplement to Soil Classification System (7th Approximation), SCS, USDA, Second Printing, March 1967

2.2
ASTM - American Society for Testing and Materials

A. C602 - Specification for Agricultural Liming Materials.

B. D977 - Specification for Emulsified Asphalt.

C. D2026 - Specification for Cutback Asphalt (Slow-Curing Type)

D. D2027 - Specification for Cutback Asphalt (Medium-Curing Type).

E. D2028 - Specification for Cutback Asphalt (Rapid-Curing Type)

F. D2397 - Specification for Cationic Emulsified Asphalt.

G. D5268 - Specification for Topsoil Used for Landscaping Purposes

3.0
Supplier's Drawings and Data Submittals

Supplier shall submit drawings and data not less than 30 days before material is to be delivered. Supplier's drawings and data shall be submitted via electronic medium in a format compatible for importing into the Buyer's information systems specified by the Buyer.

3.1
Topsoil

A. Topsoil Material:

- A copy of laboratory reports on two representative samples of topsoil. Laboratory tests shall be performed for:
- Percent deleterious material.
- Total organic content.

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their Suppliers, subSuppliers, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2001 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

- Silt and clay contents.
- Sand content.
- pH.

B. If it is anticipated that topsoil stripped from either the present site or the borrow area will be used for permanent seeding, if requested by the Buyer, the Supplier shall provide two 50-pound samples to the Buyer's Testing Service for analyses.

3.2 Seed

A. A certified copy of a statement signed by the seed supplier that each lot of seed has been tested by a recognized seed-testing laboratory within six months before the date of delivery to the plant site.

B. A certified statement signed by the seed supplier that the maximum percentage of noxious weeds in the seed mixture complies with state law.

3.3 Data on Materials as Applied

As applied data on the following items:

A. Seed mixture and seed application rate.

B. Limestone application rate.

C. Fertilizer type, trademark name (if any), chemical composition, and application rate.

D. Mulch.

E. Tackifier.

3.4 Binder Spray

Data on the binder spray (tackifier) to be used on straw mulch or with hydro seeding. If a synthetic binder (tackifier) will be used, the Supplier shall provide a complete set of Manufacturer's specifications at least 30 days prior to anticipated use. Manufacturer's specifications shall contain a description of the binder material, the recommended method of application, and the recommended application rate.

3.5 Matting

Catalog data on the proposed erosion control matting and Manufacturer's literature on the recommended method of installation.

3.6 Samples

If requested by the Buyer, submit a sample of each material designated by the Buyer for laboratory testing.

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their Suppliers, subSuppliers, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2001 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

4.0 Products

4.1 Topsoil

A. Topsoil shall consist of sandy clay loam, sandy loam, loam, clay loam, silty clay loam or silt loam as defined by the SCS Soil Classification System.

B. Topsoil shall be relatively free from large roots, sticks, weeds, brush or stones larger than 1 inch in diameter or other litter and waste products. It shall have at least 90 percent passing the No. 10 sieve.

C. The topsoil shall meet requirements of ASTM D5268 as follows:

- It shall contain not less than 2 percent nor more than 20 percent total organic matter.
- It shall contain not less than 35 percent nor more than 70 percent silt and clay.
- It shall contain not less than 20 percent nor more than 60 percent sand.
- The pH of the sample shall not be lower than 5.0 nor higher than 7.5.
- The percent deleterious material (rock, gravel, slag, cinder, roots, sod) shall not exceed 5 percent.

4.2 Seed

4.2.1 General Requirements

A. Grasses, legumes, or cover crop seed of the type specified herein shall conform to the standards of the United States Department of Agriculture for seed certification.

B. Seed or seeding mixtures shall be furnished in sealed bags or containers in accordance with standard commercial practice.

C. Each bag or container shall be tagged or labeled in accordance with state law. As a minimum, the tag or label shall provide the following information:

- Name and address of the supplier.
- Common name of seed.
- Lot number.
- Net weight.
- Guaranteed percentage of germination.
- Percentage of weed seed and inert material content.

D. Seed which has become wet, moldy, or otherwise damaged in transit or storage will not be accepted.

E. All seed furnished shall be free of primary noxious weed seed such as Russian or Canadian Thistle, European Birdweed, Johnson Grass and Leafy Spurge. The maximum allowable percentage of noxious weed seed in the seed mixture shall comply with state law.

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their Suppliers, subSuppliers, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2001 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

4.2.2
Seed Storage

If it is necessary to store seeds after their arrival on the site, they shall be stored in an approved weatherproof building in such a manner as to protect the seeds from deterioration and to permit easy access for inspection. The Buyer's approval for the storage building and the method of storage shall not relieve the Supplier of responsibility for the quality and fitness of the seeds at the time of their use.

4.2.3
Seed Mixture

A. Seed species, rate per acre, and other data relevant to permanent seeding are given in Table 1.

B. Seed species, rate per acre, and other data relevant to temporary seeding are given in Table 2.

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their Suppliers, subSuppliers, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2001 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

TABLE 1
ACCEPTABLE MIXTURES FOR PERMANENT SEEDING

Mixture	Seed Species (1)	Seeding Rate, Pure Live Seed for Conventional Seed Application (2)		Suitable pH	Site Suitability			Acceptable Dates for Seeding
		Lbs. per acre	Lbs. per 1,000 sq. ft.		Sunny, Dry	Well Drained	Wet	
1	Smooth Bromegrass or Tall Fescue	30	0.75	6.0-7.5	X	X	X	4-1 to 6-1 8-1 to 9-1
	Alfalfa or Birdsfoot Trefoil	10	0.25					
2	Smooth Bromegrass or Tall Fescue	30	0.75	6.0-8.0	X	X		4-1 to 6-1 8-1 to 9-1
	Crown Vetch	20	0.50					
3	Tall Fescue	15	0.35	5.5-7.5		X	X	4-1 to 6-1 8-1 to 9-1
	Timothy or Redtop	3	0.07					
	Birdsfoot Trefoil	15	0.35					
4	Reed Canary Grass	15	0.35	5.5-7.5	X	X		4-1 to 6-1 8-1 to 9-1
	Smooth Bromegrass or Tall Fescue	15	0.35					
	Ladino (optional)	3	0.07					

Notes: (1) Mixtures as defined by SCS for Illinois.

(2) Triple the seeding rate shown in the table when hydro seeding.

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their Suppliers, subSuppliers, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2001 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

TABLE 2
ACCEPTABLE MIXTURES FOR TEMPORARY SEEDING

MIXTURE	SEED SPECIES	MAXIMUM WEED SEED (percentage)	SEEDING RATE PER ACRE	SUITABLE pH	PLANTING DEPTH	ACCEPTABLE DATES FOR SEEDING
1	Wheat	0.50	150 lbs	5.5 to 7.0	1" to 1 ½"	3-1 to 5-15 7-1 to 10-15
2	Cereal Rye	0.50	150 lbs	5.5 to7.0	1" to 1 ½"	3-1 to 5-15 7-1 to 10-15
3	Spring Oats	0.50	100 lbs	5.5 to 7.0	1"	3-1 to 7-1
4	Perennial Ryegrass	0.50	40 lbs	5.0 to 7.5	1/4"	4-1 to 6-1 8-1 to 9-15

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their Suppliers, subSuppliers, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2001 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

4.3
Lime (Agricultural Ground Limestone)

Agricultural lime shall be flour grade meeting the requirements of ASTM C602.

4.4
Fertilizer

A. Fertilizer shall be a standard brand commercial grade of inorganic fertilizer furnished in unopened containers. The material may be separate or in a mixture containing the percentage of total nitrogen, available phosphoric acid and water-soluble potash in the amounts specified. If materials are separate, the Buyer shall be present when the separate fertilizers are mixed in the field. The fertilizer shall be odor free.

B. Fertilizer shall be supplied in one of the following forms:

- A dry free-flowing granular fertilizer suitable for application by an agricultural fertilizer spreader.
- A soluble form that will permit complete suspension of insoluble particles in water, suitable for application by power sprayer.

C. The following information shall be shown on the fertilizer container or on a tag attached thereto:

- Name and address of manufacturer.
- Name, brand or trademark.
- Number of net pounds of ready-mixed material in the package.
- Chemical composition or analysis.
- Guarantee of analysis.

4.5
Mulch

4.5.1
Straw Mulch

A. Straw shall be stalks of small grain straw of wheat, rye, oats, barley or other approved grain. Straw shall be air dried and free of grain and noxious weed seed, other materials detrimental to plant life, and mold.

B. Straw shall be seasoned before bailing or loading. Straw mulch shall be suitable for spreading with mulch blower equipment.

C. Old dry straw which breaks up in the crimping process instead of bending, or straw in such advanced stages of decomposition that it will smother or retard the normal growth of grass, is not acceptable.

4.5.2
Wood Cellulose Fiber Mulch

A. Wood cellulose fiber shall be partly digested wood fibers.

B. The material shall be dyed green.

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their Suppliers, subSuppliers, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2001 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

C. The material shall not contain growth or organism inhibiting agents.

D. The material shall be air-dried with a minimum of 30 percent of the fibers 3.7 mm (0.145 inch) or longer.

4.5.3
Binder Sprays

A. Cutback Asphalt shall be in accordance with ASTM D2026 (Slow-Curing Type), ASTM D2027 (Medium-Curing Type) or ASTM D2028 (Rapid-Curing Type).

B. Emulsified Asphalt shall be in accordance with D977 (Emulsified Asphalt) or D2397 (Cationic Emulsified Asphalt).

4.6
Tackifier (Synthetic Binder)

A. Tackifier material shall be an acrylic copolymer or a polyvinyl acetate emulsion in a liquid form. The material may contain additives to enhance its ability to penetrate the soil.

B. The material shall be non-toxic, non-flammable, and biodegradable.

C. Approved Materials:

- Soil Seal Concentrate manufactured by Soil Seal Corp., 1111 W. Sixth St., Los Angeles California 90017, telephone number 213-481-7185.
- Reinco Mulch Binder and Terra Tac manufactured by Reinco Mulch Binder Corp., 520 North Avenue, Plainfield, New Jersey 07060, telephone number 1-800-526-7687.
- Aerospray 70 Binder manufactured by American Cyanamid Company, Mobile, Alabama 36601, telephone number 205-476-5800.

4.7
Inoculant

A. The inoculant for treating legume seeds shall be a pure culture of nitrogen fixing bacteria prepared specifically for the species and shall not be used later than the date indicated on the container. A mixing medium, as recommended by the manufacturer, shall be used to bond the inoculant to the seed.

B. All legumes not pre-inoculated shall be inoculated within 12 hours of seeding. If the seed was pre-inoculated more than 60 days prior to seeding then it must be reinoculated.

4.8
Matting for Erosion Control

A. Matting for erosion control may be one of the following unless a specific matting is specified on the Design Drawings.

- Jute mat shall be cloth of a uniform plain weave of undyed and unbleached single jute yarn, 48 inches in width, plus or minus 1 inch and weighing an average of 1.2 pounds per linear yard of cloth with a tolerance of plus or minus 5 percent, with approximately 78 warp ends per width of cloth and 41 weft ends per linear yard of cloth. The yarn shall be

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their Suppliers, subSuppliers, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2001 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

of a loosely twisted construction having an average twist of not less than 1.6 turns per inch and shall not vary in thickness by more than one-half its nominal diameter

- Excelsior mat shall be wood excelsior, 48 inches in width plus or minus 1 inch and weighing 0.8 pounds per square yard plus or minus 10 percent. The excelsior material shall be covered with a netting to facilitate handling and to increase strength.
- Glass fiber matting of bonded textile glass fibers with an average fiber diameter of 8 to 12 microns, 2 to 4 inch strands of fiber bonded with phenol formaldehyde resin. Mat shall be roll type, water permeable, minimum thickness 1/4 inch, maximum thickness 1/2 inch, density not less than 3 pounds per cubic foot.

B. Staples for anchoring soil stabilizing materials shall be No. 11 gauge wire or heavier. Their length shall be 6 to 10 inches. Ten inch long staples shall be used on loose, unstable soils.

5.0 Execution

5.1 Site Preparation

A. Prior to seeding, install all erosion control facilities specified on the Design Drawings. These include: diversions, berms, sediment control traps, silt fences and straw bale dikes.

B. Grade areas as specified on the Design Drawings. Gullied and uneven areas shall be smoothed before starting seedbed preparation.

5.2 Limestone for pH Adjustment

A. The Supplier shall apply limestone as required to raise the pH of the subsoil. Apply a minimum of 4 tons of limestone per acre for clayey soils, 3 tons of limestone per acre for sandy loam, and 2 tons of limestone per acre for loamy sand or silty soils.

B. Thoroughly work the limestone into the subsoil to a depth of 2 to 3 inches with a harrow or disk. The limestone may be applied prior to or concurrently with the fertilizer described.

5.3 Fertilizer

A. The Supplier shall apply a 12-12-12 fertilizer to the subsoil at a rate of 300 pounds per acre.

B. Work the fertilizer into the soil to a depth of 2 to 3 inches with a harrow, disk, or rake. On slopes, operate the disk or rake across the slope.

C. If hydro seeding is used, the fertilizer may be added to the hydroseed mixture.

5.4 Tilling of Subsoil

Prior to placing the topsoil, scarify the subsoil to a depth of 3 inches immediately prior to spreading topsoil to ensure bonding of the topsoil and the subsoil. Repeat scarification in areas where equipment used for hauling and spreading topsoil has compacted the subsoil.

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their Suppliers, subSuppliers, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2003 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

5.5
Placing Topsoil

Note: topsoil does not have to be placed for temporary seeding. Topsoil must be placed prior to permanent seeding.

A. Place topsoil during dry weather on a dry, unfrozen subgrade. Topsoil shall not be spread if it is frozen or muddy.

B. Remove large pieces of organic matter and foreign non-organic material from topsoil while spreading. There shall be no large roots, branches or trash of any kind in the topsoil.

C. Spread the topsoil to provide a compacted thickness of not less than 4 inches.

D. Compact the topsoil with a roller not exerting more than 100 pounds per square inch. The topsoil must be loose enough for water infiltration and root penetration. The soil surface on slopes shall be roughened to catch seeds if they are to be broadcast.

5.6
Seeding (Conventional Method)

A. Tables 1 and 2 list acceptable seed mixtures that may be used for seeding. The Supplier shall select a mixture from the appropriate table and plant within the dates shown in that table for that mixture.

B. Apply seed uniformly at the rate shown in the appropriate table with a rangeland grass drill or cultipacker type seeder, or broadcast seed uniformly. The seeding methods and equipment shall be submitted to the Buyer for approval prior to beginning work.

C. All seeders shall be calibrated and adjusted to sow seeds at the proper rate. Equipment shall be operated to ensure a complete and even coverage. Do not seed areas greater than that which can be mulched on the same day.

D. Do not sow immediately following a rain, where the ground is too dry, during windy periods, or otherwise when conditions are not proper for seeding.

E. No seeds shall be sown until the purity test has been completed for the seeds to be used and the tests show that the seed meets the noxious weed seed requirements.

F. Within 12 hours, all seeded areas shall be rolled at right angles to the runoff with a cultipacker or approved roller to compact the seedbed and place the seed in contact with the soil. The optimum depth for planting shall be 1/4 inch. Rolling is not required if the seeding equipment is equipped with a roller that achieves the desired compaction or a grass drill has been used. Note: For temporary seeding planted without topsoil, the optimum planting depth is shown in Table 2.

5.7
Mulching (Conventional Method)

5.7.1
Straw Mulching

A. All seeded areas shall be mulched with straw mulch within 24 hours after seeding. The mulch may be hand or machine applied. The mulch shall be uniformly applied in a loose enough condition to permit air to circulate, but compact enough to reduce erosion. About 25 percent of

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their Suppliers, subSuppliers, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2003 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

the solid surface should show through the mulch. If baled mulch material is used, care shall be taken that the material is in a loosened condition and contains no lumps or knots of compacted material.

B. Straw mulch shall be applied at the rate of 2 tons per acre, or 75 to 100 (two bales) pounds per 1,000 square feet.

C. Straw mulch shall be anchored immediately after placement to minimize loss by wind or water. Straw mulch shall be anchored using a mulch anchoring tool or by spraying with a liquid binder.

5.7.2 Anchoring Mulch Using a Mulch Anchoring Tool

A. The mulch anchoring tool shall be designed to punch and anchor the mulch into the top 2 to 3 inches of soil at 6 inch intervals. As an alternative, a smooth disk set in a straight position may be used.

B. On slopes flatter than 3 horizontal to 1 vertical, mulch anchoring shall cross the contour of the land (across slopes). On slopes steeper than 3 horizontal to 1 vertical, the mulch shall be anchored by tracking a bulldozer with 1-1/2 inch track cleats up and down slope making grooves running across the slope.

5.7.3 Anchoring Using a Sprayed Liquid Binder

A. A sprayed liquid binder may be used in lieu of crimping to anchor the mulch. The binder may be sprayed into the mulch as it leaves the blower pipe or it may be applied as an over spray. If over sprayed, the binder spray should be heavier at the edges where wind catches the mulch, in valleys and at crests of banks. Binder shall be applied uniformly over the remainder of the area. Caution shall be used when spraying binder near areas occupied by construction personnel.

B. Binder Spray shall be applied at the following rates:

- Cutback asphalt - Rapid curing (RC-70, RC-250, and RC-800) or medium curing (MC-250 or MC-800). Apply 5 gallons per 1,000 square feet or 218 gallons per acre.
- Emulsified asphalt - (SS-1, CSS-1, CMS-2, MS, RS-1, RS-2, CRS-1, and CRS-2). Apply 5 gallons per 1,000 square feet or 218 gallons per acre.
- Synthetic binders - Synthetic binders such as Acrylic Dir (Agri-Tac), DCA-70, Petroset or Terra Tack may be used at rates recommended by the manufacturer to anchor mulch material.

5.7.4 Repairing and Reseeding

A. Areas not mulched and anchored within 24 hours after seeding shall be reseeded and mulched.

B. Areas not properly mulched, or damaged due to construction activities, shall be repaired, reseeded, and remulched.

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their Suppliers, sub-Suppliers, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2001 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

5.8
Hydro Seeding

A. Hydro seeding consists of spraying a slurry mixture of water, seed, fertilizer, mulch, and a tackifier on a prepared seed bed.

B. The slurry mixture shall be mixed and applied using a hydraulic seeder. Hydraulic seeding equipment shall include a pump rated and operated at not less than 100 gallons per minute and 100 psi pressure. The tank shall have a mechanical agitator powerful enough to keep the slurry mixture in a uniform suspension in water.

C. Hydrated lime **shall not** be added to the slurry mixture.

D. The slurry mixture shall contain a maximum of 55 percent solids (125 pounds of solids per 100 gallons of water).

E. The seed mixture shall be as specified in Table 1 or Table 2 except that the weight of seed in the slurry mixture shall be a minimum of three times the weight of pure live seed per acre specified in the appropriate table for conventional seed application.

F. The slurry mixture shall contain a minimum of 1500 pounds of wood cellulose fiber mulch per acre or 2000 pounds of straw mulch per acre.

G. The amount of tackifier provided per acre shall be in accordance with Manufacturer's recommendations.

H. The slurry-mixture shall contain a minimum of 1000 pounds of grade 12-12-12 fertilizer per acre or the equivalent weight of chemicals if another grade is used.

I. The soil surface shall be moist when the slurry mixture is applied.

5.9
Laying and Securing Matting

5.9.1
Laying and Securing Jute Matting

A. Prepare the seed bed as specified and lime, fertilize, and seed, except that when using jute matting, apply approximately one-half of the seed after laying the mat.

B. Most drainage channels will require multiple widths of jute matting. The total width shall be as specified on the Design Drawings. Unroll matting starting at the upper end of the channel allowing a 4 inch overlap of mattings along center of channel.

C. Bury the top ends of jute matting in a narrow trench. Backfill the trench and tamp firmly to conform to channel cross-section. Secure the matting with a row of staples about 4 inches down slope from the trench. Spacing between staples shall be a maximum of 6 inches.

D. Staple the 4 inch overlap in the center of the channel using an 18 inch spacing between staples. Before stapling the outer edges of the matting, make sure the matting is smooth and in firm contact with the soil. Staples shall be placed 2 feet apart along the outer edge of matting.

E. Where one roll of jute matting ends and another begins, the end of the top strip shall overlap the upper end of the lower strip by 4 inches, shiplap fashion.

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their Suppliers, subSuppliers, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2001 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

F. Where matting crosses erosion stops, reinforce with a double row of staples placed six (6) inches apart in a staggered pattern on either side of erosion stop. Likewise, overlaps joining the length of matting together and the discharge end of the matting liner should be similarly secured with 2 double rows of staples.

5.9.2
Laying and Securing Excelsior Matting

A. Provide the same seedbed preparation as specified for jute matting with the exception that all seeding must be completed before laying excelsior matting.

B. Bury the top ends of excelsior matting in a trench as described for jute matting. As the blankets are unrolled down slope, the matting must be on top with the wood fibers in contact with the soils. Butt snugly at the ends and sides before stapling.

C. Using two (2) foot spacing between staples, excelsior matting shall be secured with four rows for each strip, with one row along each edge and alternating parallel rows down the center. The stapling over erosion stops, entrance and discharge ends of matting and butted end joints shall be the same as described for jute matting.

5.10
Construction Completed after Acceptable Seeding Dates

When construction is completed between October 15 and March 1 prepare the seedbed, fertilize and mulch as specified. Apply seed for permanent seed sometime between December 1 and March 1 increasing the seeding rates shown in Table 1 by 50 percent.

6.0
Protection

Planted areas shall be protected from damage and erosion. The Supplier shall provide and erect temporary barriers and signs as necessary to prevent vehicles, equipment and foot traffic from damaging seeded areas.

7.0
Maintenance

The Supplier shall perform the following maintenance tasks:

A. Keep seedbed continually moist with light, frequent sprinklings several times a day to prevent seedlings from drying out.

B. Inspect periodically after planting to see that vegetative stands are adequately established. Immediately reseed areas which show bare spots larger than 2 feet by 2 feet after germination.

C. Check for erosion damage after storm events and repair damage. Reseed and mulch, if necessary.

D. Fertilize newly permanent seeded areas one year after seeding with 300 pounds per acre of a complete (N-P-K) 10-10-10 or equivalent turf type slow release fertilizer.

- Application rate per acre shall be:

  Nitrogen (N) - 120 pounds of actual nitrogen

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their Suppliers, subSuppliers, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2001 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

Phosphorus (P) - 120 pounds of P_2O_5

Potassium (K) - 120 pounds of K_2O

This document contains information which is confidential and proprietary to Sargent & Lundy (S&L). It was prepared by S&L for use by S&L, its clients, their Suppliers, subSuppliers, and bidders on projects where S&L provides engineering services and shall not otherwise be reproduced in whole or in part or released to any third party without the prior written consent of S&L. Copyright Sargent & Lundy 2001 all rights reserved. Specifications located in the Document Management System are to be considered as the official version of the Specification.

Appendix E: Hennepin Power Station; West Ash Disposal Pond Maintenance Plan (2013)

DYNEGY MIDWEST GENERATION, LLC

Hennepin Power Station
Hennepin, Illinois

Putnam County

West Ash Disposal Pond

IDNR Permit No. (not permitted)

Dam ID No. (not permitted)

Maintenance Plan

September 2013

TABLE OF CONTENTS

Paragraph	Description	Page
1.0	GENERAL	1
2.0	EMERGENCY OPERATIONS	1
2.1	Unusual Conditions	1
2.2	Dewatering	2
3.0	MAINTENANCE	2
3.1	Vegetation	2
3.2	Discharge Structure	2
3.3	Animal Damage and Repairs	2
3.4	Restriction of Unauthorized Vehicles	2
3.5	Inspections/Remedial Measures	3
3.5.1	Weekly Inspections	3
3.5.2	Quarterly Inspections	3
3.5.3	Five-year Inspections	
4.0	INSPECTION CHECKLISTS	3

1.0 GENERAL

The following operations and maintenance procedures are provided to maintain the structural integrity of the west ash storage surface impoundment at the Hennepin Power Station, which is unclassified and unpermitted, by the Illinois Department of Natural Resources, Office of Water Resources.

2.0 EMERGENCY OPERATIONS

2.1 Unusual Conditions

Any unusual condition discovered during major storm events or routine inspection, which may constitute an emergency, shall be handled as follows. Notice of any type of emergency involving the dikes or outfall shall be made to the Shift Leader on duty [(815) 339-9211]. The Shift Leader on duty shall notify the Station Manager, Ted Lindenbusch [home: (815) 875-2381], or, in his absence, the Environmental Coordinator, John P. Augspols [home: (815) 925-7488]. One of the above designated personnel shall notify the following city, county, state and federal regulatory authorities of the emergency condition.

- Division of Water Resources, Dam Safety Section, Dam Safety Engineers (217) 782-3862
- Illinois Emergency Management Agency, 24-hour service 1-(800) 782-7860
- Putnam County Sheriff/Hennepin Police Department (815) 925-7015
- Senior Director – Environmental Compliance, Dynegy Operating Company (618) 206-5912

2.2 Dewatering

The Station Manager or the Environmental Coordinator shall have the responsibility of determining how repairs shall be accomplished and whether dewatering of the disposal facility is necessary. Emergency dewatering shall be accomplished by portable pumps.

3.0 MAINTENANCE

3.1 Vegetation

Dikes shall be maintained to protect the structural integrity of the disposal facility. Damaged and barren areas shall be repaired as soon as appropriate after being discovered. Damaged areas shall be filled with topsoil. Limed, fertilized, and seeded with appropriate vegetation. Trees and shrubs observed during semiannual inspections shall be cut and removed from the dikes and discharge channel. This shall be done as frequently as is necessary to insure that no tree reaches a size where the root structure would require removal and filling. Woody vegetation, shrubs, and trees shall be removed during the early stages of growth before reaching a three-inch diameter.

Low growing vegetation, a prairie grass mixture that grows to a height of no more than six inches, shall be planted and maintained to facilitate inspections.

3.2 Discharge Structure

The discharge structure shall be inspected periodically for significant corrosion and deterioriation. Any defects discovered shall be promptly repaired.

3.3 Animal Damage and Repairs

Animal burrows discovered during inspections shall be promptly repaired by filling with grout.

3.4 Restriction of Unauthorized Vehicles

Facility approaches shall be posted with signs restricting unauthorized travel on the roadways and slopes.

3.5 Inspections/Remedial Measures

3.5.1 Weekly Inspections

Weekly inspections of the perimeter berms shall be conducted, looking for seepage and slumping, and unusual seepage at and/or blockage of the outfall structures in each cell. All findings shall be entered into the weekly inspection checklist, discussed in Section 4.0. Maintenance activities shall be initiated, if required. Refer to Section 4.0 for the recommended inspection checklist to be used for the weekly inspections.

3.5.2 Quarterly Inspections

Inspections shall be made quarterly by Station personnel to determine the general condition of the dam and embankments. During these inspections, embankment erosion, tree growth, and embankment seepage shall be monitored. Seepage shall be observed for change in quantity and coloration. Refer to Section 4.0, for the recommended inspection checklist to be used for documenting the quarterly inspections.

3.5.3 Annual Inspections

An annual inspection shall be made by a licensed professional engineer. This inspection shall follow the Illinois Department of natural Resources (IDNR) *Guidelines and Forms for Inspection of Illinois Dams*, and shall be followed by verbal and written reports by the consulting engineer. Based on the findings of the inspection, the Station Manager shall implement corrective action as required to promote dam safety. Procedures and methods for corrective action shall be performed in accordance with recommendations of the consulting engineer and as outlined above. Because the dam is not permitted by the IDNR, copies of the engineer's report, along with corrective action taken, will not be reported to the IDNR.

4.0 INSPECTION CHECKLISTS

The following Inspection checklists should be used during the weekly and quarterly inspections.

WEEKLY DAM INSPECTION FORM

Dam Location: Hennepin Power Station – West Ash Pond
Owner: Dynegy Midwest Generation, LLC, Havana Power Station
Permit No.:Not permitted **Class of Dam: Not classified**
Type of Dam: Homogeneous earth dam
Type of Spillway: Drop structure

Date Inspected: _____
Weather Conditions: _____
Pool Elevation: _____

Inspection Personnel:

_____ _____
Name / Title **Signature**

Inspection Item	Conditions	Location of Problem and Recommended Remedial Measures and Implementation Schedule
Vertical and Horizontal Alignment of Crest		
Unusual Movement or Cracking at or Beyond Toe		
Seepage		
Vegetative Cover		
Embankment Erosion		
Structural Cracking		
Outfall Structures		
Other		

QUARTERLY DAM INSPECTION FORM

Dam Location: Hennepin Power Station – West Ash Pond
Owner: Dynegy Midwest Generation, LLC, Hennepin Power Station
Permit No.: Not permitted **Class of Dam: Not classified**
Type of Dam: Homogeneous earth dam
Type of Spillway: Drop structure

Date Inspected: _____
Weather Conditions: _____
Pool Elevation: _____

Inspection Personnel:

_____
Name / Title **Signature**

Inspection Item	Conditions	Location of Problem and Recommended Remedial Measures and Implementation Schedule
Vertical and Horizontal Alignment of Crest	Good condition, with no significant issues	
Downstream Fill Slopes	Good condition, with no significant issues	
Upstream Fill Slopes	Good condition, with no significant issues	
Unusual Movement or Cracking at or Beyond Toe	Good condition, with no significant issues	
Seepage (Condition/Color)	Good condition, with no significant issues	
Vegetative Cover (Tree growth)	Good condition, with no significant issues	
Animal Damage	Good condition, with no significant issues	
Embankment Erosion	Good condition, with no significant issues	
Water Passages	Good condition, with no significant issues	
Structural Cracking	Good condition, with no significant issues	
Outfall Structures	Good condition	
Other		

Appendix F: Hennepin Power Station; Old East Ash Disposal Pond Maintenance Plan (2013)

DYNEGY MIDWEST GENERATION, LLC

Hennepin Power Station
Hennepin, Illinois

Putnam County

Old East Ash Disposal Pond

IDNR Permit No. (not permitted)

Dam ID No. (not permitted)

Maintenance Plan

September 2013

TABLE OF CONTENTS

Paragraph	Description	Page
1.0	GENERAL	1
2.0	EMERGENCY OPERATIONS	1
2.1	Unusual Conditions	1
2.2	Dewatering	2
3.0	MAINTENANCE	2
3.1	Vegetation	2
3.2	Discharge Structure	2
3.3	Animal Damage and Repairs	2
3.4	Restriction of Unauthorized Vehicles	2
3.5	Inspections/Remedial Measures	3
3.5.1	Weekly Inspections	3
3.5.2	Quarterly Inspections	3
3.5.3	Five-year Inspections	
4.0	INSPECTION CHECKLISTS	3

1.0 GENERAL

The following operations and maintenance procedures are provided to maintain the structural integrity of the old east ash storage surface impoundment at the Hennepin Power Station, which is unclassified and unpermitted, by the Illinois Department of Natural Resources, Office of Water Resources.

This is primarily the @ 0.5 mile significant berm system that extends along the Illinois River. The old east ash pond system consists of the inactive cells # 2 and # 4. As a result of the May 2011 USEPA dam assessment, a dam safety permit was submitted to IDNR in May 2013, to address major modifications to this significant berm. These major modifications include extensive tree removal and resloping. Resloping is required to improve slope stability and allow safe access to slope, for long-term mowing and maintenance.

2.0 EMERGENCY OPERATIONS

2.1 Unusual Conditions

Any unusual condition discovered during major storm events or routine inspection, which may constitute an emergency, shall be handled as follows. Notice of any type of emergency involving the dikes or outfall shall be made to the Shift Leader on duty [(815) 339-9211]. The Shift Leader on duty shall notify the Station Manager, Ted Lindenbusch [home: (815) 875-2381], or, in his absence, the Environmental Coordinator, John P. Augspols [home: (815) 925-7488]. One of the above designated personnel shall notify the following city, county, state and federal regulatory authorities of the emergency condition.

- Division of Water Resources, Dam Safety Section, Dam Safety Engineers (217) 782-3862
- Illinois Emergency Management Agency, 24-hour service 1-(800) 782-7860
- Putnam County Sheriff/Hennepin Police Department (815) 925-7015
- Senior Director – Environmental Compliance, Dynegy Operating Company (618) 206-5912

2.2 Dewatering

Not applicable.

3.0 MAINTENANCE

3.1 Vegetation

Dikes shall be maintained to protect the structural integrity of the disposal facility. Damaged and barren areas shall be repaired as soon as appropriate after being discovered. Damaged areas shall be filled with topsoil. Limed, fertilized, and seeded with appropriate vegetation. Trees and shrubs observed during semiannual inspections shall be cut and removed from the dikes and discharge channel. This shall be done as frequently as is necessary to insure that no tree reaches a size where the root structure would require removal and filling. Woody vegetation, shrubs, and trees shall be removed during the early stages of growth before reaching a three-inch diameter.

Low growing vegetation, a prairie grass mixture that grows to a height of no more than six inches, shall be planted and maintained to facilitate inspections.

3.2 Discharge Structure

Not applicable.

3.3 Animal Damage and Repairs

Animal burrows discovered during inspections shall be promptly repaired by filling with grout.

3.4 Restriction of Unauthorized Vehicles

Facility approaches shall be posted with signs restricting unauthorized travel on the roadways and slopes.

3.5 Inspections/Remedial Measures

3.5.1 Weekly Inspections

Weekly inspections of the perimeter berms shall be conducted, looking for seepage and slumping. All findings shall be entered into the weekly inspection checklist, discussed in Section 4.0. Maintenance activities shall be initiated, if required. Refer to Section 4.0 for the recommended inspection checklist to be used for the weekly inspections.

3.5.2 Quarterly Inspections

Inspections shall be made quarterly by Station personnel to determine the general condition of the dam and embankments. During these inspections, embankment erosion, tree growth, and embankment seepage shall be monitored. Seepage shall be observed for change in quantity and coloration. Refer to Section 4.0, for the recommended inspection checklist to be used for documenting the quarterly inspections.

3.5.3 Annual Inspections

An annual inspection shall be made by a licensed professional engineer. This inspection shall follow the Illinois Department of natural Resources (IDNR) *Guidelines and Forms for Inspection of Illinois Dams*, and shall be followed by verbal and written reports by the consulting engineer. Based on the findings of the inspection, the Station Manager shall implement corrective action as required to promote dam safety. Procedures and methods for corrective action shall be performed in accordance with recommendations of the consulting engineer and as outlined above. Because the dam is not permitted by the IDNR, copies of the engineer's report, along with corrective action taken, will not be reported to the IDNR.

4.0 INSPECTION CHECKLISTS

The following Inspection checklists should be used during the weekly and quarterly inspections.

WEEKLY DAM INSPECTION FORM

Dam Location: Hennepin Power Station – Old East Ash Pond
Owner: Dynegy Midwest Generation, LLC, Havana Power Station
Permit No.:Not permitted **Class of Dam: Not classified**
Type of Dam: Homogeneous earth dam
Type of Spillway: N/A

Date Inspected: _____
Weather Conditions: _____
Pool Elevation: _____

Inspection Personnel:

_____ _____
Name / Title **Signature**

Inspection Item	Conditions	Location of Problem and Recommended Remedial Measures and Implementation Schedule
Vertical and Horizontal Alignment of Crest		
Unusual Movement or Cracking at or Beyond Toe		
Seepage		
Vegetative Cover		
Embankment Erosion		
Structural Cracking		
Outfall Structures		
Other		

QUARTERLY DAM INSPECTION FORM

Dam Location: Hennepin Power Station – Old East Ash Pond
Owner: Dynegy Midwest Generation, LLC, Hennepin Power Station
Permit No.: Not permitted **Class of Dam: Not classified**
Type of Dam: Homogeneous earth dam
Type of Spillway: Not applicable

Date Inspected: _____
Weather Conditions: _____
Pool Elevation: _____

Inspection Personnel:

_____
Name / Title **Signature**

Inspection Item	Conditions	Location of Problem and Recommended Remedial Measures and Implementation Schedule
Vertical and Horizontal Alignment of Crest	Good condition, with no significant issues	
Downstream Fill Slopes	Good condition, with no significant issues	
Upstream Fill Slopes	Good condition, with no significant issues	
Unusual Movement or Cracking at or Beyond Toe	Good condition, with no significant issues	
Seepage (Condition/Color)	Good condition, with no significant issues	
Vegetative Cover (Tree growth)	Good condition, with no significant issues	
Animal Damage	Good condition, with no significant issues	
Embankment Erosion	Good condition, with no significant issues	
Water Passages	Good condition, with no significant issues	
Structural Cracking	Good condition, with no significant issues	
Outfall Structures	Good condition	
Other		

Appendix G: Hennepin Power Station; East Ash Disposal Pond Maintenance Plan (2014)

DYNEGY MIDWEST GENERATION, LLC

Hennepin Power Station
Hennepin, Illinois

Putnam County

East Ash Disposal Pond

Small Class III Dam

IDNR Permit No. DS2011079

Dam ID No. IL50363

Maintenance Plan

Revised – August 2014

TABLE OF CONTENTS

Paragraph	Description	Page
1.0	GENERAL	1
2.0	EMERGENCY OPERATIONS	1
2.1	Unusual Conditions	1
2.2	Dewatering	2
3.0	MAINTENANCE	2
3.1	Vegetation	2
3.2	Discharge Structure	2
3.3	Animal Damage and Repairs	2
3.4	Restriction of Unauthorized Vehicles	2
3.5	Inspections/Remedial Measures	3
3.5.1	Weekly Inspections	3
3.5.2	Quarterly Inspections	3
3.5.3	Five-year Inspections	
3.6	Annual Statement	3
4.0	INSPECTION CHECKLISTS	3

1.0 GENERAL

The following operations and maintenance procedures are provided to maintain the structural integrity of the east ash storage surface impoundment at the Hennepin Power Station, which is classified as a small Class III dam by the Illinois Department of Natural Resources, Office of Water Resources. The primary pond's maximum normal poll elevation will be 489.5 msl with a dam crest at elevation 494.0 msl. The secondary pond's maximum normal pool elevation will be 480.5 with a dam crest at 494.0 msl.

2.0 EMERGENCY OPERATIONS

2.1 Unusual Conditions

Any unusual condition discovered during major storm events or routine inspection, which may constitute an emergency, shall be handled as follows. Notice of any type of emergency involving the dikes or outfall shall be made to the Shift Leader on duty [(815) 339-9211]. The Shift Leader on duty shall notify the Managing Director, Byron Veech [cell: (309) 543-8714], or, in his absence, the Environmental Coordinator, John P. Augspols [home: (815) 925-7488]. One of the above designated personnel shall notify the following city, county, state and federal regulatory authorities of the emergency condition.

- Division of Water Resources, Dam Safety Section, Dam Safety Engineers (217) 782-3862
- Illinois Emergency Management Agency, 24-hour service 1-(800) 782-7860
- Putnam County Sheriff/Hennepin Police Department (815) 925-7015
- Senior Director – Environmental Compliance, Dynegy Operating Company (618) 343-7761

2.2 Dewatering

The Station Manager or the Environmental Coordinator shall have the responsibility of determining how repairs shall be accomplished and whether dewatering of the disposal facility is necessary. Dewatering shall be accomplished by manually removing the concrete beams from the primary and/or secondary pond structures until the desired water level is reached.

3.0 MAINTENANCE

3.1 Vegetation

Dikes shall be maintained to protect the structural integrity of the disposal facility. Damaged and barren areas shall be repaired as soon as appropriate after being discovered. Damaged areas shall be filled with topsoil. Limed, fertilized, and seeded with appropriate vegetation. Trees and shrubs observed during periodic inspections shall be cut and removed from the dikes and discharge channel. This shall be done as frequently as is necessary to insure that no tree reaches a size where the root structure would require removal and filling. Woody vegetation, shrubs, and trees shall be removed during the early stages of growth before reaching a three-inch diameter.

Low growing vegetation shall be planted and maintained to facilitate inspections.

3.2 Discharge Structure

The discharge structure shall be inspected periodically for significant corrosion, spalling, and cracking. Any defects discovered shall be promptly repaired.

3.3 Animal Damage and Repairs

Animal burrows discovered during inspections shall be promptly repaired by filling with grout.

3.4 Restriction of Unauthorized Vehicles

Facility approaches shall be posted with signs restricting unauthorized travel on the roadways and slopes.

3.5 Inspections/Remedial Measures

3.5.1 Weekly Inspections

Weekly inspections of the perimeter berms shall be conducted, looking for seepage and slumping, and unusual seepage at and/or blockage of the outfall structures in each cell. All findings shall be entered into the weekly inspection checklist, discussed in Section 4.0. Maintenance activities shall be initiated, if required. Refer to Section 4.0 for the recommended inspection checklist to be used for the weekly inspections.

3.5.2 Quarterly Inspections

Inspections shall be made quarterly by Station personnel to determine the general condition of the dam and embankments. During these inspections, embankment erosion, tree growth, and embankment seepage shall be monitored. Seepage shall be observed for change in quantity and coloration. Refer to Section 4.0, for the recommended inspection checklist to be used for documenting the quarterly inspections.

3.5.3 Five-Year Inspections

Every five years, an inspection shall be made by a licensed professional engineer. This inspection shall follow the Illinois Department of natural Resources (IDNR) *Guidelines and Forms for Inspection of Illinois Dams*, and shall be followed by verbal and written reports by the consulting engineer. Based on the findings of the inspection, the Station Manager shall implement corrective action as required to promote dam safety. Procedures and methods for corrective action shall be performed in accordance with recommendations of the consulting engineer and as outlined above. Copies of the engineer's report, along with corrective actin taken, shall be reported to the IDNR.

3.6 Annual Statement

An annual statement on forms furnished by IDNR, certifying compliance with this maintenance plan, shall be submitted to IDNR.

4.0 INSPECTION CHECKLISTS

The following Inspection checklists should be used during the weekly and quarterly inspections.

WEEKLY DAM INSPECTION FORM

Dam Location: Hennepin Power Station – East Ash Pond
Owner: Dynegy Midwest Generation, LLC, Havana Power Station
Permit No.:DS2011079 **Class of Dam: III**
Type of Dam: Homogeneous earth dam, with clay and geosynthetic / clay liner
Type of Spillway: Drop structure and stop logs

Date Inspected: _____
Weather Conditions: _____
Pool Elevation: _____

Inspection Personnel:

_____ _____
Name / Title **Signature**

Inspection Item	Conditions	Location of Problem and Recommended Remedial Measures and Implementation Schedule
Vertical and Horizontal Alignment of Crest		
Unusual Movement or Cracking at or Beyond Toe		
Seepage		
Vegetative Cover		
Embankment Erosion		
Structural Cracking		
Outfall Structures		
Other		

QUARTERLY DAM INSPECTION FORM

Dam Location: Hennepin Power Station – East Ash Pond
Owner: Dynegy Midwest Generation, LLC, Hennepin Power Station
Permit No.:DS2011079 **Class of Dam: III**
Type of Dam: Homogeneous earth dam, with clay and geosynthetic / clay liner
Type of Spillway: Drop structure and stop logs

Date Inspected: _____
Weather Conditions: _____
Pool Elevation: _____

Inspection Personnel:

_____
Name / Title **Signature**

Inspection Item	Conditions	Location of Problem and Recommended Remedial Measures and Implementation Schedule
Vertical and Horizontal Alignment of Crest	Good condition, with no significant issues	
Downstream Fill Slopes	Good condition, with no significant issues	
Upstream Fill Slopes	Good condition, with no significant issues	
Unusual Movement or Cracking at or Beyond Toe	Good condition, with no significant issues	
Seepage (Condition/Color)	Good condition, with no significant issues	
Vegetative Cover (Tree growth)	Good condition, with no significant issues	
Animal Damage	Good condition, with no significant issues	
Embankment Erosion	Good condition, with no significant issues	
Water Passages	Good condition, with no significant issues	
Structural Cracking	Good condition, with no significant issues	
Outfall Structures	Good condition	
Other		

The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 11

US EPA ARCHIVE DOCUMENT

US EPA ARCHIVE DOCUMENT

REPORT

Dam Safety Assessment of CCW Impoundments

Joppa Plant

United States Environmental Protection Agency
Washington, DC

September 24, 2010

O'BRIEN & GERE
www.obg.com

13498/46122

Dam Safety Assessment of CCW Impoundments

Joppa Plant

Prepared for:
US Environmental Protection Agency
Washington, DC



ROBERT R. BOWERS, P.E. – VICE PRESIDENT
O'BRIEN & GERE ENGINEERS, INC.



ROBERT C. GANLEY, P.E. – VICE PRESIDENT
O'BRIEN & GERE ENGINEERS, INC.

US EPA ARCHIVE DOCUMENT

US EPA ARCHIVE DOCUMENT

TABLE OF CONTENTS

1. Introduction 1
1.1. General 1
1.2. Project Purpose and Scope 1
2. Project/Facility Description 3
2.1. General 3
2.2. Management Unit Description 3
2.2.1. Northern Pond 3
2.2.2. Southern Pond 3
2.2.3. Other Impoundments 4
2.3. Hazard Potential Classification 4
2.4. Impounding Structure Details 5
2.4.1. Embankment Configuration 5
2.4.2. Type of Materials Impounded 6
2.4.3. Outlet Works 6
3. Records Review 7
3.1. Engineering Documents 8
3.1.1. Stormwater Inflows 8
3.1.2. Stability Analyses 8
3.1.3. Instrumentation 8
3.2. Previous Inspections 8
3.3. Operator Interviews 9
4. Visual Inspection 10
4.1. General 10
4.2. Summary of Findings 10
5. Conclusions 13
6. Recommendations 14
6.1. Urgent Action Items 14
6.2. Long Term Improvement 14
6.3. Monitoring and Future Inspection 14
6.4. Time Frame for Completion of Repairs/Improvements 14
6.5. Certification Statement 15

US EPA ARCHIVE DOCUMENT

Figures

Figure 1 – Site Location Map
Figure 2 – Facility Layout Plan
Figure 3 – Site Plan and Photo Location Identifier
EEI Drawing AP-109, Sheet 1

Appendices

Appendix A – Visual Inspection Checklist
Appendix B – Photographs

US EPA ARCHIVE DOCUMENT

1. INTRODUCTION

1.1. GENERAL

In response to the coal combustion waste (CCW) impoundment failure at the TVA/Kingston coal-fired electric generating station in December of 2008, the U. S. Environmental Protection Agency has initiated a nationwide program of structural integrity and safety assessments of coal combustion waste impoundments or "management units". A CCW management unit is defined as a surface impoundment or similar diked or bermed management unit or management units designated as landfills that receive liquid-borne material and are 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. Management units also include inactive impoundments that have not been formally closed in compliance with applicable federal or state closure/reclamation regulations. This project is being conducted in accordance with the terms of O'Brien & Gere's Order EP10W001240 to Contract BPA# EP10W000673 with the US EPA, dated April 8, 2010.

1.2. PROJECT PURPOSE AND SCOPE

The purpose of this work is to provide dam safety assessment of CCW management units, including the following:

- Identify conditions that may adversely affect the structural stability and functionality of a management unit and its appurtenant structures
- Note the extent of deterioration, status of maintenance, and/or need for immediate repair
- Evaluate conformity with current design and construction practices
- Determine the hazard potential classification for units not currently classified by the management unit owner or by state or federal agencies

O'Brien & Gere's scope of services for this project includes performing a site specific dam safety assessment of all CCW management units at the subject facility. Specifically, the scope includes the following tasks:

- Perform a review of pertinent records (prior inspections, engineering reports, drawings, etc.) made available at the time of the site visit to review previously documented conditions and safety issues and gain an understanding of the original design and modifications of the facility.
- Perform a site visit and visual inspection of each CCW management unit and complete the visual inspection checklist to document conditions observed.
- Perform an evaluation of the adequacy of the outlet works, structural stability, quality and adequacy of the management unit's inspection, maintenance, and operations procedures.
- Identify critical infrastructure within 5 miles downstream of management units.
- Evaluate the risks and effects of potential overtopping and evaluate effects of flood loading on the management units.
- Immediate notification of conditions requiring emergency or urgent corrective action.
- Identify all environmental permits issued for the management units.
- Identify all leaks, spills, or releases of any kind from the management units within the last 5 years.
- Prepare a report summarizing the findings of the assessment, conclusions regarding the safety and structural integrity, recommendations for maintenance and corrective action, and other action items as appropriate.

This report addresses the above issues for the Ash Pond at the Electric Energy, Inc. (EEI) Joppa Station in Joppa, Illinois. The above impoundment is owned and operated by EEI. In the course of this assessment, we obtained information through interviews with representatives of EEI and Ameren Corporation, which owns 80% of EEI.

US EPA ARCHIVE DOCUMENT

US EPA ARCHIVE DOCUMENT

2. PROJECT/FACILITY DESCRIPTION

2.1. GENERAL

The Joppa Plant is located at 2100 Portland Road in Joppa, Illinois. A Site Location Map is included as Figure 1. The generating station was commissioned in 1953 and includes a coal-fired electrical power generating facility with an approximate capacity of 1,086 megawatts (MW) gross generation capacity from its six coal-fired electric generating units, as well as 76 MW from its two natural gas units, owned by an EEI subsidiary. Coal combustion waste that is produced during power generation is managed on-site with a CCW impoundment.

The facility utilizes one impoundment known as the Ash Pond, separated by a dividing dike (Central Dike) into two sections, referred to as the Northern and Southern Ponds, for CCW management. The Ash Pond is located on the north side of the site. This safety assessment report summarizes the April 2010 inspection of the CCW management pond at the Joppa Plant. Please note that certain sections of this report describe the Northern and Southern Ponds separately; however, the Ash Pond was reported as a single unit to the USEPA, therefore, a single checklist was submitted and the Conclusions and Recommendations presented at the end of this report are provided for the Ash Pond as a whole, not the separate Northern and Southern Ponds. The two sections of the CCW management unit inspected during this safety assessment are identified on Figure 2 – Facility Layout Plan. The Northern Pond was constructed "pre-rules" for dams in the state of Illinois and as a Class III structure only requires a permit if significant modifications to the structure are made. The Southern Pond appears to have been constructed "post-rules" and may be subject to permit requirements. EEI and Ameren have developed an Emergency Action Plan (EAP) And a Dam Safety Program for the impoundment in accordance with Illinois dam safety guidelines.

2.2. MANAGEMENT UNIT DESCRIPTION

CCW consists of bottom ash and fly ash. Bottom ash generated at the Joppa Plant is hydraulically sluiced to the Southern Pond. Fly ash which is collected using electrostatic precipitators was previously sluiced to the Ash Pond but it is now pneumatically conveyed to storage silos, and finally sold for reuse. The market for the fly ash generated at the Joppa Plant has greatly diminished since the plant started injecting powdered activated carbon upstream of the electrostatic precipitators in response to Illinois mercury removal requirements. Dewatered bottom ash is excavated and sold for reuse. The Plant still reclaims "legacy" ash.

2.2.1. Northern Pond

Construction of the Northern Pond was completed in 1973. The pond embankment has not been raised since, but material has been added in some areas to increase the width. Currently, the Northern Pond is drained and no CCW is sluiced to the Northern Pond. However, overflow from the Southern Pond does enter the Northern Pond through a corrugated metal pipe (CMP) installed in the Central Dike.

2.2.2. Southern Pond

The Southern Pond was formed by construction of an additional dike south of the existing Northern Pond. This construction was completed in 1985. After construction of the Southern Pond, the former south embankment of the Northern Pond became known as the Central Dike. The Southern Pond is currently used for CCW storage. Sluiced CCW enters the pond in the southwestern corner. Sluice water that is routed through the pond is discharged into an outlet structure located near the northeast corner of the pond, near the Central Dike. The discharge flows through an underground pipe to a concrete structure located near the northernmost point of the Northern Pond (outside the impoundment), where it mixes with any discharge from the Northern Pond, is

US EPA ARCHIVE DOCUMENT

treated with acid if necessary to reduce the effluent pH to comply with the Plant NPDES permit, and finally discharged south through open channels and underground pipes to the Ohio River.

2.2.3. Other Impoundments

The Facility Layout Map provided as Figure 2 shows the location of the various impoundments on the site. There are three additional impoundments at the Joppa Station, identified as follows:

1) Capped Ash Pond – The Capped Ash Pond is located on the west side of the Joppa Station. CCW is currently not sluiced to the Capped Ash Pond. The Capped Ash Pond was the original CCW management unit constructed at the site, but it has been decommissioned since the Northern Pond came on-line in 1973. The decommissioning included grading the pond to prevent storage of water.

2) Settlement Pond – The Settlement Pond is located to the south of the Joppa Plant's coal stockpile, between the stockpile and the Ohio River. This pond was constructed at the same time as the Northern Pond. The purpose of the pond is to collect stormwater runoff from the coal stockpile.

3) Sewage Lagoon – The Sewage Lagoon is located to the west of the Capped Ash Pond (see Figure 2). It was constructed in 1995.

2.3. HAZARD POTENTIAL CLASSIFICATION

The Illinois dam safety law is contained in Illinois Compiled Statutes (615ILCS5), originally enacted June 10, 1911, and last amended February 7, 1996. The rules pertaining to the dam safety program are contained in the Illinois Administrative Code, Title 17 (Conservation), Chapter I (Dept. of Natural Resources), Subchapter h (Water Resources). These rules were originally adopted September 2, 1980, and last revised April 10, 1998. The regulations are administered by the Illinois Department of Natural Resources (IDNR). The IDNR defines a dam as "all obstructions, walls, embankments, or barriers, together with their abutments and appurtenant works, if any, constructed for the purpose of storing or diverting water or creating a pool. Not included are underground or elevated tanks to store water." (Section 3702.20)

Dams are categorized according to the degree of threat to life and property in case of failure. *Class I* dams are those for which failure has a high probability of causing loss of life or substantial economic loss, similar to that of US Army Corps of Engineers High Hazard Potential or USDA Natural Resources Conservation Service Class (c) dams. *Class II* dams are those for which failure has a moderate probability for causing loss of life or substantial economic loss, similar to USACE Significant Hazard Potential or USDA/NRCS Class (b) dams. *Class III* dams are those for which failure has a low probability for causing loss of life or substantial economic loss, similar to the USACE Low Hazard Potential or USDA/NRCS Class (a) dams.

As stated previously, the Southern Pond may meet the requirements for a regulated structure by the State of Illinois. EEI has complied with some IDNR requirements and have developed an Emergency Action Plan and a Dam Safety Program for the impoundment.

The definitions for the four hazard potentials (Less than Low, Low, Significant and High) to be used in this assessment are included in the EPA CCW checklist found in Appendix A. Based on the checklist definitions and as a result of this assessment, the hazard potential rating recommended for the Ash Pond is **LOW,** which would generally be synonymous with the State of Illinois *Class III*. Failure is not likely to cause loss of life because the nearest residences appear to lie at an elevation near the normal pool elevation and the area between the Ash Pond and the residences forms a natural drainage swale which would convey the CCW and water to the Ohio

US EPA ARCHIVE DOCUMENT

River. Additionally, EEI owns the land that would likely be inundated with CCW and sluice water should the Ash Pond embankments fail. While the Ohio River is located downstream from the Southern Pond, environmental and economic damage appears to be limited to EEI property due to the distance to the Ohio River and the railroad embankment located near the pond would limit the release of CCW downstream.

2.4. IMPOUNDING STRUCTURE DETAILS

Prior to construction of the Southern Pond, the Ash Pond consisted solely of what is now referred to as the Northern Pond. At that time, the southern dike of the pond became known as the Central Dike. The following sections summarize the structural components and basic operations of the Northern Pond, the Southern Pond and the Central Dike. The locations of these features at the Joppa Plant are shown on Figure 2. A smaller scale plan of the Ash Pond and photo location identifiers is provided as Figure 3. Additionally, photos taken during the visual inspection are incorporated in a Photographic Log provided as Appendix B.

2.4.1. Embankment Configuration

Northern Pond

The Northern Pond is a diked earthen embankment impoundment with a total surface area of approximately 49, acres based on a survey dated January 5, 2005 provided by EEI during the inspection. The area currently impounding water, however, is less than 6 acres based on the survey; the remaining storage area is filled with CCW. The Northern Pond is diked over the length of its perimeter and the height of the dike varies from approximately 15 to 45 feet above the outboard toe of slope. The crest is at approximately elevation (EL) 380 feet above mean sea level. The inboard and outboard embankment slopes were designed at an inclination of 1.5H:1V. A 24-inch CMP through the Central Dike connects the Northern and Southern Ponds. The pipe was not constructed with a control system (gate, valve, stoplogs, etc.) to manage flow between the ponds.

Southern Pond

The Southern Pond is also a diked earthen embankment structure with a height that varies from approximately 15 to 45 feet above its outboard toe. The Southern Pond total surface area is approximately 54 acres, based on the 2005 survey provided by EEI. The area currently impounding water, however, is approximately 26 acres based on the survey; the remaining storage area is filled with CCW. As with the Northern Pond, the crest is at approximately elevation (EL) 380 feet above mean sea level. Power lines cross the Southern Pond; these lines were constructed before the Ash Pond was expanded into the Northern and Southern Ponds, thus the Southern Pond was built around the lines. The lines have sagged, and, currently vehicular traffic is prohibited along the eastern portion of the Southern Pond embankment as a precaution against contact with the power line.

In addition to the impoundments described above, there are three ponds located on the Joppa Site. These impoundments were described in Section 2.2.3 of this report. These ponds were not assessed as part of this CCW impoundment assessment since their purpose is not to store actively sluiced CCW.

2.4.2. Type of Materials Impounded

Currently, influent into the Ash Pond includes water with solids consisting of primarily bottom ash with lesser quantities of miscellaneous fines such as coal fines and fly ash.

2.4.3. Outlet Works

The Northern and Southern Ponds are diked impoundments that have been designed to receive sluice flows and direct precipitation. The Southern Pond's primary outlet structure is located near the northeastern corner of the impoundment and consists of a 24-inch steel "T" structure connected to a 24-inch pipe that passes through the eastern embankment. Additionally, the Southern Pond can discharge directly into the Northern Pond through a 24-inch CMP pipe installed in the Central Dike, this pipe is referred to as the Culvert through the Central Dike. The 24-inch outlet pipe turns north at some point underground and discharges into a concrete structure located near the northeastern corner of the Northern Pond. Discharge from the Northern Pond exits through a 30-inch pipe located at its northernmost corner. The flow from the Southern Pond mixes with any outflow from the Northern Pond in the concrete structure, where the combined effluent is stabilized with acid when its pH exceeds permitted levels (pH of 9.0). The discharge flows in an open channel along the outboard toe of the Northern Pond eastern embankment for approximately 300 feet. At this point, the flow enters an underground culvert via a concrete headwall. The flow travels approximately 1,700 feet underground before exiting into an open channel located east of the impoundment. The channel passes below the Joppa Plant's coal-delivery railroad siding through a concrete culvert and terminates approximately 2,400 feet downstream at the Ohio River. The Ash Pond discharge to the Ohio River is permitted under IEPA permit # IL-0004171.

US EPA ARCHIVE DOCUMENT

US EPA ARCHIVE DOCUMENT

3. RECORDS REVIEW

A review of the available records related to design, construction, operation and inspection of the Joppa Plant CCW impoundment was performed as part of this assessment. The documents provided by EEI and Ameren are listed below:

Table 3.1 *Summary of Documents Reviewed*

Document	Dates	By	Description
East Ash Pond Soil Survey Profile Cross Section, Shts. 1 & 2	Unknown	Unknown	Boring Logs
Dwg. AP-102	07/19/71	EEI	East Ash Pond Canal Profile
Ash Pond Soil Survey	03/12/73	SO-BI-CO	Subsurface investigation in preparation of Ash Pond design/construction
Detail Process for Design Specifications for Ash Pond	03/21/73	WAPORA, Inc.	Preliminary design document for Ash Pond construction
Dwg. 4229-8200	03/29/73	WAPORA, Inc.	Plan View – Proposed (East) Ash Pond
Aerial Photo	11/17/73	Unknown	Pre-construction Aerial Photo of NE corner of Ash Pond
Dwg. 4229-8218	09/11/77	WAPORA, Inc.	Plans and Sections, Ash [Northern] Pond
Dwg. AP-109, Shts. 1 – 6	07/13/82	EEI	East Ash Pond – Sections, Proposed Levee
Aerial Photo	09/20/85	Unknown	Aerial Photo of Ash Pond
Dwg. 4229-8211, Shts. 1, 2 & 5	06/13/86	EEI	As-Built Plan and Sections, Southern Pond
Dwg. AP-112	04/29/92	EEI	Proposed Modifications to Ash Pond – New Outlet from Southern Pond
Memorandum	06/10/92	EEI	EEI Memo to IEPA regarding proposed discharge line
Letter to IEPA	09/18/92	EEI	Letter to IEPA requesting permit for construction of new discharge line from Southern Ash Pond
Memorandum	04/20/93	EEI	Brief memorandum on Ash Pond construction history
Ash Pond Topo Survey Report	12/29/04	Mikon Corp.	Memorandum summarizing results of bathymetric survey of the Ash Pond
Dwg. 00032854	01/05/05	Mikon, Inc.	Plan - Bathymetric Survey of Ash Pond
Water Detention Facilities Inspection Letter Report	03/17/09	Hanson Professional Services, Inc.	Letter Report detailing results of visual inspection of Joppa Plant ponds
Dam Safety Program	06/17/09	EEI	Dam Safety Program for Ash Pond dikes
Ash Pond Dike Emergency Action Plan	07/08/09	EEI	Emergency Action Plan for the Ash Pond
IEPA NPDES Permit	08/07/09	IEPA	NPDES Permit IL0004171
ICR Response	01/26/10	EEI and Ameren	Response to EPA inquiry
Weekly Inspection Log	02/23-/09 – 04/23/10	EEI	Weekly Inspection Logs for the Ash Pond

US EPA ARCHIVE DOCUMENT

3.1. ENGINEERING DOCUMENTS

Review of the documents and drawings revealed information on the design details for the Northern and Southern Ponds which is summarized below:

- The Northern Pond was constructed in 1973 by Barter Construction. At the time, it was known as the (East) Ash Pond. It replaced the existing (West) Ash Pond that had been used for CCW management since the Plant was commissioned.
- The soils at the Joppa Plant are generally classified as Clayey-Silts (CL) in accordance with the Unified Soil Classification procedure. Recorded permeabilities ranged from $5.2x10^{-4}$ to $4.6x10^{-7}$ cm/sec. Due to the low permeability of the native soils, the embankments were designed without a liner.
- The inboard and outboard slopes of the embankments were designed and constructed at 1.5H:1V, which is steeper than generally recommended for dam and dike construction.
- Construction of the Southern Pond began in 1977 and was completed in 1985. The design drawings for the expansion indicate that the portions of the embankment that was to be constructed over an underlying foundation identified as "Fly Ash" would have a cutoff trench through the ash into native soils. Sections of the embankment that were constructed directly on native soils were designed without a cutoff trench. The embankments were to be "Compacted to 95%" (Standard or Modified Proctor was not identified).
- The Northern and Southern Ponds were constructed to a crest elevation of 380 feet above mean sea level (msl). The crests have not been raised since their completion.
- The 24-inch discharge pipe system for the Southern Pond was constructed in 1992. Prior to its construction, all flow from the Southern Pond passed into the Northern Pond through the 24-inch CMP ("Culvert") in the Central Dike before discharging from the impoundment through the outlet structure located at the northern end of the Northern Pond. The original HDPE structure was replaced by a steel "T" in 1998.
- Slope stability analyses for the design of the embankments were not found.

3.1.1. Stormwater Inflows

Stormwater inflows to both the Northern and the Southern Ponds are minimal. The impounding structures are comprised of diked embankments on four sides which direct storm water away from the impoundment and limit runoff to that which falls directly on the water surface and crest of the embankments.

3.1.2. Stability Analyses

As stated above, no slope stability analyses were included in the records made available by EEI and Ameren. A subsurface investigation program of the Northern and Southern Pond embankments is scheduled for the summer of 2010, with stability analyses based on the results of the investigation to follow.

3.1.3. Instrumentation

No instrumentation is present at either pond.

3.2. PREVIOUS INSPECTIONS

EEI personnel perform weekly inspections of the ponds and record the results in a log. EEI retained the services of Hanson Professional Services, Inc. to perform visual inspections of the Plant impoundments. The results of the inspections are presented in a letter report dated March 17, 2009. The report stated that the embankments appeared to be in Fair condition with some deleterious vegetative growth and minor erosion observed.

US EPA ARCHIVE DOCUMENT

3.3. OPERATOR INTERVIEWS

Numerous plant and corporate personnel took part in the inspection proceedings. The following is a list of participants for the inspection of the Ash Pond.

Table 3.2 *List of Participants*

Name	Affiliation	Title
Bruce Parker	EEI	Senior Engineer
Michael Mercer	EEI	Senior Chemical and Environmental Specialist
Chris Skates	EEI	Plant Chemistry Supervisor
Terry Larbes	EEI	Manager, Technical Services
Steve Bluemner	Ameren	Supervising Engineer
Johan Anestad	O'Brien & Gere	Technical Associate
Rob Ganley	O'Brien & Gere	Vice President

The EEI and Ameren personnel provided a good working knowledge of the Ash Pond, provided general plant operation background as well as available historical documentation.

US EPA ARCHIVE DOCUMENT

4. VISUAL INSPECTION

The following sections summarize the inspection of the Joppa Plant Ash Pond (Northern and Southern Ponds), which occurred on April 27, 2010. Following the inspection, O'Brien & Gere completed an EPA inspection checklist that briefly summarizes the results of the inspection. The checklist was submitted electronically to EPA on May 4, 2010. A copy of the completed inspection checklist is included as Appendix A.

4.1. GENERAL

The weather on the date of the inspection included some rain showers, wind and mostly cloudy conditions; the temperature was approximately 55 - 65 degrees. The visual inspection consisted of a thorough site walk along the crest, outboard slope, and toe of the embankments, and along exposed portions of the inboard slopes. The team also inspected the inlet/outlet structures.

Photos of relevant features and conditions observed during the inspection were taken by O'Brien & Gere and are provided in Appendix B. A Site Plan of the Northern and Southern Ponds is presented as Figure 3, which also provides photograph locations and directions.

4.2. SUMMARY OF FINDINGS

Northern Pond

The following observations were made during the inspection:

- Sluiced CCW by-product discharge does not currently enter the Northern Pond on a regular basis. Overflow from the Southern Pond may discharge to the Northern Pond through a 24-inch CMP (the "Culvert") installed in the Central Dike.
- The 24-inch connecting pipe does not have a control structure (gate, valve, stoplogs, etc.) to regulate the amount of flow between the impoundments. Riprap has been placed, or fallen into, the opening of the pipe and was observed within the pipe, near its midpoint. The riprap limits the capacity of the pipe and may have slightly raised the water surface elevation in the Southern Pond (Photos 2 & 3).
- CCW has accumulated above the normal pool level over an estimated 90 percent of the pond area. Water in the pond is isolated to primarily the northeastern corner (Figures 2 & 3, Photos 4 & 5).
- Portions of the outboard slopes of the embankments are covered with rock fill and small riprap. The majority of the outboard slopes are overgrown with vegetation such as grasses, and small shrubs (Photos 6 – 8).
- The outboard slope is steeper than generally recommended for dam and dike construction, and surface erosion has occurred. EEI procedure is to dump rockfill over the eroded areas to prevent the deterioration from spreading.
- An access road runs along the toe of the western embankment. A section of the western embankment was modified to more safely accommodate truck traffic by reconstructing the embankment, effectively moving it to the east. The finished slope of the modified section matches the 1.5H:1V of the remainder of the outboard slope.
- The outboard toe area was generally well drained, although some standing water was observed in the area of the Central Dike and further north near the drainage channel culvert entrance.
- In addition to the Ash Pond effluent, discharge from a drainage area east of the EEI railroad siding enters the outlet drainage channel (Photo 10).
- The inboard slope was also constructed at a slope of 1.5H:1V, originally with a riprap layer to protect the embankment against erosion. The riprap is now generally buried below bottom ash that has been dredged

US EPA ARCHIVE DOCUMENT

from inside the impoundment and placed on the inboard slope. The inboard slope was also generally overgrown with reedy grasses (Photo 5).
- A crushed-stone access road was constructed over the length of the crest. The road appears to be in good condition with no rutting, erosion or standing water observed.
- The outlet structure was covered with dried reeds but appeared to be in good condition and functioning normally (Photo 12).

Southern Pond

The following observations were made during the visual inspection:

- Sluiced CCW by-product discharge enters the pond in the southwestern corner (Photo 13) and flows along the southern embankment in a channel dredged into dried CCW (Photo 14). Sluice water exits the pond through a 24-inch steel "T" structure located near the northeast corner of the impoundment (Photos 15 & 16).
- Water can also flow from the Southern Pond into the Northern Pond through a 24-inch CMP installed in the Central Dike. The condition of the pipe was described above.
- CCW has accumulated above the normal pool level over an estimated 50 percent of the pond area. Water in the pond is isolated to primarily the eastern half of the pond (Figures 2 & 3, Photo 17).
- Portions of the outboard slope are covered with rock fill and small riprap. The rock was reportedly dumped from the crest to protect areas that had experienced erosion (Photos 18 - 20).
- The majority of the outboard slope is overgrown with vegetation such as grasses, and small shrubs. Large trees were not observed growing on the embankment, although evidence of past tree growth was evident.
- The outboard slope is steeper than generally recommended for dam and dike construction. The design drawings (See attached EEI Drawing AP-109) indicate the slope should be 2H:1V, but the observed slope appeared to be steeper and matched the 1.5H:1V slope of the Northern Pond.
- Surface erosion, sloughs and slides were observed along the outboard slope. The most significant erosion was observed in the area below the power lines that cross the Southern Pond (Photos 20 - 22).
- Erosion gullies were also observed in the lower portion of the embankment near the southeastern corner of the impoundment. The extent of the gullies could not be investigated due to heavy vegetative growth.
- Seepage was observed in multiple locations along the outboard toe of the embankment. The most significant area of seepage is located approximately 500 feet north of the power lines (Photos 23 & 24). Other areas where seepage was observed include an area approximately 200 feet south of the power lines and along the southern embankment of the Southern Pond. The approximate locations of seepage are identified on Figure 3.
- Based on Drawing AP-109, Sht. 1 (attached), the Southern Pond embankment was keyed into a suitable foundation through a layer of fly ash for a portion of the embankment. Section A-A, which is indicative of construction in the area near the power lines (Dwg. 4229-8211, Sht. 1), indicates that this section of the embankment was not keyed into the underlying foundation.
- EEI is in the process of constructing an access road along the outboard toe of the embankment. Wet conditions and vegetation have prevented the project from being completed.
- A crushed-stone access road was constructed over the length of the crest. The road appears to be in good condition with no rutting, erosion or standing water observed. Jersey barriers prevent vehicular traffic from using the access road along the eastern half of the southern embankment and along the eastern embankment south of the Central Dike. The barriers were installed as a safety precaution to prevent vehicular traffic from crossing below the power lines when they started to sag.
- The inboard slope was also constructed at a slope of 1.5H:1V, originally with a riprap layer to protect the embankment against erosion. The riprap is now generally buried below bottom ash that has been dredged from inside the impoundment and placed on the inboard slope. The inboard slope was also generally

overgrown with reedy grasses.

Based on conversations with plant personnel, no releases have occurred from the Ash Pond. Some patchwork repairs and regrading of the embankment are known to have been performed.

US EPA ARCHIVE DOCUMENT

US EPA ARCHIVE DOCUMENT

5. CONCLUSIONS

Based on the ratings defined in the RFP (Satisfactory, Fair, Poor and Unsatisfactory), the information reviewed and the visual inspection, the overall condition of the Ash Pond is considered to be **FAIR**. Acceptable performance is expected under all loading conditions; however, some deficiencies exist that require repair and/or additional studies or investigations. The deficiencies include the following:

- Sloughs, slides and erosion of the Southern Pond embankment.
- Deleterious vegetation growing along the length of the inboard and outboard slopes of the embankment.
- Riprap in the 24-inch culvert through the Central Dike limiting the pipe capacity.
- Seepage in multiple locations along the outboard toe of the Southern Pond embankment.
- Portions of the Southern Pond embankment constructed on "Fly Ash" foundation, other portions on native soils without a cutoff trench.

Other than the conditions cited above, the owner has conducted regular inspections and maintenance which enable the impoundment to be kept in reasonably good working order.

In addition to the physical deficiencies, it was noted that no geotechnical evaluations or slope stability analyses are on record for the Ash Pond embankments. According to EEI and Ameren, a subsurface investigation and slope stability analyses should be completed by the end of the year. Completion of these additional studies for critical slopes (highest and steepest) will formally document the stability of the earth structure in accordance with applicable safety criteria for earth dams. During the course of the meetings and inspection, the owners stated that only two lines of borings, taken at the critical sections (highest/steepest) of the Northern and Southern Pond embankments, were planned. It was recommended that additional borings be considered due to the length of the perimeter embankment and the seepage observed at the toe of the eastern and southern embankments of the Southern Pond. Additionally, O'Brien & Gere recommended that open-well PVC piezometers be installed in the borings to allow EEI to monitor phreatic conditions within the embankment. EEI and Ameren indicated that they were agreeable to the idea of installing the piezometers, but noted that the Ash Pond is scheduled to be taken out of service, and all CCW landfilled or sold for beneficial reuse in a 10-15 year timeframe, therefore, a much more extensive subsurface investigation program may not be undertaken.

The plant staff maintains available documents in a well organized manner, performs regular inspections and maintenance, has developed an Emergency Action Plan and a Dam Safety Program in accordance with IDNR guidelines, and plans to conduct additional investigations/analyses to supplement the existing data. Based on these findings, O'Brien & Gere is of the opinion that the operations and maintenance procedures being practiced at the Ash Pond are adequate, although some additional maintenance/improvement actions are recommended to correct some of the conditions observed.

US EPA ARCHIVE DOCUMENT

6. RECOMMENDATIONS

Based on the findings of our visual inspection and review of the available records for the Ash Pond, O'Brien & Gere recommends that additional investigations/analyses and maintenance of the embankments be performed to correct the deficiencies cited above.

6.1. URGENT ACTION ITEMS

None of the recommendations are considered to be urgent, since the issues noted above do not appear to threaten the structural integrity of the impoundment in the near term.

6.2. LONG TERM IMPROVEMENT

The deficient conditions observed during the inspection do not require immediate attention, but should be corrected in the near future as part of a regular maintenance plan. The recommended maintenance/improvement actions are described below:

- Outboard slopes – remove deleterious vegetation and continue regular maintenance of the slopes; repair any areas of sloughs, slides and erosion.
- Outboard toe – investigate the extent of seepage, monitor the seepage on a regular basis, and develop alternatives for treating the deteriorated sections of the embankment.
- Inboard slopes – keep vegetation under control to allow for visual inspection of the exposed portion of the slope above the waterline.
- Additional studies – perform geotechnical investigation, cross-sectional topographic survey, and slope stability analyses of critical sections. Install piezometers to check phreatic levels within the embankment. Analyze for normal pool with steady state seepage, maximum surcharge pool, and seismic loading conditions and, depending on the results of the analyses, consider alternatives for stabilizing the embankments and control the seepage.

6.3. MONITORING AND FUTURE INSPECTION

Consideration should be given to inspections by licensed dam safety engineers on a regular basis to document the continued proper maintenance and operation of the Ash Pond. This is especially critical for the portion of the Southern Pond embankment where seepage was observed.

6.4. TIME FRAME FOR COMPLETION OF REPAIRS/IMPROVEMENTS

Based on conversations with representatives of EEI and Ameren, the subsurface investigation and stability analysis is scheduled to be performed by the end of 2010. It is O'Brien & Gere's recommendation that the owner continue toward this schedule as planned, to consider installing piezometers in the sample locations and to expand the scope of the investigation. It is recommended that the other improvements and analyses recommended above be completed in a timely manner.

6.5. CERTIFICATION STATEMENT

I acknowledge that the Ash Pond (Northern and Southern Ponds) CCW management unit referenced herein were personally inspected by me on April 27, 2010 and was found to be in the following condition:

~~SATISFACTORY~~
FAIR
~~POOR~~
~~UNSATISFACTORY~~



Signature: _____ Date: September 24, 2010

Robert C. Ganley, PE
IL PE # 062-045829

US EPA ARCHIVE DOCUMENT

FIGURES

US EPA ARCHIVE DOCUMENT

FIGURE 1



ADAPTED FROM: JOPPA, ILLINOIS QUADRANGLE, U.S.G.S. 7.5 MIN. QUAD 2010



QUADRANGLE LOCATION

US EPA
DAM SAFETY ASSESSMENT OF CCW IMPOUNDMENTS
JOPPA PLANT
JOPPA, ILLINOIS
SITE LOCATION MAP

1 0 1/2 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 5 0 1 KILOMETER

SCALE: 1:24000

46122-JOPPA-F01
SEPTEMBER 2010

O'BRIEN & GERE

2010 © O'Brien & Gere Engineers, Inc.

I:\US-EPA.13498\46122.ASSESS-OF-DAM-S\DOCS\DWG\SHEETS\46122-JOPPA-F01.DWG, 09/22/2010 11:03AM

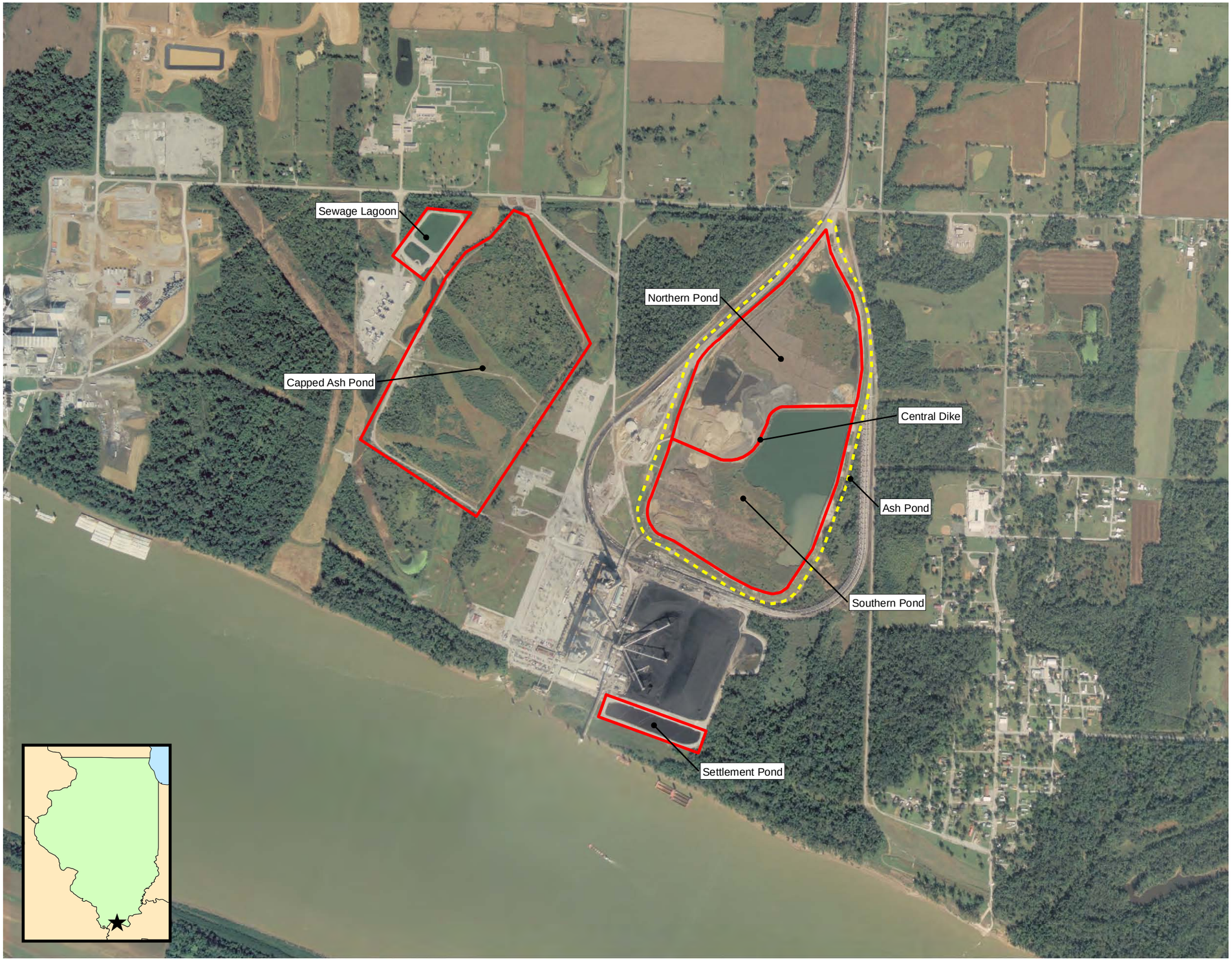
US EPA ARCHIVE DOCUMENT

PATH: I:\Us-Epa.13498\STDS\GIS\Coal_Impoundments\Figures\Joppa_FIG-2_site.mxd

NAME: KaufmaDR

DATE: 9/1/2010 10:48:38 AM

FIGURE 2



NOTE
Aerial imagery provided by National Agriculture Imagery Program (USDA), 2009.

ELECTRIC ENERGY, INC.
JOPPA PLANT
JOPPA, ILLINOIS

SITE LAYOUT MAP

0 500 1,000 2,000
Feet

SEPTEMBER 2010
13498/46122

O'BRIEN & GERE
www.obg.com

This document was developed in color. Reproduction in B/W may not represent the data as intended.

US EPA ARCHIVE DOCUMENT

PATH: I:\Us-Epa.13498\STDS\GIS\Coal_Impoundments\Figures\Joppa_FIG-3_photo.mxd
NAME: KaufmaDR
DATE: 9/1/2010 10:52:27 AM



This document was developed in color. Reproduction in B/W may not represent the data as intended.

FIGURE 3

N

LEGEND

1 Photograph Direction/Location

NOTE
Aerial imagery provided by National Agriculture Imagery Program (USDA), 2009.

ELECTRIC ENERGY, INC.
JOPPA PLANT
JOPPA, ILLINOIS

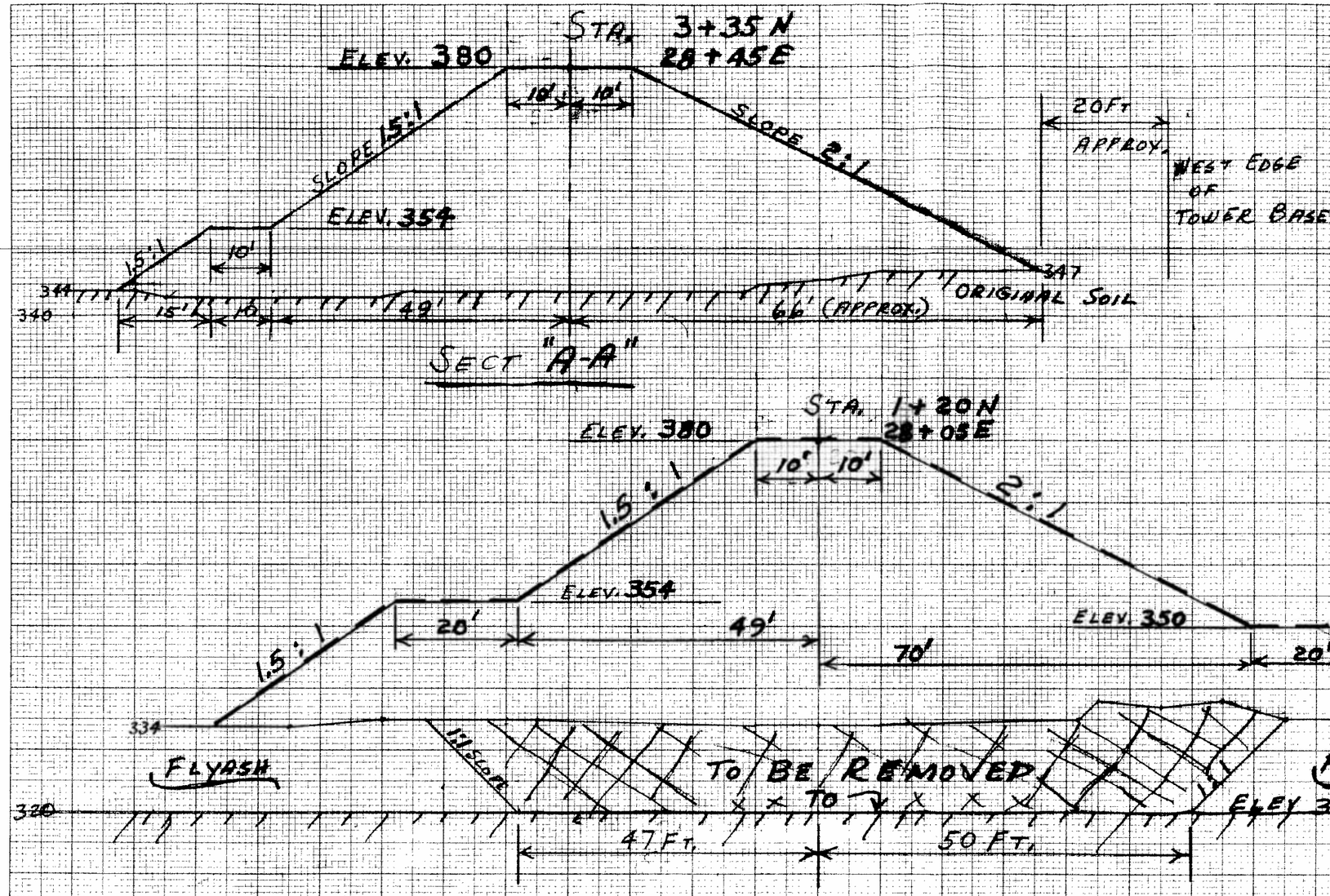
PHOTO LOCATIONS AND SITE FEATURES

0 200 400 800
Feet

SEPTEMBER 2010
13498/46122

O'BRIEN & GERE
www.obg.com

47 1322



SECT "A-A"

SECT. "B-B"

95% COMPACTION DESIRED

TO BE CONSTRUCTED WITH 6" COMPACTED LAYERS

WORKING COPY
COPIED BY: acb
DATE: 4/23/10

EAST ASH POND

PROPOSED LEVEE - SECTIONS

REF: 4229-8211 FOR LAYOUT 5-27-82 H.M^c
7-13-82

AP-109 SH 1

10 X 10 TO ½ INCH • 10 X 15 INCHES
KEUFFEL & ESSER CO. MADE IN U.S.A.

APPENDIX A

Visual Inspection Checklist

US EPA ARCHIVE DOCUMENT

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name:	Joppa Plant	Date:	04/27/10
Unit Name:	Ash Pond	Operator's Name:	Electric Energy, Inc.
Unit I.D.:		Hazard Potential Classification:	High Significant Low ✓

Inspector's Name: Robert C. Ganley, P.E. and NJ Anestad, P.E.

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?	Weekly		18. Sloughing or bulging on slopes?	✓	
2. Pool elevation (operator records)?	374.0		19. Major erosion or slope deterioration?		✓
3. Decant inlet elevation (operator records)?	NA		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	NA		Is water entering inlet, but not exiting outlet?		✓
5. Lowest dam crest elevation (operator records)?	380.0		Is water exiting outlet, but not entering inlet?		✓
6. If instrumentation is present, are readings recorded (operator records)?	NA		Is water exiting outlet flowing clear?	✓	
7. Is the embankment currently under construction?		✓	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)?	NA		From underdrain?		✓
9. Trees growing on embankment? (If so, indicate largest diameter below)	✓		At isolated points on embankment slopes?	✓	
10. Cracks or scarps on crest?		✓	At natural hillside in the embankment area?		✓
11. Is there significant settlement along the crest?		✓	Over widespread areas?		✓
12. Are decant trashracks clear and in place?	✓		From downstream foundation area?		✓
13. Depressions or sinkholes in tailings surface or whirlpool in the pool area?		✓	"Boils" beneath stream or ponded water?		✓
14. Clogged spillways, groin or diversion ditches?	NA		Around the outside of the decant pipe?		✓
15. Are spillway or ditch linings deteriorated?	NA		22. Surface movements in valley bottom or on hillside?		✓
16. Are outlets of decant or underdrains blocked?		✓	23. Water against downstream toe?	✓	
17. Cracks or scarps on slopes?	✓		24. Were Photos taken during the dam inspection?	✓	

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.

Inspection Issue #	Comments
9	Trees <4"dia (Eastern Embankment of Southern Pond)
17, 18, 19	Scarps and sloughing of embankment observed in area below power lines that cross the South Pond (Eastern embankment of South Pond). Erosion of lower portion of berm observed approximately 100' south of power lines.
21	Seepage observed at various locations along the toe of the eastern embankment on South Ponds. Seepage area extends approximately 100', starting approximately 500' North of power lines. Seepage was also observed on the Southern embankment of the South Pond in the area facing the coal piles. Evidence of seepage on the embankment slope was observed in this location, but seepage was not.
23	Discharge from ponds travels in open channel at the toe of the East embankment of the North Pond before entering a 48" dia CMP culvert.

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit #: IL0004171 INSPECTOR: RC Ganley, P.E., NJ Anestad, P.E.
Date: April 27, 2010

Impoundment Name: Ash Pond
Impoundment Company: Electric Energy, Inc.
EPA Region: 5
State Agency (Field Office) Address: Illinois EPA - 2309 W. Main Street, Marion, IL 62959

Name of Impoundment:
(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New X Update

	Yes	No
Is impoundment currently under construction?		X
Is water or ccw currently being pumped into the impoundment?	X	

IMPOUNDMENT FUNCTION: Storage of bottom ash, settling pond

Nearest Downstream Town: Name Joppa
Distance from the impoundment Approximately 0.5 miles
Impoundment Location: Longitude 81 Degrees 51 Minutes 00 Seconds
Latitude 37 Degrees 12 Minutes 55 Seconds
State IL County Massac

Does a state agency regulate this impoundment? YES NO X

If So Which State Agency?

US EPA ARCHIVE DOCUMENT

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.

__X__ **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.

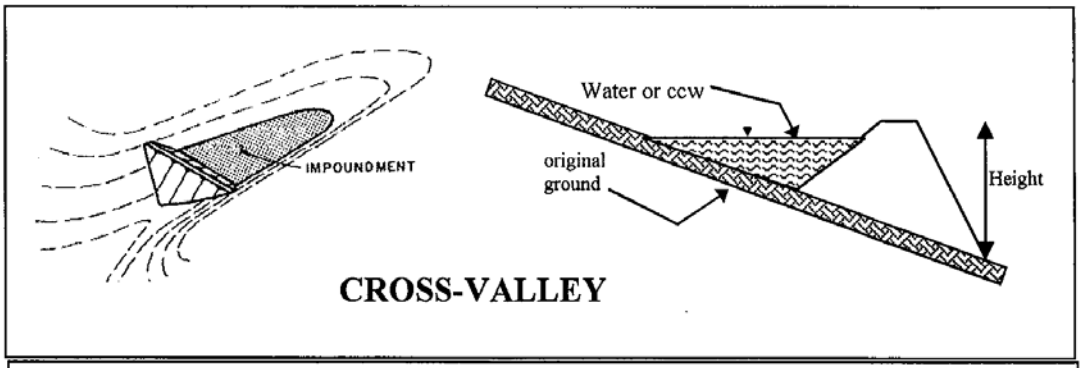
DESCRIBE REASONING FOR HAZARD RATING CHOSEN:

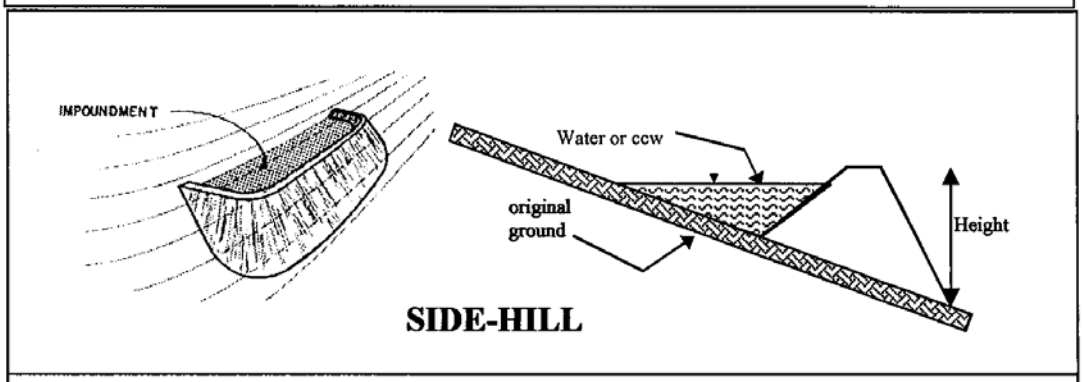
North Pond has limited water volume stored and failure would likely discharge to low area between impoundment and railroad tracks. South Pond water volume mainly present in the East and Northeast of the Pond. If impoundment failed, water would likely flow to East and South into the low area between impoundment and railroad tracks, where current Ash Ponds outfall travels to Ohio River. Since Electric Energy, Inc. owns property to the East and South of the Ash Ponds, including the railroad tracks, impact would principally be to their property. Inhabited areas to the East are separated from the Ash Ponds by the low area bounded by the embankment and the railroad.

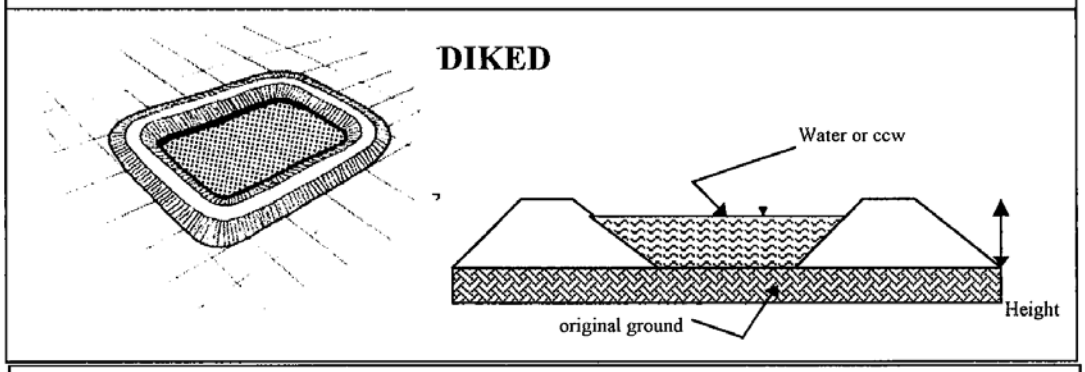
US EPA ARCHIVE DOCUMENT

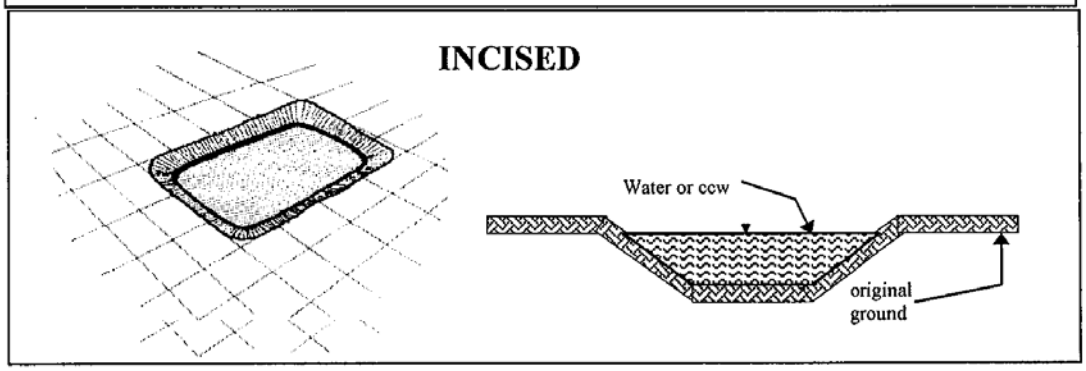
US EPA ARCHIVE DOCUMENT

CONFIGURATION:





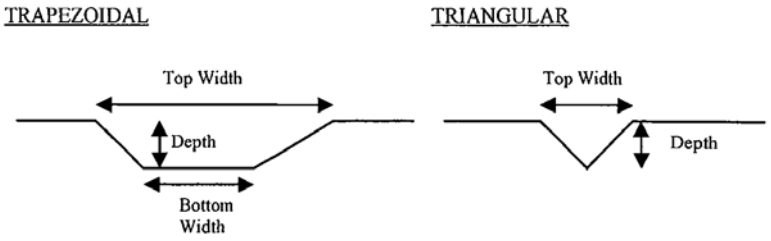




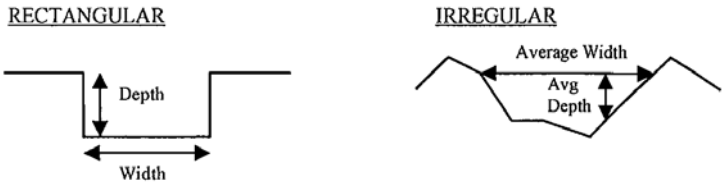
_____ Cross-Valley
_____ Side-Hill
__X___ Diked
_____ Incised (form completion optional) _____ Combination Incised/Diked
Embankment Height: max. 45' (based on design drawings)
Embankment Material: _silt, sand, possibly fly-ash
Pool Area _____32_____ acres Liner _____none_____
Current Freeboard ____6_____ feet Liner Permeability __N/A_____

TYPE OF OUTLET (Mark all that apply)

_____ **Open Channel Spillway**
_____ Trapezoidal
_____ Triangular
_____ Rectangular
_____ Irregular



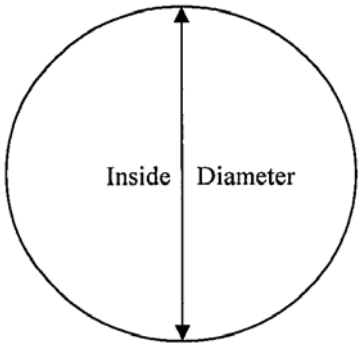
_____ depth
_____ bottom (or average) width
_____ top width



__X___ **Outlet**

__24___ inside diameter

Material
_____ corrugated metal
_____ welded steel
_____ concrete
__X___ plastic (hdpe, pvc, etc.)
_____ other (specify)
_____



Is water flowing through the outlet? YES ___X____ NO _____

_____ **No Outlet**

_____ **Other Type of Outlet** (specify) _Secondary outlet from South to North Basin is 36-inch corrugate metal pipe through dividing dike_____

The Impoundment was Designed By _Wapora, inc._____
_____

US EPA ARCHIVE DOCUMENT

Has there ever been a failure at this site? YES _____ NO ___X_____

If So When? _____

If So Please Describe: _____

US EPA ARCHIVE DOCUMENT

Has there ever been significant seepages at this site? YES _____ NO ___X____

If So When? _____

IF So Please Describe: _____

US EPA ARCHIVE DOCUMENT

Has there ever been any measures undertaken to monitor/lower Phreatic water able levels based on past seepages or breaches at this site? YES _____NO ____X____

If so, which method (e.g., piezometers, gw pumping,...)? _____

If so Please Describe : _____

US EPA ARCHIVE DOCUMENT

APPENDIX B

Photographs

US EPA ARCHIVE DOCUMENT

US EPA ARCHIVE DOCUMENT



Photo 1 – Central Dike, looking west. Note vegetative growth on inboard slope of Southern Pond.



Photo 2 – Central Dike Culvert entrance in Southern Pond.
Note water surface elevation in pond in relation to pipe invert.



Photo 3 – Interior of Central Dike Culvert. Note riprap "dam" limiting pipe's capacity.



Photo 4 – Interior of Northern Pond, looking north from Central Dike.
Channel to direct flow from Culvert to Pond outlet structure.

US EPA ARCHIVE DOCUMENT



Photo 5 – Interior of Northern Pond, looking south from northern corner.
Note vegetative growth on inboard slope..



Photo 6 – Outboard slope of Northern Pond near the northern end.

US EPA ARCHIVE DOCUMENT



Photo 7 – Outboard slope of Northern Pond near the northern end.
Note repairs near the crest.



Photo 8 – Outboard slope of Northern Pond near the northern end.
Note reedy grasses at toe.

US EPA ARCHIVE DOCUMENT



Photo 9 – pH balance outlet structure. Note HDPE pipe running parallel to toe (Southern Pond discharge) joining with concrete pipe (Northern Pond discharge) outside of structure.



Photo 10 – Runoff from drainage area east of Ash Pond merging with Pond effluent..

US EPA ARCHIVE DOCUMENT



Photo 11 – Ash Pond outlet channel transitioning from open channel to underground culvert.



Photo 12 – Northern Pond outlet structure, located at northern end of impoundment.

US EPA ARCHIVE DOCUMENT



Photo 13 – CCW discharge from Joppa Plant into Ash Pond at southwestern corner of Southern Pond..



Photo 14 – Channel dredged into CCW that conveys inflow from pipes to eastern side of Southern Pond.

US EPA ARCHIVE DOCUMENT



Photo 15 – Southern Pond primary outlet structure.



Photo 16 – Interior of Southern Pond primary outlet structure.

US EPA ARCHIVE DOCUMENT



Photo 17 – Interior of Southern Pond, looking south from primary outlet structure.



Photo 18 – Outboard slope of southern embankment of Southern Pond.
Note Jersey barrier blocking vehicular access to eastern embankment.

US EPA ARCHIVE DOCUMENT



Photo 19 – Outboard slope of eastern embankment of Southern Pond.
Note repairs near crest and partially completed access road along toe.



Photo 20 – Outboard slope of Southern Pond near power lines.

US EPA ARCHIVE DOCUMENT



Photo 21 – Erosion on east embankment of Southern Pond below the power lines.



Photo 22 – Slides and sloughs on east embankment of Southern Pond, approximately 200 feet south of power lines.

US EPA ARCHIVE DOCUMENT



Photo 23 – Outboard toe of Southern Pond eastern embankment approximately 500 feet north of power lines. Note reedy grasses indicating moist conditions, signs of seepage.



Photo 24 – Seepage at toe of east embankment of Southern Pond, near location indicated in Photo 23 above.

US EPA ARCHIVE DOCUMENT



Photo 25 – Ash Pond outlet channel pass-through below EEI railroad siding.

US EPA ARCHIVE DOCUMENT

The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 12

COAL ASH IMPOUNDMENT
SITE ASSESSMENT FINAL REPORT



Meredosia Power Station
Ameren Energy Generating Company
Meredosia, Illinois

Prepared by:

KLEINFELDER
Bright People. Right Solutions.

611 Corporate Circle, Suite C
Golden, CO 80401

KLEINFELDER PROJECT NUMBER 112618-7

May 10, 2011

I acknowledge that the management units referenced herein:

- Fly Ash Pond
- Bottom Ash Pond

Were assessed on August 10, 2010

Signature: Brian T. Havens Date: 5/10/11

Brian T. Havens, P.E.
Lead Geotechnical Engineer



Copyright 2011 Kleinfelder West, Inc.

EXECUTIVE SUMMARY

Background information taken from the U. S. Environmental Protection Agency's (EPA's) website:

> "Following the December 22, 2008 dike failure at the TVA/Kingston, Tennessee coal combustion waste (CCW) ash pond dredging cell that resulted in a spill of over 1 billion gallons of coal ash slurry, covered more than 300 acres and impacted residences and infrastructure, the EPA is embarking on an initiative to prevent the catastrophic failure from occurring at other such facilities located at electric utilities in an effort to protect lives and property from the consequences of a impoundment or impoundment failure of the improper release of impounded slurry."

As part of the EPA's effort to protect lives and the environment from a disaster similar to that experienced in 2008, Kleinfelder was contracted to perform a site assessment at the Meredosia Power Generating Station that is owned and operated by Ameren Energy. This report summarizes the observations and findings of the site assessment that occurred on August 10, 2010.

The coal combustion waste impoundments observed during the site assessment included:

- Fly Ash Pond – Commissioned in 1968
- Bottom Ash Pond – Commissioned in 1972

Preliminary observations made during the site assessment are documented on the Site Assessment Checklist presented in Appendix A. A copy of this checklist was transmitted to the EPA following the field walk-through. A more detailed discussion of the observations is presented in Section 4, "Site Observations".

The fly ash and bottom ash pond impoundments are not regulated by any state agency and therefore do not currently have a designated hazard rating. Due to the potential environmental and economic impacts that a failure at either of these impoundments would present by breaching the south banks into the Illinois River, it is recommended a hazard classification of "Significant" be assigned to both impoundments.

Overall, the site is reasonably well maintained and operated with a few areas of concern as discussed in Section 6, "Recommendations".

On the date of this site assessment, there appeared to be no immediate threat to the safety of the impoundment embankments. No assurance can be made regarding the impoundments condition after this date. Subsequent adverse weather and other factors may affect the condition.

Copyright 2011 Kleinfelder West, Inc.

A brief summary of the Priority 1 and 2 Recommendations is given below. A more detailed discussion is provided in Section 6, “Recommendations”.

Priority 1 Recommendations

1. Prepare an Emergency Action Plan (EAP) for the facility.

2. Perform a hydrologic and hydraulic study.

3. Establish a seepage and groundwater monitoring program.

4. Perform embankment and structural stability analyses.

5. Perform video assessments of culvert piping.

6. Control vegetation on the upstream and downstream slopes. Remove the trees from the embankment including the large tree at the overflow outlet discharge point.

Priority 2 Recommendations

1. Repair erosion of embankment.

2. Review the condition of riprap at the downstream toe of the bottom ash embankment and upgrade the riprap, if needed, to meet typical requirements for riprap size and placement.

3. Maintain a log of maintenance and other activities at the fly ash impoundments and supporting facilities.

4. Develop an Operation and Maintenance (O&M) manual for the impoundments and the facility.

Copyright 2011 Kleinfelder West, Inc.

Table of Contents

EXECUTIVE SUMMARY 2

SECTION 1 – INTRODUCTION 6
1.1 General 6
1.2 Project Location 6
1.3 Site Documentation 6

SECTION 2 – SITE ASSESSMENT 7
2.1 Attendees 7
2.2 Impoundments Inspected 7
2.3 Weather During Assessment 7

SECTION 3 – SITE INFORMATION AND HISTORY 8
3.1 Site Information and History 8
3.2 Pertinent Data 9
3.3 Regional Geology and Seismicity 11
3.4 Hydrology and Hydraulics 12
3.5 Geotechnical Considerations 12
3.6 Structural Considerations 12
3.7 Performance Evaluations 13
3.8 Hazard Classification 13
3.9 Site Access 14

SECTION 4 – SITE OBSERVATIONS 15
4.1 Bottom Ash Pond 15
4.1.1 Upstream Slope 15
4.1.2 Crest 15
4.1.3 Downstream Slope 16
4.1.4 Downstream Toe Areas 16
4.1.5 Outlet Works 16
4.1.6 Impoundment Inlet 17
4.2 Fly Ash Pond 17
4.2.1 Upstream Slope 17
4.2.2 Crest 17
4.2.3 Downstream Slope 17
4.2.4 Toe Areas 18
4.2.5 Outlet Works 18
4.2.6 Impoundment Inlet 18
4.3 Other 19

SECTION 5 – OVERALL CONDITION OF THE FACILITY IMPOUNDMENTS 20
5.1 Analysis and Conclusions 20
5.2 Summary Statement 21

SECTION 6 – RECOMMENDATIONS 22
6.1 Definitions 22
6.2 Priority 1 Recommendations 22
6.3 Priority 2 Recommendations 23

SECTION 7 – GLOSSARY OF TERMS 24

SECTION 8 – LIMITATIONS 27

SECTION 9 – REFERENCES 28

Copyright 2011 Kleinfelder West, Inc.

List of Figures

Figure 1	Locations of Critical Infrastructure
Figure 2	Meredosia Power Generating Station Aerial Map
Figure 3	Typical Cross Section – Bottom and Fly Ash Ponds
Figure 4	Locations of Site Assessment Photos – Fly Ash Pond
Figure 5	Locations of Site Assessment Photos – Bottom Ash Pond

List of Appendices

Appendix A	Site Assessment Checklists
Appendix B	Site Assessment Photographs
Appendix C	Response Letter to the EPA's Section 104(e) Request for Information

Copyright 2011 Kleinfelder West, Inc.

SECTION 1 – INTRODUCTION

1.1 General

This report has been prepared for the United States Environmental Protection Agency (EPA) to document findings and observations from a site assessment at the Meredosia Power Station on August 10, 2010.

The following sections present a summary of data collection activities, site information, performance history of the facility's impoundment ponds, a summary of site observations, and recommendations resulting from the site investigation.

1.2 Project Location

The Meredosia Power Generating Station is located on the eastern bank of the Illinois River approximately one mile south of Meredosia, Illinois as shown in Figure 1. The town of Meredosia is located in Morgan County at approximately 39^{o}49'48'' N and 90^{o}33'30'' W. In general, the town of Meredosia is a rural agricultural community with the town population hovering around 1,000 people.

1.3 Site Documentation

Ameren Energy provided the following documents during the time of this inspection to aid in the review of the impoundments:

- Ameren, Impoundment Safety Program for Non-Illinois Department of Natural Resources (IDNR) Regulated Facilities, AER-DSP-004, April 3, 2009
- Ameren, Annual Engineering Inspection Report, July, 31, 2009
- Ameren, Flood Control Works Inspection Report, March 18, 2008
- Hanson Engineers, Capacity Survey and Stability Analysis Fly Ash Impoundment, Meredosia Power Station, June 13, 1991
- Sargent and Lundy, Design Drawings B-331 thru B-334, 1971
- Hanson Engineers, Utility Site Plan Drawing, 1980
- The CECO Corporation, Weir Box Design Drawing, 1971

Copyright 2011 Kleinfelder West, Inc.

SECTION 2 – SITE ASSESSMENT

2.1 Attendees

The site assessment was performed on August 10, 2010 by Brian Havens, P.E. and Matt Gardella, E.I.T. of Kleinfelder. Other persons present during the site assessment included:

- Paul Pike – Ameren Energy
- Michael Wagstaff – Ameren Energy
- Michael Long – Ameren Energy
- Joe Schnelten – Ameren Energy
- Mitch White – Ameren Energy
- Craig Dufficy – United States Environmental Protection Agency

2.2 Impoundments Inspected

Impoundments and associated structures that were observed during the site assessment included:

- Fly Ash Pond – Commissioned in 1968
- Bottom Ash Pond – Commissioned in 1972

Observations from the site assessment are documented on the Site Assessment Evaluation Checklists presented in Appendix A. A summary of observations from the site assessment is presented in Section 4.

2.3 Weather During Assessment

During the assessment of the Meredosia Power Station impoundments, the weather was sunny and clear with high humidity. Temperatures ranged from 95^{o} to 100^{o} F, and wind ranged from 0 to 5 miles per hour (mph).

Copyright 2011 Kleinfelder West, Inc.

SECTION 3 – SITE INFORMATION AND HISTORY

3.1 Site Information and History

The Meredosia Power Generating Station is a coal fired facility that has been in operation since 1948. The facility currently sluices Bottom Ash and Fly Ash, by-products of coal fired energy generation, into two separate impoundments. These impoundments are referred to as the "Bottom Ash Pond" and the "Fly Ash Pond". An aerial image of these impoundments can be seen in Figure 2. These ponds act as settling basins for the bottom and fly ash prior to the water being treated and released back into the Illinois River. Disposal of the fly ash and bottom ash currently differ at the site. The bottom ash residual is removed from the Bottom Ash Pond, dried on site, and then sold to various organizations for beneficial use such as the topping of roadways. The fly ash residual is allowed to dry, then is removed, and is disposed of in offsite landfills. Beneficial use of the fly ash is not currently economically feasible at the Meredosia site, but could possibly hold potential in the future depending on local construction projects and their need for concrete admixtures.

The Bottom Ash Pond is a combination earthen embankment and incised impoundment. Sluice pipes transporting bottom ash from power generating operations outlet at the northeastern corner of the pond. From here the bottom ash slurry is directed through a settling channel into a larger portion of the pond. This channel is approximately 500 feet long and is separated from the main pond by a peninsula composed of dried and compacted bottom ash jutting out from the main embankment of the pond. The intention of this settling channel is to allow additional time for suspended solids to drop out of suspension before entering the main body of the Bottom Ash Pond where they are harder to collect and remove for drying. Both the settling channel and main portion of the pond are considered to be components of the larger Bottom Ash Pond.

Another key component of the Bottom Ash Pond is the pond's outlet works structure. The outlet works of the Bottom Ash Pond are located near the northwestern embankment and are accessible by a 75 foot long catwalk that extends from the crest of the embankment toward the center of the pond. The outlet works consist of a weir box with adjustable intake levels that leads to a 12 inch vitrified clay pipe. This clay pipe extends to the northwest and outlets in the Illinois River.

The Bottom Ash Pond has an emergency spillway consisting of a 12" corrugated metal pipe extending through the crest of the embankment on the north side of the impoundment.

The Fly Ash Pond is a combination earthen embankment and incised impoundment, and is divided into 4 cells by compacted bottom ash/fly ash dikes. One of these cells is a "clarifying" or "polishing" pond (Cell 4) and is used as a final settling pond before discharging water from the pond to the Illinois River. The other 3 cells that make up

Copyright 2011 Kleinfelder West, Inc.

the Fly Ash Pond alternate impounding fly ash slurry. This is done so that a cell can be dried and the fly ash solids excavated and disposed of, before impounding more fly ash while another cell is dried and cleared. Equalization pipes and spillways cut in the internal dikes exist between all of the cells so that one cell is not allowed to overtop while the adjacent cell remains dry in extreme circumstances.

The Fly Ash Pond's outlet structure is very similar to the Bottom Ash Pond's outlet structure. The outlet works of the Fly Ash Pond are located near the western embankment of Cell 4 and are accessible by a 75 foot long catwalk that extends from the crest of the embankment toward the center of the pond. The outlet works consist of a weir box with adjustable intake levels that leads to a 12 inch vitrified clay pipe. This clay pipe extends to the northwest and outlets in the Illinois River.

The Fly Ash Pond does not have an emergency spillway that we are aware of.

Prior to the current operational layout at the Meredosia Power Generating Station, there had been an additional fly ash impoundment with two cells as well as a bottom ash impoundment at the site. The old fly ash pond was located immediately east of the current Fly Ash Pond, and the old bottom ash pond was located somewhere to the north of the current Bottom Ash Pond. The old fly ash impoundment was decommissioned and capped sometime in the 1970's but an exact date is unknown. The old bottom ash impoundment was decommissioned and capped sometime before the old fly ash impoundment, but an exact date is unknown.

In reviewing the response letter to the EPA's section 104(e) request for information, shown in Appendix C, it was noted that previously there had been a release of impounded water at the Meredosia Power Generating Station. Specifically, Ameren Energy reported that they released a small amount of water (less than 500 gallons) from the fly ash pond to the land in late December 2006. In response, they modified the pond and developed internal procedures to prevent a recurrence of the situation. They are not aware of any other spills or unpermitted releases of coal combustion by-products from their surface impoundments to surface water or to the land.

3.2 Pertinent Data

A. GENERAL

1. Name ..... Meredosia Power Generating Station
2. State ..... Illinois
3. County ..... Morgan
4. Latitude ..... 39° 49' 02'' North
5. Longitude ..... 90° 34' 20'' West
6. River used for operations ..... Illinois River
7. Year Constructed 1948
8. Modifications ..... None to current impoundments
9. Current Hazard Classification ..... None
10. Proposed Hazard Classification ..... Significant
11. Size ..... Unregulated Currently – Small Impoundment[2]

Copyright 2011 Kleinfelder West, Inc.

B. IMPOUNDMENTS

BOTTOM ASH POND

1. Type ..... Earthen – Diked/Incised Combination
2. Crest Elevation ..... ±450[1]
3. Crest Length ..... Approximately 3,000 ft
4. Crest Width ..... 8 ft
5. Impoundment Height ..... App. 20 ft
6. Upstream Slope 3H:1V
7. Downstream Slope 3H:1V
8. Volume of Stored Ash……139 acre-feet

FLY ASH POND

1. Type ..... Earthen – Diked/Incised Combination
2. Crest Elevation ..... ±452[1]
3. Crest Length ..... Approx. 5,000 ft
4. Crest Width ..... 8 ft
5. Impoundment Height ..... App. 20 ft
6. Upstream Slope 3H:1V
7. Downstream Slope 3H:1V
8. Volume of Stored Ash……650 acre-feet

C. DRAINAGE BASIN

1. Area of Drainage Basin.....Unknown
2. Downstream Description: .....Discharges directly into the Illinois River

D. RESERVOIR INLET

BOTTOM ASH POND

1. Reservoir Inlet .....Multiple inlet sluice pipes from the generating station

FLY ASH POND

1. Reservoir Inlet .....Multiple inlet sluice pipes from the generating station

E. RESERVOIR

BOTTOM ASH POND

1. Reservoir Capacity.....Normal Storage is approximately 186 acre-feet

FLY ASH POND

2. Reservoir Capacity.....Normal Storage is approximately 620 acre-feet

F. PRIMARY SPILLWAY

BOTTOM ASH POND

1. Description.....Outlet works with conduit per Section G below

FLY ASH POND

1. Description.....Outlet works with conduit per Section G below

G. OUTLET WORKS

BOTTOM ASH POND

1. Description.....Rectangular weir box with adjustable V-notch weir connected to 12" VCP
2. Location ..... Near northwest embankment app. 75' into the center of the pond

Copyright 2011 Kleinfelder West, Inc.

3. Intake Structure ..... Weir box with adjustable V-notch weir
   a. Intake Invert Elevation ..... Adjustable
4. Discharge Conduit ..... Vitrified Clay Pipe
   a. Length ..... 150 ft
   b. Diameter ..... 12 inches
5. Outlet Structure ..... Gate valve at weir box
   a. Outlet Invert Elevation ..... 425.3[1]
   b. Energy Dissipation ..... Concrete slab with surrounding riprap[3]
6. Discharge Channel ..... ~20' x 20' bay that empties directly into the Illinois River
7. Discharge Capacity with Water Surface at Top of Impoundment ..... Unknown

FLY ASH POND

1. Description ..... Rectangular weir box with adjustable V-notch weir connected to 12" VCP
2. Location ..... Near west embankment app. 75' into the center of the pond
3. Intake Structure ..... Weir box with adjustable V-notch weir
   a. Intake Invert Elevation ..... Adjustable
4. Discharge Conduit ..... Vitrified Clay Pipe
   a. Length ..... 150 ft
   b. Diameter ..... 12 inches
5. Outlet Structure ..... Gate valve at weir box
   a. Outlet Invert Elevation ..... 427.3[1]
   b. Energy Dissipation ..... Concrete slab with surrounding riprap[3]
6. Discharge Channel ..... ~20' x 30' bay that empties directly into the Illinois River
7. Discharge Capacity with Water Surface at Top of Impoundment ..... Unknown

H. MANAGEMENT

1. Owner ..... Ameren Energy
2. Purpose ..... Coal Fired Energy Generation

Notes:
1. All elevations in feet based on original construction drawings by Sargent and Lundy Engineers
2. Impoundment is unregulated; size is based on Illinois Department of Natural Resources Administrative Code for Impoundment Safety
3. Structure was inundated during the time of inspection and was not able to be inspected

3.3 Regional Geology and Seismicity

The plant site is situated in the Illinois River Valley. As such, the subsurface conditions are expected to include Quaternary alluvial deposits overlying sedimentary bedrock. Based on the available data, it is uncertain whether the regional glacial deposits are present at the plant site between the alluvium and the bedrock.

Based on our review of historical soil borings and information from the Web Soil Survey, it appears that the upper alluvial deposits at the site include combinations of silty clay, clayey silt, silty sand and clayey sand. Based on our review of data published by the United States Geological Survey (USGS), the sedimentary rock formations in Morgan County include shale, sandstone and limestone.

The plant site is situated in a Seismic Zone 1 area. We have noted that the New Madrid Fault has a documented history of seismic activity, but is located more than 200 miles south of the plant site.

Copyright 2011 Kleinfelder West, Inc.

3.4 Hydrology and Hydraulics

Both the Bottom Ash and Fly Ash Ponds are designed and situated in such a manner that the watershed drainage contributing to the stored volume of the ponds is minimal and most likely limited to pumping operations and storm water that falls within the impoundments themselves. However, the exact extents of the watershed cannot be determined without a current topographic survey of the surrounding area and of the impoundments themselves.

During the assessment, documents such as hydrologic studies, hydraulic design calculations and assumptions, and impoundment break analyses were not available for our review. As a result, the design inflow, design freeboard and other important components of the impoundment designs are unknown at this time. The project plans do identify that the Bottom Ash Pond was designed to store up to 300,000 cubic yards of ash and the Fly Ash Pond was designed to store up to 1,000,000 cubic yards of ash.

3.5 Geotechnical Considerations

Regarding stability of the embankment slopes, we have reviewed a report dated May 17, 1991 by Hanson Engineers Incorporated. This study was apparently completed at a time when Central Illinois Public Service Company (now Ameren Energy) was considering raising the pool elevation in the Fly Ash impoundment. The study included stability analyses under the condition of a higher pool elevation at Elevation 449, but did not document stability of the impoundments in their present configuration (pool at Elevation 447). It appears that the pool elevation (and embankment elevation) were not raised following this study. We understand that embankment stability analyses are currently being completed for both impoundments by another consultant retained by Ameren Energy.

Regarding seepage, we understand that seepage at various locations along the downstream embankment of the Fly Ash pond has been witnessed by Ameren Energy and Hanson Professional Services at various times including 1991, 2008, 2009 and other intervening years. The seepage noted by Hanson Engineers in 2008 was at a low rate and appeared to be clear and free of transported or piped soils.

3.6 Structural Considerations

According to the inspection conducted in July, 2009, a fractured cross brace was noted in the middle support of the catwalk at the bottom ash pond. The assessment conducted in 2010 by Kleinfelder shows that the same fractured cross member is not repaired (see Photo 14 in Appendix B). The catwalk bridge access portion appears to be in satisfactory condition and the superstructure appears to be intact with minor corrosion. The catwalk substructure concrete foundations appear to be in satisfactory condition as well with little to no concrete spalling or scaling.

The 6’ X 6’ reinforced concrete weir box appears to be in satisfactory condition. A sluice gate within the weir box controls flows in and out of the fly ash pond. The weir

Copyright 2011 Kleinfelder West, Inc.

box is approximately 30 feet high and connects with the catwalk mentioned above. Due to the water level at the time of inspection, we were not able to observe the foundation condition of the weir box.

The bottom ash pond inlet pipe appears to be supported on wood supports. The supports appeared to be weathered, although not to the point of structural failure. Due to the age of the facility, a structural engineering evaluation is merited to determine the condition of the supports.

Documentation of the structural portions of the impoundments under seismic loading was not available for our review. Although the plant site is located in a zone of relatively low risk for damaging seismic activity, evaluation of the structural components of the impoundments under applicable seismic loading conditions merits consideration.

3.7 Performance Evaluations

There have been no previous federal or state assessments of the Meredosia Power Generating Station's Bottom Ash or Fly Ash impoundments. Based on observations by Ameren Energy in their annual assessments, weekly assessments and other documents and accounts, there have been no major incidents involving the Bottom Ash or Fly Ash Ponds. Currently Ameren Energy's local plant personnel perform weekly assessments of the impoundments and their associated structures. Ameren Energy also performs annual assessments of the Meredosia impoundments, similar to this assessment, via their Impoundment Safety and Environmental personnel. In addition, Ameren Energy retained Hanson Professional Services, Inc. to make a site assessment and provide recommendations on January 11, 2008.

3.8 Hazard Classification

The Meredosia Power Generating Station's two impoundments are not regulated by any state agency and therefore do not currently have a designated hazard rating. However, the Fly Ash and Bottom Ash ponds were rated by Ameren Energy's internal impoundment safety organization as being Significant Hazard and Low Hazard impoundments respectively. However, due to the potential environmental and economic impacts that a failure at either of these impoundments would present, it is recommended that a hazard classification of "significant" be assigned to both impoundments. A "High Hazard" rating was not assigned to the impoundments, as it is not expected that a loss of life situation would be likely in the event of a failure. A loss of life situation is not expected as the Bottom Ash and Fly Ash Ponds sit immediately adjacent to the Illinois River without any homes, recreational facilities, businesses, roads or other structures immediately downstream of the impoundments. However, a hazard classification analysis is needed to determine the hazard classification of the impoundments.

Copyright 2011 Kleinfelder West, Inc.

3.9 Site Access

We were required to seek permission from Ameren Energy to gain access to the plant site. After arriving at the site and meeting with representatives of Ameren Energy, we were escorted by facility personnel to assess the impoundments. The impoundments can be accessed by standard car during normal weather conditions via gravel-surfaced roadways on the Meredosia Power Generating Station property.

Copyright 2011 Kleinfelder West, Inc.

The impoundment embankments, toes and outlet works (portions not inundated at the time of inspection) of both the Bottom Ash and Fly Ash Pond were observed during the August 10, 2010 site assessment. General observations of these features are presented below; more specific observations of the site and facilities are documented in the Site assessment Evaluation Checklist provided in Appendix A.

4.1 Bottom Ash Pond

4.1.1 Upstream Slope

Overall, the upstream slope of the impoundment was in fair condition. Photos 1, 6 and 23 in Appendix B show the conditions of the upstream slope. Specific observations include:

- The upstream slope was laid back at approximately 1.5H:1V, based on visual observations. This varies from the construction documents provided by Ameren, probably due to the build-up of bottom ash on the embankment. However, it is possible that cleanout operation at the Bottom Ash Pond could have cut into the embankment and steepened it over time.
- Minor erosion rills, less than 6 inches deep, were noted on some of the upstream slopes.
- Grasses and woody bushes were observed on the upstream slope for the majority of the impoundment.
- Mowing/Vegetation control had not been completed on the majority of the upstream slope.

4.1.2 Crest

Overall, the crest of the impoundment was in satisfactory condition. Photos 1 through 3 show the condition of the crest. Specific observations include:

- The impoundment crest is a gravel road.
- Sparse grasses and bushes were observed on the crest.
- No major depressions or rutting was noted on the impoundment crest.
- Transecting the crest with minimal cover are two Fly Ash sluice lines. Photo 24 in Appendix B shows these sluice lines.
- A chain link fence is located around the majority of the Bottom Ash Pond at the crest.
- Multiple light poles penetrate the crest of the levee. These light poles can be seen in Appendix B photos 23 and 28.
- Minor erosion was noted on crest in multiple locations. This erosion was typically less than six inches in depth and typically appeared on the edges of the crest where grade breaks occurred when transitioning to embankment slopes.

Copyright 2011 Kleinfelder West, Inc.

- Foundations for the pipeline that runs along the crest of northern embankment penetrate the crest in multiple locations.

4.1.3 Downstream Slope

Overall, the downstream slope was in fair to poor condition. Photos 7, 8 , 9, 18 and 20 show the conditions of the downstream slope. Specific observations include:

- There was slope protection on the downstream slope adjacent to the Illinois River. It was comprised of riprap that ranged greatly in size. Riprap armoring was sparse in some areas of the downstream slope.
- Minor erosion rills, less than 6 inches deep, were noted on some of the downstream slope.
- Grasses, woody bushes and large mature trees were observed on the downstream slope and at the toe of the embankment for the majority of the impoundment.
- Driven sheet pile used to form an access to the oil delivery area intersects the downstream slope of the Bottom Ash Pond as shown in Photos 12 and 13.

4.1.4 Downstream Toe Areas

The toe areas of the embankment were in fair to poor condition. See photos 15 and 17 for the condition of these areas. Key features and observations of these areas include:

- The toe areas were almost impassible in certain locations due to mud. The Illinois River had been up against the downstream bank of the impoundment and had just recently receded.
- The toe area had sparse grasses, some bushes, and multiple large mature trees.

4.1.5 Outlet Works

The outlet works of the Bottom Ash pond consist of a weir box located at the northwestern corner of the impoundment, approximately 75 feet toward the center of the pond. The weir box is accessible via a metal catwalk. The weir box has stop logs and a v-notch weir that can adjust the height of intake for the outlet structure. A sluice gate separates the weir box from a 12 inch vitrified clay pipe leading to the discharge location on the Illinois River. Operation of this sluice gate in flood conditions is possible by one person without any mechanized equipment. According to Ameren Energy personnel and the provided documents, the discharge location of the outlet pipe has a concrete slab to protect against slope erosion during discharge. However, this slab could not be observed during the assessment as it was inundated.

- The discharge location of the outlet pipe was not able to be observed as it was inundated at the time of assessment

Copyright 2011 Kleinfelder West, Inc.

- One cross brace of the catwalk used to access the weir box has rusted through.
- No video monitoring of the clay pipe was available at the time of assessment
- Overall, the outlet works system appears to be functioning as intended at this time.

4.1.6 Impoundment Inlet

Inflow into the Bottom Ash Pond is via metal piping on the northeastern corner of the impoundment, as well as storm water runoff that flows naturally into the pond. The inlet pipe can be seen in photo 4 of Appendix B. From this inlet location the ash and water slurry then flows through an interior settling channel and into the larger storage pool of the impoundment. The inlet pipe appears to be in satisfactory condition.

4.2 Fly Ash Pond

4.2.1 Upstream Slope

Overall, the upstream slope of the impoundment was in satisfactory condition. Photo 32 in Appendix B shows the conditions of the upstream slope. Specific observations include:

- The upstream slope was laid back at approximately 3H:1V
- Mowing had not been completed on the majority of the upstream slope.
- Grasses, bushes and woody debris were observed on the slope.

4.2.2 Crest

Overall, the crest of the impoundment was in satisfactory condition. Photos 29 and 31 show the condition of the crest. Specific observations include:

- The impoundment crest is a gravel road.
- Sparse grasses and bushes were observed on the crest.
- No major depressions or rutting was noted on the impoundment crest.
- Minor erosion was noted on crest in multiple locations. This erosion was typically less than six inches in depth and typically appeared on the edges of the crest where grade breaks occurred when transitioning to embankment slopes.

4.2.3 Downstream Slope

Overall, the downstream slope was in fair condition. Photos 30 and 31 show the conditions of the downstream slope. Specific observations include:

- Grasses, woody bushes and large mature trees were observed on the downstream slope and at the toe of the embankment for a large portion of the impoundment.

Copyright 2011 Kleinfelder West, Inc.

- There was slope protection on the majority of the slope for the Fly Ash Pond. Typically it consisted of large riprap that was typically vegetated.
- Typically the embankment was well maintained with recent mowing operations

4.2.4 Toe Areas

The toe areas of the embankment were in fair to poor condition. See photos 30 and 33 for the condition of these areas. Key features and observations of these areas include:

- The toe areas were in almost impassible in certain locations due to mud. The Illinois River had been up against the downstream bank of the impoundment and had just recently receded.
- The toe area had multiple locations where large mature trees still remained along with recently felled trees that had not been removed from the toe and slope of the impoundment

4.2.5 Outlet Works

The outlet works of the Fly Ash Pond are almost identical to that of the Bottom Ash Pond. The outlet works intake weir box is located in cell 4 near the western embankment, approximately 75 feet toward the center of the pond. The weir box is accessible via a metal catwalk. The weir box has stop logs and a v-notch weir that can adjust the height of intake for the outlet structure. A sluice gate separates the weir box from a 12 inch vitrified clay pipe leading to the discharge location on the Illinois River. Operation of this sluice gate in flood conditions is possible by one person without any mechanized equipment. According to Ameren Energy personnel and the provided design drawings, the discharge location of the outlet pipe has a concrete slab to protect against slope erosion during discharge. However, this slab could not be observed during the assessment as it was inundated.

- The discharge location of the outlet pipe was not able to be observed as it was inundated at the time of assessment
- No video monitoring of the clay pipe was available at the time of assessment
- Overall, the outlet works system appears to be functioning as intended at this time.

4.2.6 Impoundment Inlet

Inflow into the Fly Ash Pond is via multiple inlet pipes on the northeastern corner of the impoundment in cell 1, as well as storm water runoff that flows naturally into the pond. From this inlet location the ash and water slurry then flows through a series of pipes to fill either cell 2 or 3 (depending on which cell is being cleaned out) and then into cell 4 which contains the outlet works for the impoundment. The inlet pipe and pipes connecting all of the cells appear to be in functional condition.

Copyright 2011 Kleinfelder West, Inc.

4.3 Other

Internal dikes of the Fly Ash Pond cells appear to be laid back at approximately a 2.5H:1V slope. Surface erosion up to 12 inches in depth can be seen along the crest and slope of the majority of the internal dikes. Sparse vegetation can be observed on the slopes of the dikes, but provides little or no protection against surface erosion. Currently there are two known piezometers in the dikes that consist mainly of fly ash and bottom ash. However, these piezometers are not monitored with any specific frequency.

We inquired if Ameren Energy had developed an Emergency Action Plan (EAP) related to a potential failure of the impoundments. We understand that an EAP has not been developed for the site.

We also inquired if Ameren Energy had developed an Operation and Maintenance (O&M) Manual for the Meredosia Power Generating Station bottom ash and fly ash impoundments. We understand that an O&M Manual has also not been developed for the site. The above referenced EAP should be part of this O&M Manual, but should be capable of being a stand-alone document.

Copyright 2011 Kleinfelder West, Inc.

5.1 Analysis and Conclusions

Our analysis is summarized in three general considerations that are presented as follows:

Safety of the Impoundments including Maintenance and Methods of Operation

We understand that the impoundments have a history of safe performance. However, the future performance of these impoundments will depend on a variety of factors that may change over time, including surface water hydrology, changes in groundwater levels, changes in embankment integrity, etc. In light of this situation, we have noted several items as follows that present some concern in this regard:

- Large mature trees exist on the toe and slopes of both the Bottom Ash Pond and Fly Ash Pond and stumps remain in some areas where trees were recently cut down. These stumps can decompose over time and eventually create preferential paths for uncontrolled seepage
- An Emergency Action Plan (EAP) is not currently in place at the site to mitigate damage in the event of an emergency related to failure of the impoundment(s)
- Analyses of the slope stability for the embankments are not currently available for our review. However, we understand that these analyses are in the process of being developed.
- Documentation of the impoundment capacity under potential hydrologic and hydraulic loading is not currently available for review.
- We understand that an Operation and Maintenance (O&M) Manual is not currently in place for the site. Developing an O&M manual which includes a section that discusses the safety inspection and monitoring program would be recommended to standardize safety inspection and monitoring practice.

Changes in Design or Operation of the Impoundments following Initial Construction

We are not aware of significant changes in the design or operation of the impoundments that have been implemented. We reviewed a 1991 study for raising the pool level in the Fly Ash Pond, but we believe that this concept was never implemented.

Adequacy of Program for Monitoring Performance of the Impoundments

The present monitoring program primarily involves visual inspections by plant personnel and by the Ameren Energy Dam Safety Group. These visual inspections seem to be adequate to address issues such as surface erosion and general condition of the impoundments. However, a more detailed monitoring program is recommended to be established to quantify various important factors associated with embankment stability. Those factors include, but are not limited to seepage quantities

Copyright 2011 Kleinfelder West, Inc.

through the embankment, the amount of sediments carried by the seepage water, and the fluctuation of ground water levels.

5.2 Summary Statement

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

FAIR

Signature: Brian T. Havens Date: 5/10/11

Brian T. Havens, P.E.
Lead Geotechnical Engineer

Copyright 2011 Kleinfelder West, Inc.

SECTION 6 – RECOMMENDATIONS

6.1 Definitions

Priority 1 Recommendation: Priority 1 Recommendations involve the correction of severe deficiencies where action is required to ensure the structural safety, operational integrity of a facility, and that may threaten the safety of the impoundment.

Priority 2 Recommendation: Priority 2 Recommendations where action is needed or required to prevent or reduce further damage or impair operation and/or improve or enhance the O&M of the facility, that do not appear to threaten the safety of the impoundment.

Based on observations during the site assessment, it is recommended that the following actions be taken at the Meredosia Power Generating Station.

6.2 Priority 1 Recommendations

1. **Prepare an emergency action plan (EAP) for the facility by 8/2/2011.** An EAP should be prepared for the Fly Ash and Bottom Ash Ponds as well as any other pertinent features related to the impoundments. The EAP should be reviewed by the EPA.
2. **Perform a hydrologic and hydraulic study by 8/1/2011.** This study should be performed to determine if the existing ponds are capable of impounding the appropriate inflow design flood without overtopping of the impoundments. At a minimum, documentation required for this evaluation will include a current topographic survey of the site and surrounding drainage basin, basin characteristics (surface runoff/infiltration condition) and sufficient hydrologic data to determine the design storm event. The results of this evaluation should be reviewed by the EPA.
3. **Establish seepage and ground water monitoring program by 8/1/2011**. As discussed in Section, 3.5, seepage water at various locations along the downstream embankment of the Fly Ash pond was observed. The presence of seepage water at the downstream embankment raises serious questions regarding the integrity and the stability of the embankment. Therefore, a detailed monitoring program should be established to quantify various important factors including seepage quantities through the embankment, the amount of sediments carried by the seepage water, and the fluctuation of ground water levels. The results of this evaluation should be reviewed by the EPA.
4. **Perform embankment and structure stability analyses by 8/1/2011.** The slopes of the Bottom Ash Pond were steep, appearing to be 1H:1V in some cases, and their stabilities are is unknown. Due to the lack of documented engineering design analysis, new stability analyses of both impoundments should be performed. The analyses should incorporate seepage monitoring data and include

Copyright 2011 Kleinfelder West, Inc.

evaluation of the embankments and the structures under seismic loading scenarios. According to Ameren, we understand that this task is currently being completed by another consultant retained by Ameren Energy. The results of this evaluation should be reviewed by the EPA.

5. **Perform video assessments of culvert piping by 8/1/2011.** Culvert piping used for the outlet works of the impoundments is vitrified clay pipe. As this pipe is either past or nearing the end of its life expectancy, a video assessment should be performed of all culvert piping to determine its effectiveness and if remedial actions are necessary.
6. **Control vegetation on the upstream and downstream slopes. Remove the trees and stumps from the embankment including the large tree at the overflow outlet discharge point by 8/1/2011.** Refer to FEMA Manual 534 (Impact of plants on Earthen Impoundments) for guidance on vegetation removal. This manual is available on the FEMA website.

6.3 Priority 2 Recommendations

1. **Repair erosion of embankment.** Minor surface erosion was noted at both the Bottom Ash Pond and Fly Ash Pond. Areas where erosion has occurred should be filled in and re-dressed with appropriate fill in order to prevent erosion from cutting further into the embankments.
2. **Review the condition of riprap at the downstream toe of the bottom ash embankment and upgrade the riprap, if needed, to meet typical requirements for riprap size and placement by 12/1/2011.**
3. **Maintain a log of maintenance and other activities at the fly ash impoundments and supporting facilities.** We believe that this log will provide continuity during periods of staff change.
4. **Develop an Operation and Maintenance (O&M) manual for the impoundments and the facility by 8/1/2011.** The O&M manual should include at least the following three key elements:
   - Procedures needed for operation and maintenance of the impoundments during typical operating conditions
   - Procedures for monitoring performance of the impoundments, including visible changes such as surface erosion, settlement and sloughing; internal embankment changes such as erosion due to uncontrolled seepage; and fluctuations in groundwater level
   - The EAP

Copyright 2011 Kleinfelder West, Inc.

SECTION 7 – GLOSSARY OF TERMS

For the EPA Ash Pond Assessment program, the following glossary of terms shall be used for classification unless otherwise noted.

Hazard Potential Rating

"Hazard potential" means the possible adverse incremental consequences that result from the release of water or stored contents due to the failure of the impoundment or reservoir or the misoperation of the impoundment, reservoir, or appurtenances. The hazard potential classification of a impoundment or reservoir shall not reflect in any way on the current condition of the impoundment or reservoir and its appurtenant works, including the impoundment's or reservoir's safety, structural integrity, or flood routing capacity. These classifications are as described below:

1. **Low Hazard Potential**

   "Low hazard" means a impoundment's or reservoir's failure will result in no probable loss of human life and low economic loss or environmental loss, or both. Economic losses are principally limited to the owner's property.

2. **Significant Hazard Potential**

   "Significant hazard" means a impoundment's or reservoir's failure will result in no probable loss of human life but can cause major economic loss, environmental damage, disruption of lifeline facilities, or impact other concerns. Significant hazard potential classification impoundments or reservoirs are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

3. **High Hazard Potential**

   "High hazard" means a impoundment's or reservoir's failure will result in probable loss of human life.

Size Classification

In accordance with the Illinois Department of Natural Resources (IDNR) Administrative Code for Impoundment Safety, "Part 3702 - Construction and Maintenance of Impoundments" dated January 13, 1987, a impoundment system is classified by size based on its height and potential storage capacity. Size classification is determined by which category (storage or height) is greatest (produces the larger size classification).

Copyright 2011 Kleinfelder West, Inc.

Category	Storage (acre-feet)	Height (feet)
Small	<1,000	<40
Intermediate	≥ 1,000 to <50,000	≥ 40 to <100
Large	≥ 50,000	≥ 100

Overall Classification of Impoundment

In a system similar to the New Jersey Department of Environmental Protection Impoundment Safety Guidelines for the Inspection of Existing Impoundments (January 2008), when the following terms are capitalized they denote and shall be used to describe the overall classification of the impoundment as follows:

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

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

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

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

*the term expected is to be defined as likely

Condition Rating Criteria

In a system similar to the U.S. Department of Interior, Safety Evaluation of Existing Impoundments (SEED 1995), the terms satisfactory, fair, poor, and unsatisfactory are used in a general sense when describing the structural condition and the operational adequacy of the equipment for a impoundment or reservoir and its appurtenant works during the visual assessment. In addition the term unknown may be utilized as applicable.

Copyright 2011 Kleinfelder West, Inc.

Satisfactory – Expected to fulfill intended function.

Fair – Expected to fulfill intended function, but maintenance or other actions are recommended.

Poor – May not fulfill intended function; maintenance, repairs, or other actions are necessary.

Unsatisfactory – Is not expected to fulfill intended function; repair, replacement, or modification is necessary.

Unknown – Not visible, not accessible, not inspected, or unable to determine the condition rating based on the observation taken.

Recommendation Listing

Recommendations shall be written concisely and identify the specific actions to be taken. The first word in the recommendation should be an action word (i.e. "Prepare", "Perform", or "Submit"). The recommendations shall be prioritized and numbered to provide easy reference. Impoundment Safety recommendations shall be grouped, listed or categorized similar to the U.S. Department of Interior, Reclamation Manual - Directives and Standards - Review/Examination Program for High- and Significant-Hazard Impoundments (July, 1998 FAC 01-07) as follows:

Priority 1 Recommendations: Priority 1 Recommendations involve the correction of severe deficiencies where action is required to ensure the structural safety, operational integrity of a facility, and that may threaten the safety of the impoundment.

Priority 2 Recommendations: Priority 2 Recommendations where action is needed or required to prevent or reduce further damage or impair operation and/or improve or enhance the O&M of the facility, that do not appear to threaten the safety of the impoundment.

Copyright 2011 Kleinfelder West, Inc.

SECTION 8 – LIMITATIONS

The scope of this work is for a preliminary screening for the EPA and plant owner/operator of the visible performance and apparent stability of the impoundment embankments based only on the observable surface features and information provided by the owner/operator. Other features below the ground surface may exist or may be obscured by vegetation, water, debris, or other features that could not be identified and reported. This site assessment and report were performed without the benefit of any soil drilling, sampling, or testing of the subsurface materials, calculations of capacities, quantities, or stability, or any other engineering analyses. The purpose of this assessment is to provide information to the EPA and the plant owner/operator about recommended actions and/or studies that need to be performed to document the stability and safety of the impoundments.

This work was performed by qualified personnel in a manner consistent with that level of care and skill ordinarily exercised by other members of Kleinfelder's profession, practicing in the same locality, under similar conditions, and at the date the services are provided. Kleinfelder's conclusions, opinions, and recommendations are based on a limited number of observations. It is possible that conditions could vary between or beyond the observations made. Kleinfelder makes no other representation, guarantee, or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided. Kleinfelder makes no warranty or guaranty of future embankment stability or safety.

This report may be used only by the client and the registered design professional in responsible charge and only for the purposes stated for this specific engagement within a reasonable time from its issuance but in no event later than one (1) year from the date of the report.

The information, included on graphic representations in this report, has been compiled from a variety of sources and is subject to change without notice. Kleinfelder makes no representations or warranties, expressed or implied, as to accuracy, completeness, timeliness, or rights to the use of such information. These documents are not intended for use as a land survey product nor are they designed or intended as a construction design document. The use or misuse of the information contained on these graphic representations is at the sole risk of the party using or misusing the information.

Recommendations contained in this report are based on preliminary field observations without the benefit of subsurface explorations, laboratory tests, or detailed knowledge of the existing construction. If the scope of the proposed recommendations changes from that described in this report, the conclusions and recommendations contained in this report are not considered valid unless the changes are reviewed and the conclusions of this report are modified or approved in writing by Kleinfelder. Kleinfelder cannot be responsible for interpretation by others of this report or the conditions encountered in the field.

Copyright 2011 Kleinfelder West, Inc.

SECTION 9 – REFERENCES

Ameren, *Annual Engineering Inspection Report*, July, 31, 2009.

Ameren, *Flood Control Works Inspection Report*, March 18, 2008.

Ameren, Impoundment Safety Program for Non-Illinois Department of Natural Resources (IDNR) Regulated Facilities, AER-DSP-004, April 3, 2009.

Hanson Engineers, *Capacity Survey and Stability Analysis Fly Ash Impoundment*, Meredosia Power Station, June 13, 1991.

Hanson Engineers, Utility Site Plan Drawing, 1980.

Illinois Department of Natural Resources (IDNR), *Construction and Maintenance of Impoundments*, Part 3702 – Administrative Code for Impoundment Safety, January 13, 1987.

New Jersey Department of Environmental Protection, *Impoundment Safety Guidelines for the Inspection of Existing Impoundments,* January 2008.

Sargent and Lundy, Design Drawings B-331 thru B-334, 1971.

The CECO Corporation, Weir Box Design Drawing, 1971.

US Department of Agriculture (USDA)/ Natural Resources Conservation Service (NRCS), "Web Soil Survey", http://websoilsurvey.nrcs.usda.gov

US Department of Interior, *Directives and Standards – Review/Examination Program for High and Significant Hazard Impoundments*, Reclamation Manual, July 1998.

US Department of the Interior, *Safety and Evaluation of Existing Impoundments (SEED)*, 1995.

Copyright 2011 Kleinfelder West, Inc.

Appendix A

Site assessment Evaluation Checklists

Appendix B

Site assessment Photographs

Appendix C

Response Letter to the EPA's Request for Information



AERIAL IMAGE

NTS

IMAGE SOURCE: GOOGLE EARTH PRO - IMAGE DATE 08/19/10

KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

PROJECT NO.	112618
DATE:	08/19/10
DRAWN BY:	MAG
CHECKED BY:	BDH
FILE NAME:	

LOCATION OF CRITICAL INFRASTRUCTURE

MEREDOSIA POWER GENERATING STATION
800 SOUTH WASHINGTON STREET
MEREDOSIA, IL 62665

FIGURE

1

10 Sep 2010, 2:19pm, MGardella

U:\MGardella\ASH PONDS\Reports\Meredosia Report\



AERIAL IMAGE

NTS

IMAGE SOURCE: GOOGLE EARTH PRO - IMAGE DATE 08/19/10

KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

PROJECT NO.	112618
DATE:	08/19/10
DRAWN BY:	MAG
CHECKED BY:	BDH
FILE NAME:	

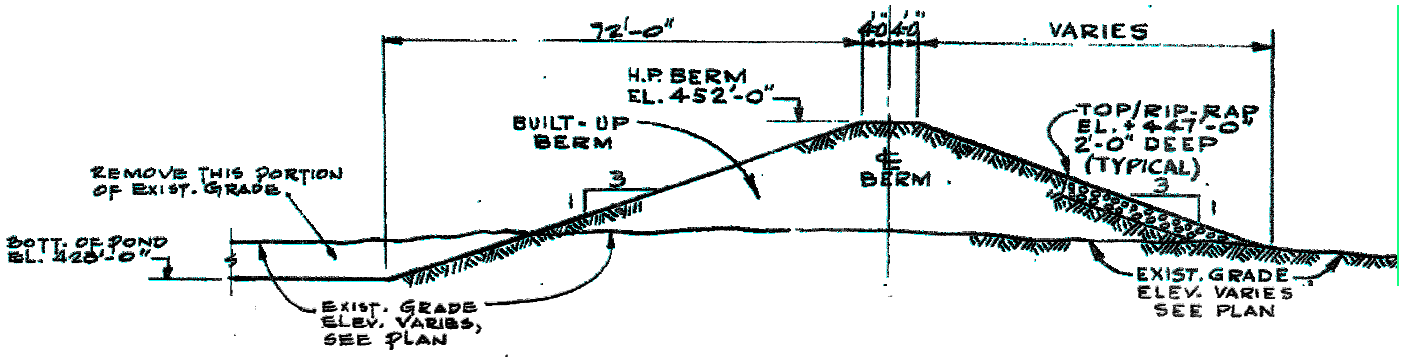
MEREDOSIA POWER STATION
AERIAL MAP

MEREDOSIA POWER GENERATING STATION
800 SOUTH WASHINGTON STREET
MEREDOSIA, IL 62665

FIGURE
2

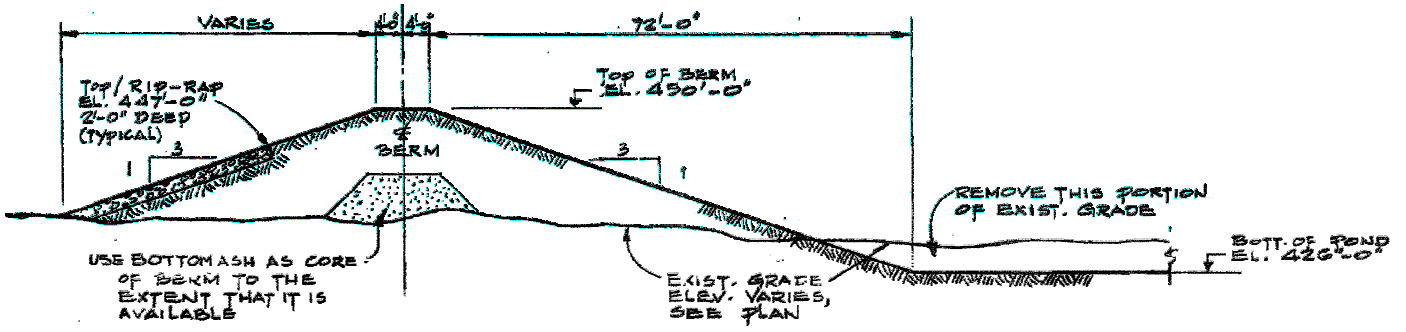
10 Sep 2010, 2:22pm, MGardella

U:\MGardella\ASH PONDS\Reports\Meredosia Report\



TYPICAL EMBANKMENT SECTION - FLY ASH POND

NTS



TYPICAL EMBANKMENT SECTION - BOTTOM ASH POND

NTS

IMAGE SOURCE: SARGENT AND LUNDY - ASH POND STORAGE PLAN DRAWING B-331 DATED 02/02/72

KLEINFELDER
Bright People. Right Solutions.
www.kleinfelder.com

PROJECT NO.	112618
DATE:	08/19/10
DRAWN BY:	MAG
CHECKED BY:	BDH
FILE NAME:	

TYPICAL CROSS SECTION
BOTTOM AND FLY ASH PONDS

MEREDOSIA POWER GENERATING STATION
800 SOUTH WASHINGTON STREET
MEREDOSIA, IL 62665

FIGURE
3

18 Apr 2011, 4:55pm, MGardella
W:\112618 EPA Ash Pond Inspections\Task 7 - Meredosia\Meredosia Report\

ATTACHED IMAGES:
ATTACHED XREFS:
Den-L:\2008\95399

CAD FILE: W:\112618 EPA Ash Pond Inspectlons\Task 7 - Meredosla\Meredosla Report\ LAYOUT: General (2)



IMAGE SOURCE: GOOGLE EARTH PRO - IMAGE DATE 08/19/10

FIGURE
4
1 of 1 sheets

DESIGNED BY: N/A
DRAWN BY: M. GARDELLA
CHECKED BY: B. HAVENS
DATE: 08/18/10
SCALE: NTS

LOCATIONS OF SITE ASSESSMENT PHOTOS FLY ASH POND

MEREDOSIA POWER GENERATING STATION
800 SOUTH WASHINGTON STREET
MEREDOSIA, IL 62665

KLEINFELDER
Bright People. Right Solutions.
611 Corporate Circle, Suite C
Golden, Colorado 80401
PH. 303-237-6601 FAX. 303-237-6602
www.kleinfelder.com

PROJ. NO.: 112618
ACAD FILE: Meredosia Figure 4.dwg

NO.	REVISION	BY	DATE
0	-	—	—
0	-	—	—
0	-	—	—
0	-	—	—
0	-	—	—

PLOTTED: 18 Apr 2011, 4:51pm, MGardella

ATTACHED IMAGES:
ATTACHED XREFS:
Den-L:\2008\95399

CAD FILE: W:\112618 EPA Ash Pond Inspectlons\Task 7 - Meredosla\Meredosla Report\ LAYOUT: General (2)



IMAGE SOURCE: GOOGLE EARTH PRO - IMAGE DATE 08/19/10

FIGURE 5
1 of 1 sheets

SCALE: NTS
DATE: 08/18/10
CHECKED BY: B. HAVENS
DRAWN BY: M. GARDELLA
DESIGNED BY: N/A

LOCATIONS OF SITE ASSESSMENT PHOTOS BOTTOM ASH POND

MEREDOSIA POWER GENERATING STATION
800 SOUTH WASHINGTON STREET
MEREDOSIA, IL 62665

KLEINFELDER
Bright People. Right Solutions.
611 Corporate Circle, Suite C
Golden, Colorado 80401
PH. 303-237-6601 FAX. 303-237-6602
www.kleinfelder.com

PROJ. NO.: 112618
ACAD FILE: Meredosia Figure 5.dwg

NO.	REVISION	BY	DATE
0	-	—	—
0	-	—	—
0	-	—	—
0	-	—	—
0	-	—	—

PLOTTED: 18 Apr 2011, 4:48pm, MGardella

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name: MEREDOSIA POWER STATION Date: 08-10-10

Unit Name: BOTTOM ASH POND Operator's Name: AMEREN ENERGY

Unit I.D.: Hazard Potential Classification: High (Significant) Low

Inspector's Name: BRIAN MAVENS, MATT GARDELLA

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?	WEEKLY WITH ANNUAL REVIEW		18. Sloughing or bulging on slopes?		X
2. Pool elevation (operator records)?	441.8 MG		19. Major erosion or slope deterioration?		X
3. Decant inlet elevation (operator records)?	VARIES (STOP LOGS) OUTLET PIPES 426		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	N/A		Is water entering inlet, but not exiting outlet?		X
5. Lowest dam crest elevation (operator records)?	450'		Is water exiting outlet, but not entering inlet?		X
6. If instrumentation is present, are readings recorded (operator records)?	N/A PLANS M. WELLS	FOR PIEZOS	Is water exiting outlet flowing clear?	UNKNOWN	N/A
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)?	UNKNOWN	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	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.

Inspection Issue #	Comments
8	ON DRAWINGS & OTHER INFORMATION PROVIDED CLEARING AND GRUBBING OPERATIONS ARE NOT CALLED OUT EXCEPT IN NOTES REFERENCING SPECIFICATIONS THAT ARE UNACCOUNTED FOR AND SUBSEQUENTLY UNAVAILABLE FOR REVIEW.
9	TREES ON EMBANKMENT SLOPES & TOES RANGE FROM LESS THAN 1" TO ~18"
20	OUTLET LOCATIONS FOR THE BOTTOM ASH POND WAS SUBMERGED DURING TIME OF INSPECTION & OUTFLOW COLOR COULD NOT BE DETERMINED
23.	WATER HAS BEEN AGAINST THE TOE RECENTLY WITH THE RAISED ILLINOIS RIVER LEVEL. HOWEVER, IT WAS RECEDED AT THE TIME OF INSPECTION

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # IL 0000116-003 INSPECTOR BRIAN HAVENS, MATT GARDEZELA

Date 08-10-10

Impoundment Name BOTTOM ASH POND

Impoundment Company AMEREN ENERGY

EPA Region V

State Agency (Field Office) Addresss 5415 N. UNIVERSITY
PEORIA, IL 61614

Name of Impoundment BOTTOM ASH POND

(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New X Update _____

	Yes	No
Is impoundment currently under construction?	_____	X
Is water or ccw currently being pumped into the impoundment?	X	_____

IMPOUNDMENT FUNCTION: SETTLING POND FOR BOTTOM ASH

Nearest Downstream Town : Name NAPLES, IL

Distance from the impoundment APPROXIMATELY 5 MILES

Impoundment Location: Longitude W 90 Degrees 34 Minutes 16 Seconds
Latitude N 39 Degrees 49 Minutes 12 Seconds
State ILLINOIS County MORGAN

Does a state agency regulate this impoundment? YES _____ NO X (DAM SAFETY NOT MONITORED ONLY DISCHARGE)

If So Which State Agency? ILLINOIS ENVIRONMENTAL PROTECTION AGENCY (DISCHARGE ONLY)

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.

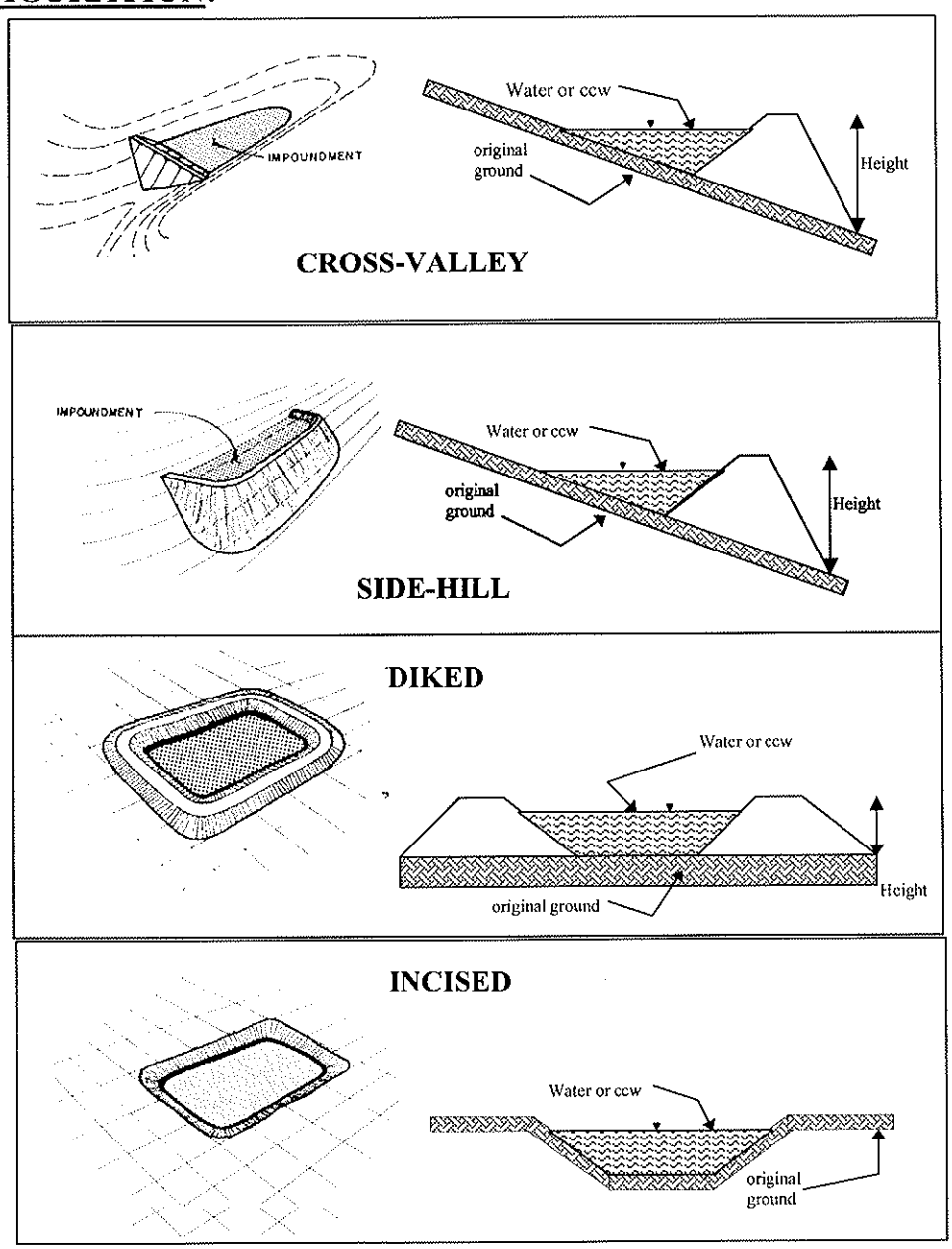
__X__ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. 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:

THE BOTTOM ASH POND SITS IMMEDIATELY ADJACENT TO THE ILLINOIS RIVER. IN THE EVENT OF AN EMBANKMENT FAILURE AT THIS LOCATION BOTTOM ASH SLURRY WOULD ENTER THE ILLINOIS RIVER ALMOST IMMEDIATELY. THIS COULD RESULT IN LARGE ENVIRONMENTAL DAMAGES AS WELL AS ECONOMIC LOSS AS THIS IS A NAVIGABLE WATERWAY USED FOR COMMERCE. LOSS OF LIFE WOULD NOT BE EXPECTED AS THERE ARE NO STRUCTURES OR FACILITIES BETWEEN THE BOTTOM ASH POND AND THE ILLINOIS RIVER. ALSO, NO SIGNIFICANT STRUCTURES SEEM TO APPEAR UNTIL 5 MILES DOWNSTREAM OF THE IMPOUNDMENT NEAR THE TOWN OF NAPLES.

CONFIGURATION:



_____ Cross-Valley
_____ Side-Hill
_____ Diked
_____ Incised (form completion optional)
__X__ Combination Incised/Diked

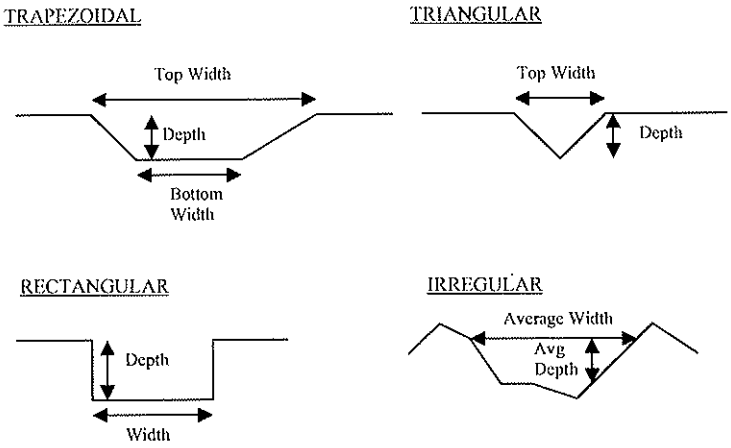
Embankment Height 450 feet
Pool Area ~ 22 acres
Current Freeboard ~ 8.2' MSL feet

Embankment Material BOTTOM ASH CORE + EARTH EMBANKMENT
Liner N/A
Liner Permeability N/A

TYPE OF OUTLET (Mark all that apply)

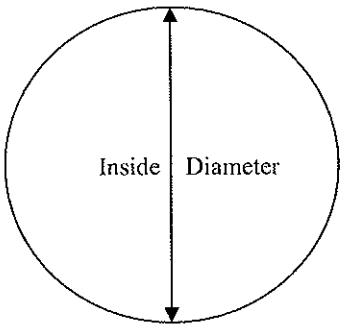
N/A **Open Channel Spillway**
_____ Trapezoidal
_____ Triangular
_____ Rectangular
_____ Irregular

_____ depth
_____ bottom (or average) width
_____ top width
_____



X **Outlet**

12" inside diameter



Material
_____ corrugated metal
_____ welded steel
_____ concrete
_____ plastic (hdpe, pvc, etc.)
X other (specify) VITRIFIED CLAY PIPE

_____

Is water flowing through the outlet? YES X NO _____

_____ **No Outlet**

_____

X **Other Type of Outlet** (specify) WEIR BOX (TRIANGULAR) CONNECTED TO 12" VCP

The Impoundment was Designed By SARGENT & LUNDY ENGINEERS

Has there ever been a failure at this site? YES _____ NO ___X_____

If So When? _____

If So Please Describe : _____

Has there ever been significant seepages at this site? YES _____ NO X

If So When? _____

IF So Please Describe: _____

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES _____ NO __X__

If so, which method (e.g., piezometers, gw pumping,...)? _____

If so Please Describe : _____

Coal Combustion Dam Inspection Checklist Form

US Environmental Protection Agency

Site Name: MEREDOSIA POWER STATION Date: 08-10-10

Unit Name: FLY ASH POND Operator's Name: AMEREN ENERGY

Unit I.D.: Hazard Potential Classification: High (Significant) Low

Inspector's Name: BRIAN HAVENS, MATT GARDERLA

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?	WEEKLY W/ ANNUAL REVIEW		18. Sloughing or bulging on slopes?		X
2. Pool elevation (operator records)?	~447.0'		19. Major erosion or slope deterioration?		X
3. Decant inlet elevation (operator records)?	VARIES (STOP LOGS) OUTLET PIPES 428		20. Decant Pipes:		
4. Open channel spillway elevation (operator records)?	N/A		Is water entering inlet, but not exiting outlet?		X
5. Lowest dam crest elevation (operator records)?	~~450.0'~~ 450.9'		Is water exiting outlet, but not entering inlet?		X
6. If instrumentation is present, are readings recorded (operator records)?	N/A PLANS PIEZOS	FOR EM.WELL	Is water exiting outlet flowing clear?	UNKNOWN N/A	
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)?	UNKNOWN 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	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.

Inspection Issue #	Comments
8	ON PROVIDED DRAWINGS & OTHER INFORMATION CLEARING AND GRUBBING INFORMATION IS NOT CALLED OUT EXCEPT IN NOTES REFERENCING SPECIFICATIONS THAT ARE UNAVAILIBLE FOR REVIEW.
9	TREES ON EMBANKMENT SLOPES AND TOES RANGE FROM LESS THAN 1" TO ≈ 12"
20	OUTLET LOCATION SUBMERGED DURING TIME OF INSPECTION & OUTFALL COLOR COULD NOT BE DETERMINED.
23	WATER WAS PRESENT AT THE TOE OF EMBANKMENT FROM ELEVATED LEVELS OF THE ILLINOIS RIVER & HIGH PRECIPITATION IN THE AREA

U. S. Environmental Protection Agency

Coal Combustion Waste (CCW)
Impoundment Inspection

Impoundment NPDES Permit # IL 0000116-004 INSPECTOR BRIAN HAVENS, MATT GARDERCA

Date 08-10-10

Impoundment Name FLY ASH POND

Impoundment Company AMEREN ENERGY

EPA Region V

State Agency (Field Office) Addresss 5415 N. UNIVERSITY
PEORIA, IL 61614

Name of Impoundment FLY ASH POND

(Report each impoundment on a separate form under the same Impoundment NPDES Permit number)

New X Update _____

	Yes	No
Is impoundment currently under construction?	_____	X
Is water or ccw currently being pumped into the impoundment?	X	_____

IMPOUNDMENT FUNCTION: SETTLING POND FOR FLY ASH

Nearest Downstream Town : Name NAPLES, IL

Distance from the impoundment APPROXIMATELY 5 MILES

Impoundment Location:
Longitude W 90 Degrees 34 Minutes 20 Seconds
Latitude N 39 Degrees 49 Minutes 2 Seconds
State ILLINOIS County MORGAN

Does a state agency regulate this impoundment? YES _____ NO X (DAM SAFETY NOT MONITORED ONLY DISCHARGE

If So Which State Agency? ILLINOIS ENVIRONMENTAL PROTECTION AGENCY (DISCHARGE ONLY)

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.

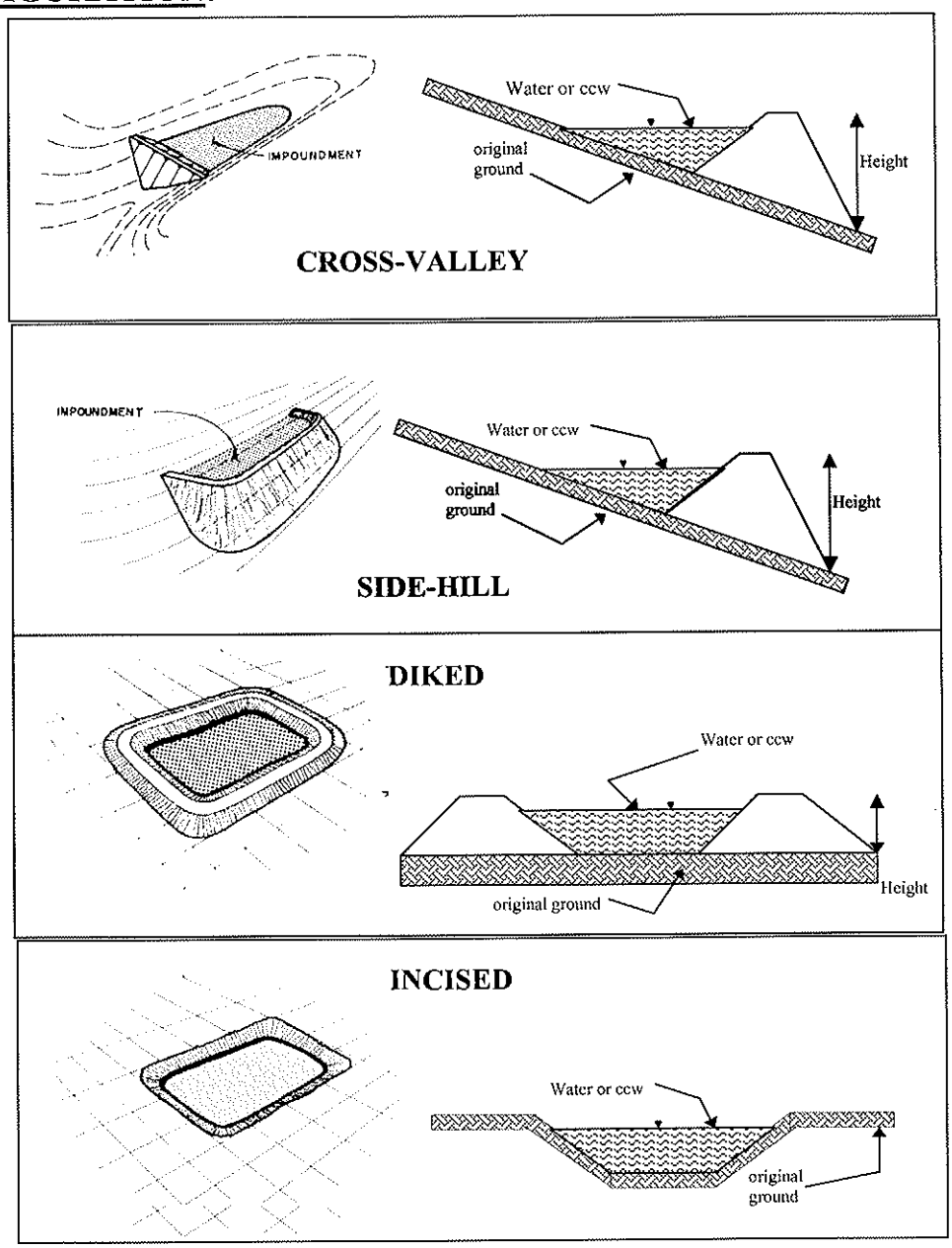
__X__ **SIGNIFICANT HAZARD POTENTIAL:** Dams assigned the significant hazard potential classification are those dams where failure or misoperation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. 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:

THE FLY ASH POND IS LOCATED ADJACENT TO THE ILLINOIS RIVER. IN THE EVENT OF AN EMBANKMENT FAILURE AT THE FLY ASH POND, FLY ASH SLURRY WOULD ENTER THE ILLINOIS RIVER ALMOST IMMEDIATELY. IF THIS WERE TO OCCUR IT COULD RESULT IN LARGE ENVIRONMENTAL DAMAGES AS WELL AS ECONOMIC LOSSES, AS THE ILLINOIS RIVER IS A NAVIGABLE WATERWAY USED FOR COMMERCE. LOSS OF LIFE WOULD NOT BE EXPECTED AS NO RESIDENCES, STRUCTURES OR FACILITIES EXIST BETWEEN THE FLY ASH POND AND THE ILLINOIS RIVER. ALSO, NO SIGNIFICANT STRUCTURES SEEM TO APPEAR UNTIL 5 MILES DOWN STREAM OF THE FLY ASH NEAR THE TOWN OF NAPLES.

CONFIGURATION:



_____ Cross-Valley
_____ Side-Hill
_____ Diked
_____ Incised (form completion optional)
__X__ Combination Incised/Diked

Embankment Height 450.9 - 452 feet
Pool Area ~77 acres
Current Freeboard 3.9' - 5' min feet

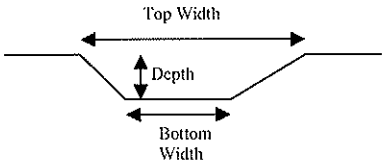
Embankment Material COMPACTED EARTH FILL
Liner N/A
Liner Permeability N/A

TYPE OF OUTLET (Mark all that apply)

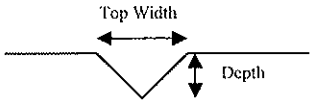
N/A **Open Channel Spillway**
_____ Trapezoidal
_____ Triangular
_____ Rectangular
_____ Irregular

_____ depth
_____ bottom (or average) width
_____ top width

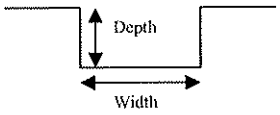
TRAPEZOIDAL



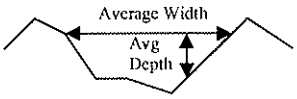
TRIANGULAR



RECTANGULAR

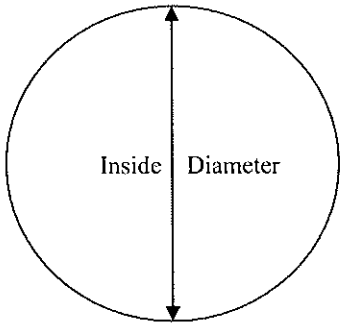


IRREGULAR



X **Outlet**

12" inside diameter



Material
_____ corrugated metal
_____ welded steel
_____ concrete
_____ plastic (hdpe, pvc, etc.)
X other (specify) VITRIFIED CLAY PIPE (VCP)

Is water flowing through the outlet? YES X NO _____

_____ **No Outlet**

X **Other Type of Outlet** (specify) WEIR BOX CONNECTED TO VCP (12")

The Impoundment was Designed By SARGENT & LUNDY ENGINEERS

Has there ever been a failure at this site? YES _____ NO ___X_____

If So When? _____

If So Please Describe : _____

Has there ever been significant seepages at this site? YES _____ NO x

If So When? _____

IF So Please Describe: _____

2 LOCATIONS OF MINOR ~~POSSIBLE~~ SEEPAGE NOTED IN PAST INSPECTION REPORT. NO DOCUMENTATION OR KNOWLEDGE OF SIGNIFICANT SEEPAGE.

Has there ever been any measures undertaken to monitor/lower Phreatic water table levels based on past seepages or breaches at this site? YES _____ NO X

If so, which method (e.g., piezometers, gw pumping,...)? _____

If so Please Describe : _____

Appendix B

Site Visit Photographs



Photo 1 – Bottom Ash Pond Embankment Looking Southwest (Note Pipeline, Foundations and Fence)



Photo 2 – Minor Surface Erosion of Bottom Ash Pond Crest (Note Typical Crest Condition and Pipeline)



Photo 3 – Minor Surface Erosion of Crest and Downstream Slope of the Bottom Ash Pond (Typical)



Photo 4 – Bottom Ash Pond Inlet Piping (Note Coal Stockpile in Background)



Photo 5 – Bottom Ash Pond Inlet Piping



Photo 6 – Settling Channel of Bottom Ash Pond near Inlet



Photo 7 – Riprap and Mature Trees on the Downstream Slope of the Bottom Ash Pond (Typical)



Photo 8 – Riprap on Downstream Slope of Bottom Ash Pond (Typical)



Photo 9 – Undersized Riprap on Downstream Embankment of the Bottom Ash Pond



Photo 10 – Emergency Spillway Pipe for the Bottom Ash Pond



Photo 11 – Emergency Spillway Pipe for the Bottom Ash Pond without any Noticeable Obstructions



Photo 12 – North Side of the Oil Delivery Sheet Pile Platform (Note Penetration into Embankment)



Photo 13 – South Side of the Oil Delivery Sheet Pile Platform (Note Penetration into Embankment)



Photo 14 – Outlet Works for the Bottom Ash Pond (Note Broken Support of Walkway)



Photo 15 – Bottom Ash Pond Outlet Piping Outfall (Submerged)



Photo 16 – Bottom Ash Pond Outlet Pipe Discharge Bay (Note Illinois River in Background)



Photo 17 – Debris Pile and Heavy Vegetation at the Downstream Toe of the Bottom Ash Pond (Typical)



Photo 18 – Vegetated Riprap on the Bottom Ash Pond Southwest Embankment



Photo 19 – Area between the Fly Ash and Bottom Ash Impoundments Looking Northwest



Photo 20 – Riprap on Downstream Slope of Bottom Ash Pond (Note Fence at Crest)



Photo 21 – Area between the Fly Ash and Bottom Ash Impoundments Looking Southeast



Photo 22 – General Photo of Bottom Ash Pond Looking Northeast



Photo 23 – Upstream Slope of the Bottom Ash Pond (Note Steep Slopes and Light Pole Penetrations)



Photo 24 – Sluice Pipe Penetrations through Crest of Bottom Ash Pond Embankment



Photo 25 – General Bottom Ash Pond Photograph (Note Bottom Ash Stockpile and Settling Channel)



Photo 26 – General Photograph of the Bottom Ash Pond (Note Settling Channel and Main Pond)



Photo 27 – Stockpile of Bottom Ash Recovered from the Bottom Ash Pond



Photo 28 – Typical Crest Condition of the Bottom Ash Pond (Note Light Pole Penetrations in Crest)



Photo 29 – Typical Embankment of Fly Ash Pond (Note Fly Ash Cell Divider Embankment to Left in Photo)



Photo 30 – Vegetation on the Downstream Slope and Toe of the Fly Ash Pond



Photo 31 – Fly Ash Pond Embankment (Note Riprap and Felled Tree Debris near Toe)



Photo 32 – Fly Ash Pond Outlet Works



Photo 33 – Fly Ash Pond Outlet Works Pipe Outfall (Submerged)



Photo 34 – Flooded Timber and Felled Tree Debris at the Toe of the Fly Ash Pond



Photo 35 – Mowed Woody Vegetation on Downstream Slope of Fly Ash Pond (Note Intact Root System)



Photo 36 – Fly Ash Pond Culvert Pipe between cells 1 and 4 (Note Emergency Spillway Cut)

Appendix C

Response Letter to the EPA's Request for Information

Ameren Services

Environmental Services
314.554.2388 (Phone)
314.554.4182 (Facsimile)
ppike@ameren.com

One Ameren Plaza
1901 Chouteau Avenue
PO Box 66149
St. Louis, MO 63166-6149

March 26, 2009

Mr. Richard Kinch
US Environmental Protection Agency (53306P)
1200 Pennsylvania Avenue, NW
Washington, DC 20460



RE: Request for Information under Section 104 (e) of the Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. 9604(e)

Dear Mr. Kinch:

This letter and attachments are AmerenEnergy Generating and AmerenEnergy Resources Companies' response to the United States Environmental Protection Agency's request for information relating to the surface impoundments or similar diked or bermed management unit(s) or management units designated as landfills which receive liquid-borne material from a surface impoundment 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.

AmerenEnergy Generating and AmerenEnergy Resources Companies have received requests for information about their five coal-fired power stations in Illinois. Although most of our surface impoundments are not considered to be dams by State or Federal regulations, we are subject to State and Federal NPDES regulations and have had Agency personnel inspect these units. We are providing a full and complete response to each separate request for information set forth in your Enclosure A (attached) with responses corresponding to numbering in your questions. If you have any further questions please feel free to contact Paul Pike at (314) 554-2388.

I certify that the information contained in this response to EPA's request for information and the accompanying documents is true, accurate, and complete. As to the identified portions of this response for which I cannot personally verify their accuracy, I certify under penalty of law that this response and all attachments were prepared in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, those persons directly responsible for gathering the information, the information submitted is, to the best of my

knowledge, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Sincerely,

Michael L. Menne
Vice President – Environmental Services

Enclosure A

Please provide the information requested below for each surface impoundment or similar diked or bermed management unit(s) or management units designated as landfills which receive liquid-borne material 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. This includes units that no longer receive coal combustion residues or by-products, but still contain free liquids. .

1. Relative to the National Inventory of Dams criteria for High, Significant, Low, or Less-than-Low, please provide the potential hazard rating for each management unit and indicate who established the rating, what the basis of the rating is, and what federal or state agency regulates the unit(s). If the unit(s) does not have a rating, please note that fact.

2. What year was each management unit commissioned and expanded? ;

3. What materials are temporarily or permanently contained in the unit? Use the following categories to respond to this question: (1) fly ash; (2) bottom ash: (3) boiler slag; (4) flue gas emission control residuals; (5) other. If the management unit contains more than one type of material, please identify all that apply. Also, if you identify "other," please specify the other types of materials that are temporarily or permanently contained in the unit(s).

4. Was the management unit(s) designed by a Professional Engineer? Is or was the construction of the waste management unit(s) under the supervision of a Professional Engineer? Is inspection and monitoring of the safety of the waste-management unit(s) under the supervision of a Professional Engineer?

5. When did the company last assess or evaluate the safety (i.e., structural integrity) of the management unit(s)? Briefly describe the credentials of those conducting the structural integrity assessments/evaluations. Identify actions taken or planned by facility personnel as a result of these assessments or evaluations. If corrective actions were taken, briefly describe the credentials of those performing the corrective actions, whether they were company employees or contractors. If the company plans an assessment or evaluation in the future, when is it expected to occur?

6. When did a State or a Federal regulatory official last inspect or evaluate the safety (structural integrity) of the management unit(s)? If you are aware of a planned state or federal inspection or evaluation in the future, when is it expected to occur? Please identify the Federal or State regulatory agency or department which conducted or is planning the inspection or evaluation. Please provide a copy of the most recent official inspection report or evaluation.

7. Have assessments or evaluations, or inspections conducted by State or Federal regulatory officials conducted within the past year uncovered a safety issue(s) with the management unit(s), and, if so, describe the actions that have been or are being taken to deal with the issue or issues. Please provide any documentation that you have for these actions.

8. What is the surface area (acres) and total storage capacity of each of the management units? What is the volume of materials currently stored in each of the management unit(s)? Please provide the date that the volume measurement(s) was taken. Please provide the maximum height of the management unit(s). The basis for determining maximum height is explained later in this. Enclosure.

9. Please provide a brief history of known spills or unpermitted releases from the unit within the last ten years, whether or not these were reported to State or federal regulatory agencies. For purposes of this question, please include only releases to surface water or to the land (do not include releases to groundwater).

10. Please identify all current legal owner(s) and operator(s) at the facility.

AmerenEnergy Generating Company Response

Meredosia Power Station
800 W. Washington
Meredosia, Illinois 62665

1. Coal-combustion by-product surface impoundments at this Station are not classified as dams by State or Federal regulatory agencies so they have not been rated.

2. See table below.

Management Unit	Year Commissioned or Expanded
Fly Ash Pond	1968
Bottom Ash Pond	1972

3. See table below.

Management Unit	Materials Contained in Unit*
Fly Ash Pond	1
Bottom Ash Pond	2

*Use the following categories to respond to this question: (1) fly ash; (2) bottom ash: (3) boiler slag; (4) flue gas emission control residuals; (5) other.

Other types of materials that are temporarily or permanently contained in the unit(s) include, but are not limited to residual wastes remaining following treatment of wastewater from these systems: primary water treatment; boiler water make-up treatment; laboratory and sampling streams; boiler blowdown; floor drains; coal pile run off; house service water systems; and pyrites.

4. The management units at this facility were designed by a Professional Engineer. The construction of the management units were done under the supervision of a Professional Engineer. And, inspection and monitoring of the safety of the waste management units is under the supervision of a Professional Engineer.

5. The most recent annual internal professional engineering inspection of the management units occurred in 2009. Since these management units are not classified by regulation as dams the evaluation only included a visual inspection of the units. AmerenEnergy Resources Company has formed a Dam Safety Group consisting of civil engineers who oversee the

implementation of the company Dam Safety Program and this Group is supervised by a licensed Professional Engineer. The Dam Safety Program requires routine, annual and special inspection of the ash ponds and employees performing these inspections receive dam safety training. If maintenance issues are identified in these visual inspections, then corrective actions are taken by either plant employees or contractors to remedy the issue and final acceptance of the work is reviewed and evaluated by Dam Safety Group personnel.

6. No State, or Federal regulatory official has inspected or evaluated the safety (structural integrity) of the management unit(s), and we are not aware of a planned state or federal inspection or evaluation in the future.

7. Not applicable, see response to Question 6.

8. See table below.

Management Unit	**Surface Area (Acres)**	**Total Storage Capacity (Acre-ft)**	**Volume of Stored Ash (Acre-ft)**	**Maximum Height of Unit (ft.)**
Fly Ash Pond	186	700	650	24
Bottom Ash Pond	34	186	139	24

The volume measurement includes area excavated below natural surface level and was determined in 2007.

9. Assuming that brief history means incident(s) which could have occurred in the last ten (10) years, we are only aware of one instance when there was a release from our surface impoundments to the land. The incident occurred in late December, 2006, when we released a small amount of water (less than 500 gallons) from the fly ash pond to the land. In response, we modified the pond and developed internal procedures to prevent a recurrence of the situation. We are not aware of any other spills or unpermitted releases of coal-combustion by-products from our surface impoundments to surface water or to the land.

10. The current legal owner and operator at the facility is AmerenEnergy Generating Company.

The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 13

GEOTECHNOLOGY INC
FROM THE GROUND UP

CLOSURE PLAN
FLY ASH POND AND BOTTOM ASH POND
MEREDOSIA POWER STATION
800 SOUTH WASHINGTON STREET
MEREDOSIA, ILLINOIS

Prepared for:

AMERENENERGY MEDINA VALLEY COGEN, LLC
St. Louis, Missouri

Prepared by:

GEOTECHNOLOGY, INC.
St. Louis, Missouri

Project No. J024917.01

December 9, 2016

J024917.01

CLOSURE PLAN
FLY ASH POND AND BOTTOM ASH POND
MEREDOSIA POWER STATION
800 SOUTH WASHINGTON STREET
MEREDOSIA, ILLINOIS

TABLE OF CONTENTS

		Page
1.	INTRODUCTION	1
2.	SITE LAYOUT	1
3.	SITE HISTORY	1
4.	SLOPE STABILITY ANALYSIS	2
5.	CLOSURE ACTIVITIES	3
	5.1 Grading	4
	5.2 ClosureTurf®/HydroTurf® Installation	4
	5.3 Surface Water Management	4
	5.4 Construction Quality Assurance (CQA) Program	4
6.	HYDROGEOLOGIC SITE INVESTIGATION	5
7.	GROUNDWATER	5
	7.1 Groundwater Monitoring Program	5
	7.2 Groundwater Monitoring System	5
	7.3 Groundwater Trend Analysis	5
	7.4 Mitigation of Statistically Significant Trends	5
8.	TIME AND COST ESTIMATES	6
	8.1 Time to Complete Closure	6
	8.2 Time to Reach Hydrostatic Equilibrium of Groundwater	6
	8.3 Remediation Time Frame	6
	8.4 Cost of Closure	6
	8.5 Cost of Post-Closure Care	6
9.	REFERENCES	7
10.	LICENSED PROFESSIONAL SIGNATURE/SEAL	8

CLOSURE PLAN
FLY ASH POND AND BOTTOM ASH POND
MEREDOSIA POWER STATION
800 SOUTH WASHINGTON STREET
MEREDOSIA, ILLINOIS

TABLE OF CONTENTS
(continued)

PLATES

	Plate
Site Location and Topography	1
Aerial Photograph of Site	2

APPENDICES

	Appendix
Stability Analysis	A

J024917.01

CLOSURE PLAN
FLY ASH POND AND BOTTOM ASH POND
MEREDOSIA POWER STATION
800 SOUTH WASHINGTON STREET
MEREDOSIA, ILLINOIS

1.0 INTRODUCTION

This Closure Plan for the AmerenEnergy Medina Valley Cogen, LLC Meredosia Power Station (Meredosia Power Station) Fly Ash Pond and Bottom Ash Pond Coal Combustion Waste Surface Impoundments has been prepared in general accordance with the requirements of the site-specific rule in 35 Illinois Administrative Code (IAC) Part 840.101 through 840.152 and the United States Environmental Protection Agency (USEPA) regulation at 40 Code of Federal Regulations (CFR) Parts 257 and 261. Supporting documents to this Closure Plan are listed in the Reference Section of this report.

2.0 SITE LAYOUT

The Meredosia Power Station is located at 800 South Washington Street, Meredosia, Illinois. The Fly Ash and Bottom Ash Ponds are located southwest of the coal pile and plant facilities. The site location and topography are shown on Plate 1. The existing structures, ash ponds, and boring/monitoring wells are shown on Plate 2.

3.0 SITE HISTORY

The Meredosia Power Station is located south of Meredosia in Morgan County, Illinois, which is located in west-central Illinois. The Meredosia Power Station ash ponds are located in the south half of Section 21 and the north half of Section 28, T.16N, R.13W. The plant generated electricity from 1948 until February 2012. The plant is located on the floodplain east of the Illinois River. A third ash pond referred to as the "Old Ash Pond" was reportedly closed, and will not be further discussed in this report. Reportedly, the Bottom Ash and Fly Ash Ponds were constructed of native materials.

The Bottom Ash Pond was constructed in 1972 with a design surface area of 11 acres, a height of 24 feet and a volume of approximately 90 acre-feet. The Bottom Ash Pond had received low-volume wastewater, bottom ash and storm water runoff. The site operates under NPDES Permit IL0000116, Outfall 003, which is for the Bottom Ash Pond. Reportedly, the Bottom Ash Pond did not have standing water within two months of the plant closure.

The Fly Ash Pond was constructed in 1968. The Fly Ash Pond has a surface area of 34 acres, a height of 24 feet and a volume of approximately 500 acre-feet. The Fly Ash Pond reportedly received fly ash, low-volume wastewater and storm water runoff. The site operates under NPDES Permit IL0000116, Outfall 004, which is for the Fly Ash Pond. The Fly Ash Pond was reportedly dry by October 2012.

A feasibility analysis was performed regarding the closure options for the Fly Ash and Bottom Ash Ponds on the site. The options included no action, complete clean closure, soil/geosynthetic composite cap, and partial clean closure with a ClosureTurf® cap alternatives. The no closure option was not selected due to the known groundwater impacts at the site and facility decommissioning activities. Clean closure of both ponds was cost and time prohibitive due to ash disposal and subsequent backfilling and grading of the site. The soil/geosynthetic composite cap option was not selected due to the long term maintenance issues, lack of personnel on site to perform maintenance activities, cost, and the longer time frame needed to close the ponds. Partial clean closure of the bottom ash pond, moving the bottom ash to the fly ash pond, and capping the fly ash pond and bottom ash pond berm with ClosureTurf® was selected as an effective and efficient option.

4.0 SLOPE STABILITY ANALYSIS

Slope stability analysis consists of comparing the driving forces within a cross-section of slope to the resisting forces and calculating the factor of safety. Per the Illinois Department Natural Resources (IDNR)[1], embankments should have a minimum factor of safety of 1.5 for long-term static stability, and 1.0 for the pseudo-static condition (seismic condition). Major flood conditions and rapid drawdown conditions were also analyzed due to the proximity of the site to the Illinois River. Slope stability analysis discussion, section profiles, and calculated critical failure arcs at selected locations are presented in Appendix A. Global stability analysis results, at current groundwater elevations in relation to mean sea level (MSL) and design grades for the Fly Ash and Bottom Ash Ponds, are summarized in the following table.

[1] *Rules for Construction and Maintenance of Dams*, Illinois Department of Natural Resources, Office of Water Resources, Springfield, Illinois.

SUMMARY OF STABILITY ANALYSES			
Section Location	**Case**	**Calculated Factor of Safety**	**Target Factor of Safety**
Fly Ash Pond West Embankment	Static Condition Normal River Stage	2.1	1.5
	Static Condition Major Flood Stage (447'MSL)	2.5	1.5
	Rapid Drawdown Major Flood Stage (447'MSL)	1.7	1.2
	Seismic Condition	1.3	1.0
Bottom Ash Pond West Embankment	Static Condition Normal River Stage	1.8	1.5
	Static Condition Major Flood Stage (447'MSL)	1.6	1.5
	Rapid Drawdown Major Flood Stage (447'MSL)	1.7	1.2
	Seismic Condition	1.3	1.0

The stability models for each section at the Fly Ash Pond and Bottom Ash Pond closures have calculated factors of safety greater than or equal to the recommended IDNR target factor of safety for the static and seismic conditions.

5.0 CLOSURE ACTIVITIES

The remedial action for the facility is the relocation and clean closing of the east ash storage pile, capping of the Fly Ash Pond, and the partial clean closure and capping of the Bottom Ash Pond. The Bottom Ash Pond will be closed by the removal of most coal combustion residuals (CCR) to the Fly Ash Pond. The remaining CCR under the roadway and pipeline will be capped in-place. The ash in the east ash storage pile will be removed and placed in the Fly Ash Pond.

The proposed closure activities associated with the remedial action includes grading, installation of high performance high density polyethylene (HDPE) geomembrane, and establishment of surface water control features for the Fly Ash and Bottom Ash Ponds. Closure activities will be performed in accordance with the Closure Plans and Specifications. Quality control will be performed in accordance with the Construction Quality Assurance (CQA) Plan prepared for this project and will be documented by a professional engineer licensed in Illinois.

Refer to the Plans and Specifications completed for this project (CDG, 2016) for details on the closure system.

5.1 Grading. Ash and other material (i.e. embankment soils, bottom ash, and approved demolition debris) will be moved within and between the Fly Ash and Bottom Ash Ponds to achieve design grades. Embankment materials and bottom ash may be used to bring the subgrade to within one foot of design elevations. At least one foot of fly ash will be placed on top of the bottom ash to provide a working surface for ClosureTurf® installation. Ash will be placed at a maximum slope of 1V:10H (10 percent slope). Slopes are designed to promote surface runoff and reduce ponding. The final subgrade surface will be compacted and drum-rolled to provide a smooth surface prior to placement of the high performance HDPE system.

5.2 ClosureTurf®/HydroTurf® Installation. The ClosureTurf®/HydroTurf® system is a low permeability synthetic liner used to control storm water infiltration and limit exposure of the capped material to humans and vectors (i.e. animals). The design grades facilitate storm water runoff to the surface water management features outside the Fly Ash and Bottom Ash Ponds.

The ClosureTurf®/HydroTurf® is generally installed in the following manner (Refer to the CQA Plan for specific installation guidelines):

- The geomembrane component is installed per the manufacturer's requirements including the use of heat welding for seaming.
- The turf component is installed per the manufacturer's requirements including the use of a sewing machine for seaming.
- Sand or hydrobinder infill is placed and hydrated per the manufacturer's requirements.
- The perimeter of the geomembrane and turf components is secured by an anchor trench.

5.3 Surface Water Management. Surface water management features have been incorporated into the final cover design. Surface water features, such as ditches, will be formed in the subgrade to facilitate runoff. The ClosureTurf®/HydroTurf® will be placed over the berms and into ditches. Additional details are provided in the Plans and Specifications (CDG, 2016).

Surface water features are designed to handle runoff from a 20-year precipitation event without damage to the final cover and water ponding.

5.4 Construction Quality Assurance (CQA) Program. Refer to the CQA Plan (Geotechnology, 2016) for details on the project specific CQA program.

6.0 HYDROGEOLOGIC SITE INVESTIGATION

The Hydrogeologic Site Investigation includes a summary of geologic data, hydrogeologic data, and known impacts to the groundwater for the site. Boron and arsenic are typically the best indicator chemicals for coal combustion waste related impacts at the site. Please refer to the separate Hydrogeologic Site Investigation Report (Geotechnology, 2016) for detailed information.

7.0 GROUNDWATER

7.1 Groundwater Monitoring Program. Requirements for the groundwater monitoring program and associated quality assurance are found in the Groundwater Monitoring Plan (Geotechnology, 2016). Quarterly groundwater sampling of the groundwater monitoring system will occur for the first five years after the CQA acceptance report is submitted, and sampling frequencies may be reduced after that time frame. Monitoring data and trend analysis data will be maintained at the offices of Medina Valley Cogen, LLC until a post-closure completion report is accepted by the IEPA.

7.2 Groundwater Monitoring System. Nine monitoring wells (Groundwater Monitoring Program, Plate 2) have been installed in the vicinity of the Fly Ash and Bottom Ash Ponds. These monitoring wells are used for the groundwater monitoring system. Additional monitoring wells are not planned at this time. The monitoring well network will be evaluated two years after completion of the ash pond closures for effectiveness. One monitoring well (APW-1) will be sampled for background values, and eight monitoring wells will be sampled for groundwater assessment. Please refer to the separate Groundwater Monitoring Plan (Geotechnology, 2016) for additional information.

7.3 Groundwater Trend Analysis. Intrawell analysis will be used to assess groundwater trends over time. Please refer to the separate Groundwater Monitoring Plan (Geotechnology, 2016) for additional information.

7.4 Mitigation of Statistically Significant Trends. If statistically significant increasing trends are noted in the groundwater analysis, additional investigation into the cause of the increasing trends will be needed. Refer to the Groundwater Monitoring Plan (Geotechnology, 2016) for additional information.

8.0 TIME AND COST ESTIMATES

8.1 Time to Complete Closure. Completion of closure activities is dependent on weather and final approval of the closure plan by the IEPA. However, closure activities are anticipated to begin and be completed in 2017.

8.2 Time to Reach Class I Groundwater Standards. Boron and arsenic concentrations for the current ash pond configurations were modeled for 25 years to represent a scenario where the ash ponds were not closed. After 25 years, Monitoring Well APW-3 (the well with historically highest boron and arsenic concentrations) stabilized at 16.9 mg/L of boron and 0.208 mg/L of arsenic, which exceed the respective Class I Groundwater standards. Monitoring Wells APW-2, APW-6, APW-7, and APW-8 also exceeded the Class I Groundwater standards for boron and arsenic at 25 years with no action.

After the dewatering and closure activities of the Fly Ash and Bottom Ash Ponds are complete, it will take approximately three years for boron concentrations and six years for arsenic concentrations to decrease below the Class I Groundwater standards for each well on site according to the model results.

Refer to the Hydrogeologic Site Investigation Report (Geotechnology, 2016) for more information regarding the groundwater modeling.

8.3 Remediation Time Frame. Once the ClosureTurf® caps for the Fly Ash and Bottom Ash Ponds are in place, precipitation will be diverted away from the ash ponds. Infiltration of precipitation into the ash ponds will be reduced or eliminated and further reductions of the concentrations of COCs are anticipated. Boron and arsenic exhibited the highest concentration over the largest area and were used as the indicator contaminants for contaminant transport modeling. Based on the modeling results, the lengths of time required for the concentration of boron and arsenic to decrease below the Class I Groundwater Standards are approximately three years and six years, respectively. Additional contamination transport modeling information is in the Hydrogeologic Site Investigation Report (Geotechnology 2016). Groundwater sampling and post-closure activities are anticipated to be 30 years.

8.4 Cost of Closure. The cost for closure activities related to the closure of the Fly Ash and Bottom Ash Ponds as specified in the drawings and specifications is estimated to be $10,000,000.

8.5 Cost of Post-Closure Care. The cost for post-closure care activities related to the closure of the Fly Ash and Bottom Ash Ponds as specified in the Post-Closure Plan is estimated to be $20,000 annually while quarterly groundwater sampling is in progress.

9.0 REFERENCES

CDG, 2016. "Specifications and Construction Plans, Fly Ash and Bottom Ash Ponds Closure, Meredosia Power Station." CDG Engineers Architects Planners, Inc., St. Louis, Missouri, 2016

Geotechnology, Inc., Construction Quality Assurance Plan, Meredosia Power Station, Ameren, 2016.

Geotechnology, Inc., Groundwater Monitoring Plan, Meredosia Power Station, Ameren, 2016.

Geotechnology, Inc., Groundwater Management Zone Plan, Meredosia Power Station, Ameren, 2016.

Geotechnology, Inc., Post-Closure Plan, Meredosia Power Station, Ameren, 2016.

10.0 LICENSED PROFESSIONAL SIGNATURE/SEAL

I hereby affirm that the information and design documents contained in this closure plan are true and accurate to the best of my knowledge and professional opinion.

Rosanna M. Saindon, P.E., Ph.D.
Illinois Licensed Professional Engineer
Project Manager
Geotechnology, Inc.



printed on recycled paper

Enclosure 2

ATTACHMENT 14

WILL COUNTY LAND USE DEPARTMENT
RESOURCE RECOVERY & ENERGY DIVISION
58 E. Clinton Street, Suite 100 · Joliet, Illinois 60432
Ph 815/727-8834 · Fax 815/727-3410

August 25, 2017

Illinois Environmental Protection Agency
Bureau of Land
Attn: Permit Section
1021 N. Grand Avenue E, Box 19276
Springfield, IL 62794-9276

Re: IEPA Permit Log No. 2017-302
Application request to dispose bottom ash from other generating stations.
LPC No. 1978090001 – Lincoln Stone Quarry
Southwest of Brandon & Patterson Rd, Joliet

Dear Permit Reviewer:

The Resource Recovery and Energy Division of the Will County Land Use Department (County) appreciates the opportunity to comment on the above referenced Application for Significant Modification to Permit dated June 21, 2017 and submitted to your Agency by KPRG and Associates, Inc. on behalf of Midwest Generation, LLC.

Furthermore, the County appreciates the dependable energy sources and employment opportunities provided by the Joliet 9 & 29 Generating Stations located within our County. The recent conversion of the two stations from coal-fired to gas-fired demonstrates an investment by the station operator in the community and in the improvement of air quality within the community and surrounding area. While the County enjoys and appreciates all efforts and improvements in air quality conducted by Midwest Generation, LLC, the County also appreciates similar efforts and improvements in water quality.

Prior to 2017, the Joliet 9 & 29 generating stations operated coal-fired boilers that required a disposal facility for coal combustion waste generated by the stations. The designated disposal facility for this waste has been the Lincoln Stone Quarry since 1962. Lincoln Stone Quarry is permitted by the Illinois EPA as a disposal facility similar to other modern disposal facilities in the County. However, the major difference between the other modern disposal facilities and the Lincoln Stone Quarry, is that it does not have a modern bottom liner system consisting of engineered impermeable materials designed to halt the flow of leachate or waste impacted water from the disposal facility into the surrounding media or area.

The lack of a modern bottom liner system within the disposal facility has allowed for the off-site migration of impacted water to enter the shallow groundwater aquifer and flow to the south-southeast causing the exceedance of the Applicable Groundwater Quality Standards of various parameters within the facility's south perimeter monitoring wells. In an effort to halt or reverse this migration, Midwest Generation installed a groundwater extraction system that has fully

operated now for over five years, since February 2012. The facility's 2016-2017 Annual Groundwater Flow Evaluation indicated that the extraction system has established the desired hydraulic effect, which is a cone of depression between the facility's south perimeter wells and the disposal facility to prevent further off-site migration of groundwater constituents. According to the facility's evaluation this cone of depression has generally drawn the groundwater from the south perimeter of the site within shallow aquifer zone back to the north to the extraction well system. Furthermore, the evaluation indicates that the system is also intercepting groundwater flowing from the disposal facility and being discharged back into the facility. Overall, the goal of the extraction system is to intercept enough water flow to facilitate the facility in meeting Applicable Groundwater Quality Standards in the south perimeter wells over time.

The Annual Facility Report dated 04/27/2017, which contains 2016 groundwater data, indicates that Applicable Groundwater Quality Standards continue to be exceeded for various parameters on a regular basis within three of the four shallow south perimeter groundwater wells. The 2nd Quarter 2017 Confirmed Exceedances report also indicates the exceedances at the wells. The reports indicate exceedances are on a decreasing trend over time for some parameters and variable to steady for others.

According to this application, 2,700,000 cubic yards of coal combustion waste has been disposed at the facility, with a remaining permitted capacity of 2,000,000 cubic yards of additional coal combustion waste that could be disposed at the facility. The Facility's Annual Report indicates that approximately 500 to 1,000 additional tons of ash from the ash ponds adjacent to Joliet #29 Generating Station will be disposed at the facility in 2017. While the County finds the remaining ash disposal from onsite ash ponds to be rather insignificant and most likely to cause minimal impact to the facility's groundwater program, an additional 2,000,000 cubic yards from off-site generating stations that increase the amount of waste on site by 43% is likely to have a significant impact on the facility's groundwater program. The increase in waste mass will only increase the volume of the constituents that are capable of entering the facility's groundwater and exacerbating the off-site migration of groundwater constituents, which is currently being held in a steady state at the facility by the constant pumping of groundwater back into the facility. Coal combustion ash not reprocessed into a usable product should be disposed in a lined landfill. It is recommended that the Midwest Generation site in Joliet not be allowed to accept additional coal ash and be capped, to prevent any further contamination of the groundwater.

In addition, other disposal options are in closer proximity to the Will County Station in Romeoville, Waukegan Station in Waukegan and the Powerton Station in Pekin , IL. Please feel free to contact me at 815-774-7891 for any questions or concerns regarding this matter.

Sincerely,

Dean Olson
Resource Recovery & Energy Director

ATTACHMENT 15

EARTHJUSTICE

October 12, 2017

Illinois Environmental Protection Agency
Bureau of Land
Attn: Imran Syed, Permit Section
1021 N. Grand Avenue E, Box 19276
Springfield, Illinois 62794-9276

RE: Log #2017-302; Application for Significant Modification to Permit – Bottom Ash Disposal from Midwest Generation, LLC Stations; Joliet/Lincoln Stone Quarry; Midwest Generation, LLC; Joliet, Illinois; Permit No. 1994-241-LFM; IEPA Site No. 1978090001; dated June 12, 2017.

COMMENTS AND REQUEST FOR HEARING

Dear Mr. Syed,

On behalf of Citizens Against Ruining the Environment ("CARE"), Earthjustice, Eco-Justice Collaborative, Environmental Law & Policy Center, Prairie Rivers Network, and Sierra Club ("Citizen Organizations"), please accept the following public comments on Midwest Generation's ("Midwest Gen") above-referenced Application for Significant Modification to Permit ("Application"). In light of the significant public concern about this matter, Citizen Organizations request that IEPA schedule a public hearing on the Application.

Midwest Gen seeks to transport toxic coal ash produced at its remaining operational coal-fired power plants and dump it into the already-contaminated Lincoln Stone Quarry ("Quarry" or "site"), located just south of the Des Plaines River in Joliet, Illinois. Doing so would add to the heavy pollution burden that local residents already bear and exacerbate the longstanding contamination problems at the site, in violation of Illinois Environmental Protection Act (the "Act") and its implementing regulations. The Application should be denied.

I. The Lincoln Stone Quarry Should Never Have Been Approved For Disposal of Coal Ash.

The Lincoln Stone Quarry should never have been approved as a dumping site for coal ash. The Quarry, which is unlined, was dug deep into the earth, well under the water table – meaning that coal ash dumped into the Quarry is perpetually leaching toxic contaminants into the groundwater. Historic documents confirm this: in 1994, Commonwealth Edison ("Edison")—the prior owner of the Quarry—informed the Illinois Pollution Control Board ("Board") that the water level at the site was maintained "about 20-30 feet below the adjacent water table," meaning that groundwater is perpetually flowing from that higher water table into the Quarry.[1] Compounding the problem, the subsurface at the site is a conduit for pollution: the Quarry is

[1] *In re: Petition of Commonwealth Edison Co. for an Adjusted Standard from 35 Ill. Adm. Code Parts 811 and 814,* PCB No. AS 96-9 (Aug. 15, 1996), at 2.

"located in fractured dolomitic rock…. [where] flow rates within individual fractures and bedding planes can be very rapid."[2] In 1994, when Edison first sought approval from the Board to continue dumping coal ash at the Quarry (which it had been doing, without a permit, since the early 1960s), testing revealed that groundwater at the Quarry was already contaminated with toxic pollutants associated with coal ash, including, among others, arsenic, boron, cadmium, chloride, manganese, molybdenum, selenium and sulfate.[3]

Recognizing that the Quarry could not meet the normally applicable requirements to limit contamination at landfills, Commonwealth Edison sought an "adjusted standard" based largely on the premise that "the only environmental receptor affected…is the [Des Plaines] River."[4] The contamination, Edison claimed, "does not impact any known or potential receptors," and Edison stated it would control future use of groundwater. *Id*. The Illinois Pollution Control Board granted Edison's petition for adjusted standard for the Quarry in part based on those assertions.[5]

Edison's assertions, however, proved to be wrong. Coal ash has continued to pollute not only the Des Plaines River, but also groundwater at the Quarry, with onsite groundwater wells repeatedly showing concentrations of arsenic, boron, barium, sulfate, molybdenum, and other toxic contaminants at levels far above health-based standards.[6] That contamination has spread offsite: in 2006, residential water wells to the east and southeast of the Quarry were found to contained elevated levels of coal ash pollutants.[7] Midwest Gen's consultants recognized then, and continue to acknowledge now, that contaminated groundwater is flowing not just north and west into the Des Plaines River but also southeast, toward an elementary school and businesses. [8] Thus, contrary to Edison's assertions, receptors of the toxic coal ash contamination from the Quarry are no longer – and perhaps never were – just the Des Plaines River. Because the assertions on which the Board based its approval of the Quarry's "adjusted standards" have long been demonstrated to be wrong, IEPA cannot continue to rely on those standards (or permits that incorporate them) to keep residents' water safe, and certainly should not allow Midwest Gen to dump hundreds of thousands of tons more toxic coal ash into the Quarry.

---

[2] *Id*. at 10 (citing Edison's Petition at 73-75).

[3] *Id*.

[4] *Id*.

[5] *Id.* at 14 ("Moreover, because Edison commits to controlling future use of the groundwater, it appears granting the requested adjusted standard will not result in environmental or health effects substantially more adverse than the effects considered by the Board in adopting the rule of general applicability.")

[6] *See* Environmental Integrity Project, Earthjustice and Sierra Club, "IN HARM'S WAY: Lack Of Federal Coal Ash Regulations Endangers Americans And Their Environment: Thirty-nine New Damage Cases of Contamination from Improperly Disposed Coal Combustion Waste" (Aug. 26, 2010) (Hereafter "In Harm's Way") *available at* https://earthjustice.org/sites/default/files/files/report-in-harms-way.pdf, at pp. 41-47.

[7] *Id*.

[8] *See id*. and KPRG, "Midwest Generation Joliet/Lincoln Stone Quarry 2016-2017 Annual Groundwater Flow Evaluation" (July 10, 2017), attached hereto as Exhibit A, at pp. 6-7.

II. Midwest Generation's Proposal Would Exacerbate Toxic Pollution at the Quarry.

Midwest Gen and its predecessors have already dumped immense amounts of toxic coal ash into the Quarry: more than 4 million tons, according to Midwest Gen's Application.[9] Those millions of tons of coal ash continue to take their toll on the site. Recent groundwater monitoring reports from the Quarry show that, at multiple wells – particularly wells located on the site's southeast side – dangerously high levels of arsenic, boron, sulfate and molybdenum continue to pollute groundwater. Arsenic concentrations as high as .19 mg/L—nearly 20 times USEPA's and Illinois EPA's health-based standard of .010 mg/L—were measured just months ago at the site.[10] Molybdenum—a pollutant linked to gout (joint pain, fatigue), high blood pressure, liver disease, and potential adverse impacts on the reproductive system[11]—was found in concentrations as high as 2.3 mg/L, nearly three times USEPA's health advisory, in late 2016. Boron, a recognized indicator of coal ash pollution, was found at concentrations up to 8 times higher than Illinois' Class I groundwater standards and nearly 6 times EPA's children's health advisory level of 3 mg/L. Sulfate, barium, fluoride, and other pollutants associated with coal ash were also found at elevated levels in the Quarry's monitoring wells in the last year.

Critically, the full extent of the groundwater pollution is not known. Midwest Gen placed monitoring wells mainly onsite at the Quarry, with only a few wells offsite and none in the residential areas where contamination problems have been found.[12] Moreover, what monitoring has been done has been incomplete. Several pollutants associated with coal ash – including highly carcinogenic hexavalent chromium[13] – have not been tested for at the Quarry.

Even with all the dangerous contamination already tainting the Quarry's groundwater, Midwest Gen wants to dump much more coal ash there. The company proposes to dump between 90,000 and 190,000 cubic yards more coal ash in the Quarry each year – equaling, by the company's admission, an additional 135,000 to 285,000 tons of coal ash each year.[14] This additional coal ash will exacerbate both air and water pollution at the site.

Increased fugitive dust, greenhouse gases, particulate matter and toxic pollutants in diesel fuel will all exacerbate air pollution at and near the site. Fugitive dust pollution will increase as Midwest Gen dumps vast quantities of coal ash into the Quarry. Midwest Gen states that will transport the coal ash from other coal plants by truck, and then dump the ash into the Quarry from the surface. Application at 3. No mention whatsoever is made as to whether the ash will be

---

[9] Midwest Gen states in its Application that the Quarry already contains about 2,700,000 cubic yards of coal ash, and that coal ash weighs approximately 1.5 tons per cubic yard. 2,700,000 x 1.5 = 4,050,000.

[10] KPRG, "Midwest Generation Joliet/Lincoln Stone Quarry, Annual Report: Year Ending December 31st, 2016" (Apr. 25, 2017), attached hereto as Exhibit B.

[11] Agency for Toxic Substances and Disease Registry, "Toxicological Profile for Molybdenum: Draft for Public Comment, April 2017," *available at* https://www.atsdr.cdc.gov/toxprofiles/tp212.pdf, at pp. 8-10.

[12] *See* "In Harm's Way," *supra* note 6.

[13] *See* http://earthjustice.org/sites/default/files/CoalAshChromeReport.pdf.

[14] *See* Application at pp. 3-4.

dry or wet when transported and dumped from those trucks, and what measures will be taken – if any – to minimize fugitive dust pollution during those operations.

Moreover, those trucks will be traveling hundreds of miles to haul the coal ash to and from the Quarry from the Waukegan, Powerton and Will County stations. The Waukegan coal plant is 80 to 90 miles from the Quarry by major road; 160 to 180 miles roundtrip. The Powerton plant is 130 to 140 miles from the Quarry; 260 to 280 miles roundtrip. Midwest Gen does not indicate in its Application how frequently coal ash hauling will take place, so neither Citizen Organizations nor IEPA can calculate the exact environmental toll those haul trips will take. But the fuel – likely diesel fuel – burned for each haul trip will add significant amounts of carbon pollution, particulate pollution, and other toxic pollution to the air at and near the Quarry, further harming nearby communities.[15]

Groundwater pollution at the site will likewise be worsened by the addition of hundreds of tons more coal ash dumped there each year. Groundwater monitoring from coal ash ponds at the Waukegan, Will County and Powerton coal plants – the plants from which Midwest Gen proposes to bring coal ash – shows that the coal ash produced at those coal plants is also chock full of toxic pollutants, including antimony, arsenic, boron, chloride, iron, manganese, nitrate, selenium, sulfate, and thallium.[16] The pumping wells at the Quarry – the one mechanism slowing the flow of the contaminated groundwater from the site towards the elementary school and businesses to the southeast – are, without the addition of hundreds of thousands of tons more coal ash, already failing to reduce pollution to safe levels. Joliet residents should not be forced to take on even more contamination.

II. The Illinois Environmental Protection Act and Implementing Regulations Require IEPA to Deny the Application.

The Illinois Environmental Protection Act and implementing regulations do not allow Midwest Generation's permit to be modified so that the company can dump hundreds of thousands of additional tons of toxic coal ash into the unlined Lincoln Stone Quarry. Under 35 Ill. Adm. Code § 813.204, "[a]pplications for significant modifications [to approved permits] shall be subject to all requirements…in Subpart A." Subpart A of 35 Ill. Adm. Code 813, in turn, sets out standards for issuance of a permit and limitations thereto. Critically, a permit – or permit modification – may issue only if the applicant provides "proof that the facility… will not cause a violation of this Act or of Board regulations set forth in 35 Ill. Adm. Code: Chapter 1." 35 Ill. Adm. Code § 813.104(a); 35 Ill. Adm. Code § 813.204. Midwest Generation cannot satisfy that standard because its Lincoln Stone Quarry is already causing a violation of the Act and the Application would make that violation worse.

---

[15] Citizen Organizations recognize that some hauling may be necessary to transport coal ash to safer disposal in dry, properly-lined landfills, but a thorough analysis should be done to locate the closest proper disposal location to each coal plant, as well as to implement other measures to cut pollution from those haul trips, such as the use of electric vehicles or clean diesel.

[16] *See, e.g.*, groundwater monitoring reports for Waukegan, Will County and Powerton, attached as Exhibits A9-A13, B10-B12, C9-C11, and D16-D18 to the Memorandum of Law In Support of Complainants' Partial Motion for Summary Judgment in IPCB 2013-015 (June 1, 2016), *available at* http://www.ipcb.state.il.us/documents/dsweb/Get/Document-92815

A. Midwest Generation has "cause[d] or threaten[ed] or allow[ed]" the discharge of contaminants into the environment at the Lincoln Stone Quarry.

The Application may not be approved because the Lincoln Stone Quarry is already causing a violation of Section 12(a) of the Act, which prohibits any person from "[c]aus[ing] or threaten[ing] or allow[ing] the discharge of any contaminants into the environment in any State so as to cause or tend to cause water pollution in Illinois, either alone or in combination with matter from other sources...." 415 ILCS 5/12(a).

In determining whether a party has "cause[d] or threaten[ed] or allow[ed] the discharge of any contaminants" into a waters of the State, Illinois courts and the Illinois Pollution Control Board focus on two factors: first and primarily, whether the party has the "capability of control" over the water pollutants or the premises where the water pollution occurred, and second, whether the party has taken "extensive precautions" to prevent pollution from occurring. *See, e.g., Gonzalez v. Pollution Control Bd*., 960 N.E.2d 772 (Ill. App. First Dist. 2011) ("Property owners are responsible for the pollution on their land unless the facts establish the owners either lacked the capability to control the source or had undertaken extensive precautions to prevent vandalism or other intervening causes") (internal quotations omitted); *People v. A.J. Davinroy Contractors*, 249 Ill. App. 3d 788, 794 (1993) (defendant liable when it "neither lacked the capability to control the source of the pollution nor undertook any precautions to prevent the pollution"); *Perkinson v. Ill. Pollution Control Bd*., 187 Ill. App. 3d 689, 694-95, 543 N.E.2d 901, 904 (1989) (Illinois has a "long line of precedent… which holds that the owner of the source of the pollution causes or allows the pollution… and is responsible for that pollution unless… the owner either lacked the capability to control the source… or had undertaken extensive precautions to prevent vandalism or other intervening causes").

When a party owns the premises where pollution occurs, Illinois courts and the Board presume that party has control over those premises. *See, e.g., People v. Inverse Investments*, PCB 11-79, 2012 Ill. Env. Lexis 92, *25 (PCB Feb. 16, 2012) (denying motion to dismiss when complaint alleged that defendant owned site "that contained contamination that is migrating offsite and polluting groundwater"); *Meadowlark Farms, Inc. v. Ill. Pollution Control Bd*., 17 Ill. App. 3d 851, 861; *Freeman Coal Mining Corp. v. Ill. Pollution Control Bd*., 21 Ill. App. 3d 157, 163 (1974). Parties who operate the premises or the source of pollution likewise exercise control over those premises or pollution sources. *See A.J. Davinroy Contractors*, 249 Ill. App. 3d at 794; *People v. Michel Grain*, PCB No. 96-143, 2002 Ill. Env. Lexis 489 at *7- *9 (PCB Aug. 22, 2002); *see also Allaert Rendering, Inc. v. Ill. Pollution Control Bd*., 91 Ill. App. 32 153, 155-56 (Ill. App. Ct. Third Dist. 1980).

Illinois precedent holds that a party with control over the premises or source of pollution cannot avoid liability unless that party has taken "extensive precautions" to prevent the pollution. *See, e.g., Gonzalez*, 960 N.E.2d at 779; *Perkinson*, 187 Ill. App. 3d at 694-95. When a material that is likely to leach is present, and the party controlling the source of pollution fails to install liners to retain leachate or monitoring wells "built to track" contamination, the party has not taken sufficient precautions to avoid liability under § 12(a) of the Act. *Wasteland, Inc. v. Pollution Control Bd*., 118 Ill. App. 3d 1041, 1049 (Ill. App. 3rd 1983) (upholding the Illinois Pollution Control Board's holding that § 12(a) of the Act was violated in light of "the presence

of unpermitted material, likely to create leachate problems, and the lack of natural or required safeguards against water pollution…").

Here, Midwest Generation owns and operates the Lincoln Stone Quarry in Joliet, Illinois, and therefore controls the site. *See Inverse Investments*, PCB 11-79, 2012 Ill. Env. Lexis 92, *25; *Meadowlark Farms, Inc.*, 17 Ill. App. 3d at 861; *Freeman Coal Mining Corp.*, 21 Ill. App. 3d at 163; *A.J. Davinroy Contractors*, 249 Ill. App. 3d at 794. As owner and operator of the Quarry, it is and has been Midwest Gen's obligation to take "extensive precautions" to protect against contamination from the toxic coal ash dumped at the site – contamination it has long known about. *See id* and above. Yet Midwest Gen has failed to fulfill that obligation.

As discussed above, significant coal ash contamination of groundwater has long been documented at the Quarry. Midwest Gen did install a pumping system in an attempt to alleviate that contamination in 2010 and 2012, but those wells have not reduced pollution to safe levels. Years after putting the pumping system into operation, Midwest Generation's groundwater monitoring reports reveal that contaminants including arsenic, boron, sulfate and molybdenum – all constituents of coal ash – continue to exceed Illinois' groundwater protection standards and federal health-based standards in groundwater monitoring wells on the southeast side of the Quarry. Yet, notwithstanding the monitoring results clearly revealing the inadequacy of the pumping system, Midwest Gen has taken no further actions to address the contamination: it has not installed a liner beneath the vast quantities of coal ash soaking in the groundwater at the site, nor has it excavated the toxic ash there.[17] Midwest Generation also has failed to evaluate the full extent of contamination at the site. For example, even though hexavalent chromium – the highly carcinogenic contaminant at issue in the film *Erin Brockovich* – has long been known to leach from coal ash[18], it is not among the pollutants monitored for at the site. In short, the precautions Midwest Gen has taken at the Lincoln Stone Quarry are far from "extensive" and have shown themselves to be wholly inadequate to stop the contamination at the site. As such, Midwest Gen is *already*, even without adding hundreds of thousands of tons more coal ash, "caus[ing], threaten[ing] or allow[ing] the discharge of …contaminants into the environment" at the Lincoln Stone Quarry.

B. Contamination from the Lincoln Stone Quarry is Causing, and Threatening to Cause, Continued Water Pollution in Illinois.

The contamination leaching from the Lincoln Stone Quarry is causing, and threatening to cause, water pollution in Illinois. The Act defines "water pollution" as:

> such alteration of the physical, thermal, chemical, biological or radioactive properties of any waters of the State, or such discharge of any contaminant into any waters of the State, as will or is likely to… render such waters harmful or detrimental or injurious to public health, safety or welfare, or to domestic,

[17] *See, e.g.*, Midwest Gen's Application, and CCR COMPLIANCE CCR FUGITIVE DUST CONTROL PLAN Midwest Generation, LLC Joliet #9 Generating Station and Lincoln Stone Quarry 1601 South Patterson Road Joliet, Illinois, at 3 ("Existing ash in the Main Quarry is predominantly submerged…"), *available at* http://3659839d00eefa48ab17-3929cea8f28e01ec3cb6bbf40cac69f0.r20.cf1.rackcdn.com/LSQ_LSQ1_OCI.pdf

[18] *See* http://earthjustice.org/sites/default/files/CoalAshChromeReport.pdf.

> commercial, industrial, agricultural, recreational, or other legitimate uses, or to livestock, wild animals, birds, fish, or other aquatic life.

415 ILCS 5/3.545. "Waters," in turn, is defined as "all accumulations of water, surface and underground, natural, and artificial, public and private, or parts thereof, which are wholly or partially within, flow through, or border upon this State." 415 ILCS 5/3.550. Waters of the state includes water in wells. *Tri-County Landfill Co. v. Illinois Pollution Control Board*, 41 Ill. App. 3d 249, 253-54, 353 N.E.2d 316, 320-21 (1976); *People ex rel. Ryan v. Stonehedge, Inc*., 288 Ill. App. 3d 318, 321-22, 680 N.E.2d 497, 500 (1997); *see also People v. John Chalmers*, PCB 96-111 7 (Jan. 6, 2000).

The Illinois Pollution Control Board has made clear that water pollution exists when contaminants are present in excess of the groundwater quality standards adopted by the Board. *See Int'l Union v. Caterpillar*, PCB No. 94-240, 1996 Ill. Env. Lexis 579, at *88-*89 (PCB Aug. 1, 1996); *Inverse Investments*, PCB 11-79, 2012 Ill. Env. Lexis 92, at *2, *25-*26; *see also People v. Hicks Oil & Hicks Gas, Inc*, PCB No. 10-12, 2009 Ill. Env. Lexis 308, *1-*2 (Aug. 6, 2009).

The principle that groundwater contamination in excess of the Board's Class I standards constitutes water pollution holds true even when those standards are not in effect, as is the case where, as at the site at issue here, a Groundwater Management Zone ("GMZ") has been approved for a site for a given pollutant. *See* 35 Ill. Adm. Code §§ 620.250(e), 740.530 (d). As noted above, water pollution is present when a discharge of any contaminant into the groundwater "will or is likely to…render such waters harmful or detrimental or injurious to public health, safety or welfare…." 415 ILCS § 5/3.545. When the Board adopted the groundwater quality standards in 1991, it noted that the Class I: Potable Resource Groundwater quality standards were being set at levels "equal to the USEPA's Maximum Concentration Levels," which are health-based standards designed to be protective of human health, Safe Drinking Water Act § 1412(b)(4)(A)-(B), 42 USC § 300g-1(b)(4)(A)-(B), and were intended to fulfill "the principle that groundwaters that are naturally potable should be available for drinking water supply without treatment." IPCB R89- 14(B), Nov. 7, 1991, Final Order at 18.

Regardless of whether the groundwater protection standards are in effect, contamination in excess of those standards leaves the affected groundwater "harmful or detrimental or injurious to public health, safety or welfare" under § 415 ILCS 5/3.545. When standards are set to prevent harm to health, as Illinois' groundwater protection standards were, exceedances of those standards in a water body constitute water pollution even if the standards are not in effect. *See Central Illinois Public Service Co. v. Pollution Control Board*, 116 Ill. 2d 397, 409-10 (1987) ("*CIPSCO*") (explaining that "any contamination which prevents the State's water resources from being usable … constitute[s] pollution"); *People v. Texaco Refining and Marketing, Inc.*, PCB No. 02-03, 2003 Ill. Env. Lexis 665 at *21-22 (PCB Nov. 6, 2003) (holding that "Section 12(a) of the Act provides no exemption from liability for parties that comply with another regulatory program."); *Caterpillar*, PCB No. 94-240, 1996 Ill. Env. Lexis 579 at *88-*89 (finding that "exceedances of the Part 620 standards… constitutes degradation of one of the State's water resources and indicates the presence of water pollution caused by respondent"); *see*

also People v. CSX Transp., Inc., PCB No. 07-16, 2007 Ill. Env. Lexis 296, *44-*45 (PCB July 12, 2007).

Here, Midwest Generation's recent annual groundwater monitoring report for the Lincoln Stone Quarry confirms that coal ash contaminants, including arsenic, boron, sulfate, and molybdenum, are present in the groundwater at and near the Lincoln Stone Quarry at levels exceeding Illinois' Class I groundwater quality standards. In fact, those reports show arsenic concentrations nearly 20 times higher than the Class I groundwater quality standard, boron concentrations more than 8 times higher than the Class I groundwater quality standard, and molybdenum at nearly 3 times EPA's health advisory level. In two wells, arsenic and boron have exceeded groundwater quality standards every quarter. Thus, because Midwest Generation is causing, threatening or allowing toxic coal ash constituents to leach from the Lincoln Stone Quarry in concentrations exceeding Illinois' groundwater protection standards, the company is causing water pollution at the Quarry in violation of Section 12(a) of the Act.[19]

C. Midwest Generation's Permit May Not Be Amended to Allow More Illegal Pollution.

Midwest Generation's Application may not be approved because the permit, as amended, would not and could not ensure that the Lincoln Stone Quarry "will not cause a violation of this Act or of Board regulations set forth in 35 Ill. Adm. Code: Chapter 1." 35 Ill. Adm. Code § 813.104(a); 35 Ill. Adm. Code § 813.204. Dumping hundreds of thousands of additional tons of toxic coal ash into the unlined Lincoln Stone Quarry, as Midwest Gen requests, would worsen the high levels of toxic pollution already fouling the Des Plaines River and further burden Illinois residents living near the Quarry, in violation of the Act.

As discussed above, the pumping system at the Quarry is clearly strained by the coal ash already there; as the groundwater monitoring reports reveal, the system is not up to the task of keeping coal ash pollution within the already-too-high groundwater standards that were set for the Quarry, much less to keeping that pollution to levels safe for human health. Nowhere in the Application does Midwest Generation mention any new or improved protective measures to help the strained pumping system manage the pollution stemming from the hundreds of thousands of tons of toxic coal ash it proposes to add to the Quarry each year. And there is no reason to believe that the proposed mountain of additional coal ash won't contribute significant pollution to the Quarry. To the contrary, groundwater monitoring at the Waukegan, Will County and Powerton plants – from which Midwest Gen proposes to bring the new ash – has for years shown

[19] Importantly, it is no defense that some of the leaching coal ash in the Quarry was placed there by Midwest Generations' predecessors. A party with control over the pollution or the premises where that pollution occurs may be liable for allowing water pollution in violation of § 12(a) even if that party did not place the contaminants at issue in the ground or water, because it allowed that pollution to continue. *See Inverse Investments*, PCB 11-79, 2012 Ill. Env. Lexis 92 at *25; *People v. Michel Grain*, PCB No. 96-143, 2002 Ill. Env. Lexis 489 at *7 (PCB Aug. 22, 2002); *Illinois v. State Oil Co*., PCB 97-103, Order, April 4, 2002, at 12-16 .

It is likewise no defense for Midwest Generation to claim that it did not "intend" to cause, threaten or allow the continued pollution leaching from the Lincoln Stone Quarry. A party's intent, or lack thereof, has no bearing on liability. *People v. Fiorini*, 143 Ill. 2d 318, 346, 574 N.E.2d 612, 623 (1991) ("[I]ntent is not an element to be proven for a violation under Illinois Environmental Protection Act.").

extensive coal ash pollution of groundwater at those sites.[20] Moreover, the dumping of hundreds of tons of ash from trucks into the Quarry is likely to create significant fugitive dust air pollution, yet Midwest Gen does not explain in its Application which, if any, measures it will take to abate that pollution. The Application must be denied.

IV. Conclusion

Midwest Gen's proposal to add hundreds of thousands of tons of toxic coal ash to the unlined, saturated Lincoln Stone Quarry will exacerbate the existing contamination of groundwater and air at and around the Quarry, resulting in continuing violations of the Act and continued threats to nearby residents and the environment. Therefore, pursuant to 35 Ill. Adm. Code §§ 813.104(a) and 813.204, Midwest Generation's Application must be denied.

Respectfully submitted,



Coal Ash Project Attorney
Earthjustice
1101 Lake Street, Suite 308
Oak Park, IL 60301
jcassel@earthjustice.org
(215) 717-4525

[20] *See, e.g.*, groundwater monitoring reports for Waukegan, Will County and Powerton, attached as Exhibits A9-A13, B10-B12, C9-C11, and D16-D18 to the Memorandum of Law In Support of Complainants' Partial Motion for Summary Judgment in IPCB 2013-015 (June 1, 2016), *available at* http://www.ipcb.state.il.us/documents/dsweb/Get/Document-92815.

ATTACHMENT 16

EVALUATION AND PROFESSIONAL OPINIONS REGARDING ONE OF EPA'S 2020 PROPOSED PERMITTING RULES FOR CCR DISPOSAL FACILITIES

PREPARED BY:
Steven K. Campbell, Ph.D., P.G.
3900 Albion Drive, Winterville, North Carolina 28590
Telephone: (252) 717-9766
Email: skcampbell@suddenlink.net

MAY 13, 2020



Steven K. Campbell, Ph.D., P.G.
Consulting Geologist and Hydrogeologist



I. Purpose and Scope

On February 20, 2020, the Environmental Protection Agency (EPA) published a Proposed Permitting Rule to set out permitting requirements associated with the 2015 coal combustion residuals (CCR) rule (EPA, 2015). I evaluate and opine on EPA's Proposed Permitting Rule as described in the preamble and rule for 40 C.F.R. § 257.150(b) pertaining to limiting any evaluation of CCR disposal site suitability "*at the time of permit modification or revocation and reissuance*" (Federal Register, Volume 85, Number 34, page 9967). I address aspects of EPA's specific example offered in the preamble on page 9967 of 85 F.R. that states "…*this provision might be triggered if the elevation of the aquifer beneath the unit had significantly and permanently increased over time…such that the CCR unit located above the aquifer would no longer meet the requirements of* (a minimum physical separation of five feet)". I identify why the proposed rule at § 257.150(b) is in conflict with other proposed and existing CCR rules, and I supply examples that indicate a need for the EPA and the CCR facility owner/operator to continue explicit evaluation of water-level changes in the context of the 5-foot separation criteria.

II. Qualifications, Retainer, and Conflicts of Interest

A. I, Steven K. Campbell, am the sole investigator for the evaluation and opinions described in this expert report. The opinions provided herein are based upon my education, professional training, and personal experience with environmental assessments involving soil, surface water, and groundwater conditions, including both their natural characteristics and impacts from human activities. Specifically, I have conducted and/or evaluated (1) environmental and hydrogeologic assessments of coal-fired power plants, (2) the disposal of CCRs in landfills, open pits (ponds), and former mine voids, and (3) the associated impacts of CCRs on surface and subsurface geologic media (e.g., groundwater). I have worked on aspects of CCR disposal sites in the United States of America in Alabama, Alaska, Arizona, Maryland, Michigan, North Carolina, Pennsylvania, Illinois, Indiana, and Kentucky, CCR sites located in the countries of Australia, India, and South Africa, and with regard to CCR-related regulatory issues originating in Washington D.C.

B. My opinions reflect a reasonable degree of scientific validity, and are based on widely-accepted principals of geology and hydrogeology, common industry practices, and pertinent documents and publically-available information. I reserve the right to modify or amend any opinion described herein upon consideration of additional information or data that may become available. My curriculum vitae is provided in Appendix I.

C. I have been retained by Earthjustice to evaluate and render opinions regarding § 257.150(b) of EPA's 2020 Proposed Permitting Rule, including the sole physical example cited by EPA in the preamble to § 257.150(b).

D. I have no known conflicts of interest that impact my evaluation and opinions regarding § 257.150(b) of EPA's 2020 Proposed Permitting Rule.

III. Information Reviewed

I have considered or employed the following documents and sources of information in conjunction with my evaluation of EPA's 2020 Proposed Permitting Rule. These references are not a comprehensive list of all published information pertinent to my prior experience, this expert report, and/or my professional opinions.

Environmental Protection Agency (EPA), 1982, Hazardous Waste Management System; Standards Applicable to Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities; and EPA Administered Permit Programs, 47 FR 32274-01

Environmental Protection Agency (EPA), 1984, A Ground-Water Protection Strategy for the Environmental Protection Agency, 813R84101

Environmental Protection Agency (EPA), 1993, Solid Waste Disposal Facility Criteria, Technical Manual, EPA530-R-93-017, Revised 1998

Environmental Protection Agency (EPA), 1998, Report to Congress, Wastes from the Combustion of Fossil Fuels, Volume 2 Methods, Findings, and Recommendations

Environmental Protection Agency (EPA), 2007, Monitored Natural Attenuation of Inorganic Contaminants in Ground Water, Volume 2 Assessment for Non-Radionuclides Including Arsenic, Cadmium, Chromium, Copper, Lead, Nickel, Nitrate, Perchlorate, and Selenium, EPA/600/R-07/140

Environmental Protection Agency (EPA), 2015, Hazardous and Solid Waste Management System, Disposal of Coal Combustion Residuals from Electric Utilities, Final Rule, 40 CFR Parts 257 and 261

Environmental Protection Agency (EPA), 2018, Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals from Electric Utilities; Amendments to the National Minimum Criteria (Phase One); Proposed Rule, 40 CFR Part 257

Environmental Protection Agency (EPA), 2020, Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals from Electric Utilities; Federal CCR Permit Program; Proposed Rule, 40 CFR Part 257 (specifically § 257.150(b)).

Fecht, S., 2019, How Climate Change Impacts our Water, Columbia University, accessed at https://blogs.ei.columbia.edu/2019/09/23/climate-change-impacts-water/ on 3/30/2020

Geosyntec, 2016, History of Construction, East and West Ash Basins, Waukegan Station, October 2016, 91 p.

Geosyntec, 2018, Placement above the Uppermost Aquifer Location Restrictions, East and West Ash Basins, Waukegan Station, October 2018, 2 p.

Groundwater Management Associated, Inc., (GMA), 2017, Evaluation and Professional Opinions Regarding Geologic And Hydrogeologic Aspects of the 2016 Draft Environmental Impact Statement as it Pertains to Scheduled Facility Closure in 2019 or Extending Operation Until 2044, Navajo Generating Station – Kayenta Mine Complex Project, Navajo Nation, Arizona, USA, 26 p.

KPRG and Associates, Inc., 2020, CCR Compliance Annual Groundwater Monitoring and Corrective Action Report – 2019, 191 p.

Melillo, J.M., Richmond, T.C., and Yohe, G.W., Eds., 2014: Highlights of Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program, 148 pp. (accessed at https://nca2014.globalchange.gov/ on 3/31/2020)

NOAA - Great Lakes Environmental Research Laboratory (GLERL), Great Lakes Water Level Observations, accessed at https://www.glerl.noaa.gov/data/wlevels/levels.html#observations on 3/31/2020

NRG Energy, 2016, Annual and Quarterly Groundwater Monitoring Report, Waukegan Generating Station, 90 p.

IV. Evaluation and Opinions Regarding § 257.150(b) of EPA's 2020 Proposed Modifications to the 2015 CCR Rules

IV.1 EPA's Language Regarding *"Modification or revocation and reissuance of an individual permit at EPA's initiative"* per § 257.150(b)

The full text of EPA's 2020 Proposed Permitting Rule for CCR disposal facility siting at § 257.150(b) (85 F.R. page 9986) states: "*Suitability of the existing facility location will not be considered at the time of permit modification or revocation and reissuance unless new information, standards, or regulations indicate that a there is a reasonable probability of adverse effects to health or the environment exists which was unknown to the administrator at the time of permit issuance*." The term "administrator" refers to the EPA or its regulatory proxy who issued the CCR facility permit(s) or subsequent modification(s). The preamble on 85 F.R. page 9967 must be used to decipher the intended application of this rule modification, and in particular within the context of the 5-foot vertical separation distance between disposed CCRs and the water table of the underlying aquifer. However, any elaboration or example provided in the preamble may not be binding on interpretation and application of the actual rule.

Opinion: The proposed rule at § 257.150(b) conflicts with the existing 2015 CCR Rule and another proposed rule, as described below.

IV.2 Responsibilities per § 257.150(b) and a Cure in Search of a Problem

The title of rule § 257.150(b) identifies permit adjustments "*at EPA's initiative*", yet the preamble indicates that EPA's impetus to act depends on the CCR facility owner/operator voluntarily identifying and reporting any deficiencies or conditions to EPA, including measuring and disclosing increases in the elevation of the water table surface that violate the 5-foot vertical separation criteria. EPA's assumption is that *"the likelihood that a unit's compliance with the location criteria would change over time is low"* (85 F.R. page 9967). Based on that assumption, EPA *"will not routinely require the owner and operator to evaluate whether an existing CCR facility or existing CCR unit continues to be properly sited during routine permit modifications."* (85 F.R. page 9967). EPA's intention appears to be empowering the owner/operator to decide if they do or do not disclose or headline any change that might put the facility out of compliance with the facility siting criteria.

The proposed rule limits deficiencies in siting conditions to those that were "*unknown to the administrator at the time of permit issuance*" (85 F.R. page 9986), which implicitly excludes any "unknowns" resulting from the (in)actions of the owner/operator when the permit or modification was sought. For example, a poorly designed or inept evaluation of the water table position beneath the facility prior to CCR disposal is apparently exempt from further scrutiny. Although EPA's preamble

states that *"lateral expansions are considered new CCR units that must be permitted and must comply with all the requirements applicable to new units, including the location criteria"* (85 F.R. page 9967), it is not clear that any negative conditions identified during such expansions would be "considered" in the context of the existing CCR facility because that would be information "unknown" to the administrator (the EPA or its proxy) at the time of the original permit.

The preamble implies that EPA's motivation is financial by stating that *"it may be technically difficult* (i.e., expensive) *to address issues once the unit has been built and is operating."* (85 F.R. page 9967) In reality, the pertinent water-level measurements are already being collected by the owner/operator as part of compliance monitoring, so the additional expense and effort of evaluating and notifying EPA of pertinent changes in the water table position are trivial, and thus place almost no extra burden on the owner/operator or EPA (or its proxy) to verify ongoing compliance with this fundamental aspect of the 2015 CCR Rule. A generic assumption that site-specific conditions will be "technically difficult" to rectify is poor justification for not evaluating, reporting, and acting upon the information that is already being acquired.

Opinion: The proposed rule at § 257.150(b) discourages evaluation or reporting by the CCR disposal facility owner/operator that would stimulate EPA's "initiative", implying that EPA does not wish to be informed of any information that would require action, which is inherently contrary to the fundamental purpose of the 2015 CCR Rule to protect human health and the environment. It is my opinion that § 257.150(b) does not remove any substantial ongoing physical or financial burden on the owner/operator or EPA unless they identify non-compliant site conditions, so the true purpose of the proposed rule for correcting some flaw in the 2015 CCR rules is dubious. I provide in section IV.5 of this expert report a real-world example of a CCR facility with changes in siting conditions that contravene the 5-foot separation criteria. However, the owner/operator of that facility is not evaluating or disclosing the negative information that might trigger EPA's "initiative" to act, and proposed § 257.150(b) erodes further the likelihood of appropriate action at that CCR facility.

IV.3 Conflicts with Proposed Rules and the 2015 CCR Rule Regarding the 5-Foot Separation between the Water Table and Disposed CCRs

There are conflicts between proposed rules § 257.150(b) and § 257.151 because the latter states that a *"permittee must apply for a modification to a permit at any time during the life of the permit when there is a chance to either a CCR unit or related solid waste management operations…which would impact…the applicability of requirements of subpart D of this part."* This language indicates that an owner/operator is required to seek a permit modification if they, for example, identify a rise in the elevation of the water table (e.g., contravening the minimum 5-foot separation criteria). However, proposed rule § 257.150(b) indicates that EPA would only need to "consider" that information if they determined that the change in water table elevation would pose a "*reasonable probability of adverse effects to health and the environment.*" (85 F.R. page 9986) [Note: the word "consider" is not present in the actual rule, it only appears in the preamble.] The 2015 CCR Rule at § 257.60(a) states that violations of the 5-foot groundwater separation criteria requires that there be no *"intermittent, recurring, or sustained hydraulic connection between any portion of the base of the CCR unit and the uppermost aquifer due to normal fluctuations in groundwater elevation"* (80 F.R. at 21361). This

existing rule is incompatible with the preamble to proposed § 257.150(b) that states that only a *"significant and permanent"* increase in the water table elevation would pose a *"reasonable probability"* of adverse effects to health and the environment (85 F.R. at 9967), and even then EPA would only need to *"consider"* requiring a permit modification or revocation.

Opinion: The two proposed rules cited above are incompatible, and proposed rule § 257.150(b) is contrary to § 257.60(a) of the 2015 CCR Rule with respect to violations of the minimum 5-foot separation between disposed CCRs and the water-table surface. Furthermore, EPA's language only indicates that they need to "consider" acting on any information that comes to their attention that indicates a violation of the CCR-groundwater separation criteria. I address the problems inherent with EPA's inclusion of the terms "significant" and "permanent" in the next section.

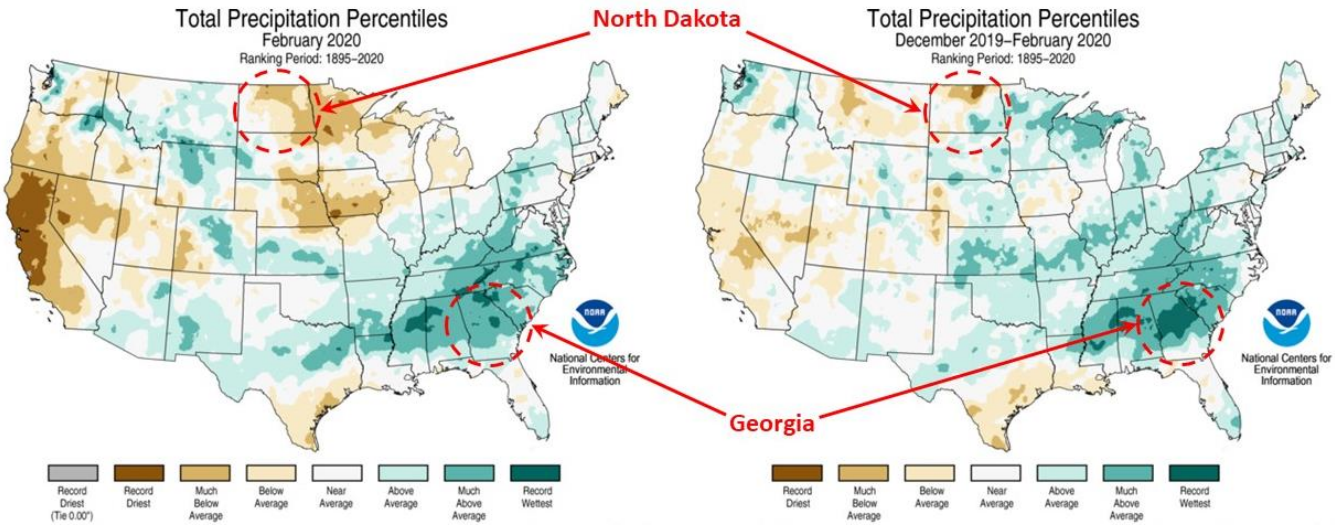
IV.4 EPA's Example of Changes in the Water Table Elevation and the Real World

EPA's single example of a "change" in siting conditions at a CCR facility states that *"if the elevation of the aquifer beneath the unit had significantly and permanently increased over time…such that the CCR unit would no longer meet the requirements of § 257.60(a).*.(then)…*The proposed provision at § 257.150(b) would clarify that in such a case EPA could modify or revoke and reissue the CCR permit with updated permit terms*…(but that EPA's actions are) *limited to situations in which the risk was unknown at the time of permit issuance."* (85 F.R. at 9967) This language is internally inconsistent because the increase in water-table elevation would postdate the initial assessment that established initial compliance with the 5-foot separation compliance, and no "what-if" risk evaluation would have occurred for "unknown" future changes. The term "permanent" is particularly ill suited to characterizing inherently dynamic water-table aquifer systems that respond to non-permanent changes in groundwater recharge and discharge. For example, seasonal changes in local precipitation are scientifically-indisputable primary drivers of short-term vertical changes in the elevation of the water-table surface in response to the dynamics of aquifer recharge and discharge. Longer-term changes in recharge rates can be caused, for example, by changing temporal and/or spatial patterns of precipitation (e.g., Melillo, et al., 2014), which in turn can be amplified by ongoing climate change that will cause some regions to experience increasing or decreasing precipitation relative to the time that the CCR permit was issued. Changes in the elevation of adjacent surface water bodies (e.g., lakes) can also play an important role in vertical changes in the water-table aquifer's elevation, as I demonstrate below in section IV.5 of this expert report. EPA has provided no guidance regarding precisely what it intends by including the terms "permanent" or "significant" in proposed rule § 257.150(b), but employing those modifiers essentially redefines the CCR-aquifer separation standard in the 2015 CCR Rule without any supporting scientific basis or justification.

Over the short period of one month, significant differences in local or regional precipitation rates, a proxy for aquifer recharge rates, are well known. Precipitation patterns over a longer period, such as three months or a year or a decade, show more meaningful patterns of concomitant aquifer recharge and water-table rise or fall. Two time scales are illustrated in Figure 1, which compares precipitation during February 2020 (left side) with the three-month period that includes the prior two months (right side). Precipitation rates in Figure 1 are shown relative to the average since 1895, and the scale is (unquantified) percentiles. [Note: similar maps employing units such as inches are readily available.]

As examples, precipitation in North Dakota during February 2020 ranged from average to much below average, while portions of Georgia experienced above average to record precipitation during the same month (Figure 1). Expanding the period of interest to December 2019 through February 2020 reveals considerable differences between northern and southern portions of North Dakota, while much of central Georgia experienced record precipitation (Figure 1, right side). The rate and degree with which the elevation of an unconfined water-table aquifer responds to changes in precipitation are influenced by many parameters (e.g., infiltration capacity of surface materials), but one can reasonably expect rising groundwater elevations in Georgia and northern North Dakota, and decreasing elevations in southern North Dakota in response to the local and regional precipitation patterns. Figure 2 illustrates an 8-foot rise in the water-table elevation in Greene County, Georgia (located in the east-central area of high precipitation) during the same 3-month period. Note that if a CCR disposal facility were present near the monitored Greene County location (Figure 2), then the CCR facility would have been in compliance with the minimum 5-foot separation between the disposed CCRs and the water table in December of 2019, but the facility would have been out of compliance by early January 2020.

Figure 1: Precipitation patterns in the USA during February 2020 (left) and December 2019 through February 2020 (right). [Image modified from NOAA at https://www.ncei.noaa.gov/news/national-climate-202002 to identify North Dakota and Georgia.]



Precipitation measurements since 1901 show that, since at least 1991, much of the United States has been experiencing wetter conditions than were present prior to 1960 (Figure 3). Likewise, much of the contiguous United States will more likely than not experience increasing precipitation as the climate warms during coming decades (e.g., Melillo, et al., 2014). Indeed, large portions of the United States had record annual precipitation in 2018 and 2019 (Fecht, 2019). Nevertheless, it is true that groundwater is at significant depth in some arid portions of the United States, such as in an unconfined sandstone aquifer in Arizona with a water table 900 feet below the surface (GMA, 2017).

Figure 2: Groundwater hydrograph for a water-table aquifer in Greene County, Georgia (12/1/2019-02/29/2020) [Image modified from https://waterdata.usgs.gov/ga/nwis/uv?cb_72019=on&format=gif_default&site_no=332808083010201&period=&begin_date=2019-12-01&end_date =2020-02-299 to add a map showing the location of Greene County.]

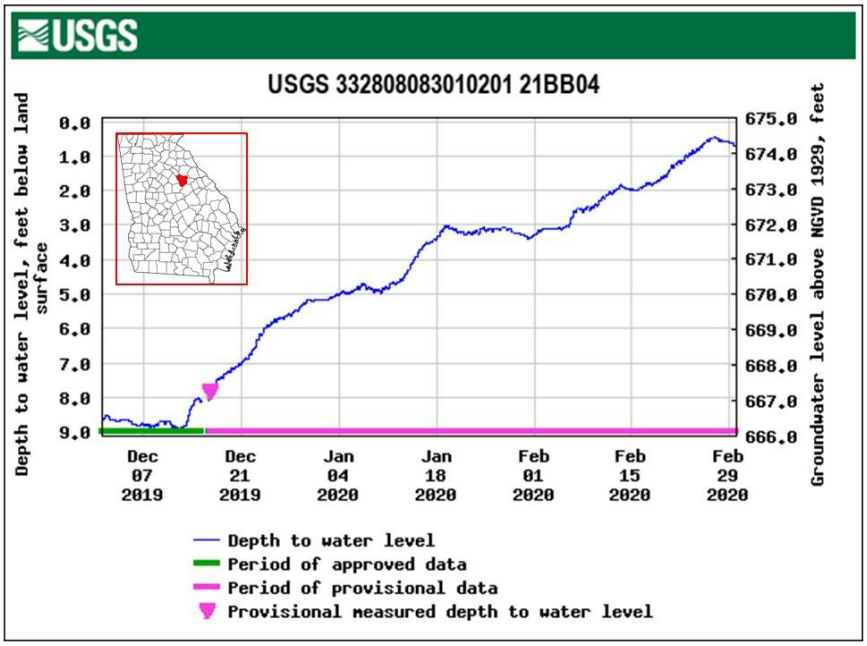
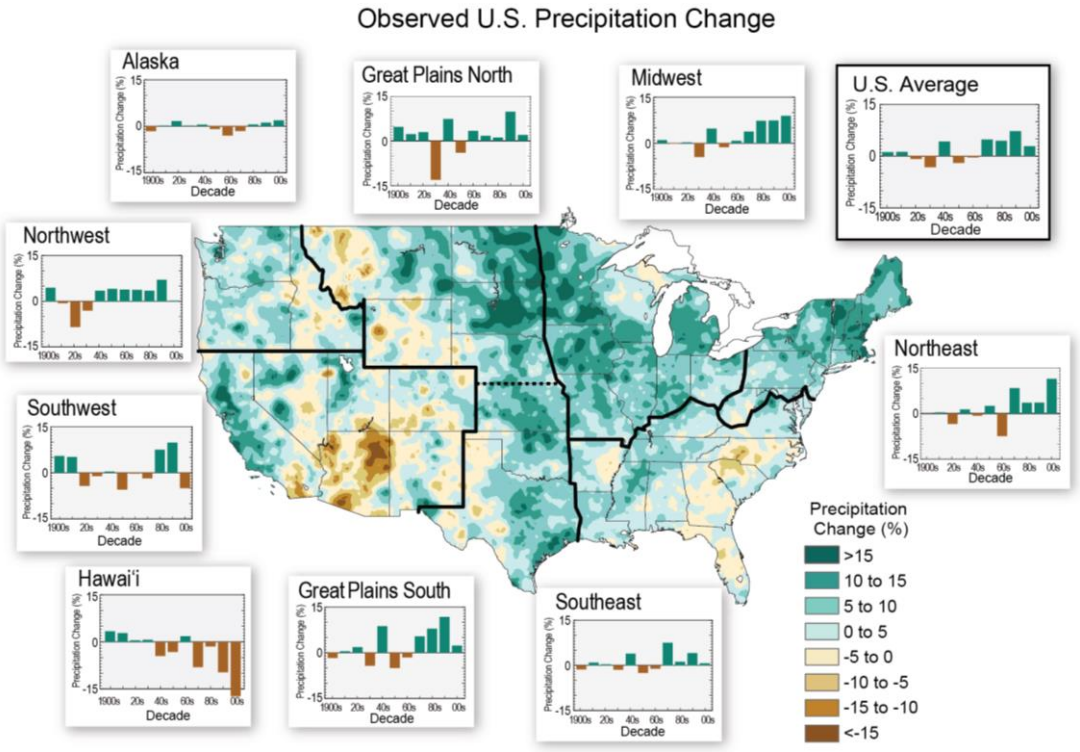
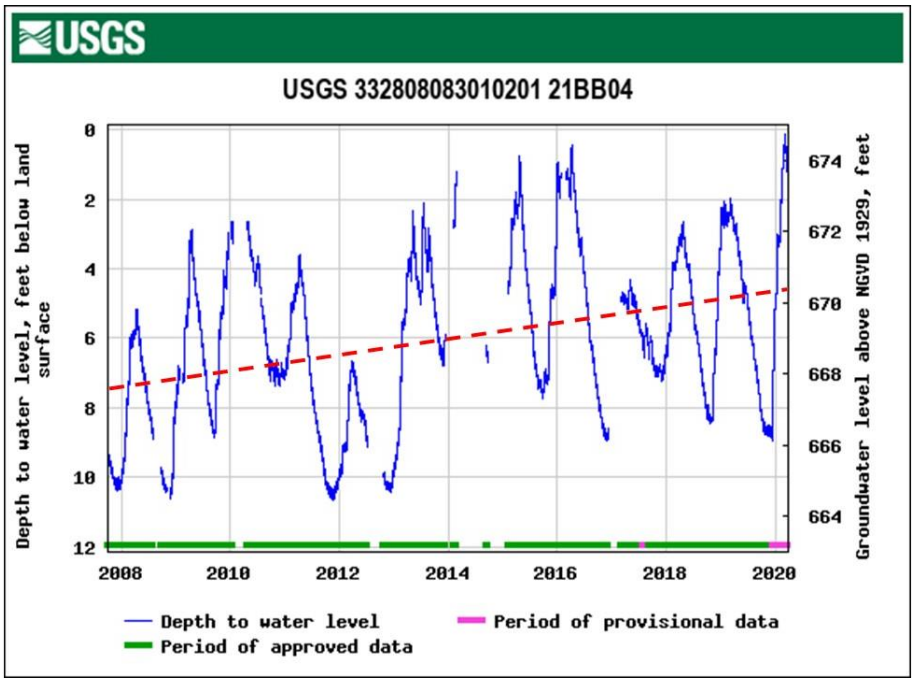


Figure 3: Precipitation patterns in selected regions of the USA during the period 1991 through 2012 relative to the 1901-1960 average (https://nca2014.globalchange.gov/highlights/report-findings/our-changing-climate/graphics/observed-us-precipitation-change)



Although there are seasonal cycles of rising and falling water-table elevations, a linear fit to the available 12.5-year data set (10/2007-3/2020) for the Green County, Georgia, aquifer (Figure 4) reveals an overall increase of more than two feet in the water table's elevation since 2007. The trend in Figure 4 is particularly instructive when one considers that Georgia has been one of the driest states east of the Rocky Mountains since 1991 (Figure 3).

Figure 4: Groundwater hydrograph for a water-table aquifer in Greene County, Georgia for the full period of well measurements (10/1/2007-03/29/2020) [Image modified from https://nwis.waterdata.usgs.gov/ga/nwis/uv/?ts_id=182421&format=img_default&site_no=332808083010201&set_arithscale_y=on&begin_date=20071001&end_date=20200329 to include a red-dashed line showing the linear best fit to the data.]



Opinion: The scientific consensus is that much of the contiguous United States is already experiencing, and will continue to experience, increasing precipitation relative to historic averages (e.g., Melillo, et al., 2014). Because disposed CCRs can remain potent sources of groundwater contaminants for many decades (e.g., EPA, 2007), there is a clear need to require many CCR facility owners/operators to monitor, evaluate, and report changes in groundwater elevation on a regular basis and for EPA or its regulatory proxy to evaluate and act upon those data in the context of the 2015 CCR Rule and the required minimum separation between disposed CCRs and the water table. It is true that some CCR facilities in arid portions of the United States, such as the northern Arizona example (GMA, 2017), are unlikely to contravene the 5-foot separation criteria under any likely scenario for changing precipitation. However, many CCR disposal facilities are located in areas with relatively shallow groundwater, pertinent data are already being collected as part of routine monitoring, and the additional effort and expense required to evaluate and report those date trends to EPA is trivial. Even if EPA is correct that it will be "rare" that changes in the water-table elevation would violate the 5-foot separation criteria, terminating the evaluation, reporting, and "consideration"

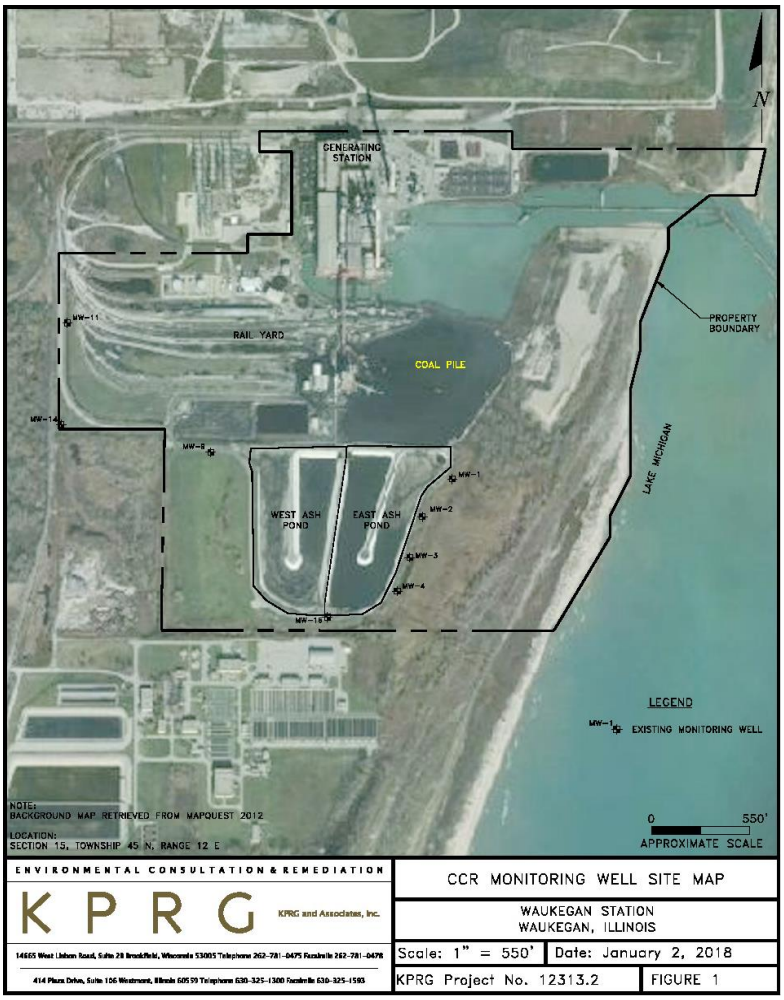
of siting criteria for existing CCR facilities where the water table is in close proximity to disposed CCRs will prevent discovery of site conditions that may threaten human health and the environment.

EPA's inclusion of terms like "permanent" and "significant" in proposed § 257.150(b) to define actionable changes in site conditions are not representative of the dynamic characteristics of water-table aquifers, as illustrated by the Green County, Georgia, aquifer example provided in Figures 2 and 4. Furthermore, such terms do not enhance or clarify compliance with the 2015 CCR Rule, nor do they fulfill the ultimate imperative to act in a protective manner with regard to human health and the environment. The site-specific example provided in the next section illustrates further why employing terms such as "permanent" are inherently inappropriate to water-table aquifers.

IV.5 CCR Facility Example of Ongoing Changes in the Water Table Elevation and Contravention of the 5-Foot Separation Criteria

The likelihood that a CCR facility's compliance with the location criteria would change over time is *not* low (*contra* 85 F.R. at 9967), and EPA *should* routinely require evaluation of ongoing compliance with siting criteria. Site condition changes identified at the Waukegan Power Station (WPS) in Illinois are illustrative of why proposed § 257.150(b) is not appropriate or protective. Since 2012, the water table beneath the WPS coal ash disposal ponds has been experiencing a significant and protracted rise in response to increasing aquifer recharge via precipitation changes and/or due to the ongoing rise in adjacent Lake Michigan. EPA's preamble to § 257.150(b) recognizes that the water table may rise *"…as a result of* (changes in) *intersecting surface water…"* (85 F.R. at 9967), just as I interpret is happening now at the WPS. The WPS is located in Waukegan, Illinois, on the western shore of Lake Michigan approximately 35 miles north of Chicago (Figure 5). The base of disposed CCRs in the East and West Ash Ponds (Figure 5) is at 585 feet above mean sea level (AMSL; Geosyntec, 2016). The depth to groundwater at the ash ponds is gauged in CCR monitoring wells MW-1 through MW-4 and MW-16 (Figure 5) at least twice per year. The wells are located atop the ash pond containment berm at elevations of between 604 and 608 feet AMSL. Groundwater elevations measured in those wells tend to rise and fall together, and the measurements for well MW-4 (Table 1) are representative of the patterns described below. The hydrograph for well MW-4 (Figure 6) that I produced from the Table 1 data displays a pattern of decreasing groundwater elevations from mid-2011 through the end of 2012, followed by generally rising water levels that also display cyclic variations due to seasonal precipitation patterns. Specifically, the approximately 4-foot rise of the average groundwater elevation at well MW-4 (Figure 6) mirrors the 4-foot rise in adjacent Lake Michigan (Figure 7), which is exactly the hydraulic response expected for a water-table aquifer that is in direct hydraulic connection with a large body of surface water. Figure 6 also shows the elevation of the base of disposed CCRs at well MW-4, indicating that (1) the 5-foot separation criteria has been violated during most of the period since mid-2011, and (2) the ongoing rise in Lake Michigan's elevation (plus projected increases in annual precipitation in the USA's upper Midwest) has reduced the separation of CCRs and groundwater from roughly 5.5 feet to approximately 1 foot at present.

Figure 5: Site layout and monitoring well locations at the WPS [Image from KPRG, 2020]



The WPS 2015 annual groundwater monitoring report states correctly that *"there has also been an overall general rise in water levels in all wells since the fourth quarter 2012"* (NRG Energy, 2016, page 2). Figure 8 was provided as an appendix to that report, and it shows that all wells at the WPS site show similar cyclic patterns of seasonal variations (e.g., highest levels in the second quarter) plus the general rise reported by NRG Energy. However, there is no mention of the proximity of the water table relative to the disposed CCRs, and a different consultant took over monitoring and reporting duties in 2016 (through present). The current consultant provides no mention of the separation between CCRs and the water table, provides no narrative acknowledgement of ongoing rise in water levels, provides no hydrographs, and does not acknowledge ongoing rise of adjacent Lake Michigan (e.g., KPRG, 2020). Most disturbing is the WPS' owner/operator certification that *"The East and West Basins are so located so that there will not be intermittent, recurring, or sustained hydraulic connection between any portion of the base of the Basins and the uppermost aquifer due to normal fluctuations in groundwater elevations"* (Geosyntec, 2018). If the EPA or its proxy is not motivated and vigilant independent of routine monitoring and reporting by the owner/operator, then no violations of the 5-foot separation criteria would be recognized. Proposed § 257.150(b) does nothing to correct this specific situation, and in fact I opine that the language would actively discourage either

the permitting authority or the owner or operator from recognizing and correcting violations of the 2015 CCR Rule (including by closure of the CCR unit).

Table 1: Groundwater elevation measurements for WPS monitoring well MW-4 [Data are from NRG Energy (2016) and KPRG (2020). Different values for the top of casing (TOC) elevation presumably represent subsequent surveyor measurements, and MSL is mean sea level.]

Date of Groundwater Measurement	Top of Casing (TOC) Elevation (feet above MSL)	Ground Elevation (feet above MSL)	Depth to Groundwater (feet below TOC)	Groundwater Depth in Feet Below Surface	Groundwater Elevation (feet above MSL)
6/13/2011	603.15	603.53	19.80	20.18	583.35
9/13/2011	603.15	603.53	21.96	22.34	581.19
12/6/2011	603.15	603.53	21.92	22.30	581.23
3/14/2012	603.15	603.53	21.95	22.33	581.20
6/18/2012	603.15	603.53	22.27	22.65	580.88
9/28/2012	603.15	603.53	23.60	23.98	579.55
12/19/2012	603.15	603.53	23.81	24.19	579.34
3/7/2013	603.15	603.53	22.79	23.17	580.36
6/6/2013	603.15	603.53	20.77	21.15	582.38
7/25/2013	603.15	603.53	21.82	22.20	581.33
11/4/2013	603.15	603.53	22.02	22.40	581.13
3/11/2014	603.15	603.53	21.28	21.66	581.87
5/16/2014	603.15	603.53	20.04	20.42	583.11
8/21/2014	603.15	603.53	21.46	21.84	581.69
11/6/2014	603.15	603.53	21.29	21.67	581.86
2/17/2015	603.15	603.53	21.01	21.39	582.14
4/21/2015	603.15	603.53	19.59	19.97	583.56
8/12/2015	603.15	603.53	20.83	21.21	582.32
11/2/2015	603.19	603.53	20.83	21.17	582.36
2/29/2016	603.19	603.53	20.70	21.04	582.49
5/2/2016	603.19	603.53	20.94	21.28	582.25
8/23/2016	603.19	603.53	22.69	23.03	580.50
12/2/2016	603.17	603.53	22.18	22.52	580.99
2/21/2017	603.17	603.53	22.36	22.70	580.81
5/15/2017	603.17	603.53	20.04	20.38	583.13
7/5/2017	603.17	603.53	21.46	21.80	581.71
9/11/2017	603.17	603.53	21.05	21.39	582.12
11/28/2017	603.17	603.53	21.54	21.88	581.63
5/30/2018	603.17	603.53	18.88	19.22	584.29
11/6/2018	603.17	603.53	19.96	20.30	583.21
5/14/2019	603.17	603.53	19.35	19.69	583.82
11/18/2019	603.17	603.53	19.36	19.70	583.81

Figure 6: Groundwater hydrograph for CCR monitoring well MW-4 [Graph produced from Table 1 data, CCR elevation information in Geosyntec, 2016, and Lake Michigan elevation information shown in Figure 7]

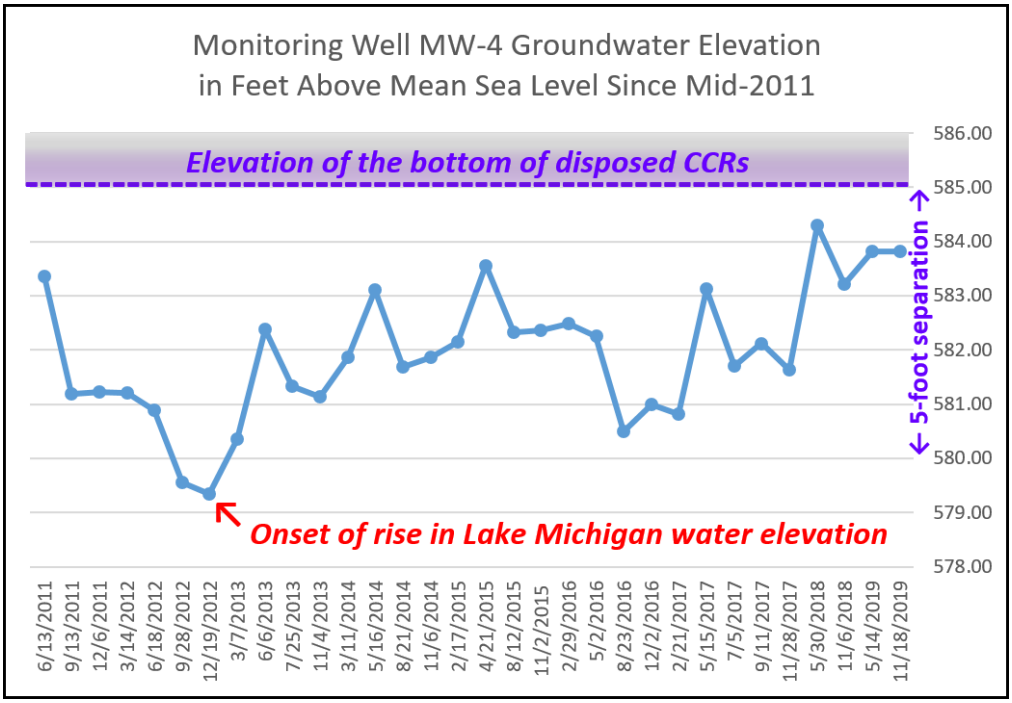


Figure 7: Hydrograph for Lake Michigan for the period 1860-03/31/2020) [Image modified from https://www.glerl.noaa.gov/data/wlevels/lowlevels/plot/MichHuron.jpg to superimpose and label a red-dashed line highlighting water level changes since early 2013.]

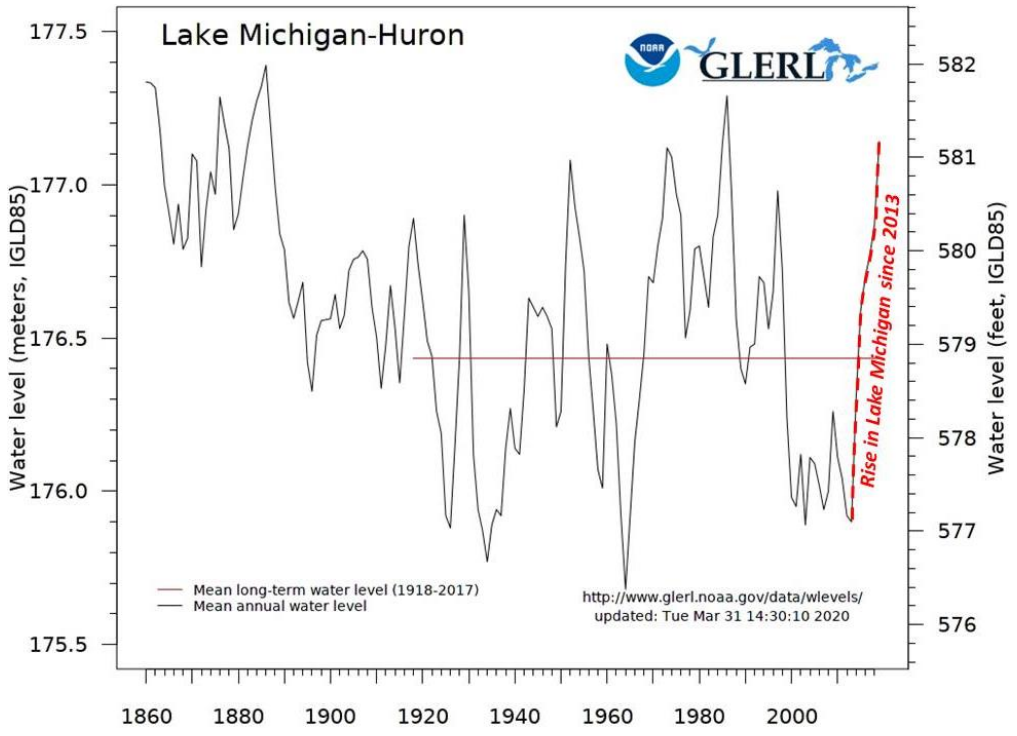
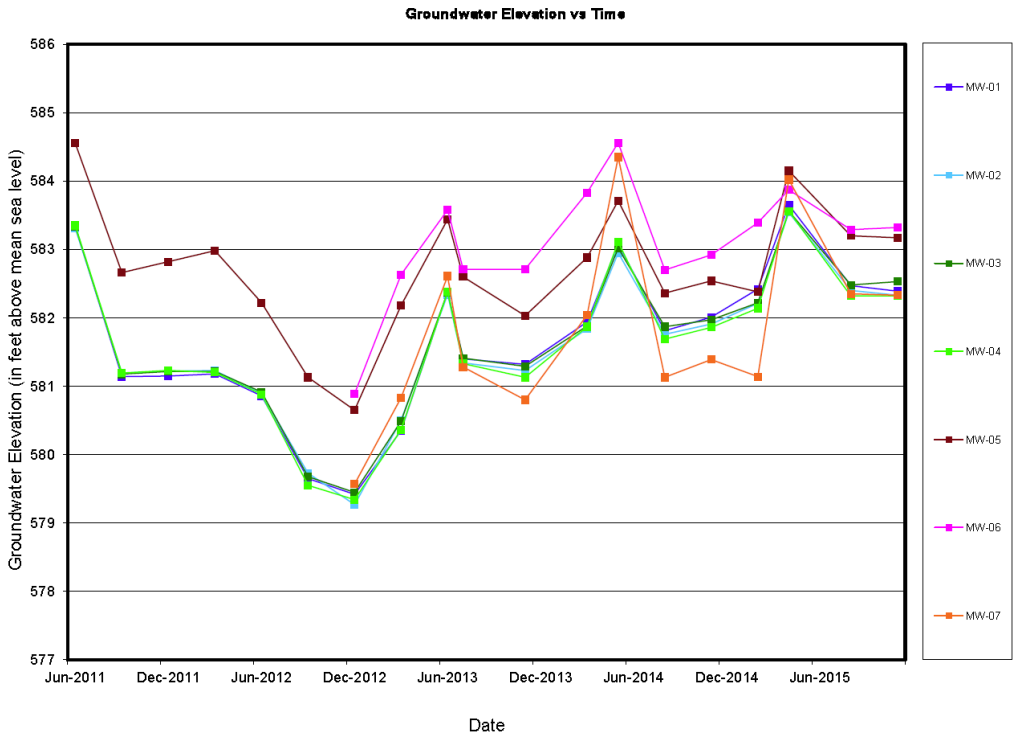


Figure 8: Groundwater hydrographs for 7 CCR monitoring wells at WPS for the period 6/2011-11/2015 [Image from NRG Energy, 2016]



Opinion: The situation at WPS illustrates why EPA's proposed § 257.150(b) is inappropriate as a general template for ongoing CCR monitoring, interpretation, compliance, and permitting. WPS' water-level data displays a clear response to, and correspondence with, ongoing rise of Lake Michigan (local and/or regional changes in precipitation) since 2012. The rise of groundwater elevation contravenes the 5-foot separation criteria, but the owner/operator fails to identify the separation distance, fails to evaluate the data trends, fails to identify a probably cause of the demonstrated rise, and fails to notify EPA or their proxy of the change in site conditions. The effort necessary by the owner/operator to perform the appropriate evaluation and notify the regulatory agency is trivial. I opine that, if anything, the EPA should *strengthen*, not weaken, the requirements for data collection, evaluation, and reporting changes in site conditions. In addition to strengthening the permit application process, I opine that the rule language should be modified to require a more complete accounting of compliance with the CCR-groundwater separation requirements, *and* the permitting authorities should be tasked with evaluating independently if there is a possibility of an intermittent, recurring, or sustained hydraulic connection between groundwater and disposed CCRs.

There are undoubtedly many other CCR facilities that have similar changes in siting conditions that are increasing the risk posed by disposed CCRs. For example, there are at least 16 different CCR facilities located along the shorelines of the Great Lakes, all of the Great Lakes are presently at or near record water elevations, and all of the lakes have been rising steadily since 2012 (e.g., NOAA-GLERL, 2020). As Figure 8 shows, lake levels are not "permanent", which is why the CCR facility owner/operator and the permitting authority must perform a new determination of site suitability and conditions as an integral part of the permitting process. As a specific example, the decommissioning plan for the coal ash ponds at the Edgewater Generating Station in Sheboygan, Wisconsin, advocates in-place abandonment of the disposed CCRs even though the facility is located on the shore of Lake Michigan, a physical and hydraulic situation identical to what I evaluated and described for the Waukegan Power Station. Similarly, the Monroe Power Plant in Monroe, Michigan, is located on the shore of Lake Eire, which is experiencing rising water levels that parallel those of Lake Michigan. Like Edgewater, the CCR ponds at the Monroe facility are also scheduled for in-place abandonment.

V. Summary of Expert Opinions and Recommendation

All five parts of section IV of this expert report identifies reasons that EPA's proposed rule at § 257.150(b) should not be enacted. Specifically, I opine that the proposed language conflicts with other rules or proposed rule changes; employs ambiguous and scientifically-unsupported language; encourages a don't ask-don't tell approach to data interpretation, reporting, and compliance; fails to alleviate any obvious or onerous problem with the existing 2015 CCR Rule; and encourages an owner/operator to ignore existing data that shows evidence of decreasing separation between disposed CCRs and the underlying groundwater. This expert report is focused on EPA's single example provided in the preamble to § 257.150(b), the violation of the 5-foot separation criteria between disposed CCRs and the water table surface of the underlying aquifer. In addition to the fallacy of applying the term "permanent" to the inherently dynamic character of water-table aquifer systems, EPA's term fails to acknowledge that a change such as flooding of disposed CCRs with groundwater can cause substantial environmental impacts and increases in risk without the water

table position remaining "permanent". The example that I provided of groundwater changes at the Waukegan Power Station due to the ongoing rise of Lake Michigan is a powerful reminder that CCR facility owner/operator are already collecting the data necessary to identify changes that increase risk from disposed CCRs, but the owners/operators are sometimes not properly evaluating, interpreting, or reporting those changes to the EPA or its regulatory proxy. In my opinion, CCR facility owners/operators are implicitly discouraged from doing so under EPA's Proposed Permitting Rule at § 257.150(b). Therefore, I recommend abandoning § 257.150(b) and redoubling efforts to employ properly the 2015 CCR Rule.

VI. Certification by Signature and Professional Seal

This expert report was prepared by Steven K. Campbell, Ph.D., a geologist and hydrogeologist licensed to practice geology by the states of North Carolina and Virginia.



Steven K. Campbell, Ph.D., P.G.



Appendix I: Curriculum Vitae for Steven K. Campbell, Ph.D., P.G.

Steven K. Campbell, Ph.D., P.G.

Education

Ph.D., Geology, Florida State University, Tallahassee, Florida (1994)
M.S., Geology, East Carolina University, Greenville, North Carolina (1985)
B.S., Geology, East Carolina University, Greenville, North Carolina (1981)

Professional Licenses and Certifications

North Carolina Licensed Professional Geologist #1414
Virginia Certified Professional Geologist #2801 001800
North Carolina Certified Well Contractor #2815-A (inactive)
MSHA Part 48 Surface Miner Training (24 Hours)
OSHA 40-Hour HAZWOPER Certified

Professional Affiliations

Geological Society of America (GSA)
American Geophysical Union (AGU)
National Ground Water Association (NGWA)
Colorado Scientific Society
New Mexico Geological Society (Lifetime)

Professional Experience

East Carolina University – Greenville, NC *(1999 through present)*

Adjunct Assistant Professor, Department of Geological Sciences

- *Physical Geology* and *Environmental Geology* - Developed and administered all class lectures and multi-media presentations, quizzes, and exams for 15 sections ranging from 14 to 110 students.
- *North Carolina Geology Field Course* - Design teaching exercises, update and edit each annual NCGFC Student Manual, provide field and classroom instruction, and lead field excursions during two weeks of a six-week, Senior-level course in geologic mapping and field methods. The NCGFC is taught each summer in Colorado and New Mexico, with an average class size of ~35 students, and ranging from 10 to 48 students. Developed and led new field exercises near Abiquiu and San Ysidro, New Mexico, in 1999, 2007, and 2017. Instruction has been provided to 26 different field courses (including FSU and ECU).

Consulting Geologist and Hydrogeologist – Winterville, NC *(2018 through present)*

- Provide geologic, hydrogeologic, and related consulting in support of litigation regarding environmental contamination resulting from coal mining, coal ash production and disposal, and related issues. Consulting has involved sites in the USA in the states of AL, AK, AZ, MD, MI, NC, PA, IL, IN, KY, and in Washington D.C., Australia, India, and South Africa.

Groundwater Management Associates, Inc. – Greenville, NC *(1994 through 2018)*

Senior Hydrogeologist

- Director of Environmental Services and manager of GMA's Greenville office.
- Managed projects involving environmental contamination, including petroleum and coal-related contamination of groundwater, surface water, and soil.
- Managed water resources exploration and development projects, and provide hydrogeologic technical support to other water-resources staff members.
- Project manager for North Carolina's first Aquifer Storage and Recovery (ASR) project.
- Provided hydrogeologic litigation support, expert report production, and (occasional) expert witness testimony for cases involving environmental contamination in the USA in the states of AL, AZ, MD, NC, PA, IL, and in India, and South Africa.

- Project manager and lead hydrogeologist for a seven-year contract with the Federal Trust Fund program (FTF) of NCDENR, DWM, UST Section, for numerous underground storage tank (UST) contamination sites located in the NC Coastal Plain and Piedmont.
- Provided technical oversight and review reports prepared by GMA's hydrogeology staff.
- Supervised and mentored GMA's hydrogeologists and environmental scientists.

Florida Geological Survey – Tallahassee, FL *(1991 through 1994)*

Geologist

- Interpreted and correlated thousands of meters of rock cores, well cuttings, and geophysical logs for deep (>0.75 km) injection wells and exploratory boreholes for the wastewater-disposal injection well program operating in southern Florida.
- Organized and edited a proprietary Geographic Information Systems (GIS) database of subsurface lithologic and geophysical logs for more than 3,800 wells and exploratory boreholes located throughout Florida.

Florida State University – Tallahassee, FL *(1988 through 1993)*

Instructor, Department of Geology

- Developed and administered all class lectures and multi-media presentations, quizzes, and exams for nine sections of an undergraduate-level course in physical geology. Class size was between 60 and 100 students.

East Carolina University – Greenville, NC *(1990)*

Visiting Assistant Professor, Department of Geology

- *Advanced Igneous Petrology* - Developed and administered all class lectures and multi-media presentations, quizzes, and exams for one section of a Graduate-level course to a class of 12 Geology M.S. students.
- *Physical Geology* - Developed and administered all class lectures and multi-media presentations, quizzes, and exams for one section of an undergraduate-level course to a class of approximately 35 students.

Tallahassee Community College – Tallahassee, FL *(1989 through 1994)*

Adjunct Instructor, Division of Mathematics and Science

- *Environmental Geology* - Developed and administered all class lectures and multi-media presentations, quizzes, and exams for two sections of a college-level course in environmental geology. Each class size was approximately 30 students.
- *Physical Geology* - Developed and administered all class lectures and multi-media presentations, quizzes, and exams for one section of a college-level course in physical geology. Class size was approximately 30 students.
- *Oceanography* - Developed and administered all class lectures and multi-media presentations, quizzes, and exams for two sections of a college-level course in oceanography. Each class size was approximately 30 students.
- *Earth Science* - Developed and administered all class lectures and multi-media presentations, quizzes, and exams for five sections of a college-level survey course introducing physical geology, meteorology, oceanography, and astronomy. Class size ranged between 60 and 100 students.

Florida State University – Greenville, NC *(summers of 1988, 1990 through 1993)*

Teaching Assistant, FSU Geology Field Course

- Coordinated logistical and teaching activities and exercises, provided ongoing instruction in the field and office, and lead or assist with regional field trips during all of a six-week-long, Senior-level course in field geology and field techniques that is taught each summer in New Mexico. Class size ranged from 12 to 35 students. Developed base maps and scope for a new field exercise in northern New Mexico in 1991.

Florida State University – Tallahassee, FL *(1986 through 1988)*

Teaching Assistant, Department of Geology

- *Structural Geology* **-** Developed and taught graphical and numerical solutions to structural problems, prepared relevant exercises, and prepared and administered laboratory exams for two sections of this majors-only laboratory course.
- *Mineralogy* **-** Developed and taught hand specimen and crystal model laboratory exercises, and prepared and administered laboratory exams for four sections of this majors-only laboratory course.
- *Petrology* **-** Assisted the lecture professor with teaching hand specimen and microscope laboratory exercises, and helped to prepare and administer laboratory exams for one section of this majors-only laboratory course.
- *Physical Geology* **-** Developed and taught mineral and rock hand specimen identification and other physical geology laboratory exercises, and prepared and administered laboratory exams, for four sections of this undergraduate course.

Florida State University – Tallahassee, FL *(1986)*

Research Assistant, Department of Geology

- Separated and purified minerals comprising igneous and metamorphic rocks, prepared and purified chemical reagents, used column chemistry to prepare pure separations of the elements rubidium (Rb) and strontium (Sr), and prepared sampled for analysis on a NBS thermal ionization mass spectrometer.
- Assisted with maintaining and operating the mass spectrometer, measuring Rb and Sr isotopic ratios that were used to date rocks and minerals, and determining Sr isotopic ratios used in petrogenetic studies.

Olin Chemical Corporation – St. Marks, FL *(1985)*

Quality Control Laboratory Technician

- Evaluated the chemical and ballistic properties of powder propellant supplied to the United States military using a variety of testing devices and statistical methods.

East Carolina University – Greenville, NC *(1982 through 1984)*

Teaching Assistant, Department of Geology

- *Mineralogy* **–** Assisted a professor with teaching a combination lecture and laboratory course, and helped to prepare and administer exercises, quizzes, and exams for four sections of this majors-only laboratory course.
- *Petrology* **-** Assisted a professor with teaching a combined lecture and laboratory course, and helped to prepare and administer exercises, quizzes, and exams for four sections of this majors-only laboratory course.
- *Structural Geology* **-** Assisted a professor with teaching a combined lecture and laboratory course, and helped to prepare and administer exercises, quizzes, and exams for two sections of this majors-only laboratory course.

- *Field Methods* **-** Assisted a professor with teaching a combined lecture and laboratory course, and helped to prepare and administer exams for one section of this majors-only laboratory course.
- *Physical Geology* **-** Developed and taught mineral and rock hand specimen identification and other physical geology exercises, and prepared and administered laboratory exams, for three sections of this undergraduate laboratory course.

East Carolina University – Greenville, NC *(Summer of 1982)*

Teaching Assistant, North Carolina Geology Field Course

- Coordinated logistical and teaching activities and exercises, provided ongoing instruction in the field and office, and assisted with regional field trips during all of a six-week-long, Senior-level course in field geology and field techniques taught each summer in Colorado and New Mexico. Class size was 45 students.

Military Service

United States Air Force, Active Duty: 1973 through 1977 (Sergeant/E4)
United States Air Force, Active Reserves: 1983 through 1992 (Staff Sergeant/E5)
Avionic Communications and Navigational Systems Technician

Publications, Abstracts, and Presentations

Campbell, S.K., 2017, Impacts of Coal Mining and Ash Disposal on India's Water Resources: Towards Clean Energy Dialogue on Legal, Policy, and Scientific Issues of Coal Mining and Coal Fired Power Plants, Workshop by LIFE (India) and Earthjustice (USA), New Delhi, India.

Campbell, S.K., 1994, A geochemical and strontium-isotopic investigation of Laramide and younger igneous rocks in central Colorado, with emphasis on the petrogenesis of the Thirtynine Mile volcanic field: [Ph.D Dissertation] Florida State University, Tallahassee, Florida, 614 p.

Campbell, S.K., 1994, Geochemistry, Sr-isotopic composition, and distribution of the Wall Mountain Tuff and the Badger Creek Tuff, central Colorado: Geological Society of America Abstracts with Programs, v.26, no.6. p.7.

Campbell, S.K., 1988, Geology, petrology, and geochemistry of metamorphosed mafic and felsic dikes intruding the Lemon Springs pluton, southwestern margin of the Raleigh belt, North Carolina: Geological Society of America Abstracts with Programs, v. 20, no. 4, pg. 256.

Campbell, S.K., 1985, Geology, petrography, and geochemistry of the Lemon Springs pluton and associated rocks, Lee County, North Carolina: [M.S. Thesis] East Carolina University, Greenville, North Carolina, 132 p.

Campbell, S.K., and Kish, S.A., 1991, New K-Ar ages for the Oligocene Waugh Mountain volcanic center and constraints on timing of volcanism within the Thirtynine Mile volcanic field, central Colorado: Geological Society of America Abstracts with Programs, v. 23, no. 3, pg. 10.

Campbell, S.K., and Kish, S.A., 1989, Middle-Tertiary alkaline volcanism in the eastern Rocky Mountains: An example from the Waugh Mountain volcanic center, Thirtynine Mile volcanic field, central Colorado: Geological Society of America Abstracts with Programs, v. 21, no. 6, pg. 15.

Campbell, S.K., and Kish, S.A., 1989, Geochronological studies of the Lemon Springs pluton: Middle Paleozoic igneous activity and extent of Alleghenian metamorphism in the eastern North Carolina Piedmont: Geological Society of America Abstracts with Programs, v. 21, no. 3, pg. 7.

Campbell, S.K., Spruill, R.K., Pyne, R.D.G., Elks, R.D., and Wise, J.J., 2010, North Carolina's First Aquifer Storage Recovery (ASR) Program, Greenville Utilities Commission, Greenville, Pitt County, North Carolina: Water Resource Research Institute 2010 Annual Conference and North Carolina Water Resources Association Symposium, Raleigh, North Carolina.

Campbell, S.K., and Spruill, R.K., 1986, Geology, petrography, and geochemistry of the Lemon Springs pluton and associated rocks, Lee County, North Carolina: Geological Society of America Abstracts with Programs, v. 18, no. 3, pg. 214.

Holley, J.K., Campbell, S.K., and Spruill, R.K., 2015, Challenges and Lessons Learned in the Construction and Operation of Aquifer Storage Recovery (ASR) Wells, North Carolina AWWA-WEA, Contemporary Topics in Water/Wastewater Construction, Greenville, NC.

Holley, J.K., Campbell, S.K., Spruill, R.K., and Smith, K.A., 2015, The Hydrostratigraphic Framework of Onslow County, North Carolina, North Carolina AWWA-WEA, 14th Annual Spring Conference, Wilmington, NC.

Tull, J.F., Kish, S.A., Groszos, M.S., and Campbell, S.K., 1998, Laurentian magmatism of the Southern Appalachian Blue Ridge: Post-Iapetan rifting: Geological Society of America Bulletin, v. 110, no. 10, pgs. 1281 to 1303.

Scott, E.C., Matzke, N.J., Branch, G.,…, Campbell, S.K.,…,Chu, S.,…Hawking, S.W.,…Weinberg, S.,…Zegura, S.L., 2004, The Morphology of Steve: Annals of Improbable Research, July-August 2004, pgs. 24 to 29.

Kish, S.A., and Campbell, S.K., 1986, A middle Paleozoic plutonic terrane in the eastern Piedmont of North Carolina: Geological Society of America Abstracts with Programs, v. 18, no. 6, pg. 658.

Kish, S.A., Campbell, S.K., Groszos, M.S., and Tull, J.F., 1991, Geochemistry and petrology of metaigneous rocks in the Murphy syncline, Tate, Georgia: Geologic setting and origin: Geological Society of America Abstracts with Programs, v. 23, no. 1, pg. 53.

Kish, S.A., Groszos, M.S., Campbell, S.K., and Tull, J.F., 1989a, An igneous record of the opening and closing of the Iapetus ocean: Mafic igneous rocks of the eastern Laurentian margin -- western Blue Ridge of the southern Appalachians: Geological Society of America Abstracts with Programs, v. 21, no. 6, pg. 225.

Kish, S.A., Groszos, M.S., Campbell, S.K., and Tull, J.F., 1989b, Mafic metaigneous rocks within the Great Smoky Group and Murphy belt -- western Blue Ridge: Geologic setting and origin; Geological Society of America Abstracts with Programs, v. 21, no. 3, pg. 45.

Kish, S.A., Groszos, M.S., Tull, J.F., and Campbell, S.K., 1996, Post-Iapetan igneous activity of the Southern Appalachian western Blue Ridge: Geological Society of America Abstracts with Programs, v. 28, no. 2, pg. 18.

Whitehead, A.D., and Campbell, S.K., 2010, Greenville Utilities Commission Aquifer Storage and Recovery Project: Professional Engineers of North Carolina, PENC 2010 Raleigh Conference.

Litigation Testimony

Trial

2009 Expert witness testimony in the case of Clifford Keffer et al. Vs. S.H. Tevis et al., Circuit Court for Carroll County, Maryland, Case Number C-05-42864, Judge Lawrence B. Daniels presiding. Retained by Bruce C. Hill, Law Offices of Peter G. Angelos, Baltimore, Maryland.

Mediation

2008 Expert witness in mediation for the case of Gayle Queen, Donald J. Freeman, et al. Vs. Constellation Power Source Generation, Inc., Circuit Court for Baltimore City, Maryland, Case Number 24-C-07009389. Retained by Roy L. Mason, Murphy & Falcon, P.A., Baltimore, Maryland. Mediator was Howard S. Chasanow, former Judge in the Court of Appeals, 4th Appellate Circuit (Prince George's County, Maryland). (Settled 12/2008)

2007 Expert witness in mediation for the Administrative Hearing of G&S Land Company Vs. NCDENR-UST Section, Division of Waste Management, Office of Administrative Hearings 07 HER 1323. Retained by Mary MacLean D. Asbill and Alan H. McConnell, Kilpatrick Stockton, Raleigh, North Carolina. Mediator was Thomas R. West, former North Carolina Administrative Law Judge. (Settled 7/2008)

Deposition

2016 Expert witness deposition in the cases of State of North Carolina et al. Vs. Duke Energy Progress, LLC, Superior Court for Wake County, North Carolina, File Number 13-CVS-11032 *and* State of North Carolina et al. Vs. Duke Energy Carolinas, LLC, Superior Court for Mecklenburg County, North Carolina, File Number 13-CVS-14661. Retained by John Suttles, Southern Environmental Law Center, Chapel Hill, North Carolina.

2009 Expert witness deposition in the case of Clifford Keffer et al. Vs. S.H. Tevis et al., Circuit Court for Carroll County, Maryland, Case Number C-05-42864. Retained by Bruce C. Hill, Law Offices of Peter G. Angelos, Baltimore, Maryland.

2009 Expert witness deposition in the case of John Beazley et al. Vs. Carroll Independent Fuel Company, et al., Circuit Court for Baltimore County, Maryland, Case Number 03-C-07-004668. Retained by Bruce C. Hill, Law Offices of Peter G. Angelos, Baltimore, Maryland.

2008 Expert witness deposition in the case of Raymond Benson et al. Vs. Marex Corporation, et al., Circuit Court for Harford County, Maryland, Case Number 12-C-06-2996. Retained by Mary V. Koch, Law Offices of Peter G. Angelos, Baltimore, Maryland.

2007 Expert witness deposition in the case of Clifford Keffer et al. Vs. S.H. Tevis et al., Circuit Court for Carroll County, Maryland, Case Number C-05-42864. Retained by Mary V. Koch, Law Offices of Peter G. Angelos, Baltimore, Maryland.

ATTACHMENT 17

Geosyntec consultants

1420 Kensington Road, Suite 103
Oak Brook, Illinois 60523
Phone: 630.203.3340
Fax: 630.203.3341
www.geosyntec.com

PLACEMENT ABOVE THE UPPERMOST AQUIFER LOCATION RESTRICTIONS
EAST AND WEST ASH BASINS
WAUKEGAN STATION
OCTOBER 2018

Pursuant to Code of Federal Regulations Title 40, Part 257, Subpart D (40 CFR), Section 257.60 (Rule), Geosyntec Consultants (Geosyntec) prepared this report to document compliance with location restrictions related to placement above the uppermost aquifer for the existing East Ash Basin and West Ash Basin (the Basins) at the Waukegan Station (Site) in Waukegan, Illinois.

The work presented in this report was performed under the direction of Mr. Jesse Varsho, P.G., P.E., of Geosyntec in accordance with Section 257.60 of the Federal Coal Combustion Residual (CCR) rule. Ms. Jane Soule, P.E., reviewed this report in accordance with Geosyntec's senior review policy.

1. Federal Coal Combustion Residual Rule, 40 CRF 257

Section 257.60(a) of the Federal CCR rule states:

> "New CCR landfills, existing and new CCR surface impoundments, and all lateral expansions of CCR units must be constructed with a base that is located no less than 1.52 meters (five feet) above the upper limit of the uppermost aquifer, or must demonstrate that there will not be an intermittent, recurring, or sustained hydraulic connection between any portion of the base of the CCR unit and the uppermost aquifer due to normal fluctuations in groundwater elevations (including the seasonal high water table)." *40 CFR §257.60(a)*

"Normal Fluctuations" of the groundwater elevation is defined in the Preamble of the Federal CCR rule as:

> "including, but not limited to, seasonal or temporal variations, groundwater withdrawal, mounding effects, etc.…The phrase "normal fluctuations" has been used to clarify that EPA does not intend for the facility to account for extraordinary or highly aberrant conditions…Normal fluctuations can include those resulting from natural as well as anthropogenic sources. Natural sources that could affect groundwater levels include, but are not limited to precipitation, run-off, and high river levels." (80 Fed Reg. 74 at pg. 21362 (April 17, 2015) *Federal Register: Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule*)

2. Placement Above the Uppermost Aquifer Restriction Determination

The East and West Basins are so located so that there will not be intermittent, recurring, or sustained hydraulic connection between any portion of the base of the Basins and the uppermost aquifer due to normal fluctuations in groundwater elevations. Analysis that support this conclusion include:

- The 95 percent upper confidence limit (UCL), the seasonal high monthly average and the maximum uppermost aquifer groundwater elevations are below the base of the Basins and therefore do not intersect their base.

- Low permeability geomembrane liners (engineered liner systems) were constructed on the base and side slopes of the East and West Basins. The engineered liner systems will provide additional protection to prevent hydraulic connection between the base of the Basins and the uppermost aquifer in the event of unusually high fluctuations in groundwater elevation.

The locations of the East and West Basin are in compliance with the requirements in §257.60.

3. Limitations and Certification

This report was prepared in accordance with current practices and the standard of care exercised by scientists and engineers performing similar tasks in the field of civil engineering. The contents of this report are based solely on the observations of the conditions observed by Geosyntec personnel and information provided to Geosyntec by Midwest Generation. Consistent with applicable professional standards of care, our opinions and recommendations were based in part on data furnished by others, which was consistent with other information that we developed in the course of our performance of the scope of services. The information contained in this report is intended for use solely by Midwest Generation and their subconsultants.



Jesse Varsho, P.E.
Illinois Professional Engineer No. 062.067766
License Expires: 11/30/19

Geosyntec consultants

1420 Kensington Road, Suite 103
Oak Brook, Illinois 60523
Phone: 630.203.3340
Fax: 630.203.3341
www.geosyntec.com

WETLANDS LOCATION RESTRICTIONS
EAST AND WEST ASH BASINS
WAUKEGAN STATION
OCTOBER 2018

Pursuant to Code of Federal Regulations Title 40, Part 257, Subpart D (40 CFR), Section 257.61, Geosyntec Consultants (Geosyntec) prepared this report to document compliance with location restrictions related to wetlands for the existing East Ash Basin and West Ash Basin (the Basins) at the Waukegan Station (Site) in Waukegan, Illinois.

The work presented in this report was performed under the direction of Mr. Jesse Varsho, P.G., P.E., of Geosyntec in accordance with §257.61. Ms. Jane Soule, P.E., reviewed this report in accordance with Geosyntec's senior review policy.

1. Wetlands Location Restriction Determination

The East Ash Basin and West Ash Basin are not located in mapped wetlands included in the National Wetlands Inventory – Version 2 presented by the U.S. Fish and Wildlife Service (USFW) [USFW, 2018]. Therefore, the locations of the Basins are in compliance with the requirements outlined in §257.61(a).

2. Limitations and Certification

This report was prepared in accordance with current practices and the standard of care exercised by scientists and engineers performing similar tasks in the field of civil engineering. The contents of this report are based solely on the observations of the conditions observed by Geosyntec personnel and information provided to Geosyntec by Midwest Generation. Consistent with applicable professional standards of care, our opinions and recommendations were based in part on data furnished by others, which was consistent with other information that we developed in the course of our performance of the scope of services. The information contained in this report is intended for use solely by Midwest Generation and their subconsultants.



Jesse Varsho, P.E.
Illinois Professional Engineer No. 062.067766
License Expires: 11/30/19

3. References

USFS, 2018. "National Wetlands Inventory, Version 2," https://www.fws.gov/wetlands/data/Mapper.html, updated 1 May 2018, accessed 28 August 2018.

Geosyntec consultants

1420 Kensington Road, Suite 103
Oak Brook, Illinois 60523
Phone: 630.203.3340
Fax: 630.203.3341
www.geosyntec.com

FAULT AREAS LOCATION RESTRICTIONS
EAST AND WEST ASH BASINS
WAUKEGAN STATION
OCTOBER 2018

Pursuant to Code of Federal Regulations Title 40, Part 257, Subpart D (40 CFR), Section 257.62, Geosyntec Consultants (Geosyntec) prepared this report to document compliance with location restrictions related to fault areas for the existing East Ash Basin and West Ash Basin (the Basins) at the Waukegan Station (Site) in Waukegan, Illinois.

The work presented in this report was performed under the direction of Mr. Jesse Varsho, P.G., P.E., of Geosyntec in accordance with §257.62. Ms. Jane Soule, P.E., reviewed this report in accordance with Geosyntec's senior review policy.

1. Fault Areas Location Restriction Determination

The East Ash Basin and West Ash Basin are not located within 200 feet (60 meters) of a mapped Holocene-aged fault, as mapped by the United States Geological Survey (USGS) Quaternary Fault Database [USGS, 2018]. Therefore, the locations of the Basins are in compliance with the requirements outlined in §257.62(a).

2. Limitations and Certification

This report was prepared in accordance with current practices and the standard of care exercised by scientists and engineers performing similar tasks in the field of civil engineering. The contents of this report are based solely on the observations of the conditions observed by Geosyntec personnel and information provided to Geosyntec by Midwest Generation. Consistent with applicable professional standards of care, our opinions and recommendations were based in part on data furnished by others, which was consistent with other information that we developed in the course of our performance of the scope of services. The information contained in this report is intended for use solely by Midwest Generation and their subconsultants.



Jesse Varsho, P.E.
Illinois Professional Engineer No. 062.067766
License Expires: 11/30/19

3. References

USGS, 2018. "Quaternary Fault and Fold Database," https://earthquake.usgs.gov/hazards/qfaults/, accessed 28 August 2018.

Geosyntec consultants

1420 Kensington Road, Suite 103
Oak Brook, Illinois 60523
Phone: 630.203.3340
Fax: 630.203.3341
www.geosyntec.com

SEISMIC IMPACT ZONES LOCATION RESTRICTIONS
EAST AND WEST ASH BASINS
WAUKEGAN STATION
OCTOBER 2018

Pursuant to Code of Federal Regulations Title 40, Part 257, Subpart D (40 CFR), Section 257.63, Geosyntec Consultants (Geosyntec) prepared this report to document compliance with location restrictions related to seismic impact areas for the existing East Ash Basin and West Ash Basin (the Basins) at the Waukegan Station (Site) in Waukegan, Illinois.

The work presented in this report was performed under the direction of Mr. Jesse Varsho, P.G., P.E., of Geosyntec in accordance with §257.63. Ms. Jane Soule, P.E., reviewed this report in accordance with Geosyntec's senior review policy.

1. Seismic Impact Zones Restriction Determination

The East Ash Basin and West Ash Basin are not located within a seismic impact zone as defined in §257.53 and as mapped by the United States Geological Survey (USGS) [USGS, 2014]. Therefore, the locations of the Basins are in compliance with the requirements outlined in §257.63(a).

2. Limitations and Certification

This report was prepared in accordance with current practices and the standard of care exercised by scientists and engineers performing similar tasks in the field of civil engineering. The contents of this report are based solely on the observations of the conditions observed by Geosyntec personnel and information provided to Geosyntec by Midwest Generation. Consistent with applicable professional standards of care, our opinions and recommendations were based in part on data furnished by others, which was consistent with other information that we developed in the course of our performance of the scope of services. The information contained in this report is intended for use solely by Midwest Generation and their subconsultants.



Jesse Varsho, P.E.
Illinois Professional Engineer No. 062.067766
License Expires: 11/30/19

3. References

USGS, 2014. "2014 U.S. Geological Survey National Seismic Hazard Maps, PGA 2% in 50 Years," https://earthquake.usgs.gov/hazards/hazmaps/conterminous/index.php#2014, accessed 28 August 2018.

Geosyntec consultants

1420 Kensington Road, Suite 103
Oak Brook, Illinois 60523
Phone: 630.203.3340
Fax: 630.203.3341
www.geosyntec.com

UNSTABLE AREAS LOCATION RESTRICTIONS
EAST AND WEST ASH BASINS
WAUKEGAN STATION
OCTOBER 2018

Pursuant to Code of Federal Regulations Title 40, Part 257, Subpart D (40 CFR), Section 257.64, Geosyntec Consultants (Geosyntec) prepared this report to document compliance with location restrictions related to unstable areas for the existing East Ash Basin and West Ash Basin (the Basins) at the Waukegan Station (Site) in Waukegan, Illinois.

The work presented in this report was performed under the direction of Mr. Jesse Varsho, P.G., P.E., of Geosyntec in accordance with §257.64. Ms. Jane Soule, P.E., reviewed this report in accordance with Geosyntec's senior review policy.

1. Unstable Areas Restriction Determination

The East Ash Basin and West Ash Basin are not located in unstable areas [Geosyntec, 2016]. Therefore, the locations of the Basins are in compliance with the requirements outlined in §257.64(a).

2. Limitations and Certification

This report was prepared in accordance with current practices and the standard of care exercised by scientists and engineers performing similar tasks in the field of civil engineering. The contents of this report are based solely on the observations of the conditions observed by Geosyntec personnel and information provided to Geosyntec by Midwest Generation. Consistent with applicable professional standards of care, our opinions and recommendations were based in part on data furnished by others, which was consistent with other information that we developed in the course of our performance of the scope of services. The information contained in this report is intended for use solely by Midwest Generation and their subconsultants.



Jesse Varsho, P.E.
Illinois Professional Engineer No. 062.067766
License Expires: 11/30/19

3. References

Geosyntec, 2016. Structural Stability and Factor of Safety Assessment, Ash Surge Basin and Bypass Basin, Powerton Station, October.

The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 18

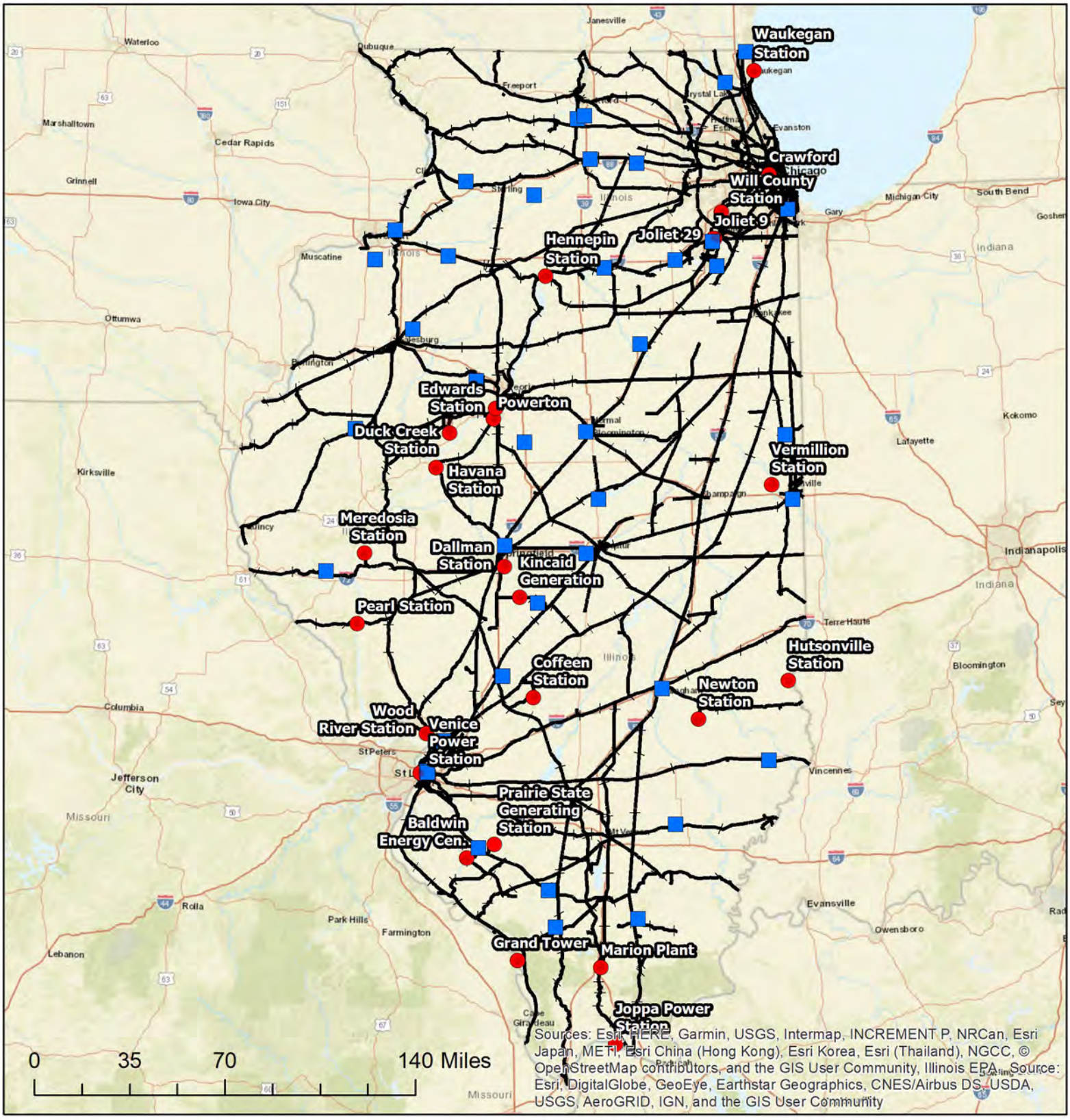
Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

Legend

- Power Plants
- Active_Landfills2016
- RailRoads
- Coal Ash Impoundment / Landfill

Statewide View



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

Northeast View



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

Waukegan



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

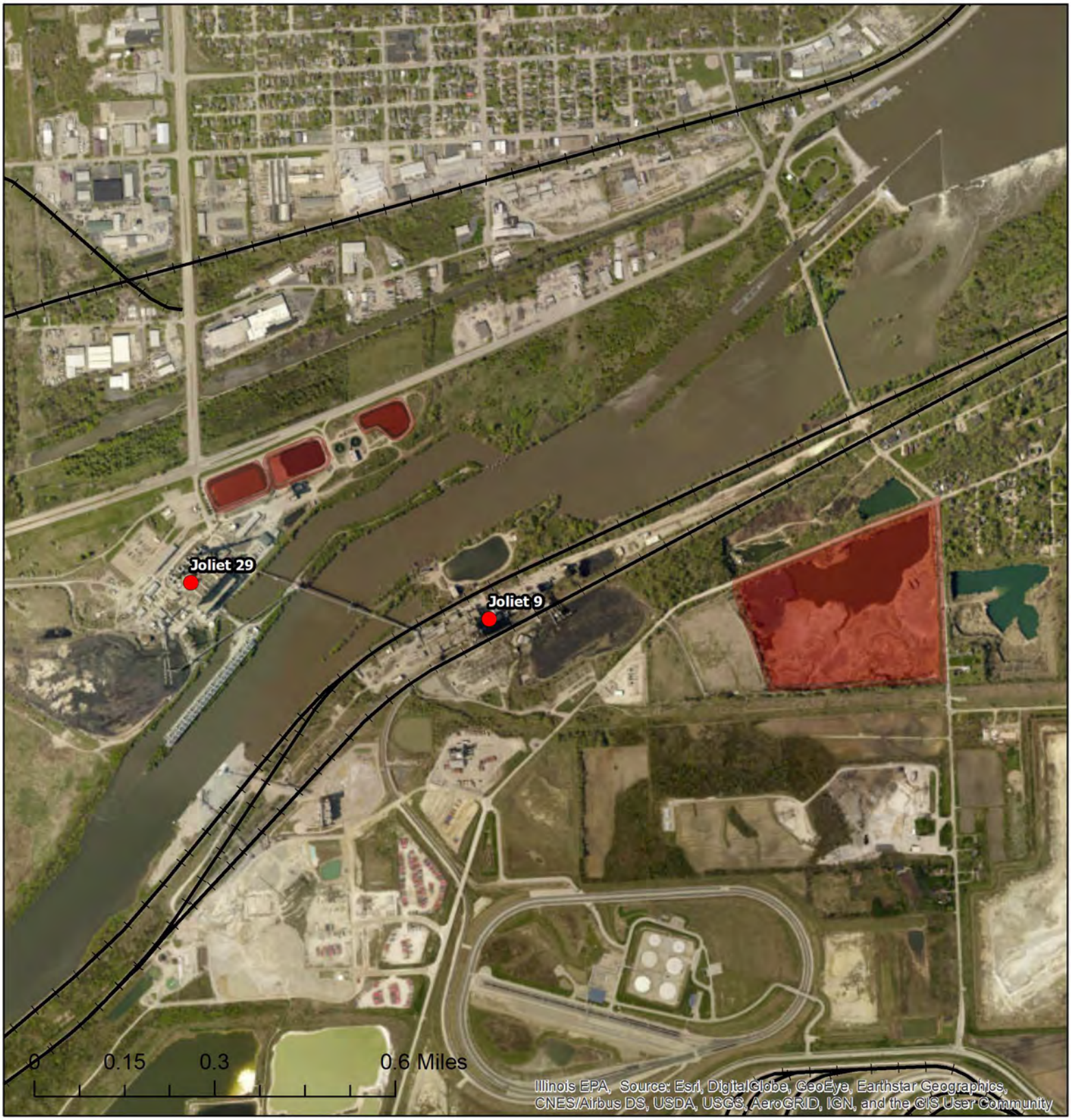
Will County



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

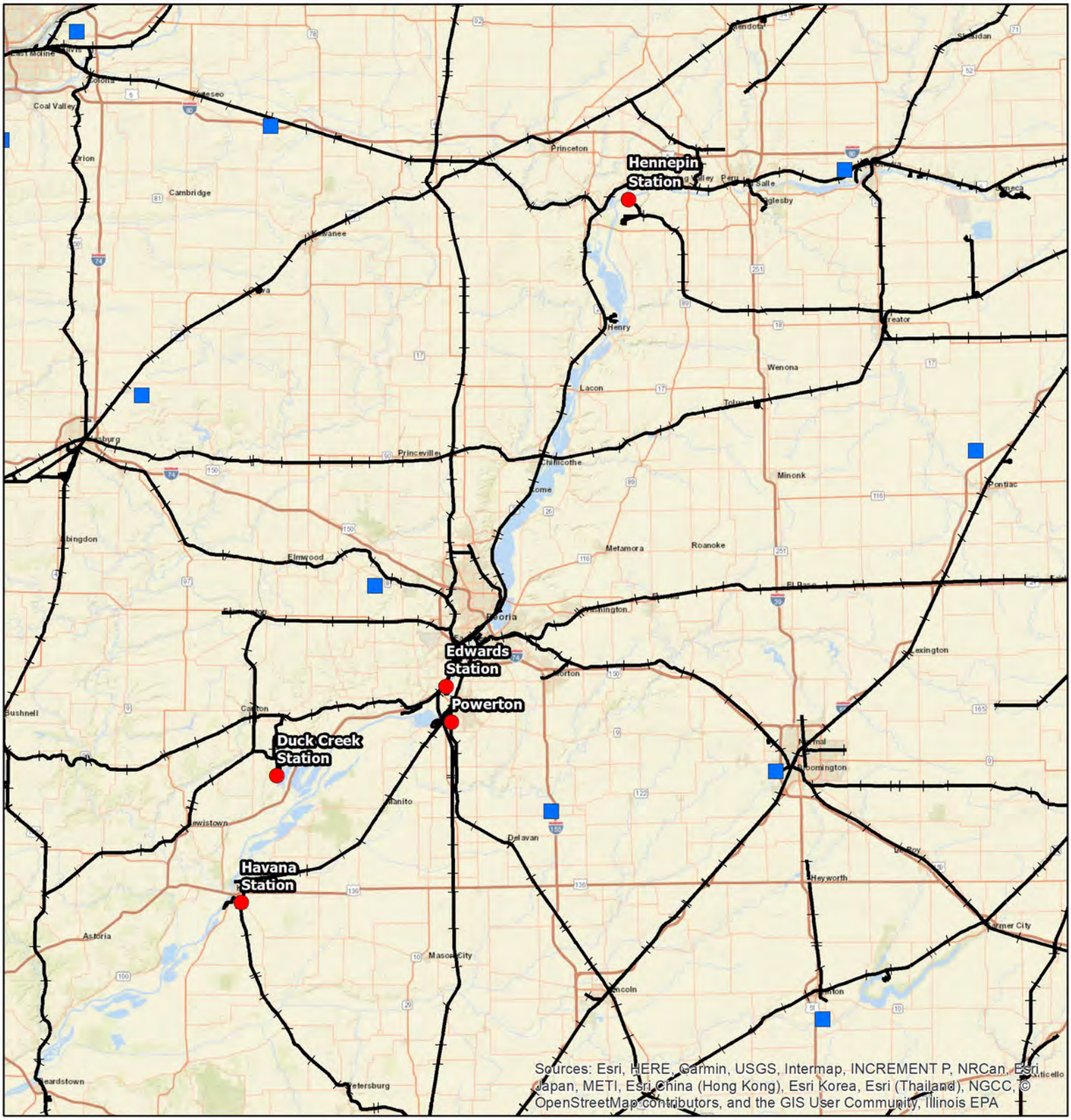
Joliet 9 & 29



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

North Central View



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

Hennepin



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

Edwards & Powerton



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

Duck Creek



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

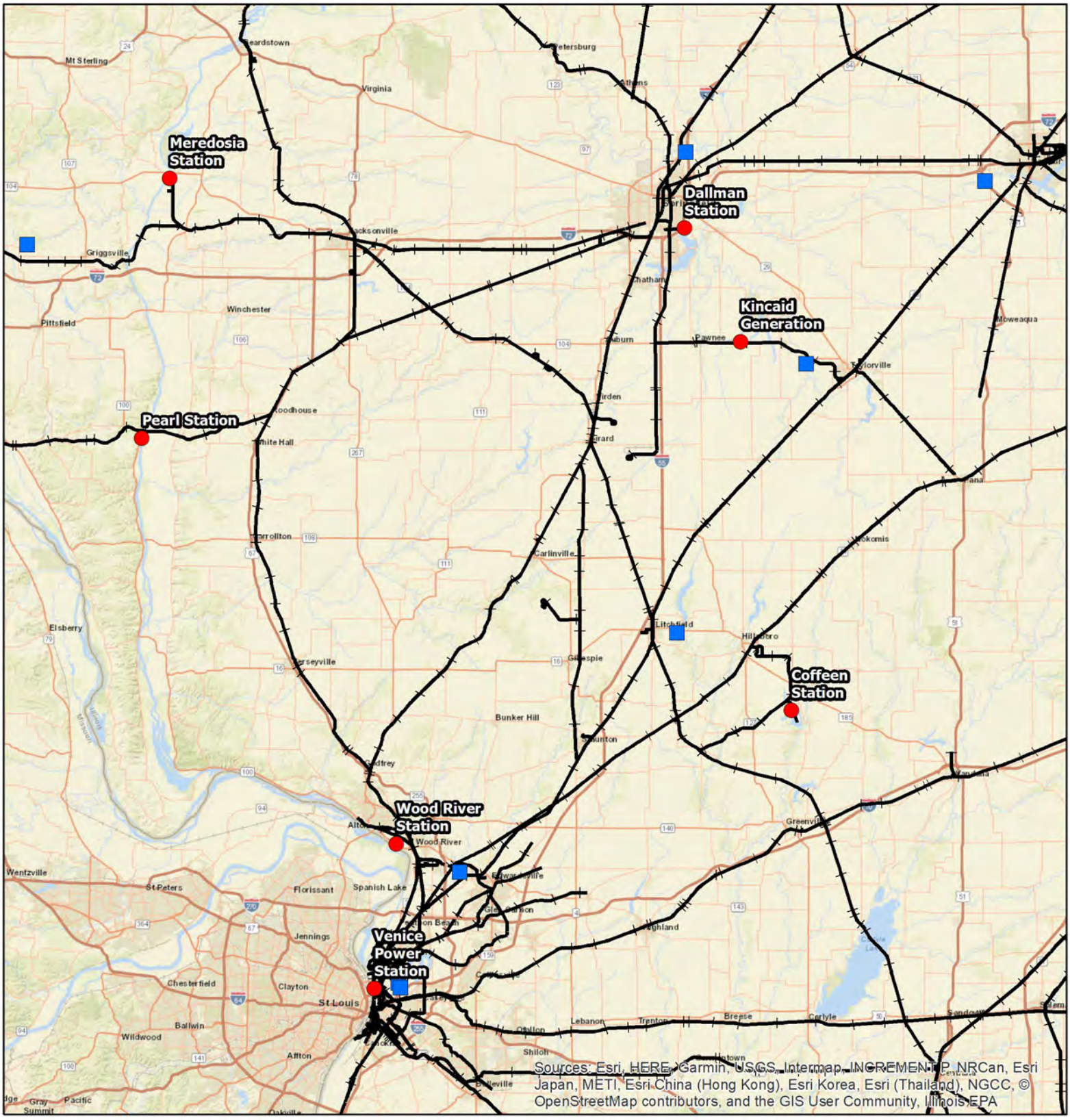
Havana



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

West Central View



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

Meredosia



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

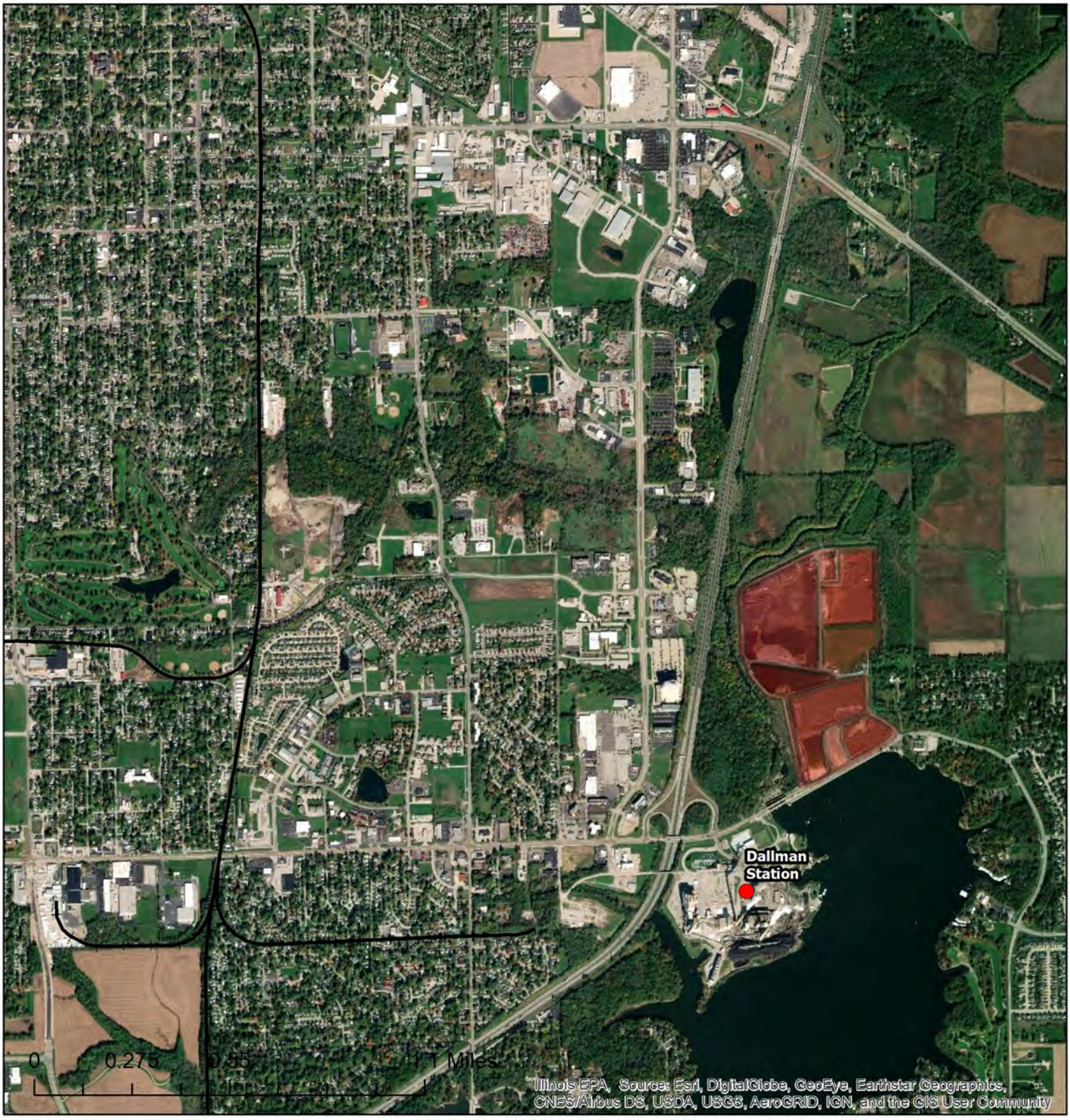
Pearl Station



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

Springfield / Dallman



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

Kincaid



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

Coffeen



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

Wood River



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

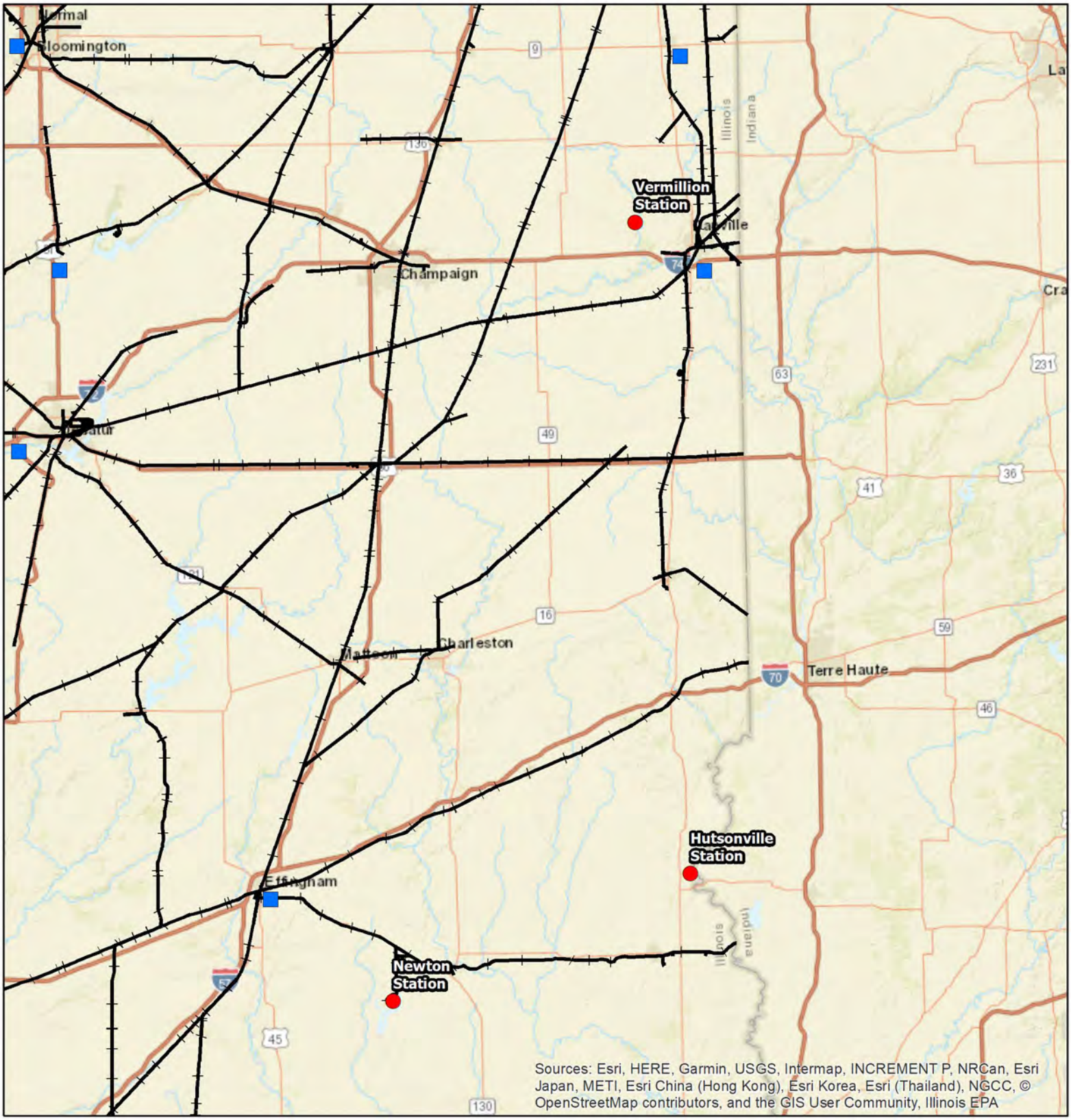
Venice



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

East Central View



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

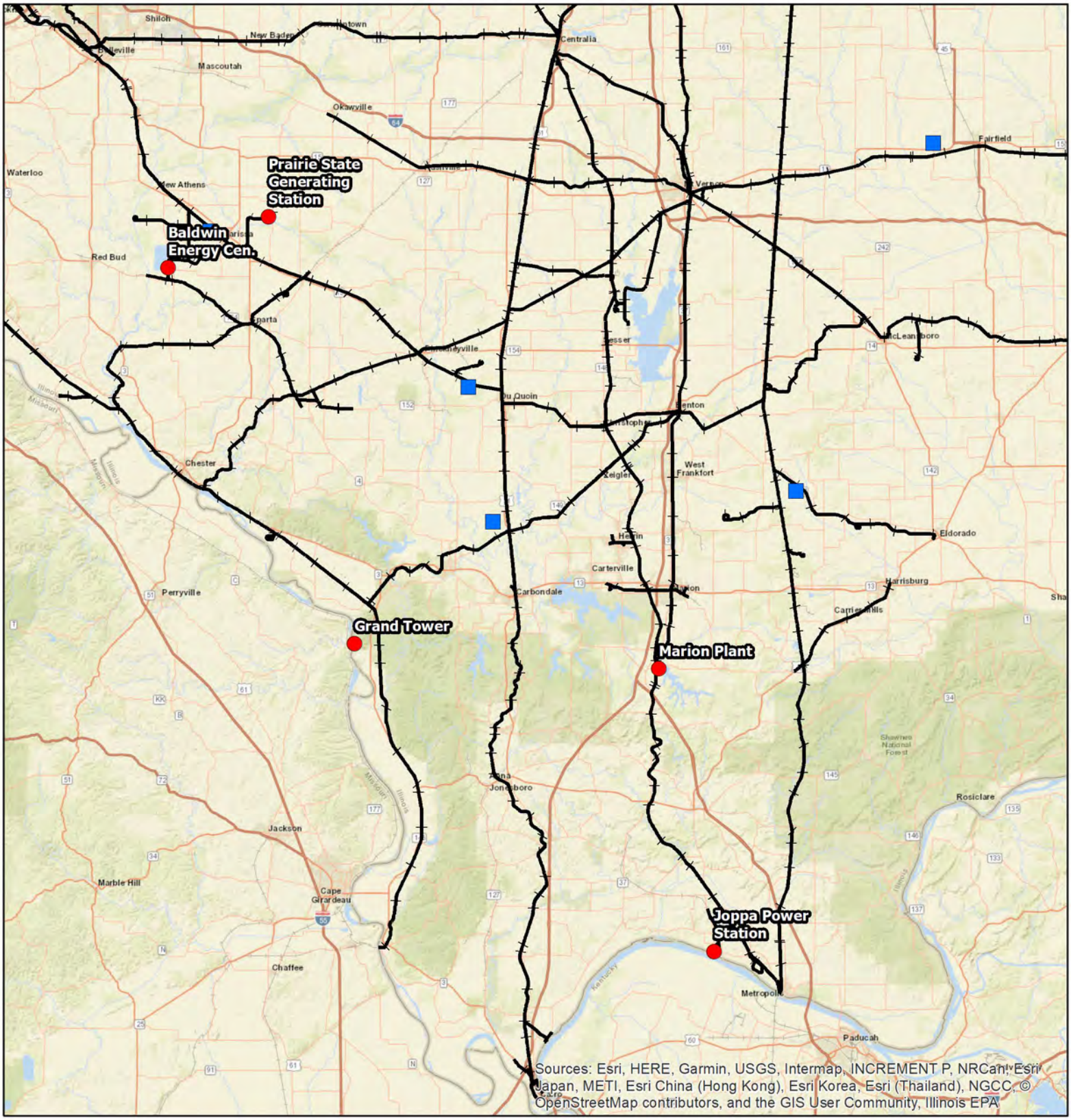
Newton



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

Southern View



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

Baldwin



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

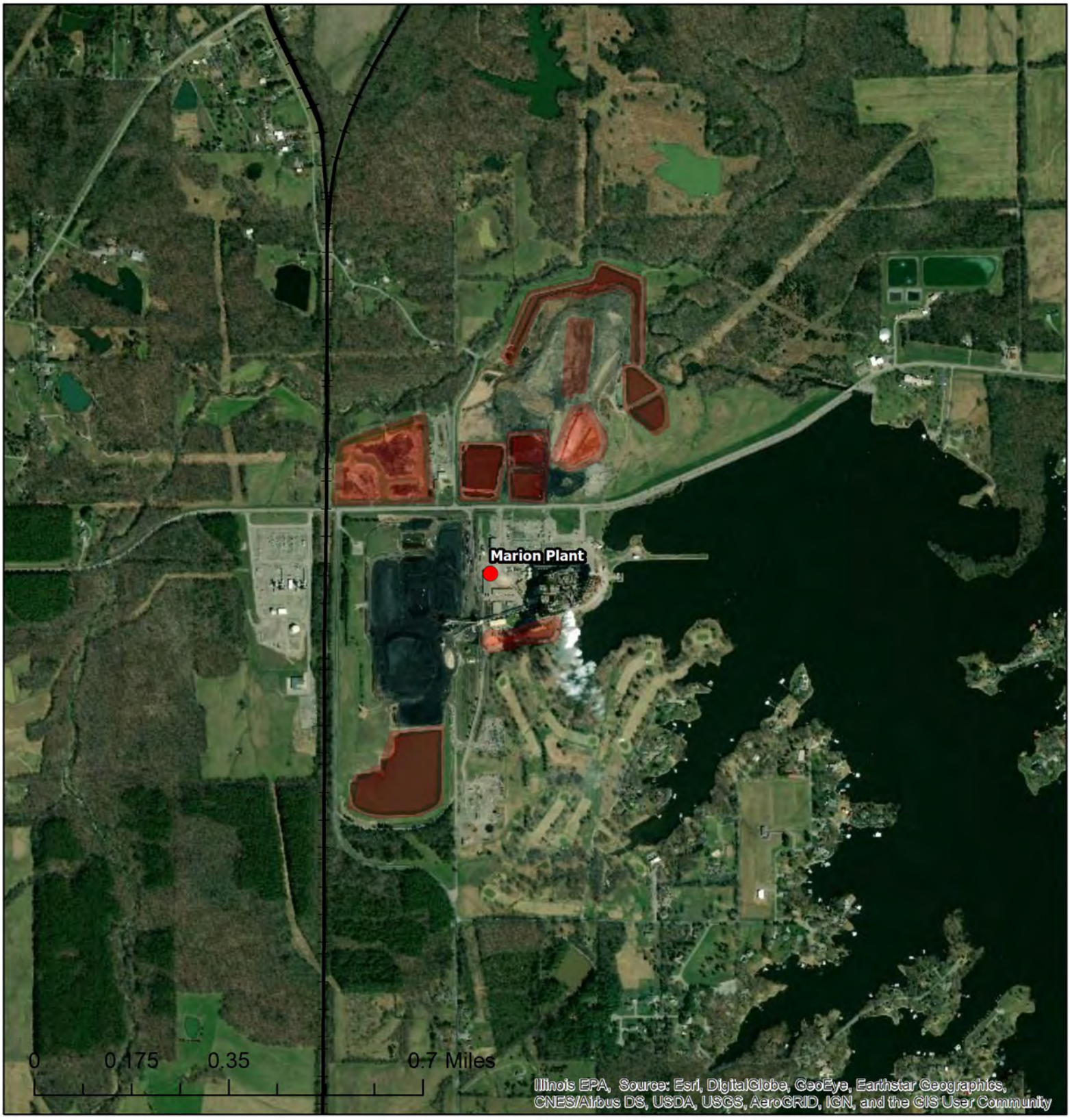
Prairie State Generating Station



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

Marion



Map of Illinois Rail Relative to Coal Ash

Rail data from IDOT Database
Landfill data from Illinois EPA
Coal Ash data from Prairie Rivers Network

Joppa



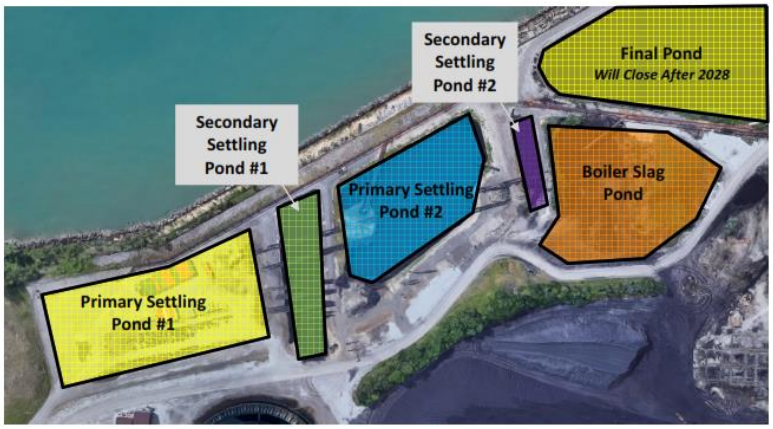
ATTACHMENT 19

Comments on Fugitive Dust Management and Lack of Air Monitoring As Part of Coal-Ash Removal Project at NIPSCO Michigan City Generating Station (MCGS)

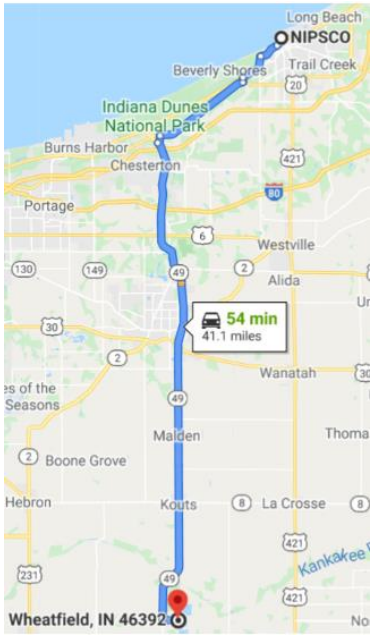
Introduction

NIPSCO plans to remove coal ash from five MCGS ponds shown in the figure below.

Estimated Area and Volumes	
Total Area	11.4 Acres
Ash Material	170,600 CY
Potential Beneficial Reuse	26,300 CY
Backfill Material	154,900 CY
Topsoil	9,200 CY



Per NIPSCO, ash will be beneficially reused or transported to a landfill at the RM Schahfer plant in Wheatfield, IN, roughly 41 miles away, per the route shown below.



Fugitive Dust Management

Given the nature of the activities, it should be assumed that dust (i.e., particulate matter (PM) of various sizes including PM10 and PM2.5) will be generated due to: ash removal from the ponds; processing after removal from the ponds such as drying to reduce moisture content; loadout onto haul trucks; during transportation; and during placement at the destination.

The only reference to any dust management in the closure documents is the following paragraph in Volume 1 of the Closure Application:

> Dust control will be a priority during the excavation performance as well as the CCR material transportation and former surface impoundment backfilling activities discussed in the following Closure Application sections. The contractor will be required to control and manage the dust throughout every phase of the project. The contractor will be required to meet the conditions of the MCGS's Air Quality Permit. A project specific Dust Control Plan will be one of the contractor's required submittals for performance of the excavation, transportation, and backfilling activities. This Dust Control Plan will be incorporated into NIPSCO's Annual CCR Fugitive Dust Control Plan.[1]

In addition, NIPSCO has prepared a document titled "Michigan City Generating Station Contractor Fugitive Dust Management Outline," whose purpose "is to describe how NIPSCO plans to manage fugitive dust during the Michigan City Generating Station (MCGS) Ash Pond Closure project." It is only an outline, however, and appears to provide direction to how a "Pond Closure Dust Management Plan" would be developed by the "civil contractor" for the project. Since it is not the plan itself but only an outline, it does not provide the necessary details to provide meaningful comments. As it stands, it is simply a conceptual document and the actual details of a fugitive dust plan, which will determine its effectiveness, are left to be developed by the contractor. As an outline, it is not enforceable because there are no quantitative targets nor required measures for how to achieve them – both being necessary elements of an effective plan.

While the elements of the plan, as noted in the outline are important, without far more detail they will not be effective since they are, at this point, just statements of purpose.

We provide below our initial comments on NIPSCO's outline of the future plan. The main outline elements are in italics followed by our comments.

[1] Wood, Surface Impoundment Closures (CCR Final Rule and RCRA Regulated), Closure Application, Volume 1 – Closure Plan and Drawings (Appendix A), December 18, 2018.

 Complete dust control is required at all times.

This is simply a "mission" statement, and it is not enforceable on its face.

 Provide sufficient water trucks for dust suppression at the project site. NIPSCO will have the right to direct the Civil Contractor to halt construction activities in the event of a dust suppression deficiency until the Civil Contractor addresses such deficiency.

"Sufficient" is not specific enough. The actual number of water trucks, their geographic responsibilities, the source of the water, as well as redundancies need to be specified. In the second sentence, since a "dust suppression deficiency" is not defined, it is too vague to be enforceable.

 Temporary stockpiles of material are to be monitored and covered with water as dust suppression or tarps as needed.

"Temporary" should be defined. How these will be "monitored" must also be specified.

 Considerations of what/how i.e., bed liners, leak-proof beds, sealed and locked tailgates, dog locks, covers/tarps, etc. the Civil Contractor proposes to use to prevent the CCR materials from spilling/leaking from the trucks during the hauling activity from MCGS to the landfill at RMSGS.

While this provides some good examples of what a leak-proof haul truck may need, it omits important additional aspects such as maintaining sufficient freeboard, minimizing vehicle speeds, how covers/tarps should be secured, etc. Again, more detail is required.[2]

o No vehicle shall be driven or moved on any public street, road, alley, highway, or other thoroughfare, unless such vehicle is so constructed as to prevent its contents from dripping, sifting, leaking, or otherwise escaping therefrom so as to create conditions which result in fugitive dust.

While this is an obviously desirable goal, how it will be implemented, detected, and therefore enforced is not discussed. Again, this is a "mission" statement.

o Fugitive dust emissions resulting from transportation of aggregate material by truck, front end loaders, or similar vehicles shall be controlled. Control measures may include one or more of the following:

 Tarping the vehicle.

[2] See, for example:

(i) Management approaches for Industrial Fugitive Dust Sources, Ontario, Canada, February 2017, available at https://www.ontario.ca/page/technical-bulletin-management-approaches-industrial-fugitive-dust-sources

(ii) City of Burbank, Fugitive Dust Control, available at https://www.burbankca.gov/home/showdocument?id=2874

 Maintaining the vehicle body in such a condition that prevents any leaks of liquid or aggregate material.

 Spraying the materials in the vehicle with a suitable and effective dust suppressant. All trucks moving aggregate material off-site must be tarped at a minimum.

 An alternate measure that provides equal or better control and approved by NIPSCO.

These are generic statements. Some don't make sense. For example how these methods will be used to control dust from front-end loaders is not clear since front-end loaders will presumably be used to move CCR waste in the ponds and possible also load the trucks. None of the options listed above would therefore apply as a practical matter. Terms such as "suitable and effective" and "equal or better" are too vague to be of any practical use.

o Fugitive dust emission resulting from activities involving CCR disposal shall be controlled. Control measures include the following:

 Hauling

 Wet suppression of the material being transported.

 Hauling the material covered.

 Minimizing the free fall distance when unloading from the particulate collection equipment and/or process equipment onto the hauling vehicle.

 An equivalent alternate measure that provides equal or better control and approved by NIPSCO.

 Unloading

 Applying water or suitable and effective chemical dust suppressant on an as needed basis to minimize visible emissions.

 Minimizing the free fall distance of the material.

 An equivalent alternate measure that provides equal or better control and approved by NIPSCO.

It is worth noting that "wet suppression" while desirable has to be carefully managed. Too much water added to the CCR will cause leaks in the trucks since it is almost impossible to maintain a liquid leak-free truck, especially if older trucks are allowed to be used. Bed liners are not perfect. "Minimizing" the free fall distance is vague. And, as noted earlier, "equal or better" is a meaningless comparison.

 Furnish a temporary truck wash system at MCGS and at RMSGS for use by the trucks before leaving each facility. The truck wash system will be a self-contained system to allow for better control of the washing, discharge of water, and accumulation of solids. The truck wash system should include a wheel wash with side curtains capable of containing the wash water within the unit.

A truck wash system is a conceptually good idea. However, its effectiveness depends entirely on its design and how it is used. Given that potentially many different types of haul trucks may be used to transport the CCR, without additional details, the effectiveness of the truck wash cannot be assessed at this time.

We also note that there is no discussion of pressure washing the sides of the truck so that materials that accumulate on the ledges and sides of the truck during loading at MCGG do not leave the site.

 Include GPS tracking equipment on the trucks used to haul the excavated CCR materials from MCGS to the landfill at NIPSCO RMSGS. Provide a submittal of the Civil Contractor's weekly reporting forms to ensure conformance with planned transportation routes.

Since the outline does not discuss the "planned" transportation routes and their appropriateness, the effectiveness of this measure is not clear.

 Include a procedure to address an abnormal visible dust event identified by NIPSCO's third party Dust Management Quality Assurance (DMQA) Contractor, NIPSCO, or the Civil Contractor.

NIPSCO intends to select a third-party DMQA as noted above and in the outline. However, this is not a substitute for actual air monitoring as discussed later in this document since it is presumed that this third-party effort will consist solely of periodic, visual, observations. PM2.5 is not typically visible to the eye. And, human observers cannot be present at all times at all activity areas. For example, NIPSCO states in the outline that this third-party contractor may "periodically" follow trucks along the route to ensure that no fugitive dust is released during hauling. But doing so "periodically" (and with notice) defeats the purpose since the contractor will undoubtedly make special efforts to be compliant during the known event. In addition, release of dust can occur when the site is not being actively worked, such as during a storm event at night. Detection of dust at such times may indicated the need for better ash storage practices, but this release would be missed if NIPSCO is entirely reliant on a third-party DMQA using visual monitoring on a periodic or occasional basis. Plus, a human observer cannot discern releases of PM2.5 during hauling simply by following a truck.

In summary, the outline provided by NIPSCO cannot be evaluated without substantially more detail that can only be included in the plan. This detail cannot be left to the contractor. NIPSCO should develop the plan and require the contractor to simply follow it. In addition, since the outline does not include any instrumented air monitoring, that is a significant deficiency. As noted above, simply hiring a third-party DMQA, as NIPSCO intends to do, does not substitute for actual air monitoring since the DMQA can only use visual means, at best, to determine the effectiveness of the dust suppression that is intended.

Air Monitoring

The discussion on dust management quoted above does not include any references to air monitoring. Ambient air monitoring is an essential aspect of any remediation project that has the potential to create PM/PM10/PM2.5 emissions that may affect not only the workers conducting the work but also members of the general public – at the sites themselves or during transportation.

The purpose of air monitoring is to ensure that the dust control approaches and techniques that will be used during remediation, transport, and placement are effective. Feedback from ambient air monitoring is often used to adjust or enhance dust control methods as needed.

A project-specific air monitoring plan should contain the following elements:

1. Scope – the plan should include baseline monitoring (i.e., pre-project monitoring) as well as monitoring during the project itself – for the entire expected duration of the project unless weather/precipitation events dictate that such monitoring can be suspended.

In addition, the monitoring should cover each aspect of the project including: activities at the MCGS, activities at RM Schahfer, and activities on the haul route, which passes through many areas where the public can be affected by dust released from the haul trucks.

2. Air Monitoring Strategy. The plan should clearly state the goals and objectives of the monitoring program and how they are to be achieved.

3. Pollutants. The monitoring should include continuous measurements for PM and PM2.5 as well as periodic sampling of metals and radionuclides (e.g., radium 226 and 226) from the dust collected in the PM monitors.

4. Monitoring Locations – The monitoring locations should include fixed and mobile monitors so that monitoring can be adjusted depending on the location of the activities. At least one or more fixed monitors should be located along the haul route to provide assurances that there is no dust entrainment when trucks pass through communities where the public can be exposed. As noted above, simply having a contractor follow a specific truck "periodically" is not sufficient to ensure that all haul trucks are properly cleaned, tarped, and therefore not releasing fugitive dust along the haul route. And, in addition to the actual pollutant monitors themselves, meteorological monitors should also be included at the MCGS and RM Schahfer locations, at a minimum.

By properly selecting the monitoring locations, false-positives can be avoided. For example, by having both upwind and downwind monitors (both of which can be moved, based on actual wind flow directions on any given day) across the working area, just the incremental dust from remediation activities can be measured, eliminating any other confounding factors. Similarly, for a fixed monitor located along the haul road, any impact from fugitive dust from a passing haul truck can be detected as a "spike" in the time history from such a monitor, if it is properly placed. If a haul truck passes and no (or an insignificant) increase of PM10/PM2.5 is detected then it can be assumed that the passing truck did not contribute to increased dust at the time of passage across the monitor. If, on the other hand, an increase or spike is observed at the time when a truck passes

the monitor, that is unambiguously attributable to the dust from the truck. These are examples where proper placement of the monitors will isolate just the dust from the remediation and hauling activities, avoiding any confounding impacts and false-positives.

5. Sampling Methods and Instruments. The monitoring plan should include details of the actual sampling methods and the instruments that will be used.

6. Sampling schedule. The frequency of analysis of the metals (suggested as monthly above) should be addressed.

7. Operational contingencies. The plan should address how weather conditions (i.e., wind speed) affects excavation, loading, hauling and disposal, and, in particular, when work must be temporarily halted due to weather conditions.

8. Placarding. The plan should describe how the haul trucks will be labeled to ensure first responders are aware of the hazardous nature of the material in the event of an accident or spill.

9. Worker training and protection. The plan should describe what training workers must receive prior to coal ash handling and transport and how workers will be protected from dust exposure.

10. Action Levels. The monitoring should discuss what constitutes an exceedance. For example, it is common to define an exceedance for PM as any increase greater than 50 ug/m3 between the upwind and downwind monitors. Similar levels should be defined for each of the pollutants, including metals.

11. Transparency. The monitoring plan should address how data will be disseminated to the Indiana Department of Environmental Management and to the public. In addition, the plan should discuss how exceedances of action levels will be addressed, including notices to the state and public.

12 . Finally, the monitoring should address quality assurance, notifications, and reporting obligations as well as defining the form of standard reports, etc.

An example of an air monitoring plan for a different project involving remediation of non-hazardous waste and transportation of the waste approximately three miles is provided in Attachment A. While the details will undoubtedly differ, the example simply shows what an air monitoring plan should include and the level of detail.

Attachment A – An Example of a Air Monitoring Plan for a Remediation Project

BMI COMMON AREAS
EASTSIDE DRY PONDS REMEDIATION

PHASE IIIB AIR MONITORING SUMMARY REPORT

Revision 1

Prepared for:

Basic Remediation COMPANY

HENDERSON, NEVADA

Prepared by:

TETRA TECH EM INC.
3380 AMERICANA TERRACE,
SUITE 201
BOISE, IDAHO 83706

6000 SOUTH EASTERN AVENUE,
SUITE 5A
LAS VEGAS, NV 89119

DECEMBER 30, 2009

TABLE OF CONTENTS

1.0 INTRODUCTION 1

2.0 SAMPLING APPROACH 3

2.1 SITE SELECTION AND LOCATIONS 3
2.2 SAMPLING EQUIPMENT CALIBRATION AND OPERATION 3
2.3 SAMPLE NOMENCLATURE 5
2.4 SAMPLE PARAMETERS 5
2.4.1 Organic Compounds 5
2.4.2 Total Suspended Particulate Matter and Metals 6
2.4.3 Asbestos 6
2.5 SIGNIFICANT SITE-RELATED EVENTS AND SAMPLING ANOMALIES 6

3.0 UPWIND AND DOWN WIND ANALYSIS 8

3.1 METEOROLOGICAL DATA SUMMARY 8
3.2 APPROACH 8
3.3 DETERMINE PREDOMINANT WIND DIRECTION 8
3.4 ASSIGN UPWIND/DOWNWIND STATIONS 9
3.5 COMPARE UPWIND/DOWNWIND RESULTS 9

4.0 ANALYTICAL RESULTS 10

4.1 TSP AND METALS RESULTS 10
4.2 ORGANIC COMPOUND RESULTS 12
4.3 ASBESTOS RESULTS 15
4.4 STATISTICAL COMPARISON OF UPWIND AND DOWNWIND CONCENTRATIONS 16

5.0 REFERENCES 19

APPENDICES

A NEVADA DIVISION OF ENVIRONMENTAL PROTECTION COMMENTS AND BRC RESPONSES TO COMMENTS

B FIELD DOCUMENTATION FORMS

C CALIBRATION AND SAMPLE VOLUME CALCULATION WORKSHEETS

D CD CONTAINING LABORATORY ANALYTICAL AND ECVP REPORTS, TABLE 3, AND REPORT

TABLES

1 SAMPLE COLLECTION SAMPLE HANDLING AND ANALYSIS SPECIFICATIONS FOR EASTSIDE DRY PONDS AREA AIR-SAMPLING STATIONS, HENDERSON, NEVADA

2 METEOROLGICAL DATA RECORD DURING EASTSIDE DRY PONDS AREA AIR SAMPLING JANUARY 23 – JUNE 25, 2009 HENDERSON, NEVADA

3 EASTSIDE DRY PONDS AREA AIR SAMPLING SUMMARY DATA, HENDERSON, NEVADA (ON CD)

TABLE OF CONTENTS (cont.)

4 SUMMARY STATISTICS AND RESULTS FOR PAIRED-DIFFERENCE TESTS COMPARING CHEMICAL CONCENTRATIONS IN UPWIND AND DOWNWIND SAMPLES EASTSIDE DRY PONDS AREA

FIGURES

1 AIR MONITORING STATION LOCATIONS

2 RAW OUTPUT FOR STATISTICAL COMPARISONS OF UPWIND AND DOWNWIND RESULTS FOR EASTSIDE DRY PONDS AIR MONITORING RESULTS

1.0 INTRODUCTION

Basic Remediation Company (BRC) retained Converse Consultants (Converse) and Tetra Tech EM Inc. (Tetra Tech) to complete a 5-month air sampling project to evaluate emissions resulting from the remediation (via excavation) of wastes from the dry ponds area (DPA) located in the Eastside area of the Basic Management Inc. (BMI) Common Areas located in Clark County, Nevada.[1] These ponds were located generally east of the sewer line alignment. This air sampling project is one phase of a 3-phased approach to evaluate air emissions from waste material hauling, dry/moisture-controlled pond excavations, and CAMU STA excavations. Reports on the other two phases – namely dealing with waste hauling across the haul road (Phase IIIA) and remediation activities at the Corrective Area Management Unit (CAMU) Slit Trench Area (Phase IIIC) have been submitted by BRC and approved by the Nevada Division of Environmental Protection (NDEP) previously.

Tetra Tech set up two temporary air-monitoring stations at the Eastside DPA and collected air samples over a 5-month period from January 6 through January 20 and again on July 3 through October 20, 2009. The 5-month period covered a substantial portion of the work associated with mass excavation and remediation of the Eastside DPA. Ambient samples at the downwind site BMI06 were collected over the entire sample period from January 6 through January 20 and July 3 through October 20, 2009. Ambient samples at the upwind site BMI11 were collected from January 6 through January 20, 2009. During the second phase of the IIIB monitoring from July 3 through October 20, 2009 ambient samples at the upwind site were collected from BMI08, which is approximately 800 feet west of BMI11. The upwind site location was changed due to safety and security reasons but still provided qualitative measurements for upwind samples, given that the bulk of the remediation activity moved from east to west during execution. Equipment was set up at each of the two stations to collect ambient air samples over a twenty-four hour (hr) period. In addition, meteorological data was collected during each sample event.

The sampling parameters were based on the BRC *Perimeter Air Monitoring Plan* (PAMP) (October 2008) and *Revised Draft BMI Complex Air Quality Monitoring Project – Phase III – Summary of Sampling Approach and Chemicals of Concern at Eastside and CAMU Areas* (Tetra Tech October 2008)

[1] Although the waste materials in the ponds were initially dry, BRC conducted appropriate pre-wetting of these ponds and implemented water management activities during remediation in order to minimize dust emissions and thereby meet its dust-control permit obligations. In a sense, the purpose of this air monitoring is to confirm that such dust-mitigation activities were effective.

reviewed and approved by the NDEP. Two identical air-sampling stations were constructed and the sampling equipment at each site of the two sites consisted of the following:

- Three identical polyurethane foam (PUF) hi-volume federal reference method (FRM) samplers designed to collect samples on three PUF cartridges for analysis of organic compounds contained in the U.S. Environmental Protection Agency (EPA) Compendium Methods TO-4, TO-9 and TO-13.
- One portable BGI PQ100 low-volume FRM (PQ100) sampler designed to collect samples on 47mm Teflon filters for analysis of total suspended particulate (TSP) and total metals contained in the U.S. EPA compendium methods IO-3.3 X-Ray Florescence.
- One SKC Model 224-PCXR8 (SKC) low-volume sample pump designed to collect samples on mixed cellulose ester (MCE) filters for analysis of asbestos using National Institute for Occupational Safety and Health (NIOSH) Method 7400 for phase contrast microscopy.
- One Honda EB 6500 gasoline-powered generators (or equivalent).

This report summarizes sample collection, analyses methodology, and analytical data collected between January 6 through January 20 and July 3 through October 20, 2009. The sampling approach, methodology, and summary of activities are presented in Section 2.0. The upwind/downwind analysis is presented in Section 3.0. The analytical data results and statistical analysis are presented in Section 4.0. Nevada Division of Environmental Protection comments and BRC responses to comments are provided in Appendix A; Field documentation forms are provided in Appendix B; calibration and sample volume calculation worksheets are provided in Appendix C; a CD containing laboratory analytical and electronic comprehensive validation reports, an electronic copy of the report and Table 3 is provided in Appendix D.

2.0 SAMPLING APPROACH

Based on the nature of the DPA excavations, one upwind and one downwind air monitoring station was identified in the Eastside DPA to collect air samples during the excavation of the dry, moisture-controlled management ponds. Each sample event included a 24-hour sample at each monitoring station collected twice per week. BMI06 downwind samples were collected from January 6 through January 20 and July 3 through October 20, 2009; BMI11 upwind samples were collected from January 6 through January 20, 2009; and BMI08 upwind samples were collected from July 3 through October 20, 2009.

2.1 SITE SELECTION AND LOCATIONS

Based on the prevailing wind direction, available ground space, and safe access at the Eastside DPA, BMI06 air monitoring station was placed to the north and BMI11 and BMI08 air monitoring stations were placed along the south side of the Eastside DPA. Sample sites BMI11 and BMI08 were located to represent potential upwind conditions while BMI06 was located to represent potential downwind conditions. The air monitoring station locations are provided in Figure 1.

2.2 SAMPLING EQUIPMENT CALIBRATION AND OPERATION

Tetra Tech assembled and calibrated the PUF, PQ100, and SKC air samplers prior to sample collection and after equipment had been serviced (battery changes). All samplers were calibrated using National Institute of Standards and Testing (NIST) or other authoritative reference certified equipment.

The initial calibrations on the PUF, BGI PQ100, and SKC samplers only required minor adjustments to set correct flow rates, but no major adjustments or equipment failures were observed. All equipment was checked again before sample collection began to ensure the correct flow rate(s) and timer operation.

Tetra Tech performed all calibrations according to EPA reference methods and all equipment was found to be within the calibration acceptance criteria prior to sample collection and equipment was operating within project goals. Equipment calibration worksheets are provided in Appendix B.

All PUF samplers were powered by portable gas-powered generators for each sample event. Samplers were set up and programmed at each station prior to sampling. Each station consisted of a sampling

platform and air samplers were secured to the platforms during the sample events. The sampling approach proposed by BRC and Tetra Tech and approved by NDEP was to collect 24-hr samples twice per week over a four month period during site excavation operations. It must be noted that a percentage of the PUF samplers ran for less than 24 hours.

All Phase IIIB samples collected and analyzed at each Dry Pond air monitoring station using EPA Methods TO-4, TO-9, and TO-13 were achieved using a portable on-site generator which had intermittent shutdowns and required refueling at least twice per sample event. The generator run-time varied for each sample event depending on ambient temperature and wind conditions. The generators were difficult to keep running continuously and had intermittent shutdowns due to motor stalling and wind gusts. In addition, each generator had to be refilled between 12-2 AM and again between 6-8AM. Each refilling took approximately 10 minutes.

The BMI Field team was instructed to collect samples for a 24-hour period based on the time run indicator on the battery-powered TSP/metals sampler. Therefore the TO-4, TO-9, and TO-13 samples were in most cases collected for slightly less than an actual 24-hour period.

Even though sample durations were less than 24-hours, the sample results were valid for the exposure period and represent an emission profile while work was being conducted. If a generator lost power, the TO-4, TO-9, and TO-13 sample would temporarily lose power and start back up when the generator began running again. Sample concentrations were not diluted or inherently decreased by a slightly shortened sample period. Furthermore, if emissions from site activities were occurring, they would be captured by the air monitoring stations. If PUF samplers lost power during a sample event, it was usually between 4 – 6 AM.

The first sample event occurred on January 6, 2009 and sampling continued through January 20, 2009, after which the equipment was relocated to the CAMU Slit Trench Area. The sampling resumed on July 3, 2009 and continued through October 20, 2009. All sample parameters were documented on BMI Site field documentation forms before and after each sample event. In total, 35 sample events were completed on the following dates:

- January 6, 9, 13, 16, 20, 2009
- July 3, 7, 10, 14, 17, 21, 24, 28, 31, 2009

- August 4, 7, 11, 14, 18, 21, 25, 2009
- September 2, 4, 11, 15, 18, 22, 25, 29, 2009
- October 2, 6, 9, 13, 16, 20, 2009

2.3 SAMPLE NOMENCLATURE

All samples collected at the Eastside DPA were given a sample ID according to the sample location and sample date as follows:

- BMI06-012009 (where BMI denotes site location, 06 denotes site #06 and 012009 denotes that sample was collected on January 20, 2009).

This sample nomenclature was used for all samples collected at the Eastside DPA and allows the reader to easily identify the location and date of the sample collection parameters.

2.4 SAMPLE PARAMETERS

Air samples were collected at the established monitoring stations for the analysis of site related chemicals including organochlorine pesticides, Polychlorinated Dibenzo-p-dioxins (PCDDs), Polychlorinated Dibenzo-p-furans (PCDFs), Polychlorinated biphenyls (PCBs), VOCs/SVOCs, TSP, metals, and asbestos fibers. Upon completion of each sample event, the samples and associated information was recorded on chain-of-custody (COC) sheets and submitted to the respective laboratories for analysis. The COC included the sample identification number, sample location, sample time, beginning and ending flow rate (to calculate sample volume) and the required analysis. For all samples collected at the Eastside DPA field blanks were collected on a frequency of 10 percent (one in 10 samples) for quality control purposes. The sampling and analysis procedures are summarized below. In addition, a summary of sample collection, sample handling, and analysis specifications procedures is provided in Table 1.

2.4.1 ORGANIC COMPOUNDS

At each sampling location, three PUF samplers were used to collect PUF samples for the analysis of organochlorine pesticides, PCDDs, PCDFs, PCBs, and VOCs/SVOCs using EPA Compendium Methods TO-4, TO-9, and TO-13. The PUF samplers draw approximately 0.2 standard cubic meters per minute of ambient air onto a 102 millimeter (mm) diameter quartz glass filter followed by a polyurethane foam plug and XAD resin contained in a glass cartridge. The actual sample rate varied based on sampler calibration, ambient temperature and pressure, and filter loading during the sample event, but sample flow rates were

within manufacturer's specifications. The TO-9 and TO-13 samples were analyzed using gas chromatography and mass spectrometry (GC/MS) and the TO-4 samples were analyzed using GC/Multi-Detector Detection (GC/MD). All PUF (organic) samples were submitted with COC form(s) to Air Toxics Ltd. Laboratory and Frontier Ltd. Laboratory for analysis. A summary of sample collection, sample handling, and analysis specifications procedures is provided in Table 1. All PUF sampler calibration and sample volume calculation spreadsheets have been provided in Appendix B.

2.4.2 TOTAL SUSPE NDED PARTICULATE MATTER AND METALS

At each sampling location, one PQ100 sampler was used to collect samples for TSP and metals. The PQ100 sampler draws approximately 0.0167 cubic meters per minute (approximately 24 total cubic meters) of ambient air onto the filter media. The TSP and metals samples were collected using 47 mm Teflon filter media and analyzed using USEPA Compendium Method IO-2.1 (gravimetric analysis). The TSP samples underwent additional analysis for metals using USEPA Compendium Method IO-3.3 X-Ray Fluorescence (Protocol number 6). All TSP and metals samples were submitted with COC form(s) to Chester Labnet Laboratory for analysis. A summary of sample collection, sample handling, and analysis specifications procedures is provided in Table 1.

2.4.3 ASBESTOS

At each sampling location, one SKC low volume sampler was used to collect samples for asbestos analysis using NIOSH Method 7400. The sampling system consisted of a low-flow pump attached to a 25-millimeter MCE filter. The SKC samplers draw approximately 1 liter per minute (lpm) (approximately 720 total liters) of ambient air onto the MCE filter. The samples were analyzed using NIOSH Method 7400 (Phase Contrast Light Microscopy). All asbestos samples were submitted with COC form(s) to AESL Laboratory for analysis. A summary of sample collection, sample handling, and analysis specifications procedures is provided in Table 1.

2.5 SIGNIFICANT SITE-RELATED EVENTS AND SAMPLING ANOMALIES

During the process of the Eastside DPA excavations, the following sampling anomalies were reported by Tetra Tech personnel and documented on field documentation sheets:

- The generator at BMI11 was stolen sometime during the weekend of January 10. An immediate replacement was unavailable from the rental company; therefore no sample was collected from BMI11 for the sample event on January 13, 2009.

- The TO-4 sample for BMI08 was not collected on August 7, 2009 due to a sample cartridge malfunction. The cartridge had slipped and became lodged in the unit.

- During the August 14, 2009 sample event, Tetra Tech field personnel were unable to access BMI06 as someone had incorrectly locked the gate bypassing Tetra Tech's padlock; Site personnel were unavailable to assist with unlocking the gate.

- The TO-13 sample for BMI08 was not collected on September 18, 2009 due to another sample cartridge malfunction.

- The generator at BMI08 was stolen sometime during the weekend of September 27. An immediate replacement was unavailable from the rental company; therefore no sample was collected from BMI08 for the sample event on September 29, 2009.

- The TO-9 sample for BMI06 was not collected on October 13, 2009 due to a sample shipment error from the laboratory.

- During the last sample event on October 20, 2009 the entire BMI remediation operation was shut down due to hazardous high wind conditions with winds gusting to over 30 mph.

3.0 UPWIND AND DOWN WIND ANALYSIS

Based on discussions with the NDEP and its consultants, Tetra Tech developed an approach for the assessment of upwind versus downwind air quality monitoring data collected during this air sampling project at the Eastside Site. The objective of the upwind/downwind evaluation was to evaluate if the DPA excavation operations contributed to the degradation of the existing air quality in the vicinity of the work area. This analysis was performed with a meteorological dataset of thirty-five sample events. Table 2 represents meteorological conditions measured during Eastside DPA sampling from January 6 through January 20, 2009 and July 3 through October 20, 2009.

3.1 METEOROLOGICAL DATA SUMMARY

The upwind/downwind evaluation was conducted using meteorological data and on-site data collected at sites BMI06, BMI08 and BMI11. Meteorological data including wind speed and direction were measured continuously at the on-site meteorological monitoring station operated by Tetra Tech near the Eastside entrance gate.

3.2 APPROACH

The general approach for conducting the upwind/downwind evaluation consists of the following steps:

- Determine predominant wind directions
- Assign upwind/downwind stations
- Compare upwind/downwind results
- Determine those air sample results that exceeded either the RBC or PRG screening criteria
- Conduct a statistical analysis

3.3 DETERMINE PREDOMINANT WIND DIRECTION

If the wind is variable, assigning a predominant wind direction may be subject to qualitative interpretations. Tetra Tech defined predominant wind direction based on the average wind direction as follows:

- The average wind direction occurred in the following five quadrants: South, southeast, southwest, west, and northeast

3.4 ASSIGN UPWIND/DOWNWIND STATIONS

Meteorological data was recorded for the duration of the 5-month sample event and the prevailing wind direction was generally from the southwest or the southeast. Two events were inconclusive with respect to upwind/downwind determination as average wind directions were out of the west and northeast. A summary of meteorological data during the sample events is presented in Table 2.

3.5 COMPARE UPWIND/DOWNWIND RESULTS

To meet project objectives the upwind concentrations of chemical constituents were compared to their corresponding downwind concentrations using two methods: 1) difference in concentration (in µg/m3), and 2) a matched-pairs design and resulting difference in concentration.

4.0 ANALYTICAL RESULTS

The air quality sample data collected at the Eastside DPA locations contains a wide range of chemical compounds as discussed earlier. All sample data was compared to EPA Region 3 risk-based concentrations (RBC) table (April 2006), EPA Region 9 preliminary remediation goals (PRG) table (October 2004), and EPA Region 6 human health medium-specific screening levels (MSSL) table (March 2008) to determine if ambient concentrations exceeded criteria. In most cases the RBC, PRG, and MSSL concentration values were either identical or very close.

The sample results demonstrate that a majority of organic (PUF) compounds were detected in measurable concentrations in ambient air at the Eastside locations. However, the majority of organic compounds did not exceed the RBC, PRG, or MSSL screening criteria. The compounds detected have been further evaluated. In addition, TSP, metals, and airborne fibers were detected.

A statistical analysis was completed for selected chemicals found in upwind and down samples using a matched-pairs design. Differences in chemical concentration (upwind-downwind) were evaluated for samples that had a valid ambient concentration for both the upwind and downwind sample.

A summary of laboratory and statistical analytical results for each subset of chemical compounds is provided below.

4.1 TSP AND METALS RESULTS

TSP was detected in all samples and concentrations ranged from 3.5 µg/m^3 to 117.4 µg/m^3. The average concentration was 19.8µg/m^3. No screening criteria or federal standards currently exist for TSP. A statistical analysis of the difference between 33 upwind BMI11 and BMI08 samples and 33 downwind BMI06samples demonstrated that there was no statistical increase at the downwind locations. A complete summary and statistical analysis of all TSP results are presented in Table 3 (Excel file on CD) Table 4, Figure 2, and Section 4.4.

Metals were detected in a majority of the TSP samples and concentrations were reported with an uncertainty of plus/minus 3 standard deviations. The XRF detection method identifies concentrations in extremely low concentration ranges (of less than 0.001 µg/m^3). The results were compared to the RBC,

PRG, and MSSL screening criterion (of those available) and four metals exceeded these criteria: Manganese, Cobalt, Arsenic, and Cadmium. It should be noted that these are the same metals detected during initial background (Phase I) air sampling.

Manganese concentrations ranged from 0.0018 µg/m^3 to 0.1611 µg/m^3 and the average concentration was 0.0448 µg/m^3. The Manganese PRG and MMSL of 0.051 µg/m^3 (RBC of 0.052 µg/m^3) was exceeded by 30 samples**.** 15 of these samples were collected at the upwind sites BMI11 and BMI08 and 15 samples were collected the downwind site BMI06. A statistical analysis of the difference between 33 upwind samples and 33 downwind samples demonstrated that there was no statistical increase in Manganese from upwind to downwind.

Cobalt concentrations ranged from 0.0003 µg/m^3 to 0.0043 µg/m^3 and the average concentration was 0.0014µg/m^3. The Cobalt PRG and MSSL of 0.001 µg/m^3 was exceeded by seven samples. Three of these samples were collected at upwind site BMI11 and BMI08 and four of these samples were collected at downwind site BMI06. A statistical analysis of Cobalt concentrations was not feasible due to the limited number of matched pairs between the upwind samples and downwind samples. However, the average Cobalt concentration increase (in µg/m^3) from upwind to downwind was actually a decrease of -0.00036 µg/m^3. It must be noted that this data set represents a significant decrease in Cobalt detections from the earlier Phase I sampling.

Arsenic concentrations ranged from 0.0001 µg/m^3 to 0.058 µg/m^3 and the average concentration was 0.0012 µg/m^3. The Arsenic PRG of 0.0004 µg/m^3, RBC of 0.00041 µg/m^3, and MSSL of 0.00045 µg/m^3 was exceeded by 33 samples. 16 of these samples were collected at the upwind sites BMI11 and BMI08 and 17 samples were collected the downwind site BMI06. A statistical analysis of the difference between 33 upwind samples and 33 downwind samples demonstrated that there was no statistical increase in Arsenic from upwind to downwind.

Cadmium concentrations ranged from 0.0005 µg/m^3 to 0.0066 µg/m^3 and the average concentration was 0.0031 µg/m^3. The Cadmium RBC of 0.001 µg/m^3 and PRG/MSSL of 0.001 µg/m^3 were exceeded by 53 samples. 27 of these samples were collected at the upwind sites BMI11 and BMI08 and 26 samples were collected the downwind site BMI06. A statistical analysis of the difference between 30 upwind samples and 30 downwind samples demonstrated that there was no statistical increase in Cadmium from upwind to downwind.

It must be noted that a majority of the Manganese, Cobalt, Arsenic, and Cadmium concentrations were reported at less than three times the XRF analytical uncertainty and have been so flagged. Given the lack of a distinct pattern or difference in upwind versus downwind concentrations it does not appear that remediation activities at the Eastside DPA negatively impacted air quality with respect to these and other metals concentrations.

While it can be argued that the upwind monitors are not entirely upwind all of the time and the downwind monitors are not downwind all of the time, the distinct lack of overall (average) differences between these two sets of ambient concentrations across multiple chemicals demonstrates a high level of consistency. If in fact, the excavation work had been the source of air emissions, a distinct pattern of higher downwind (or upwind) concentrations would have been observed, for many chemicals. Furthermore, Manganese, Cobalt, Arsenic, and Cadmium were present in the initial upwind Phase I samples and have been consistently detected in upwind samples throughout the entirety of this air monitoring project. In addition, Manganese, Cobalt, Arsenic, and Cadmium concentrations were detected at the BMI Plant Site upwind air monitoring station at Basic Water Company reservoirs, approximately 1 mile southeast of the BMI industrial complex. This presents an argument that these metals are present throughout the Henderson area and are part of the area-wide background pollutants. A complete summary and statistical analysis of metals results are presented in Table 3 (Excel file on CD), Table 4, Figure 2, and Section 4.4.

4.2 ORGANIC COMPOUND RESULTS

Six out of 27 Organochlorine pesticides (TO-4) chemical compounds were detected above laboratory detection limits and included alpha-BHC, beta-BHC, gamma-BHC (Lindane), 4,4'-DDE, 4,4'-DDT, and Endosulfan I.

Alpha-BHC concentrations ranged from 0.0005 µg/m^3 to 0.0042 µg/m^3 and the average concentration was 0.0011 µg/m^3. The alpha-BHC RBC and PRG/MSSL of 0.001 µg/m^3 was exceeded by five samples. One of these samples were collected at the upwind site BMI08 and BMI11 and 4 samples were collected the downwind site BMI06. A statistical analysis of the difference between five upwind samples and five downwind samples demonstrated that there was no statistical increase in alpha-BHC from upwind to downwind.

Beta-BHC concentrations ranged from 0.00096 µg/m^3 to 0.0015 µg/m^3 and the average concentration was 0.0012 µg/m^3. The beta-BHC RBC of 0.0035 µg/m^3 was not exceeded by any sample. Over the course of the 5-month monitoring beta-BHC was only detected on ten samples. Eight of those detection occurred during July, one in September, and one in October. Of the eight detections in July, four occurred at the upwind BMI08 site and four occurred at the downwind BMI06 site. Based on this limited data set no conclusive determinations can be made. However, the average beta-BHC concentration increase (in µg/m^3) from upwind to downwind was 0.00005 µg/m^3.

Gamma-BHC was only detected during one sample event on July 24, 2009 at both the upwind BMI08 and downwind BMI06 locations. Both samples had a concentration of 0.00096 µg/m^3. The gamma-BHC RBC of 0.0048 µg/m^3 was not exceeded by either sample.

4-4'-DDE concentrations ranged from 0.00032 µg/m^3 to 0.0034 µg/m^3 and the average concentration was 0.0011 µg/m^3. The 4-4'-DDE PRG/MSSL of 0.02 µg/m^3 was not exceeded by any samples. A total of eighteen detections occurred at the upwind sites BMI11 and BMI08 and 25 detections occurred at the downwind site BMI06. A statistical analysis of the difference between 13 upwind samples and 13 downwind samples demonstrated that there was a statistical increase in 4,4'-DDE from upwind to downwind. This is further discussed in the Section 4.4. However, no health-based screening criteria were exceeded by the 4-4'-DDE concentrations.

4,4'-DDT was only detected during one sample event on September 2, 2009 at the downwind site BMI06 with a concentration of 0.00057 µg/m^3. The 4,4'-DDT PRG/MSSL of 0.02 µg/m^3 was not exceeded by the sample.

Endosulfan I was only detected during two sample events during July 2009. The first event occurred on July 3, 2009 at upwind site BMI-08 with a concentration of 0.00044 µg/m^3. The second event occurred on July 31, 2009 at the upwind site BMI-08 and downwind site BMI06 with concentrations of 0.001 µg/m^3 and 0.00098 µg/m^3, respectively. The Endosulfan I PRG/MSSL is 22.0 µg/m^3 was not exceeded by any of the three samples. In fact, results were far smaller than the PRG/MSSL.

25 PCDDs/PCDFS (TO-9) chemical compounds were detected above laboratory detection limits, ranging from 0.005 picograms (pg)/m^3 (0.000000005 µg/m^3) to 43.7 pg/m^3 (0.0000437µg/m^3). The total toxic equivalent value (TEQ) was calculated from toxicity equivalence factors (World Health Organization

2005) for each of the upwind and downwind samples and compared to the 2,3,7,8-TCDD screening value of 0.045 pg/m^3. Consistent with previous sampling results at the Eastside Area, All 68 TO-9 samples with a calculated TEQ were above this screening value. In addition, one PCDD/PCDF exceeded the MSSL screening criteria and included 2,3,7,8-TCDD.

The upwind versus downwind statistical analysis completed for the PCDDs/PCDFS data does not appears to show any upwind/downwind trends with the exception of the sample events on September 25 and 29, 2009. Elevated PCDDs/PCDFS concentrations were detected during these sample events. The upwind and downwind TEQ concentrations on September 25 were 0.299 and 1.542 pg/m^3, respectively. This represents a TEQ increase of 1.243 pg/m^3. The exact cause of the September 25 increase could not be identified. The downwind concentration on September 29 was 0.598. Unfortunately, no upwind sample was collected on this date due to a stolen generator (as described in Section 2.5) so a comparison to an upwind concentration cannot be completed for the September 29 sample event.

2,3,7,8-TCDD concentrations ranged from 0.0043 pg/m^3 to 0.135 pg/m^3 and the average concentration was 0.020 pg/m^3. The 2,3,7,8-TCDD PRG and MSSL of 0.045 pg/m^3 was exceeded by 4 samples. Two of these samples were collected at the upwind site BMI08 and two samples were collected at the downwind site BMI06. It should be noted that all 4 exceedances occurred between September 25 and October 20, 2009. A statistical analysis of the difference between 28 upwind samples and 28 downwind samples demonstrated that there was no statistical increase in 2,3,7,8-TCDD from upwind to downwind.

Tetra Tech inquired into site activities on September 25 and 29, 2009 but there were no unusual events that occurred that could explain the elevated dioxin concentrations on these days. A complete summary and statistical analysis of PCDDs/PCDFS (TO-9) chemical compounds results are presented in Table 3 (Excel file on CD), Table 4, Figure 2, and Section 4.4.

Twenty-six VOCs/SVOCs (TO-13) chemical compounds were detected above laboratory detection limits. Of the twenty-six detected compounds, only three exceeded RBC, PRG, or MSSL screening criteria. These are Hexachlorobenzene, N-Nitroso-di-n-propylamine, Benzo(a)anthracene.

Hexachlorobenzene concentrations ranged from 0.0045 µg/m^3 to 0.100 µg/m^3 and the average concentration was 0.0208 µg/m^3. The Hexachlorobenzene RBC and PRG/MSSL of 0.004 µg/m^3 was exceeded by 47 samples. 15 of these samples were collected at the upwind sites BMI11 and BMI08 and

32 samples were collected the downwind site BMI06. A statistical analysis of the difference between 14 upwind samples and 14 downwind samples demonstrated that there was no statistical increase in Hexachlorobenzene from upwind to downwind.

N-Nitroso-di-n-propylamine was only detected during one sample event on July 17, 2009 at the upwind site BMI-08 with a concentration of 0.054 µg/m^3. The N-Nitroso-di-n-propylamine RBC of 0.0009 µg/m^3 was exceeded by this single sample.

Benzo(a)anthracene was also only detected during one sample event on July 17, 2009 at the upwind site BMI-08 with a concentration of 0.12 µg/m^3. The Benzo(a)anthracene MSSL of 0.007 µg/m^3 was exceeded by this one sample.

As such, given the lack of detection of the majority of VOC/SVOC compounds above their respective RBC, PRG or MSSL values and the lack of a distinct upwind/downwind relationship for the hexachlorobenzene detections and the sporadic (single sample) detections of only two other compounds discussed above, there does not appear to be an issue with VOC/SVOC compounds at the site.

A complete summary and statistical analysis of all VOCs/SVOCs (TO-13) chemical compounds results are presented in Table 3 (Excel file on CD), Table 4, Figure 2, and Section 4.4.

4.3 ASBESTOS RESULTS

The asbestos samples were analyzed using NIOSH Method 7400 PCM. The PCM method gives a number index of airborne fibers. It is primarily used for estimating asbestos concentrations, though PCM does not differentiate between asbestos and other fibers. Asbestos fibers include chrysotile, cummingtonite-grunerite asbestos (amosite), anthophyllite asbestos, tremolite asbestos, crocidolite, and actinolite asbestos and any of these minerals which have been chemically treated or altered. The precise chemical formulation of each species varies with the location from which it was mined. Therefore, the use of PCM is a generally accepted method for screening airborne fibers. The Occupational Safety and Health Administration (OSHA) has set an exposure limit of 0.1 fiber per cubic centimeter (cc) of air as an 8-hour time-weighted average (TWA) and a limit of 1.0 fiber per cc averaged over a sampling period of thirty (30) minutes.

The asbestos samples ranged in concentration from 0.0006 fibers per cc to 0.0055 fibers per cc and the average concentration was 0.0014 fibers per cc. The OSHA TWA limit of 0.1 fibers per cc was not exceeded in any samples and asbestos concentrations at the off site locations were consistent with asbestos concentrations during the background Phase I sampling. A complete summary of all asbestos results are presented in Table 3 (Excel file on CD).

4.4 STATISTICAL COMPARISON OF UPWIND AND DOWNWIND CONCENTRATIONS

Concentrations of selected chemicals in upwind and downwind samples were compared using a matched-pairs design. Differences in chemical concentration (upwind-downwind) were evaluated for samples collected during 33 sample events between January 6, 2009 and October 20, 2009.

Both parametric (t-test) and nonparametric (Wilcoxon signed-rank test or Fong's modified sign test) paired difference tests were used to determine whether concentrations were statistically significantly higher in the downwind group of samples. All tests were conducted using the JMP 7 (version 7.0.2) statistical software package (SAS Institute) and followed methods described in Helsel (2005), Zar (1996), and Fong et al. (2003). All tests evaluated the following one-sided null (H0) and alternative (HA) hypotheses:

H0: downwind concentrations < upwind concentrations
HA: downwind concentrations > upwind concentrations

A 5 percent ($p < 0.05$) level of significance (i.e., equivalent to a 95 percent confidence level) was used to interpret the test results. Test selection depended on the detection status of the paired results for each sampling event. Testing was only conducted for chemicals with results for at least five sampling events.

For chemicals where all pairs of results were detected, both the paired-difference t-test and Wilcoxon signed-rank test were conducted. These paired-difference tests test whether the overall mean (or median in the case of the nonparametric test) difference for all matched pairs of samples is zero. That is, some differences (upwind-downwind) may be positive (indicating the higher result is from the upwind sample) and some may be negative (indicating the higher result is from the downwind sample), but if there is no net difference between pairs the mean difference will be zero (or not distinguishable from zero within the context of the statistical tests).

The paired-difference t-test and Wilcoxon signed-rank tests are only strictly appropriate when all of the analytical results are detected (Helsel 2005). When censored (i.e., results below the detection limit [BDL] or results set to a fixed reporting limit) results are present, specialized versions of both the parametric (e.g., maximum likelihood estimation) and nonparametric (e.g., paired Prentice-Wilcoxon test, modified sign test) tests that explicitly account for varying frequencies of censored data are recommended.

Fong's modified sign test (Helsel 2005, Fong et al. 2003) was used in the present analysis for all chemicals with one or more censored results in the data for at least one sampling event. The sign test calculates the number of differences (upwind-downwind) that are greater than and lesser than zero, and determines whether the departure from zero is statistically significant. Fong's version of the sign test includes a modification to account for ties (i.e., the upwind and downwind results are equal), which are ignored in the standard version of the test. Fong's sign test was implemented using the R-language algorithm (translated to a script for use in JMP) presented in Huston and Juarez-Colunga (2009). Huston and Juarez-Colunga (2009) discuss the technique for coding paired differences for censored data as interval estimates, as well as the approach in Fong et al. (2003) for treating ties.

Metals results reported by the analytical laboratory as zero were set to a concentration equal to one standard deviation, as established by the laboratory. Because the treatment of results reported as zero constitutes another form of censorship, these results were treated as censored in the statistical analysis. Otherwise this assumption would automatically create an unnecessary bias that will skew the data.

Results below the detection limit were reported as BDL, rather than at a fixed, numeric detection limit due to the variability in air sampling equipment volumetric flow rates. This slight variability could unnecessarily skew the statistical analysis for matched pair samples reported as below detection limit (BDL). All events where BDL was reported for at least one result were also excluded from analysis. It should be noted that exclusion of this data represents a loss of information; therefore, the results for chemicals with a high proportion of excluded events may be less reliable and should be interpreted with caution.

Results of the statistical comparisons for 65 chemicals are summarized in Table 4. The raw output from the JMP software is provided in Figure 2. The conclusions presented in Table 4 are based on the most sensitive of the t-test and signed-rank test results (i.e., lowest p value) for chemicals with all detected

results, and on Fong's modified sign test for chemicals with one or more censored results. As noted earlier, only 4,4'-DDE had results that indicated a statistically significantly higher concentrations in the downwind samples - although it should be noted that data for 20 sampling events were excluded because results were reported as BDL. A series of graphics are included in the panels for each chemical in Figure 2 that show the relative distribution of the observed differences for all matched pairs of samples. Figure 2 also provides the time series plots (plots of observed result versus sequential sampling event) for the upwind and downwind results. A key is provided at the end of Figure 2 to aid in the interpretation of the raw statistical output. Chemicals with the highest proportion of excluded data (15 to 27 events) are presented at the end of Figure 2.

5.0 REFERENCES

Basic Remediation Company 2006. "*Perimeter Air Monitoring Plan for Soil Remediation Activities, BMI Upper and Lower Ponds and Ditches, Clark County, Nevada*." August 2006. Revised 2008.

Helsel, D.R. 2005. *Nondetects and Data Analysis*. Statistics for Censored Environmental Data. John Wiley and Sons, Inc. Hoboken, NJ. 250 p.

Occupational Safety and Health Administration. 1994. "*Asbestos and Other Fibers by PCM.*" August 1994.

U.S. EPA 1999. "*Compendium Method TO-4A Determination of Pesticides and Polychlorinated Biphenyls in Ambient Air Using High Volume Polyurethane Foam (PUF) Sampling Followed by Gas Chromatographic/Multi-Detector Detection (GC/MD)*".

U.S. EPA 1999. "*Compendium Method TO-9A Determination Of Polychlorinated, Polybrominated And Brominated/Chlorinated Dibenzo-p-Dioxins And Dibenzofurans In Ambient Air.*" January 1999.

U.S. EPA 1999. "Compendium Method TO-13A Determination of Polycyclic Aromatic Hydrocarbons (PAHs) in Ambient Air Using Gas *Chromatography/Mass Spectrometry (GC/MS.*" January 1999.

U.S. EPA 1999. "*Compendium Method IO-3.3 Determination of Metals in Ambient Particulate Matter Using X-Ray Fluorescence (XRF) Spectroscopy.*" June 1999.

Zar, J.H. 1996. Biostatistical Analysis. Third Edition. Prentice Hall. Upper Saddle River, New Jersey.

APPENDIX A

NEVADA DIVISION OF ENVIRONMENTAL PROTECTION COMMENTS AND BRC RESPONSES TO COMMENTS

APPENDIX B

FIELD DOCUMENTATION FORMS

APPENDIX C

CALIBRATION AND SAMPLE VOLUME CALCULATION WORKSHEETS

APPENDIX D

CD CONTAINING LABORATORY ANALYTICAL RESULTS AND ECVP REPORTS, TABLE 3, AND COMPLETE REPORT

FIGURES

FIGURE 1 INSERTED HERE

FIGURE 2 INSERTED HERE

TABLES

TABLE 1

SAMPLE COLLECTION SAMPLE HANDLING AND ANALYSIS SPECIFICATIONS FOR EASTSIDE DRY PONDS AREA AIR SAMPLING STATIONS

HENDERSON, NEVADA

Analytical Parameter	Equipment Manufacturer/ Model	Sample Media	Sample Frequency/ Sample Events	Sample Handling Temperature/ hold time	Laboratory/ Analytical Method
Organochlorine Pesticides (TO-4A)	Tisch Environmental/ TE-1000	Polyurethane foam cartridge/102 mm quartz fiber filter	24hr. (or less) cont. sample/every 3 days/10 events	<4°C/7 days	Air Toxics Ltd./Method TO-4A
PCDDs/PCDFs (TO-9A)	Tisch Environmental/ TE-1000	Polyurethane foam cartridge/102 mm quartz fiber filter	24hr. (or less) cont. sample/every 3 days/10 events	<4°C/7 days	Frontier Ltd./Method TO-9A
VOCs/SVOCs (TO-13A)	Tisch Environmental/ TE-1000	Polyurethane foam cartridge/102 mm quartz fiber filter	24hr. (or less) cont. sample/every 3 days/10 events	<4°C/7 days	Air Toxics Ltd./Method TO-13A
TSP/Metals	BGI, Inc./PQ100	47mm Teflon fiber filter	24hr. (or less) cont. sample/every 3 days/10 events	None/30 days	Chester Labnet/ Method IO-2.1; Method IO-3.3
Asbestos	SKC, Inc. 224-PCXR8	25mm mixed cellulose ester filter	24hr. (or less) cont. sample/every 3 days/10	None/N/A	AES Laboratory/ NIOSH 7400

Notes:

< = less than
°C = degree Celsius
cont. = continuous
hr = hour
PM_{10} = particulate matter less than 10-microns
N/A = not applicable
$\mu g/m^3$ = microgram per cubic meter

TABLE 2
METEOROLGICAL DATA RECORD DURING EASTSIDE DRY PONDS SAMPLING
JANUARY 06 –JANURY 20, 2009 AND JULY 03 –OCTOBER 20, 2009

HENDERSON, NEVADA

Sample Date	Average Wind Degrees	Average Wind Speed (m/s)	Quadrant Wind Blowing From	Respective Upwind Site	Respective Downwind Site
January 6, 2009	110.19	0.99	Southeast	BMI11	BMI06
January 9, 2009	154.62	1.61	Southeast	BMI11	BMI06
January 13, 2009	145.83	2.16	Southeast	BMI11	BMI06
January 16, 2009	179.32	1.67	South	BMI11	BMI06
January 20, 2009	205.72	0.96	Southwest	BMI11	BMI06
July 3, 2009	120.61	2.03	Northeast	BMI08	BMI06
July 7, 2009	204.64	5.08	Southwest	BMI08	BMI06
July 10, 2009	181.57	3.47	South	BMI08	BMI06
July 14, 2009	194.37	3.58	South	BMI08	BMI06
July 17, 2009	170.36	2.05	South	BMI08	BMI06
July 21, 2009	149.71	3.32	Southeast	BMI08	BMI06
July 24, 2009	148.42	2.01	Southeast	BMI08	BMI06
July 28, 2009	120.97	2.01	Southeast	BMI08	BMI06
July 31, 2009	136.54	2.71	Southeast	BMI08	BMI06
August 4, 2009	197.15	2.85	Southwest	BMI08	BMI06
August 7, 2009	225.43	6.61	Southwest	BMI08	BMI06
August 11, 2009	149.25	1.57	Southeast	BMI08	BMI06
August 14, 2009	186.09	3.62	South	BMI08	BMI06
August 18, 2009	152.29	2.03	Southeast	BMI08	BMI06
August 21, 2009	177.95	1.40	South	BMI08	BMI06
August 25, 2009	155.17	1.90	Southeast	BMI08	BMI06
September 2, 2009	139.78	2.30	Southeast	BMI08	BMI06
September 4, 2009	185.43	1.81	South	BMI08	BMI06
September 11, 2009	165.91	1.38	Southeast	BMI08	BMI06
September 15, 2009	211.98	3.56	Southwest	BMI08	BMI06
September 18, 2009	138.85	1.17	Southeast	BMI08	BMI06
September 22, 2009	39.05	4.89	Northeast	Indeterminate	Indeterminate
September 25, 2009	162.78	1.10	Southeast	BMI08	BMI06
September 29, 2009	155.58	3.09	Southeast	BMI08	BMI06

TABLE 2 (cont.)

Sample Date	Average Wind Degrees	Average Wind Speed (m/s)	Quadrant Wind Blowing From	Respective Upwind Site	Respective Downwind Site
October 2, 2009	136.80	1.74	Southeast	BMI08	BMI06
October 6, 2009	202.26	1.54	Southwest	BMI08	BMI06
October 9, 2009	181.22	1.43	South	BMI08	BMI06
October 13, 2009	185.05	3.97	South	BMI08	BMI06
October 16, 2009	226.57	1.16	Southwest	BMI08	BMI06
October 20, 2009	263.68	5.72	West	Indeterminate	Indeterminate

Notes:

m/s meters per second

TABLE 3

EASTSIDE DRY PONDS AREA AIR QUALITY MONITORING SUMMARY

JANUARY 6 – 20, 2009 AND JULY 3 THROUGH OCTOBER 20, 2009

(EXCEL FILE ON ATTACHED CD)

TABLE 4

SUMMARY STATISTICS AND RESULTS FOR PAIRED-DIFFERENCE TESTS COMPARING CHEMICAL CONCENTRATIONS IN UPWIND AND DOWNWIND SAMPLES EASTSIDE DRY PONDS AREA

Chemical	Units	Number of Excluded Events[a]	Upwind		Downwind		Mean Difference[b]	Paired Difference Test[c]			Downwind Significantly Greater Than Upwind?[c]
			Detection Frequency	Maximum Detected	Detection Frequency	Maximum Detected	(Upwind-Downwind)	*t*-Test p	Signed-Rank Test p	Modified Sign Test p	
1,2,3,4,6,7,8-HpCDD	pg/m^3	1	32 / 32	2.3	32 / 32	1.0	-5.70	0.17	0.78	--	No
1,2,3,4,6,7,8-HpCDF	pg/m^3	1	32 / 32	24.78	32 / 32	9.84	-54.7	0.17	0.93	--	No
1,2,3,4,7,8-HxCDD	pg/m^3	3	30 / 30	0.35	30 / 30	0.15	-0.907	0.17	0.88	--	No
1,2,3,4,7,8-HxCDF	pg/m^3	1	32 / 32	2.61	32 / 32	4.06	-24.0	0.17	0.95	--	No
1,2,3,4,7,8,9-HpCFD	pg/m^3	1	32 / 32	8.39	32 / 32	3.31	-22.1	0.17	0.92	--	No
1,2,3,6,7,8-HxCDD	pg/m^3	3	30 / 30	0.66	30 / 30	0.29	-1.71	0.17	0.89	--	No
1,2,3,6,7,8-HxCDF	pg/m^3	1	32 / 32	6.81	32 / 32	2.89	-17.4	0.17	0.94	--	No
1,2,3,7,8-PeCDD	pg/m^3	4	29 / 29	0.45	29 / 29	0.19	-1.44	0.17	0.89	--	No
1,2,3,7,8-PeCDF	pg/m^3	1	32 / 32	4.97	32 / 32	2.13	-12.3	0.17	0.97	--	No
1,2,3,7,8,9-HxCDD	pg/m^3	3	30 / 30	0.52	30 / 30	0.23	-1.27	0.17	0.83	--	No
1,2,3,7,8,9-HxCDF	pg/m^3	2	31 / 31	2.62	31 / 31	1.06	-6.82	0.17	0.94	--	No
1,4-Dichlorobenzene	µg/m^3	16	17 / 17	0.094	17 / 17	0.041	0.013	1.00	1.00	--	No
2-Methyl-naphthalene	µg/m^3	3	30 / 30	0.520	30 / 30	0.580	0.039	0.93	1.00	--	No
2,3,4,6,7,8-HxCDF	pg/m^3	1	32 / 32	3.50	32 / 32	1.51	-9.40	0.17	0.96	--	No
2,3,4,7,8-PeCDF	pg/m^3	2	31 / 31	2.44	31 / 31	0.94	-6.34	0.17	0.92	--	No
2,3,7,8-TCDD	pg/m^3	5	28 / 28	0.20	28 / 28	0.09	-0.69	0.17	0.98	--	No
2,3,7,8-TCDF	pg/m^3	1	32 / 32	2.56	32 / 32	1.05	-6.87	0.17	0.95	--	No
4,4'-DDE	µg/m^3	20	13 / 13	0.003	13 / 13	0.003	-0.0004	0.02	0.03	--	**Yes**
alpha-BHC	µg/m^3	28	5 / 5	0.002	5 / 5	0.002	-0.001	0.15	0.22	--	No
Aluminum	µg/m^3	0	33 / 33	1.34	33 / 33	1.040	0.075	0.94	0.92	--	No
Barium	µg/m^3	0	32 / 33	0.124	32 / 33	0.213	15 / 18 / 0	--	--	0.36	No

Chemical	Units	Number of Excluded Events[a]	Upwind		Downwind		Mean Difference[b]	Paired Difference Test[c]			Downwind Significantly Greater Than Upwind?[c]
			Detection Frequency	Maximum Detected	Detection Frequency	Maximum Detected	(Upwind-Downwind)	*t*-Test p	Signed-Rank Test p	Modified Sign Test p	
Benzoic Acid	µg/m^3	18	15 / 15	0.680	15 / 15	0.390	0.151	0.33	0.50	--	No
beta-BHC	µg/m^3	30	3 / 3	0.001	3 / 3	0.001	N/A	N/A	N/A	N/A	N/A
Bromine	µg/m^3	0	32 / 33	0.006	33 / 33	0.006	14 / 18 / 1	--	--	0.29	No
Cadmium	µg/m^3	0	30 / 33	0.006	27 / 33	0.007	14 / 15 / 4	--	--	0.50	No
Calcium	µg/m^3	0	33 / 33	3.12	33 / 33	2.42	0.092	0.86	0.72	--	No
Chlorine	µg/m^3	0	33 / 33	0.436	33 / 33	0.471	-0.024	0.82	0.77	--	No
Chromium	µg/m^3	0	33 / 33	0.009	32 / 33	0.023	15 / 16 / 2	--	--	0.50	No
Copper	µg/m^3	0	32 / 33	0.023	33 / 33	0.046	21 / 12 / 0	--	--	0.92	No
Dimethyl phthalate	µg/m^3	32	1 / 1	0.020	1 / 1	0.032	N/A	N/A	N/A	N/A	N/A
Gallium	µg/m^3	0	24 / 33	0.001	21 / 33	0.001	12 / 8 / 11	--	--	0.53	No
Hexachlorobenzene	µg/m^3	19	14 / 14	0.100	14 / 14	0.071	0.007	0.17	0.86	--	No
Indium	µg/m^3	0	28 / 33	0.009	28 / 33	0.010	14 / 15 / 4	--	--	0.50	No
Iron	µg/m^3	0	33 / 33	1.19	33 / 33	0.986	0.037	0.97	0.92	--	No
Lead	µg/m^3	0	30 / 33	0.026	30 / 33	0.030	15 / 17 / 1	--	--	0.39	No
Magnesium	µg/m^3	0	33 / 33	0.586	33 / 33	0.413	0.042	0.92	0.88	--	No
Manganese	µg/m^3	0	33 / 33	0.158	33 / 33	0.161	0.005	0.64	0.70	--	No
Naphthalene	µg/m^3	3	30 / 30	0.700	30 / 30	0.690	0.068	0.63	0.69	--	No
OCDD	pg/m^3	1	32 / 32	39.6	32 / 32	265	-7.09	0.18	0.44	--	No
OCDF	pg/m^3	1	32 / 32	927	32 / 32	7,410	-200	0.18	0.59	--	No
Palladium	µg/m^3	0	29 / 33	0.009	28 / 33	0.006	14 / 14 / 5	--	--	0.50	No
Phenanthrene	µg/m^3	24	9 / 9	0.021	9 / 9	0.013	0.005	0.17	0.89	--	No
Phenol	µg/m^3	26	7 / 7	0.110	7 / 7	0.094	0.029	0.17	0.95	--	No
Potassium	µg/m^3	0	33 / 33	0.748	33 / 33	0.586	0.031	0.17	0.96	--	No
Rubidium	µg/m^3	0	30 / 33	0.004	29 / 33	0.002	11 / 15 / 6	--	--	0.39	No

Chemical	Units	Number of Excluded Events[a]	Upwind		Downwind		Mean Difference[b]	Paired Difference Test[c]			Downwind Significantly Greater Than Upwind?[c]
			Detection Frequency	Maximum Detected	Detection Frequency	Maximum Detected	(Upwind-Downwind)	*t*-Test p	Signed-Rank Test p	Modified Sign Test p	
Selenium	µg/m^3	0	26 / 33	0.001	28 / 33	0.001	16 / 5 / 12	--	--	0.68	No
Silicon	µg/m^3	0	33 / 33	3.781	33 / 33	2.75	0.180	0.17	0.96	--	No
Silver	µg/m^3	0	29 / 33	0.008	29 / 33	0.008	15 / 14 / 4	--	--	0.50	No
Strontium	µg/m^3	0	33 / 33	0.039	33 / 33	0.029	0.001	0.68	0.78	--	No
Sulfur	µg/m^3	0	33 / 33	0.629	33 / 33	0.675	0.007	0.17	0.78	--	No
Tin	µg/m^3	0	29 / 33	0.009	27 / 33	0.007	11 / 13 / 8	--	--	0.47	No
Titanium	µg/m^3	0	33 / 33	0.303	33 / 33	0.546	-0.023	0.17	0.88	--	No
Total HpCDD	pg/m^3	1	32 / 32	3.59	32 / 32	1.55	-8.77	0.17	0.95	--	No
Total HpCDF	pg/m^3	1	32 / 32	46.63	32 / 32	18.34	-107	0.17	0.92	--	No
Total HxCDD	pg/m^3	2	31 / 31	4.98	31 / 31	2.15	-11.6	0.17	0.89	--	No
Total HxCDF	pg/m^3	1	32 / 32	52.77	32 / 32	22.33	-130	0.17	0.94	--	No
Total PeCDD	pg/m^3	2	31 / 31	5.69	31 / 31	2.23	-13.7	0.17	0.89	--	No
Total PeCDF	pg/m^3	1	32 / 32	50.85	32 / 32	21.33	-113	0.17	0.97	--	No
Total TCDD	pg/m^3	1	32 / 32	7.88	32 / 32	2.64	-14.7	0.17	0.83	--	No
Total TCDF	pg/m^3	1	32 / 32	46.06	32 / 32	16.99	-110	0.17	0.94	--	No
TSP	µg/m^3	0	33 / 33	117	33 / 33	49.9	5.68	1.00	1.00	--	No
Vanadium	µg/m^3	0	32 / 33	0.026	32 / 33	0.057	17 / 15 / 1	--	--	0.61	No
Yttrium	µg/m^3	0	22 / 33	0.001	21 / 33	0.001	12 / 9 / 10	--	--	0.52	No
Zinc	µg/m^3	0	33 / 33	0.023	33 / 33	0.018	0.000	0.17	0.92	--	No
Zirconium	µg/m^3	0	32 / 33	0.040	33 / 33	0.082	17 / 16 / 0	--	--	0.50	No

TABLE 4 (cont.)

Notes:

[a] The mean difference for all pairs (Upwind-Downwind) of samples

[b] Parametric (t-test) and nonparametric (Wilcoxon signed-rank) paired difference tests of the following 1-sided null (H0) and alternative (HA) hypotheses- H_0: Downwind < Upwind; H_A: Downwind > Upwind. p is the significance level for the tests. If p is less than or equal to 0.05 H0 is rejected and it is concluded that the downwind results are significantly higher. Results should be interpreted witih caution for chemicals with censored (nondetect) results in one or both data sets. Censored results were evaluated at the detection limit. Specialized parametric (maximum likelihood estimation) and nonparametric (paired Prentice-Wilcoxon tests) methods that account for left-censored results are recommended to eliminate potential bias in these cases, however, these tests are not currently available in mainstream commercial statistical software packages. Only chemicals with at least 80 percent detected results in both the upwind and downwind data sets are presented in this table (results reported as zero by the laboratory were set to one standard deviation in the database and therefore were treated as censored results for the purpose of calculating the 80 percent minimum threshold for inclusion in this table).

[c] Conclusion based on the most sensitive (lowest p value) test result.

$\mu g/m^3$ micrograms per cubic meter

pg/m^3 picograms per cubic meter

The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 20a

WPC
061
W1838000002

Luminant

Dianna Tickner
Asset Closure
Luminant
1500 Eastport Plaza Drive
Collinsville, Illinois, 62234
o 618.343.7929
m 618.381.3124

Illinois Environmental Protection Agency
Bureau of Water
Division of Public Water Supplies
Groundwater Section
1021 N. Grand Avenue East
ATTN: Mr. Richard Cobb, P.G., Deputy Division Manager

IEPA - DIVISION OF RECORDS MANAGEMENT
RELEASABLE
OCT 17 2018
REVIEWER: JMR

October 8, 2018

RE: Vermilion Site – North Ash Pond and Old East Ash Pond
2018 Groundwater Monitoring and Modeling Report

Mr. Cobb,

Pleased find enclosed three hardcopies of the above-referenced report. Contact Mr. Phil Morris, a member of our Corporate Environmental team, with any questions or concerns at phil.morris@vistraenergy.com or (618) 343-7794.

Sincerely,
Dynegy Midwest Generation, LLC

Dianna Tickner
Director – Asset Closure

Enclosures

RECEIVED
OCT 09 2018
Div. of Public Water Supplies
Illinois EPA

2018 Groundwater Monitoring and Modeling Report

Vermilion Site
North Ash Pond System and Old East Ash Pond System
Coal Combustion Residual Units
Vermilion, Illinois

Dynegy Midwest Generation LLC

October 2018

OBG

OCTOBER 2018 | PROJECT #68192

2018 Groundwater Monitoring and Modeling Report

Vermilion Site
North Ash Pond System and Old East Ash Pond System
Coal Combustion Residual Units
Vermilion, Illinois

IEPA - DIVISION OF RECORDS MANAGEMENT
RELEASABLE
OCT 17 2018
REVIEWER: JMR

Prepared for:

Dynegy Midwest Generation LLC
1500 Eastport Plaza Drive
Collinsville, IL 62234

BRIAN G. HENNINGS
Managing Hydrogeologist

JACOB J. WALCZAK, PG
Hydrogeologist

STUART J. CRAVENS, PG
Technical Director | Hydrogeology

RECEIVED
OCT 09 2018
Div. of Public Water Supplies
Illinois EPA

TABLE OF CONTENTS

LIST OF TABLES (WITHIN TEXT) ii
LIST OF TABLES (AS ATTACHMENTS) ii
LIST OF FIGURES ii
LIST OF APPENDICES iii
1 INTRODUCTION 1
1.1 Background 1
2 DATA ANALYSIS 2
2.1 Groundwater Flow 2
2.2 Review of Analytical Data 3
2.3 Summary of Changes in Groundwater Flow and Quality Compared to Previous Observations 5
3 GROUNDWATER MODEL 6
3.1 Overview 6
3.2 Conceptual Model 6
3.3 Model Approach 6
4 MODEL SETUP AND CALIBRATION 7
4.1 Model Descriptions 7
4.2 Flow and Transport Model Setup 7
4.2.1 Grid and Boundary Conditions 8
4.2.2 Flow Model Input Values and Sensitivity 8
4.2.3 Transport Model Input Values and Sensitivity 11
4.3 Flow and Tranport Model Assumptions and Limitations 12
4.4 Calibration Flow and Transport Model Results 13
5 SIMULATION OF CLOSURE SCENARIOS 14
5.1 Overview and Prediction Model Development 14
5.2 HELP Model Setup and Results 15
5.2 Simulation of Closure Scenarios 15
5.2.1 No Action Condition Predicted Hydraulic Heads and Boron Concentrations 16
5.2.2 Closure Scenario 1 Predicted Hydraulic Heads and Boron Concentrations 16
5.2.3 Closure Scenario 2 Predicted Hydraulic Heads and Boron Concentrations 17
5.2.4 Closure Scenario 3 Predicted Hydraulic Heads and Boron Concentrations 18
5.2.5 Closure Scenario 4 Predicted Hydraulic Heads and Boron Concentrations 19
5.2.6 Closure Scenario 5 Predicted Hydraulic Heads and Boron Concentrations 20
6 SUMMARY 22
REFERENCES 23

LIST OF TABLES (WITHIN TEXT)

Table A Groundwater Monitoring Parameters
Table B Flow Model Layer Descriptions and Parameters

LIST OF TABLES (AS ATTACHMENTS)

Table 1 Groundwater Levels and Elevations 2017-2018
Table 2 Vertical Hydraulic Gradients 2017-2018
Table 3 Groundwater Quality Data Summary 2017-2018
Table 4 Wilcoxon Rank Sum Results Summary
Table 5 Flow Model Input Values (calibration and sensitivity)
Table 6 Flow and Transport Model Calibration Targets
Table 7 Transport Model Input Values (calibration)
Table 8 Transport Model Input Values (sensitivity)
Table 9 HELP Model Input and Output Values
Table 10 HELP Model Sensitivity Analysis Summary
Table 11 Prediction Model Recharge and Constant Concentration Input Values (no action and closure scenario prediction)

LIST OF FIGURES

Figure 1 Site Location Map
Figure 2 Overview of Ash Pond System and Site Monitoring Well Locations
Figure 3 Potentiometric Surface Elevation Contour Map, Middle Groundwater Unit, September 2017
Figure 4 Potentiometric Surface Elevation Contour Map, Lower and Upland Groundwater Unit, September 2017
Figure 5 Potentiometric Surface Elevation Contour Map, Middle Groundwater Unit, March 2018
Figure 6 Potentiometric Surface Elevation Contour Map, Lower and Upland Groundwater Unit, March 2018
Figure 7 Closure Scenario Calibration and Prediction Model Timeline
Figure 8 MODFLOW and MT3DMS Grid and Boundary Conditions for Layers 1-8
Figure 9 Bottom Elevation (feet) Array for Layers 1-8
Figure 10 Hydraulic Conductivity (feet/day) Array for Layers 1-8
Figure 11 Recharge (feet/day) Array for Layer 1
Figure 12 Diffusion Array for Layers 1-8
Figure 13 Comparison between Simulated Heads and Field Measurements for Layers 1, 3, 4, 5, and 7
Figure 14 Steady-State MODFLOW Model Calibration Results for September 2017
Figure 15 Predicted and Observed Boron Concentrations (mg/L) 2017-2018
Figure 16 Recharge (feet/day) Array for Closure Scenarios 1-5 Layer 1
Figure 17 No Action Scenario Footprint of Boron Plume over 2 mg/L into the Future with Predicted Concentrations at Wells 04, 05, 08R, 03R, 17 and 18
Figure 18 Scenario 1 Footprint of Boron Plume over 2 mg/L 40 Years after Implementation with Predicted Concentrations at Wells 04, 05, 08R, 03R, 17 and 18
Figure 19 Scenario 2 Footprint of Boron Plume over 2 mg/L 40 Years after Implementation with Predicted Concentrations at Wells 04, 05, 08R, 03R, 17 and 18
Figure 20 Scenario 3 Footprint of Boron Plume over 2 mg/L 40 Years after Implementation with Predicted Concentrations at Wells 04, 05, 08R, 03R, 17 and 18
Figure 21 Scenario 4 Footprint of Boron Plume over 2 mg/L 40 Years after Implementation with Predicted Concentrations at Wells 04, 05, 08R, 03R, 17 and 18
Figure 22 Scenario 5 Footprint of Boron Plume over 2 mg/L 40 Years after Implementation with Predicted Concentrations at Wells 04, 05, 08R, 03R, 17 and 18

LIST OF APPENDICES

Appendix A 2011-2018 Time Series Graphs
Appendix B 2017-2018 Field and Laboratory Data
Appendix C November 2017 DMG Letter to IEPA
Appendix D MODFLOW/MT3DMS Model Files (on CD)

1 INTRODUCTION

In 2017 groundwater sampling was completed at Dynegy Midwest Generation LLC's (DMG's) Vermilion Site (Figure 1), specifically at the North Ash Pond System (NAPS) and Old East Ash Pond System (OEAP) Coal Combustion Residual (CCR) units (Figure 2). The combined areas of the NAPS and the OEAP will henceforth be referred to as the Site in this report. Groundwater monitoring was resumed in response to the Illinois Environmental Protection Agency's (IEPA's) February 14, 2017 letter requesting closure plans for the NAPS and OEAP. The Site is currently inactive and groundwater monitoring was suspended at the NAPS and OEAP in 2011. Six groundwater monitoring events were completed in 2017 and 2018. This report summarizes the groundwater quality data collected and analyzed from those six events, updates the groundwater model, and provides results of simulated site closure scenarios requested by IEPA in the February 14, 2017 letter.

1.1 BACKGROUND

Groundwater monitoring was re-established at the NAPS and OEAP in July 2017 and continued for six rounds ending in May 2018. Thirteen Site monitoring wells 01, 02, 03R, 04, 05, 06R, 08R, 10, 17, 18, 20, 21 and 34 were sampled for the water quality and field parameters listed in Table A (below). Monitoring wells 09 and 19 were also monitored for groundwater elevations only. The sampling program included the same set of wells monitored in 2011, less TW-1 (destroyed) and 07 (dry), as illustrated on Figure 2.

Table A. Groundwater Monitoring Parameters

Laboratory Parameters		
Metals (dissolved)		
Arsenic	Boron	Manganese
Barium	Iron	Selenium
Inorganics		
Fluoride (dissolved)	Sulfate (total)	
Chloride (total)	Total Dissolved Solids	
Nitrate as N (total)		
Field Parameters		
pH	Temperature	
Oxidation/Reduction Potential	Specific Conductivity	
Dissolved Oxygen	Turbidity	
Groundwater Elevation		

This groundwater monitoring and modeling report includes the following elements:

- Presentation of groundwater flow data collected in 2017 and 2018.
- Presentation of groundwater monitoring analytical data collected in 2017 and 2018.
- Discussion and summary of changes in groundwater flow and groundwater quality since the previous groundwater monitoring events in 2011.
- Discussion of updated groundwater flow and transport model calibrated to the most current dataset.
- Presentation and discussion of simulated closure scenarios.

2 DATA ANALYSIS

2.1 GROUNDWATER FLOW

Groundwater flow is represented using groundwater elevation contour maps in the primary water-bearing hydrogeologic units identified in previous hydrogeologic investigations (Kelron, 2012a and Kelron, 2012b) as the Middle Groundwater Unit (MGU) and Lower Groundwater Unit (LGU), for two sampling events in September 2017 (Figures 3 and 4) and March 2018 (Figures 5 and 6). All piezometric heads measured at the NAPS and OEAP monitoring wells in 2017 and 2018 are tabulated in Table 1. In general, the lowest piezometric heads occurred during the September 2017 sampling event and the highest piezometric heads occurred during the May 2018 sampling event (Appendix A). The ranges of piezometric heads as measured at the NAPS and OEAP monitoring wells were from 574.8 to 610.0 feet North American Vertical Datum of 1988 (ft NAVD88) in 2017 and 2018. The range of piezometric heads observed in 2017 and 2018 are consistent with previously reported piezometric heads at the Site in 2011 (Kelron, 2012a and Kelron, 2012b). Based upon piezometric heads observed from 2017 to 2018, and previously reported hydrogeologic information (Kelron, 2012a and Kelron, 2012b), areas of ash within the NAPS and OEAP are in contact with groundwater.

Intra-well variation in piezometric heads (range in heads observed at individual well locations) at most MGU monitoring locations adjacent to the NAPS and OEAP were within a range of 1.3 to 3.5 feet among the six monitoring events (i.e. wells 04, 05, 08R and 17). MGU monitoring well 18, located between the NAPS and OEAP, varied over a greater range of 4.9 feet which is likely due to the position of well 18 relative to vertical stratification within the MGU. Piezometric head data at MGU monitoring well 07, immediately east of the OEAP, could not be collected because the well was dry during all six monitoring events. Variation in piezometric heads at MGU monitoring locations over 500 feet from the NAPS (i.e. wells 09 and 19) was greater than values observed adjacent to the NAPS and OEAP and ranged from 2.4 to 5.7 feet. The variations in MGU piezometric heads are consistent with previously reported values at the Site in 2011 (Kelron, 2012a and Kelron, 2012b).

Intra-well variation in piezometric heads at LGU wells during 2017 to 2018 ranged from 1.0 to 3.2 feet (i.e. wells 02, 03R and 34). These three wells are all located adjacent to the NAPS and OEAP and within 150 feet of the center channel of the Middle Fork. Similarly, piezometric heads within the Upland Groundwater Unit (UGU) described in previous reports (Kelron, 2012a and Kelron, 2012b). (i.e. wells 01 and 21) varied by a range of 1.9 to 2 feet. These two UGU wells are located upgradient of the OEAP where the UGU is suspected to have a hydraulic connection to the LGU (Kelron, 2012a and Kelron, 2012b). The variations in LGU and UGU piezometric heads are consistent with previously reported values at the Site in 2011 (Kelron, 2012a and Kelron, 2012b).

Based on the data collected in 2017 and 2018, groundwater flow directions in the MGU (Figures 3 and 5) and LGU (Figures 4 and 6) are generally from west to east toward the Middle Fork of the Vermilion River (Middle Fork). The groundwater flow directions in 2017 and 2018 are consistent with findings in the hydrogeologic investigation reports, which indicate the Middle Fork is a groundwater discharge zone for these unlithified hydrogeologic units (Kelron, 2012a and Kelron, 2012b).

Groundwater flow in the MGU from the north portion of the NAPS was southeast towards the Middle Fork. Horizontal gradients from the northern edge of the NAPS to the Middle Fork were approximately 0.008 feet per feet (ft/ft) in both September 2017 and March 2018. Groundwater flow in the MGU at the south portion of the NAPS and the northern portion of the OEAP was towards the northeast and east-northeast, respectively. Horizontal gradients at the south portion of the NAPS were approximately 0.012 ft/ft in September 2017 and 0.009 ft/ft in March 2017.

Groundwater flow in the LGU from the southern portion of the NAPS was east-southeast to southeast towards the Middle Fork. Groundwater flow in the LGU at the central portion of the OEAP was northeast with horizontal gradients that were approximately 0.008 ft/ft in September 2017 and 0.007 ft/ft in March 2017. During the six sample events in 2017 and 2018 groundwater flow direction and horizontal gradients in the MGU and LGU were consistent with previously reported values (Kelron, 2012a and Kelron, 2012b).

Nested monitoring wells are present at five locations (wells 06R/09, 18/17, 08R/03R, 20/34, 07/02) in the NAPS and OEAP groundwater monitoring network (Figure 2). Vertical hydraulic gradients were calculated for each nested well pair for each of the recent six monitoring events and presented in Table 2. Vertical gradients were calculated to evaluate the strength and direction of the vertical component of groundwater flow. Downward vertical gradients indicate areas of recharge, while upward vertical gradient indicate areas of discharge. Vertical gradients could not be calculated for nested wells 07/02 because 07 was dry during all six monitoring events. Nested wells 06R and 09, located northeast of the NAPS, are screened in the Upper Unit (i.e. uppermost native material in the bottomlands of the Middle Fork) and MGU, respectively. Vertical gradient was determined to be slightly upward during all monitoring events except for January 2018 and March 2018, where gradients were slightly downward to flat, respectively. The lowest upward gradients observed in 2011 at well nest 06R/09 also occurred during the March monitoring event at well nest 06R/09 (Kelron, 2012a and Kelron, 2012b).

Well nest 18/17 is located between the NAPS and OEAP. Wells 18 and 17 are both screened in the MGU. Groundwater elevations at monitoring well 18 were at least 10 feet higher than groundwater elevations measured at well 17 during all six monitoring events, likely due to vertical stratification within the MGU, as well 18 is partially screened in lower permeable material (i.e. sandy silt) and the bottom of the well screen is approximately 11 feet above the top of the well screen at well 17 where only 2-feet of material was sampled during drilling for the purpose of borehole logging. Vertical gradients between these nested wells were determined to be strongly downward for all six monitoring events. Vertical gradients determined for these wells were consistent with those previously reported in 2011 (Kelron, 2012a and Kelron, 2012b).

Well nests 20/34 and 08R/03R are located adjacent to the west bank of the Middle Fork and near the northeast and central portion of the NAPS, respectively. Wells 20 and 08R are screened in the MGU and their nested wells, 34 and 03R, are screened in the LGU. Vertical gradients at both well nests near the Middle Fork are primarily upward, indicating the Middle Fork is a discharge zone for the unlithified hydrogeologic units as previously reported (Kelron, 2012a and Kelron, 2012b). Similar to the 06R/09 well nest, variation in the vertical movement of groundwater at 20/34 was observed in the 2017 and 2018 monitoring events, where vertical gradients become flat to slightly upward in January, March, and May as groundwater elevations increased. These vertical gradients and trends in vertical groundwater movement were consistent with values previously reported for 2011 (Kelron, 2012a and Kelron, 2012b).

2.2 REVIEW OF ANALYTICAL DATA

All field and laboratory analytical results for bimonthly samples collected in 2017 and 2018 (recent six rounds) at the NAPS and OEAP are tabulated and summarized in Table 3. Field and laboratory reports are found in Appendix B. Monitoring well locations 09 and 19 were not sampled as these wells are not on Dynegy property and are monitored for water levels only. Monitoring well location 07 was not sampled because the well was dry during all groundwater monitoring events. Well locations relative to the NAPS and OEAP (e.g. background, upgradient, intermediate or downgradient) established in the hydrogeologic reports are presented on Table 1.

Barium and boron were detected in all groundwater samples collected in 2017 and 2018. Chloride, fluoride, iron, manganese and sulfate were detected in greater than 80% of the groundwater samples. Arsenic and nitrate were detected in less than 59% and 31% of the groundwater samples, respectively. Selenium was detected in less than 7% of groundwater samples. A summary of wells and parameters with exceedances of the Illinois Class I groundwater quality standards (Class I standards) observed during 2017 and 2018 sampling events is provided in Table 3.

The following parameters exceeded the Class I standard in at least one of the recent six rounds of groundwater samples collected in 2017 and 2018: arsenic, boron, iron, manganese, pH, sulfate, and total dissolved solids (TDS). Other parameters which are monitored, but did not have an exceedance of the Class I standard during the recent six rounds of groundwater samples include: barium, chloride, fluoride, nitrate, and selenium.

A detailed evaluation of recent Class I standard exceedances is included below. A statistical summary comparing the population of monitored inorganic groundwater quality data from 2017 and 2018 to historic data

populations for parameters that have an exceedance of the Class I standard is provided on Table 4. The Wilcoxon rank-sum test was used to develop the statistical summary found in Table 4. The Wilcoxon rank-sum is used to assess whether the distributions of observations between two separate groups (i.e. historic and recent observations) are different from one another. Time-series graphs illustrating historic and recent concentrations for each of the groundwater parameters with exceedances at the thirteen sampled monitoring wells for the period of 2011 through 2018 are included in Appendix A.

Arsenic

Arsenic concentrations did not exceed the Class I standard (0.01 mg/L) at nine of the thirteen monitoring wells sampled during the recent six rounds (Table 3, Appendix A). Arsenic concentrations exceeded the Class I standard at four monitoring wells (wells 08R, 02, 34, and 21), including one background well (well 21). Arsenic concentrations in 2017 and 2018 at monitoring wells 08R, 02, 34, and 21 were generally equal to or less than historic concentrations (Table 4, Appendix A), indicating stable or decreasing trends over time at these monitoring wells. Concentrations at all monitoring wells ranged from less than 0.001 (i.e. not detected) to 0.0357 mg/L with a median concentration of 0.0017 mg/L (Table 3, Appendix A).

Boron

Boron concentrations did not exceed the Class I standard (2.0 mg/L) at seven of the thirteen monitoring wells sampled during the recent six rounds (Table 3, Appendix A). Boron concentrations exceeded the Class I standard at six monitoring wells (wells 04, 05, 08R, 17, 18 and 03R). Monitoring wells 04, 17 and 18 had concentrations that were generally equal to or less than the historic boron concentrations, indicating stable or decreasing trends over time in these wells (Table 4, Appendix A). Boron concentrations at wells 05, 08R and 03R were greater in 2017 and 2018 when compared to historic boron concentrations, indicating generally increasing trends in boron concentrations over time at these three monitoring wells. Concentrations at all monitoring wells ranged from 0.0812 to 52.8 mg/L with a median concentration of 1.215 mg/L (Table 3, Appendix A).

Iron

Iron concentrations did not exceed the Class I standard (5.0 mg/L) at twelve of the thirteen monitoring wells sampled during the recent six rounds (Table 3, Appendix A). Iron concentrations only exceeded the Class I standard at monitoring well 34. Iron concentrations at well 34 were generally equal to historic iron concentrations, indicating these concentrations are relatively stable (Table 4, Appendix A). Concentrations at all monitoring wells ranged from less than 0.025 to 5.45 mg/L with a median concentration of 0.246 mg/L (Table 3, Appendix A).

Manganese

Manganese concentrations did not exceed the Class I standard (0.15 mg/L) at seven of the thirteen monitoring wells sampled during the recent six rounds (Table 3, Appendix A). Manganese concentrations exceeded the Class I standard at six monitoring wells (wells, 04, 05, 06R, 08R, 17 and 18), including one background well (06R). Manganese concentrations at wells 04, 05, 08R and 17 were generally equal to or lower than historic manganese concentrations, indicating these concentrations are either stable or decreasing (Table 4, Appendix A). Manganese concentrations at wells 06R and 18 were greater in the recent six rounds when compared to historic concentrations, indicating generally increasing trends at these locations. Concentrations at all monitoring wells ranged from less than 0.001 to 1.60 mg/L with a median concentration of 0.109 mg/L (Table 3, Appendix A).

pH

The only exceedance of a Class I standard for pH in the recent six sampling rounds was observed at background monitoring well 10, where a pH value of 6.42 S.U. was observed (Table 3, Appendix A). All other samples were between the upper (9.0 S.U.) and lower (6.5 S.U.) limits of the Class I standard. Historic pH values observed at well 10 were generally greater than values observed in 2017 and 2018, indicating pH is potentially decreasing over time in this well (Table 4, Appendix A). pH values at all monitoring wells ranged from 6.42 to 8.78 with a median value of 7.12 S.U (Table 3, Appendix A).

Sulfate

Sulfate concentrations did not exceed the Class I standard (400 mg/L) at nine of the thirteen monitoring wells sampled during the recent six rounds (Table 3, Appendix A). Sulfate concentrations exceeded the Class I standard at four monitoring wells (01, 08R, 17, and 18), including one upgradient well (01). Sulfate concentrations in 2017 and 2018 at monitoring wells 01, 08R, 17 and 18 were generally equal to or less than historic concentrations (Table 4, Appendix A) indicating a stable or decreasing trend over time at these monitoring wells. Concentrations at all monitoring wells ranged from less than 10 to 1,280 mg/L with a median concentration of 163 mg/L (Table 3, Appendix A).

Total Dissolved Solids

Total Dissolved Solids (TDS) concentrations did not exceed the Class I standard (1,200 mg/L) at nine of the thirteen monitoring wells sampled during the recent six rounds (Table 3, Appendix A). TDS concentrations exceeded the Class I standard at four monitoring wells (01, 08R, 17, and 18), including one upgradient well (01). TDS concentrations in 2017 and 2018 at monitoring wells 01, 08R, 17 and 18 were generally less than historic concentrations (Table 4, Appendix A), indicating a decreasing trend over time at these monitoring wells. Concentrations at all monitoring wells ranged from 312 to 2,240 mg/L with a median concentration of 606 mg/L (Table 3, Appendix A).

2.3 SUMMARY OF CHANGES IN GROUNDWATER FLOW AND QUALITY COMPARED TO PREVIOUS OBSERVATIONS

At the site-wide scale, groundwater flow direction and gradients have not changed significantly since the hydrogeologic investigation report was completed in 2012 (Kelron, 2012a and Kelron, 2012b). At the individual well scale, groundwater elevations were within ranges previously reported with the exception of well 07, where water elevations have decreased below the screened interval and the well could not be sampled.

Groundwater statistical analysis and concentration versus time plots indicate concentration trends are stable or decreasing over time with the following exceptions:

- Boron concentrations from the recent six rounds have increased compared to previous results at wells 03R, 05, and 08R.
- Manganese concentrations from the recent six rounds have increased compared to previous results at wells 06R and 18.
- The lowest pH value from the recent six rounds was observed at well 10, where values have decreased compared to previous results.

3 GROUNDWATER MODEL

3.1 OVERVIEW

Data collected at the Site from the recent six rounds were used to update the existing groundwater model which was developed in 2012 (NRT, 2012a and NRT, 2012b), and later updated in 2014 (NRT, 2014a and NRT, 2014b). The updated model was then used to evaluate the five closure scenarios included in DMG's November 30, 2017 response to IEPA's February 14, 2017 letter requesting closure plans for the NAPS and OEAP (November 2017 Response Letter (Appendix C)). The following five closure scenarios are included in this report:

- Scenario 1: closure in place (NAPS, OEAP); consolidate ash and close in place New East Ash Pond (NEAP)
- Scenario 2: closure by removal (NAPS, OEAP, NEAP)
- Scenario 3: beneficial re use (NAPS, OEAP, NEAP)
- Scenario 4: consolidate OEAP to NAPS/NEAP, close NAPS and NEAP in place
- Scenario 5: consolidate NEAP and OEAP layback to NAPS, close OEAP and NAPS in place

The results of the five closure scenarios proposed in the November 2017 Response Letter are summarized and evaluated in this report.

3.2 CONCEPTUAL MODEL

The hydrogeologic investigation reports (Kelron, 2012a and Kelron, 2012b) are the foundation of the site setting and conceptual site model (CSM) that describes groundwater flow at the Site. The NAPS and OEAP overlie the recharge area for the underlying transmissive geologic media (i.e. MGU and LGU), which are composed of alluvium. Groundwater enters the model domain vertically via recharge, and there is also a small component of groundwater that flows into the system via thin water bearing strata in the glacial deposits upgradient of the NAPS and OEAP (i.e. UGU). The discharge point for groundwater in the model is the Middle Fork.

Boron was selected for transport modeling because it has high concentration relative to the Class I standard and is mobile in groundwater. The only significant sources of boron are the NAPS and OEAP. The NEAP is constructed over shale bedrock and is outside of the model domain for the NAPS and OEAP. Mass (boron) is added to groundwater via vertical recharge through CCR, and horizontal groundwater flow through CCR where it lies below the water table. Mass is discharged to the Middle Fork. The primary transport pathway is the MGU as indicated by groundwater observations. The LGU is also a migration pathway, although the amount of mass in this unit will be limited by the Middle Confining Unit that separates the MGU an LGU (Kelron, 2012a and Kelron, 2012b). There is no removal of mass from the groundwater system via adsorption or decay.

3.3 MODEL APPROACH

A three-dimensional groundwater flow and transport model was calibrated to represent the conceptual flow system described above. Rather than simulating fate and transport for the variable conditions leading up to the current time, modeling was performed for a sufficient period (40 years) to allow modeled concentrations in the primary transport layer (MGU) to achieve steady levels. The model was calibrated to match groundwater elevation and concentration trends observed during 2017 and 2018. Prediction simulations were then performed to evaluate the effects of the five closure scenarios for the NAPS and OEAP on groundwater quality for a period of 160 years (total modeled timeframe is 200 years). The calibration and prediction model timelines are illustrated in Figure 7.

Three model codes were used to simulate groundwater flow and contaminant transport:

- Groundwater flow was modeled in three dimensions using MODFLOW 2005
- Contaminant transport was modeled in three dimensions using MT3DMS
- Leachate percolation (recharge) after cap placement or ash fill consolidation/removal at the NAPS and OEAP was modeled using the Hydrologic Evaluation of Landfill Performance (HELP) model.

4 MODEL SETUP AND CALIBRATION

4.1 MODEL DESCRIPTIONS

MODFLOW uses a finite difference approximation to solve a three-dimensional head distribution in a transient, multi-layer, heterogeneous, anisotropic, variable-gradient, variable-thickness, confined or unconfined flow system—given user-supplied inputs of hydraulic conductivity, aquifer/layer thickness, recharge, wells, and boundary conditions. The program also calculates water balance at wells, rivers, and drains.

MODFLOW was developed by the United States Geological Survey (McDonald and Harbaugh, 1988) and has been updated several times since. Major assumptions of the code are: (1) groundwater flow is governed by Darcy's law; (2) the formation behaves as a continuous porous medium; (3) flow is not affected by chemical, temperature, or density gradients; and (4) hydraulic properties are constant within a grid cell. Other assumptions concerning the finite difference equation can be found in McDonald and Harbaugh (1988). MODFLOW 2005 was used for these simulations.

MT3DMS (Zheng and Wang, 1998) is an update of MT3D. It calculates concentration distribution for a single dissolved solute as a function of time and space. Concentration is distributed over a three-dimensional, non-uniform, transient flow field. Solute mass may be input at discrete points (wells, drains, river nodes, constant head cells), or a really distributed evenly or unevenly over the land surface (recharge).

MT3DMS accounts for advection, dispersion, diffusion, first-order decay, and sorption. Sorption can be calculated using linear, Freundlich, or Langmuir isotherms. First-order decay terms may be differentiated for the adsorbed and dissolved phases.

The program uses the standard finite difference method, the particle-tracking-based Eulerian-Lagrangian methods and the higher-order finite-volume TVD method for the solution schemes. The finite difference solution has numerical dispersion for low-dispersivity transport scenarios but conserves good mass balance. The particle-tracking method avoids numerical dispersion but was not accurate in conserving mass. The TVD solution is not subject to significant numerical distribution and adequately conserves mass, but is numerically intensive, particularly for long-term models such as developed for the APS. The finite difference solution was used for this simulation.

Major assumptions of MT3DMS are: (1) changes in the concentration field do not affect the flow field; (2) changes in the concentration of one solute do not affect the concentration of another solute; (3) chemical and hydraulic properties are constant within a grid cell; and (4) sorption is instantaneous and fully reversible, while decay is not reversible.

The Hydrologic Evaluation of Landfill Performance (HELP) model was developed by the U.S. Environmental Protection Agency (Schroeder et al., 1994). HELP is a one-dimensional hydrologic model of water movement across, into, through and out of a landfill or soil column based on precipitation, evapotranspiration, runoff, and the geometry and hydrogeologic properties of a layered soil and waste profile. For this modeling, HELP Version 3.07 (Schroeder et al., 1994) was selected to estimate the hydraulic conditions beneath caps and ash fill consolidation/removal areas.

4.2 FLOW AND TRANSPORT MODEL SETUP

The modeled area was approximately 5,000 feet by 5,000 feet and centered around the NAPS and OEAP. The eastern edge of the model is bounded by the Middle Fork. The north, west, and south edges of the model were selected to maintain sufficient distance from NAPS and OEAP to reduce boundary interference with model calculations, while not extending too far past the extent of available calibration data. The model grid and boundary conditions are displayed in Figure 8.

The MODFLOW model was calibrated to recently collected groundwater elevations from September 2017. MT3DMS was run on the calibrated flow model and model-simulated concentrations were calibrated to the median observed boron concentration values at the monitoring wells calculated from boron concentrations

results in the recent six rounds. Multiple iterations of MODFLOW and MT3DMS calibration were performed to achieve an acceptable match to observed flow and transport data. For the NAPS and OEAP, the calibrated flow and transport model were used in predictive modeling to evaluate the five closure scenarios by removing saturated ash cells and using HELP modeled recharge values as to simulate changes proposed in each scenario.

4.2.1 Grid and Boundary Conditions

An eight layer, 200 x 212 node grid was established with 25 foot grid spacing (Figure 8) The previous models created in 2012 and 2014 were constructed with six layers and focused on MGU and LGU hydrostratigraphic units primarily associated with contaminant transport. The 2014 model was selected as the starting point for this modeling effort. Layers 1 and 2 of the previous model were each split into two layers for the current model to reduce the change in layer thickness in adjacent cells, primarily near the NAPS and OEAP boundaries, thereby reducing the potential for numerical instability in the model associated with rapid changes in cell size. The new layers retained all other boundary conditions and properties found in the 2012 and 2014 models.

The north, south and west edges of the model are no-flow (Neumann) boundaries in all layers of the current model. In previous 2012 and 2014 models, the western edge of the model was a general head (Dirichlet) boundary placed in Layer 5 (equivalent to Layer 7 in the current model) to simulate flow in the thin sands composing the UGU. The general head boundary in the calibrated 2014 flow model contributed less than 3% of the cumulative water input volume and was removed in the current model update for simplification. The eastern edge of the model in Layer 5 has a river (Mixed) boundary that represents the Middle Fork. The eastern edge of the model in all other layers is a no-flow (Neumann) boundary. The bottom of the model was also a no-flow (Neumann) boundary. The top of the model was a time-dependent specified flux (Neumann) boundary, with specified flux rates equal to the recharge rate. A specified mass flux (Cauchy condition) boundary was used to simulate downward percolation of solute mass from the NAPS and OEAP. This boundary condition assigns a specified concentration to recharge water entering the node, and the resulting concentration in the node is a function of the relative rate and concentration of recharge water (water percolating from the impoundments) compared to the rate and concentration of other water entering the node.

4.2.2 Flow Model Input Values and Sensitivity

Flow model input values and sensitivity analyses results are presented in Table 5 and described below.

In the previous 2012 and 2014 models, groundwater flow was calibrated to groundwater elevations observed in October 2011 during development of the river boundary conditions and is described further in the discussion of the river boundary input values below. In the current model, the September 2017 elevation data was chosen for calibration to be consistent with the groundwater conditions and elevations observed in the October 2011 monitoring event. The flow model calibration targets (i.e. September 2017 groundwater elevations and target well locations) are summarized in Table 6. In the current flow calibration model, the target for well 18, which was previously located in layer 1 of the 2012 and 2014 models, was moved to the layer 3. Layer 3 (Upper Unit) is more representative of the materials screened at well 18 and resulted in an improved flow calibration for the target elevation at well 18. Wells and targets for locations VP1, VP2, VP3, VP4, VP5 and TW-1 found in the previous 2012 and 2014 models were also removed from the current model as no updated data was available for these locations. Well 07 located in the MGU was also removed from the current model calibration because the well was dry and could not contribute recent groundwater elevation or concentration data. No other changes were made to the relative position of the targets and wells from the 2012 and 2014 models to the current model.

Sensitivity analysis was conducted by changing input values and observing changes in the sum of squared residuals. Horizontal conductivity, vertical conductivity, and river conductance terms were all varied between one-tenth and ten times calibrated values. Recharge terms were varied between one-half and two times calibrated values. River stage terms were varied between 90 percent and 110 percent of calibrated values. When the calibrated model was tested the sum of squared residuals was 32.8. Sensitivity tests that resulted in sum of squared residuals greater than 100 were considered sufficient to nullify the calibration. Results of sensitivity analysis are in Table 5.

Layer Top/Bottom

The top of layer one was set at an elevation of 660 feet, a value roughly equivalent to the elevation at the top of the bluff above the Middle Fork. In the previous 2012 and 2014 models, the layers of the model grid were all flat lying and thicknesses were approximated from hydrostratigraphic unit thicknesses presented in the 2012 Hydrogeologic Investigation (Kelron, 2012a and Kelron, 2012b), including the bottom of the fill (ash) layer. In the current model, the base of the fill (ash) layer (layer 2) was determined by contouring the bottom of fill (ash), as determined from site borings from the 2012 Hydrogeologic Investigation (Kelron, 2012a and Kelron, 2012b) and the 2013 Geotechnical Report (URS, 2013), and importing the contour data into MODFLOW (Figure 9). The imported base elevations for fill in layer 2 were between 601 and 580 feet and resulted in an improved representation of saturated thickness of the fill (ash) within the model. Layers 3 and 4 were reduced to a thickness of 2 feet in the vicinity of fill borings VP-1 and VP-2 and layer 5 was elevated based on site conditions observed in soil boring logs and cross sections and to preserve these features that were present in the previous model. The remaining layers 6 through 8 all have constant layer thicknesses. Flow model layer description and parameters are summarized in Table B below.

Table B. Flow Model Layer Descriptions and Parameters

Layer	Hydrostratigraphic unit used to determine layer thickness	Top Elevation (feet)	Bottom Elevation (feet)	Thickness (feet)
1 & 2	Fill (ash)	660 (top of bluff, layer 1)	601-580 (layer 2)	59-80 (layer 1 and 2 combined)
3 & 4	Upper Unit	601-580 (layer 3)	579-575 (layer 4)	2-26 (layer 3 and 4 combined)
5	Middle Groundwater Unit	579-575 (layer 4)	560	15-19
6	Middle Confining Unit	560	550	10
7	Lower Groundwater Unit	550	540	10
8	Lower Confining Unit	540	530	10

Hydraulic Conductivity

Hydraulic conductivity values and sensitivity results are summarized in Table 5. When available, these values were derived from field measured values reported in the 2012 Hydrogeologic Investigation (Kelron, 2012a and Kelron, 2012b) and the Regional and Local Hydrogeology and Geochemistry: Vermilion Power Plant, Illinois (Kelron, 2003). The current model used values closer to the geometric mean of available field and laboratory measured values for each zone as compared to the previous 2012 and 2014 models to improve representation of site conditions. The sources of the hydraulic conductivity values are summarized in Table 5. Conductivity zones that did not have representative site data (i.e. zones 3 and 7) were determined through model calibration. Conductivity zones 4 and 10 were adjusted from field measured values during calibration. All calibrated values are consistent with published values (Anderson and Woessner, 1992). No horizontal anisotropy was assumed. Vertical anisotropy (presented as Kh/Kv in Table 5) was applied to alluvial deposits, fill, and shale to simulate preferential flow in the horizontal direction in these materials. Permeability tests discussed in the 2012 Hydrogeologic Investigation (Kelron, 2012a and Kelron, 2012b) also indicate alluvial deposits have vertical conductivity values that are significantly lower than horizontal.

The spatial distribution of the hydraulic conductivity zones (Figure 10) in each layer simulates the distribution of hydrostratigraphic units as reported in the 2012 Hydrogeologic Investigation (Kelron, 2012a and Kelron, 2012b). The limits of the Fill Unit hydraulic conductivity zone (zone 2) in the current model were updated to reflect the limits of the ash fill determined from the 2013 Geotechnical Report (URS, 2013). This adjustment to the ash fill extent was propagated through all related ash fill property zones and boundary condition (i.e. recharge, storage, effective porosity and constant concentration cells). A sandy unit is found in Layers 1, 2, 3, 4 and 5 in the vicinity of historic monitoring location TW-1 to represent the sandbar in which the well was

screened. The Middle Confining Unit in layer 6 is continuous except at the Middle Fork where it was assumed that it is eroded and replaced with sand-rich river alluvium. The upper unit alluvium was present within the model was split into eastern and western units because the materials are different and they are isolated from one another.

The model was highly sensitive to changes in horizontal conductivity in all zones except zone 9 (Middle Confining Unit), where the model was moderately sensitive to horizontal conductivity. The model was highly sensitive to changes in vertical conductivity in all zones except zones 2 (Fill Unit), 7 (Lower Confining Unit) and 10 (Upland Groundwater Unit), where the model exhibited a moderate to moderately high sensitivity.

Recharge

Recharge rates were determined through calibration in the 2012 and 2014 models and were adjusted during calibration of current model to the groundwater elevation and groundwater quality data collected in 2017 and 2018 (Table 5). The spatial distribution of recharge zones was developed in 2012 and 2014 and were based on the location and type of material present at land surface (Figure 11). Seven different zones were created to simulate recharge in the model area, four of which are related to the NAPS and OEAP. Consistent with the 2012 and 2014 models, the recharge occurring through the ash fill placed in the NAPS and OEAP was split into three different values. Another recharge zone (zone 5) developed in the 2012 and 2014 models was also retained in the current model to simulate recharge through the NAPS polishing pond. The remaining three zones were created to simulate recharge through the Upper Unit alluvium (eastern and western) and the Upland Confining Unit.

The model had a high sensitivity to changes in recharge in all zones except CCR fill material recharge zones 2 (CCR NAPS) and 7 (CCR OEAP). The model had a moderate and moderately high sensitivity to changes in recharge at zones 2 and 7, respectively.

Storage and Specific Yield

As in the 2012 and 2014 models, the current calibration model did not use these terms because it was run at steady state. No field data defining these terms were available so published values were used consistent with Fetter (1988). No changes from the 2012 and 2014 models were made to storage and specific yield values in development of the current model. The spatial distribution of the storage and specific yield zones were consistent with those of the hydraulic conductivity zones. The sensitivity of these parameters was tested by evaluating their effect on the transport model. Storage values were multiplied and divided by a factor of 10, and specific yield by a factor of 2. The transport model had a negligible to low sensitivity to changes in storage and specific yield (Table 8).

River Parameters

The Middle Fork was simulated using head-dependent flux nodes that required inputs for river stage, width, bed thickness, and bed hydraulic conductivity (Table 5). These river parameters were developed in the 2012 and 2014 models, and only the river stage parameter was modified in development of the current calibration model. River width, bed thickness and bed hydraulic conductivity parameters were used to calculate a conductance term for the boundary node. This conductance term was determined by adjusting hydraulic conductivity during model calibration of the 2012 and 2014 models, while bed thickness was set at 1 foot and river width was set at 100 feet. Final hydraulic conductivity value was set at 1 ft/day. The entire length of the river boundary was placed in Layer 5 in the current model (Figure 8).

The approximate stage and slope of the river were originally developed in the 2012 and 2014 models. The stage of the river was adjusted during calibration of the current model to reflect updated groundwater elevations collected in September 2017, while the slope approximated in the 2012 and 2014 models was maintained.

The current model had a high sensitivity to changes in river stage and a moderate sensitivity to changes in river conductance.

Summary of Flow Model Input Value Changes in Current Model

As described above flow model input value changes were made from the previous 2012 and 2014 flow calibration models to the current flow calibration model to reflect the updated groundwater elevation data, as well as, improve the flow model calibration results. These changes are summarized below:

- Layers 1 and 2 in the previous model were each split into two layers (equivalent to a total of four layers).
- The general head boundary at the upgradient edge of the UGU in the previous model was removed.
- Target groundwater elevations come from recent values measured in September 2017.
- Well 18 and the associated groundwater elevation target value was placed in the modeled Upper Unit (layer 3).
- Wells VP1, VP2, VP3, VP4, VP5. TW-1, and 07 and their associated groundwater elevation target values were removed.
- The base of the fill (ash) layer (layer 2) was modified by importing surface contour data into MODFLOW.
- The current model used values closer to the geometric mean of available field and laboratory measured values for each hydraulic conductivity zone as compared to the previous 2012 and 2014 models to improve representation of site conditions.
- The spatial distribution of the Fill Unit hydraulic conductivity zone (zone 2), recharge zone (zone 7) and storage/specific yield zone (zone 2) at the northeast boundary of the OEAP were adjusted to reflect the limits of the ash fill determined from the 2013 Geotechnical Report (URS, 2013).
- River stage elevations were adjusted to calibrate to September 2017 groundwater elevation targets.

4.2.3 Transport Model Input Values and Sensitivity

MT3DMS input values are listed in Table 7 and described below. Sensitivity of the transport model is summarized in Table 8.

In the previous 2012 and 2014 models, groundwater transport was calibrated to groundwater boron concentration ranges at each well as measured from the monitoring wells in 2011. The current model was calibrated to groundwater boron concentration ranges at each well as measured from the recent six rounds. The transport model calibration targets are summarized in Table 6.

Sensitivity analysis was conducted by changing input values and observing percent change in boron concentration at each well from the calibrated model boron concentration. Retardation was varied by increasing the K_d value from 0 milliliters per gram (mL/g) to 0.5 mL/g. Effective porosity was varied by decreasing and increasing calibrated model values by 0.05. Diffusion was varied by making diffusion zone 10 inactive transport cells. Results of sensitivity analysis are in Table 8.

Initial Concentrations

No initial concentrations were placed in the calibration model. The flow model was run as steady state and concentration was added to the model through recharge and constant concentration cells starting at the same time as flow simulation. Modeling was performed for a sufficient period (40 years) to allow modeled concentrations in the primary transport layer (i.e. MGU) to achieve steady levels (Figure 7).

Source Concentrations

Four concentration sources in the form of vertical percolation through CCR were simulated in Fill Unit layer 1 for calibration (Table 7): percolation through CCR in the northern portion of the NAPS (recharge zone 2), percolation through the CCR near the center of the impoundments (recharge zone 6), percolation through the CCR in the southern portion of the OEAP (recharge zone 7), and percolation through a layer of residual CCR from the NAPS polishing pond (recharge zone 5) (Figure 11). All four sources were simulated by assigning concentration to the recharge input. The CCR sources were also simulated with constant concentration cells

placed in Fill Unit layers 1 and 2 (Figure 8) to simulate saturated ash conditions. From the model perspective, this means that when the simulated water level is above the base of these cells, water that passes through the cell will take on the assigned concentration. Constant concentration cells were not used with the polishing pond because the volume of ash in this pond is minimal and it contains more water than ash. All source concentrations were recalibrated in the current transport model to the boron concentration data collected in 2017 and 2018. The source concentrations applied to the recharge zones and saturated ash cells immediately below the recharge zones have the same concentration values.

Because these are the sources of concentration in the model, the model will be highly sensitive to changes in the input values. For that reason, sensitivity testing was not completed for these parameters.

Effective Porosity

Effective porosity values are consistent with the range of values (10 to 30 percent) discussed in the Hydrogeologic Investigation (Kelron, 2012a and Kelron, 2012b). The model had a low to moderately high sensitivity to changes in porosity values in monitoring wells 20, 34, 03R, and 34 near the fringe of the modeled plume. Wells closer to the plume were had a negligible sensitivity.

Dispersivity

Dispersivity values were applied to the entire model domain and determined during calibration. Longitudinal dispersivity was set at 3 feet. The transverse and vertical dispersivity were set at 1/10 and 1/100 of longitudinal dispersivity. The sensitivity of the model to dispersivity was not tested.

Retardation

It was assumed that boron would not significantly sorb (K_d was set to 0 mL/g). The sensitivity of the model to this parameter was tested by running the model with a K_d value of 0.5 mL/g. The model was not sensitive to this change.

Diffusion Zones

Diffusion was set to 0 for the entire model domain. In the 2012 and 2014 transport calibration models, two different diffusion zones (zones 1 and 10) were placed in the model to limit transport modeling to the alluvial deposits where transport is primarily occurring and the UGU (zone 1). The rest of the model domain was assigned to zone 10 which was designated as inactive to transport in the MT3DMS transport settings. Figure 12 illustrates the spatial distribution of diffusion zones 1 and 10 in the model. This limitation on transport to the alluvial deposits and the UGU (zone 1) was removed in the current model, as the limitation on transport prevented the activation of transport cells required for the prediction modeling. Sensitivity to the presence or absence of this limitation was negligible and low for the MGU wells and the LGU wells, respectively.

4.3 FLOW AND TRANPORT MODEL ASSUMPTIONS AND LIMITATIONS

Simplifying assumptions were made while developing this model:

- Except for changes induced by cap construction and ash fill consolidation/removal, the groundwater flow system is at steady state.
- Natural recharge is constant over the long term.
- Fluctuations in river stage do not affect groundwater flow and transport over the long term.
- Hydraulic conductivity is consistent within hydrostratigraphic units
- The base of ash surface was modeled by contouring data from boring log information from the 2012 Hydrogeologic Investigations (Kelron, 2012a and Kelron, 2012b) and the 2013 Geotechnical Report (2013, URS).
- The MGU is continuous except at the Middle Fork where it is eroded and replaced with sand-rich river alluvium.

- Observed concentrations in groundwater exhibit no long-term trend.
- Leachate concentrations are assumed to remain constant over time.
- Boron is not adsorbed and does not decay, and mixing and dispersion are the only attenuation mechanisms.

4.4 CALIBRATION FLOW AND TRANSPORT MODEL RESULTS

Results of the MODFLOW/MT3DMS modeling are presented below. A disk containing the model files is attached to this report.

Flow model calibration results are presented in Figure 13. The mass balance error for the flow model was 0.08% and the ratio of the residual standard deviation to the range was 4.4 percent; these values are within the targets for these criteria of 1 percent and 10 percent respectively. Another flow model calibration goal is that residuals are evenly distributed such that there is no bias affecting modeled flow. The observed heads are plotted versus the simulated heads in Figure 14. The near-linear relationship between observed and simulated values indicates that the model adequately represents the calibration dataset. The residual mean was also near zero with a value of -0.17 feet (ft), indicating evenly distributed simulated values above and below the observed values; this is also illustrated in the observed vs. residuals plot at the bottom of Figure 14.

The range of observed boron concentrations in 2017 and 2018 for transport calibration locations are summarized in Table 6. The goals of the transport model calibration were to have predicted concentrations fall within the range of observed concentrations; and, to have predicted concentrations above and below the Class I standard for boron (2 mg/L) match observed concentrations above or below the standard at each well. Both these goals were achieved at all but 4 of the transport calibration location wells (Figure 15), and all of the wells achieved the second goal of matching observed concentrations above or below 2 mg/L. Deviations from the observed ranges are discussed below.

- The model under predicts concentration in well 04, which is screened in the MGU; however the difference between the lower limit of the range of observed concentrations (4.80 mg/L) and the predicted concentration of 4.59 mg/L is negligible (less than 0.5 mg/L). The modeled and observed concentration are both above 2 mg/L, so one of the two calibration goals was satisfied.
- Well 20, also screened in the MGU and downgradient of 04, is over predicted by greater than 1 mg/L above the upper limit of the range of observed concentrations (0.53 mg/L) at a predicted concentration of 1.80 mg/L. Observed concentrations at well 20 did not exceed the Class I standard and predicted concentration remained below the Class I standard, satisfying one of the calibration goals and indicating the transport calibration model was able to predict concentrations below the standard downgradient of a well that exceeds the standard (04).
- Well 34, screened in the LGU, is slightly under predicted by less than 0.5 mg/L below the lower limit of the range of observed concentrations (0.48 mg/L) at a predicted concentration of 0.33 mg/L; however, observed and predicted concentrations did not exceed the Class I standard, satisfying one of the calibration goals.
- As in the 2012 and 2014 models, the current transport calibration model over predicts concentration at 03R by approximately 11 mg/L as compared to the upper limit of 5 mg/L. Modeled and observed concentrations are above 2 mg/L and since the LGU is not the primary transport zone, the over prediction of concentration at this well is considered a conservative estimate.

The remaining calibration locations (05, 08R, 17, 18 and 02) had predicted concentrations that were within range of the observed boron concentration and simulated Class I standard exceedances. MGU well 08R, where the highest concentrations were observed, was also calibrated to the median concentration of the observed values in 2017 and 2018, indicating the transport calibration model was able to simulate the highest observed concentrations. Wells 06R, 01, 21 and 10 were not used as criteria for transport calibration because they are not screened in the MGU or LGU; however, observed concentrations were below the Class I standard for boron (i.e. 2 mg/L) and the simulated concentrations in the transport calibration model were also below the standard (Figure 15).

5 SIMULATION OF CLOSURE SCENARIOS

5.1 OVERVIEW AND PREDICTION MODEL DEVELOPMENT

Prediction modeling for the capping and ash fill consolidation/removal scenarios (closure scenarios) described in Section 3 was completed for a period of 160 years following the 40 year calibration modeling period (Figure 7). Closure scenarios were simulated by applying the HELP-calculated percolation rates based on a cap and consolidation/removal designs provided in the November 2017 Response Letter. HELP modeling input and output values are summarized in Table 9 and described in detail below. The predicted changes in boron concentrations from the five closure scenarios were compared to a no action condition where no cap or excavation was simulated. The following simplifying assumptions were made during the simulations:

- In the no action scenario, percolation rates developed in the calibration model were assumed to remain constant (Table 5).
- In the five closure scenarios, HELP-calculated average annual percolation rates were developed from a 30-year HELP model run. There was no significant change in percolation rates over the 30-year timeframe of HELP-simulated values. This 30-year HELP-calculated percolation rate remained constant over duration of the closure scenario prediction model runs.
- Cap construction and ash fill consolidation/removal has an instantaneous effect on recharge and percolation through surface materials.
- Cap construction in all closure scenarios was assumed to be completed with a cover system consisting of the following (listed from ground surface down): a vegetative cover (6 inches thick), rooting zone (18 inches thick), geocomposite drainage layer and 40-mil HDPE geomembrane.
- Boron source concentrations were assumed to remain constant as a function of time following the end of the calibration simulation. Boron concentration in the ash fill consolidation/removal areas was assumed to be 0 mg/L following construction to simulate removal of ash that is the source of leachate.
- The start of each closure prediction simulation was initiated at the end of the calibration model period of 40 years. Each closure scenario was assumed to take effect in the model at the completion of remedial construction based on the estimated project durations as described below (i.e. the simulation of Scenario 1 begins at 42 years - 40 years for calibration plus 2 years of no changes until construction of the closure option is completed). The prediction modeling timeline for each scenario is listed below and also illustrated in Figure 7:
  - Scenario 1: 2 Year Construction Period
  - Scenario 2: 10 Year Construction Period
  - Scenario 3: 20 Year Construction Period
  - Scenario 4: 5 Year Construction Period
  - Scenario 5: 3 Year Construction Period
- Final grade of the capping systems were assumed at or above current top of berms. Proper storm water control systems were assumed to remove excess water from the surface of the capped areas based on design drawing (November 2017 Response Letter).
- Ash fill consolidation/removal areas were assumed to be graded and include proper storm water controls to remove excess water from the surface using the design drawings provided (November 2017 Response Letter).
- All saturated ash (constant concentration cells) in the transport calibration model was consolidated into the designed footprint of each closure scenario in the prediction models. This assumes all ash in the transport calibration model is either removed or placed within the final footprint of the caps in each closure scenario. Local fill materials were assumed to replace ash fill in areas of consolidation/removal.

- Local fill materials applied to the prediction models have similar hydraulic properties as the Upper Unit materials used in the transport calibration models. However, the local fill materials were assumed to have reduced vertical anisotropy ratios, approaching isotropic, due to reworking of the material as it is placed as backfill (Kh/Kv decreased from measured values of 1000 to 10 for reworked material).
- Saturated ash (constant concentration) cells were removed within the footprint of ash removal areas in the prediction models. In areas where the proposed cap scenario expanded beyond the calibrated ash footprint, saturated ash cells were not added to the prediction model under the assumption that construction of the proposed capping scenario would not create new saturated ash cells (i.e. there would not be construction excavations below the water table that would be backfilled with ash creating new areas of saturated ash).

5.2 HELP MODEL SETUP AND RESULTS

HELP (Version 3.07; Schroeder et. al, 1994) was used to estimate percolation through the NAPS and OEAP areas for five capping and ash fill consolidation/removal scenarios. HELP input and output files are included on the disk attached the report.

HELP input data and results are provided in Table 9. All scenarios were modeled for a period of 30 years. Climatic inputs were synthetically generated using default equations developed for Indianapolis, IN (the closest weather station included in the HELP database), 30-year average precipitation and temperature values recorded at the Danville, IL weather station, and the latitude of the NAPS/OEAP sites. Soil layering was developed for the five capping and ash fill consolidation/removal scenarios using data provided in the closure scenario designs documented in the November 2017 Response Letter, as well as, data available in the 2012 Hydrogeologic Investigation (Kelron, 2012a and Kelron, 2012b).

Sensitivity analysis was performed on presence/absence of top soil and rooting zone (consolidation/removal areas), soil fill thickness (consolidation/removal areas), drainage slope and drainage length (capping areas and consolidation/removal areas), geomembrane placement quality (capping areas), and ash layer thickness and texture (capping areas). Results of the sensitivity test are summarized in Table 10. The model exhibited negligible to low sensitivity for soil fill thickness, ash fill thickness, consolidation/removal areas drainage slope and consolidation/removal areas drainage length inputs; moderate sensitivity to the presence/absence of top soil and rooting zone in consolidation/removal areas; and moderate to high sensitivity to capping area drainage length, capping area drainage slope and geomembrane placement quality.

HELP model results (Table 9) indicated 0.023 inches of percolation per year for the NAPS capping areas when the drainage length was approximately 1585 feet (Scenario 1), 0.011 inches per year (in/yr) when the drainage length was approximately 1000 feet (Scenario 3) and 0.13 in/yr when the drainage length was approximately 3730 feet (Scenarios 4 and 5). HELP model results also indicated 0.024 inches of percolation per year for the OEAP capping areas when the drainage length was approximately 1610 feet (Scenarios 1 and 5). For the NAPS ash fill consolidation/removal areas HELP model results indicated 7.1 inches of percolation per year when the drainage length was approximately 1585 feet (Scenarios 2 and 3), and 6.3, 6.9 and 6.4 in/yr for OEAP ash fill consolidation/removal areas when the drainage lengths were 150 (Scenarios 1 and 5), 1610 (Scenarios 2 and 3) and 760 feet (Scenario 4), respectively.

5.2 SIMULATION OF CLOSURE SCENARIOS

The calibrated model was used to evaluate the effectiveness of the five closure scenarios provided in the November 2017 Response Letter by changing recharge rates to simulate changes to the footprint of CCR and ash fill/removal areas at the NAPS and OEAP. Removal of leachate inputs from the ash removal areas was simulated by reducing the boron concentrations associated with recharge in the areas to 0 mg/L. Constant concentration cells that represent areas with potentially saturated ash were also removed from the ash removal areas.

Each prediction scenario was simulated as a continuation of the calibration model until the completion of the estimated construction period for each closure scenario had been reached (e.g. 40 years calibration plus 2 to 20 years for closure scenario construction). Once the construction time period had been reached, changes to recharge and constant concentration cells were placed in the model to simulate the closure scenario (Figure 7).

New recharge zones representing capping or ash fill consolidation/removal areas for each scenario are summarized in Table 11 and Figure 16. The closure scenarios represent a condition when all areas within the NAPS and OEAP are either capped or ash is consolidated/removed according to the design documented in the November 2017 Response Letter. The five closure scenarios are discussed in this report based on predicted changes in hydraulic heads and boron concentrations as described below.

5.2.1 No Action Condition Predicted Hydraulic Heads and Boron Concentrations

This scenario is a continuation of the flow and transport model calibration with the assumption that no changes to current conditions occur into the future. This simulation serves as a baseline for discussion and comparison of the five closure prediction scenarios. Predicted hydraulic heads in the no action scenario do not vary significantly from the calibrated transport and flow models. As recharge within the model domain is the primary source of water and no changes in recharge were applied to the no action scenario, no significant change in predicted hydraulic heads or flow direction was expected.

The lower half of Figure 17 illustrates simulated boron concentrations with time at all monitoring wells with median observed boron concentrations greater than 2 mg/L observed during recent groundwater sampling in 2017 and 2018 (wells 04, 05, 08R, 03R, 18, 17). The graph starts with the calibration model (0-40 years before closure scenario implementation) and continues 160 years into the future under the no action condition (40-200 years). The top half of Figure 17 illustrates the footprint of the simulated boron plume from all layers of the model after 40 years of no action conditions have passed (which occurs at 80 years on the graph as indicated by the dashed vertical blue line). Illustrating the footprint of the simulated boron plume 40 years after model calibration was selected as a point of comparison between the closure scenarios because predicted boron concentrations at many of the wells reach an inflection point around this time period, which makes it a good place to take a snapshot of predicted conditions for discussion. Figures 18 through 22 illustrating the 5 closure scenarios contain the same format of information.

As illustrated on Figure 17, concentrations in the no action scenario were predicted to continue along the concentration equilibrium plateau achieved in the transport calibration modeling 0-40 year period. Only predicted concentrations at LGU monitoring well 03R continued to increase until reaching a plateau at approximately 140 years (100 years after closure scenario implementation). As described in Section 4.4, 03R was over predicted in the transport calibration model. These results indicate the model conservatively simulates (over predicts) boron concentrations (mass) in the lower layers of the model at this well location. In other words, future observations of boron concentration collected from well 03R are expected to be lower than what is predicted in the model. Although 03R continued to increase in predicted boron concentrations, the extent of the footprint of the boron plume over 2 mg/L remained approximately the same in the no action scenario as in the transport calibration model (Figure 17).

5.2.2 Closure Scenario 1 Predicted Hydraulic Heads and Boron Concentrations

The design for closure scenario 1 includes consolidation of ash fill in an area north of the OEAP and within the polishing pond into the NAPS followed by placement of a cap over the NAPS and remaining ash fill in the OEAP (Figure 16, Appendix C). In this prediction model the number of dry cells increased in layers 1 through 4 (Fill Unit and Upper Unit), particularly in the center of the NAPS and OEAP, as compared to the no action scenario at approximately 40 years after closure scenario implementation. This increase in the number of dry cells in closure scenario 1 indicates a general decrease in predicted hydraulic heads in the Fill Unit and Upper Unit in response to placement of the caps over the NAPS and OEAP and the resulting decrease in recharge. As the cells become dry within the modeled Fill Unit, an increasing number of saturated ash cells (constant concentration cells) also become inactive and no longer contribute boron source concentrations to the model domain. There was also a decrease in predicted hydraulic heads in the primary water-bearing hydrogeologic units, layers 5 (MGU) and 7 (LGU), as indicated by an approximate 1.1-foot and 1.9-foot decrease in head at MGU well 08R and LGU well 03R, respectively, when compared to the no action scenario at approximately 40 years after closure implementation. Predicted groundwater flow direction in the MGU and LGU did not change significantly when compared to the no action scenario and was primarily toward the Middle Fork.

At all wells in the MGU, concentrations in scenario 1 were predicted to decrease rapidly following completion of remedial construction 2 years after closure scenario implementation (Figure 18). The concentrations continue to decrease for a time, then reach their minimum once equilibrium is reached. The initial decrease in concentration is in response to reduced infiltration (recharge) after placement of the caps. Following the initial decrease, boron leachate derived from infiltration through unsaturated ash reaches its minimum and the groundwater concentration at each well asymptotically reaches equilibrium. For wells that reach equilibrium above the 2 mg/L, the primary cause is due to the continued transport of ash leachate from areas of saturated ash simulated to remain beneath the caps. The time needed for boron concentrations in groundwater to reach equilibrium with leachate from saturated ash and/or vertical percolation through the cap is dependent on the position of the well relative to groundwater flow and distance from the source.

Well 03R is the only well in the LGU to have concentrations above 2 mg/L, because the LGU is further away from the source areas (deeper below the ground surface than the MGU) and overlain by the Middle Confining Unit Changes in source concentration take longer to appear in the LGU as indicated by the delayed reduction in concentrations, illustrated on Figure 18. As discussed previously, the model also over-predicts concentrations at 03R, so the concentrations illustrated on these figures is expected to be greater than what will likely be observed in the future.

The predicted extent of the footprint of the boron plume over 2 mg/L in closure scenario 1 was reduced in the north, south and west directions as compared to the no action scenario at a timeframe of approximately 40 years following closure scenario implementation. The greatest reduction in footprint was observed to the northeast of the NAPS near the polishing pond. The footprint continued to extend to the Middle Fork to the east of the NAPS and OEAP as predicted 40 years after closure implementation. Three of the six wells that exceeded the 2 mg/L Class I groundwater quality standard for boron in 2017 and 2018 are predicted to reach equilibrium at a concentration below the Class I standard within 28 years of implementation of closure scenario 1, including wells, 04, 05 and 17. Only a slight decrease (about 1 mg/L) in concentration is predicted at well 18, likely due to its vertical proximity to the source concentrations. Well 08R is predicted to decrease initially from the calibrated concentration of 43 mg/L and then reaches equilibrium approximately 65 years after closure scenario implementation at a concentration above the Class I groundwater quality standard (approximately 27 mg/L). Based on the model prediction for closure scenario 1, monitoring well 03R is not predicted to reach equilibrium below the Class I standard for boron. However, the calibration model is over calibrated at monitoring well 03R by approximately 11 mg/L when compared to the upper limit of observed boron concentrations in 2017 and 2018, indicating that 03R may stabilize below the Class I standard although the timeframe for this to occur is predicted to be significantly greater than other monitoring well locations in the MGU.

5.2.3 Closure Scenario 2 Predicted Hydraulic Heads and Boron Concentrations

The design for closure scenario 2 includes removal of all ash fill in the NAPS and OEAP (Figure 16, Appendix C). In this prediction scenario, the number of dry cells increased slightly in layers 1 through 4 (Fill Unit and Upper Unit), particularly in the center of the OEAP, as compared to the no action scenario at approximately 40 years after closure scenario implementation. This slight increase in the number of dry cells in closure scenario results from a general decrease in predicted hydraulic heads in the Fill Unit and Upper Unit in response to the slight decrease in recharge from improved storm water runoff and drainage control in the OEAP. There was not a significant change in predicted hydraulic heads in the primary water bearing hydrogeologic units, layers 5 (MGU) and 7 (LGU), as indicated by less than 0.2-foot increase in head at MGU well 08R and LGU well 03R when compared to the no action scenario at approximately 40 years after closure implementation. Predicted groundwater flow direction in the MGU and LGU did not change significantly when compared to the no action scenario and was primarily toward the Middle Fork.

At all wells in the MGU, concentrations in scenario 2 were predicted to decrease rapidly following completion of remedial construction 10 years after closure scenario implementation (Figure 19). The concentrations continue to decrease for a time then reach their minimum once equilibrium is reached at a near-zero boron concentration, primarily due to the removal of all source concentrations and replacement of source material with local fill with assumed boron concentrations of 0 mg/L. The time needed for boron concentrations in

groundwater to reach equilibrium is dependent on the position of the well relative to groundwater flow and distance from the geologic materials that previously contained leachate and that material's relative rate of leachate depletion following source removal As discussed above, well 03R takes longer to respond to remedial options due to the separation distance between the LGU and the sources of boron in the model.

Five of the six wells that exceeded the 2 mg/L Class I groundwater quality standard for boron in 2017 and 2018 are predicted to reach equilibrium at a concentration below the Class I standard within 27 years of implementation of closure scenario 2, including wells 04, 05, 08R, 18 and 17. Based on the model prediction for closure scenario 2, monitoring well 03R is not predicted to reach equilibrium below the Class I standard for boron until approximately 107 years after implementation of the closure scenario. However, the calibration model is over calibrated at monitoring well 03R by approximately 11 mg/L when compared to the upper limit of observed boron concentrations in 2017 and 2018, indicating concentrations may stabilize below the Class I standard prior to the model predicted timeframe of 107 years after implementation. The predicted extent of the footprint of the boron plume over 2 mg/L in closure scenario 2 was reduced in all directions as compared to the no action scenario at a timeframe of approximately 40 years following closure scenario implementation. The greatest reduction in footprint was observed in the south portions of the NAPS, and central and north portions of the OEAP. The footprint continued to extend to the Middle Fork to the east in the northern portion of the NAPS and southern portion of the OEAP as predicted 40 years after closure implementation. The concentrations that continued contributing to the plume extent in the southern portion of the OEAP at 40 years following closure implementation were typically found in layers of the model containing geologic materials that had lower hydraulic conductivities than the MGU and LGU, resulting in a lower leachate depletion rates (e.g. Upper Confining Unit).

5.2.4 Closure Scenario 3 Predicted Hydraulic Heads and Boron Concentrations

The design for closure scenario 3 includes consolidation or beneficial reuse of all ash fill in the OEAP, eastern portion of the NAPS and the polishing pond. Ash fill that was not fit for beneficial reuse was consolidated to the western portion of the NAPS and capped (Figure 16, Appendix C). In this scenario, the number of dry cells increased slightly in layers 1 through 4 (Fill Unit and Upper Unit), particularly in the center of the OEAP, as compared to the no action scenario at approximately 40 years after closure scenario implementation. This slight increase in the number of dry cells in closure scenario 3 results from a general decrease in predicted hydraulic heads in the Fill Unit and Upper Unit in response to the slight decrease in recharge resulting from improved storm water runoff and drainage control in the OEAP. There was also a slight decrease in predicted hydraulic heads in the primary water-bearing hydrogeologic units, layers 5 (MGU) and 7 (LGU), as indicated by an approximate 0.4-foot and 0.8-foot decrease in head at MGU well 08R and LGU well 03R, respectively, when compared to the no action scenario at approximately 40 years after closure implementation. Predicted groundwater flow direction in the MGU and LGU did not change significantly when compared to the no action scenario and was primarily toward the Middle Fork.

At all wells in the MGU, concentrations in scenario 3 were predicted to decrease rapidly following completion of remedial construction 20 years after closure scenario implementation (Figure 20). The concentrations typically continue to decrease for a time then reach their minimum once equilibrium is reached at a near-zero boron concentration, except for MGU well 08R and LGU well 03R, primarily due to the removal of all source concentrations and replacement of source material with local fill with assumed boron concentrations of 0 mg/L. The time needed for boron concentrations in groundwater to reach equilibrium is dependent on the position of the well relative to groundwater flow and distance from the geologic materials that previously contained leachate and that material's relative rate of leachate depletion following source removal. As discussed above, well 03R takes longer to respond to remedial options due to the separation distance between the LGU and the sources of boron in the model.

Four of the six wells that exceeded the 2 mg/L Class I groundwater quality standard for boron in 2017 and 2018 are predicted to reach equilibrium at a concentration below the Class I standard within 29 years of implementation of closure scenario 3, including wells, 04, 05, 18 and 17. Well 08R is predicted to decrease initially from the calibrated concentration of 43 mg/L and then reach equilibrium approximately 59 years after

closure scenario implementation at a concentration above the Class I groundwater quality standard (approximately 18 mg/L). The calibration model is over calibrated at monitoring well 03R by approximately 11 mg/L when compared to upper limit of observed boron concentration in 2017 and 2018; however, based on predicted concentrations remaining above 20 mg/L it is unlikely for 03R to stabilize below the Class I standard under closure scenario 3 (Figure 20). The predicted extent of the footprint of the boron plume over 2 mg/L in closure scenario 3 was reduced in to the north, south and west of the NAPS, and in all direction around the OEAP as compared to the no action scenario at a timeframe of approximately 40 years following closure scenario implementation. The greatest reduction in footprint was observed in the central and north portions of the OEAP. The footprint continued to extend to the Middle Fork to the east of the NAPS and southern portion of the OEAP. The concentrations that continued to contribute to the plume extent to the east of the NAPS were associated with saturated ash beneath the capped western portion of the NAPS. Concentrations that continued to contribute to the plume extent in the southern portion of the OEAP implementation were typically found in layers of the model containing geologic materials that had lower hydraulic conductivities than the MGU and LGU, resulting in a lower leachate depletion rates (e.g. Upper Confining Unit).

5.2.5 Closure Scenario 4 Predicted Hydraulic Heads and Boron Concentrations

The design for closure scenario 4 includes consolidation of all ash fill in the OEAP and within the polishing pond into the NAPS, followed by placement of a cap over the NAPS (Figure 16, Appendix C). In this scenario, the number of dry cells increased in layers 1 through 4 (Fill Unit and Upper Unit), particularly in the center of the NAPS and OEAP, as compared to the no action scenario at approximately 40 years after closure scenario implementation. This increase in the number of dry cells in closure scenario 4 in the center of the NAPS results from a general decrease in predicted hydraulic heads in the Fill Unit and Upper Unit in response to placement of the cap over the NAPS and the resulting decrease in recharge. As the cells become dry within the modeled Fill Unit, saturated ash cells (constant concentration cells) also become inactive and no longer contribute boron source concentrations to the model domain. There was also a slight increase in the number of dry cells in the center of the OEAP which results from a general decrease in predicted hydraulic heads in the Fill Unit and Upper Unit in response to the slight decrease in recharge resulting from improved storm water runoff and drainage control in the OEAP. There was also a decrease in predicted hydraulic heads in the primary water-bearing hydrogeologic units, layers 5 (MGU) and 7 (LGU), as indicated by an approximate 1.0-foot and 1.6-foot decrease in head at MGU well 08R and LGU well 03R, respectively, when compared to the no action scenario at approximately 40 years after closure implementation. Predicted groundwater flow direction in the MGU and LGU did not change significantly when compared to the no action scenario and was primarily toward the Middle Fork.

At all wells in the MGU, concentrations in scenario 4 were predicted to decrease rapidly following completion of remedial construction 5 years after closure scenario implementation (Figure 21). The concentrations continue to decrease for a time then reach their minimum once equilibrium is reached, primarily due to the continued transport of ash leachate from areas of potentially saturated ash underneath the NAPS cap. The initial decrease in concentration is in response to reduced infiltration (recharge) after placement of the caps. Following the initial decrease after cap placement in the NAPS, boron leachate derived from infiltration through unsaturated ash reaches its minimum and the groundwater concentration at each well asymptotically reaches equilibrium with concentrations released from saturated ash source areas beneath the cap. The time needed for boron concentrations in groundwater to reach equilibrium with leachate from saturated ash is dependent on the position of the well relative to groundwater flow and distance from the source. As discussed above, well 03R takes longer to respond to remedial options due to the separation distance between the LGU and the sources of boron in the model.

Four of the six wells that exceeded the 2 mg/L Class I groundwater quality standard for boron in 2017 and 2018 are predicted to reach equilibrium at a concentration below the Class I standard within 17 years of implementation of closure scenario 4, including wells, 04, 05, 18 and 17. Well 08R is predicted to initially decrease from the calibrated concentration of 43 mg/L and then reach equilibrium approximately 53 years after closure scenario implementation at a concentration above the Class I groundwater quality standard (approximately 29 mg/L). Based on the model prediction for closure scenario 4, monitoring well 03R is not

predicted to reach equilibrium below the Class I standard for boron. However, the calibration model is over calibrated at monitoring well 03R by approximately 11 mg/L when compared to the upper limit of observed boron concentrations in 2017 and 2018, indicating concentrations may stabilize below the Class I standard although the timeframe for this to occur would be significantly greater than other monitoring well locations. The predicted extent of the footprint of the boron plume over 2 mg/L in closure scenario 4 was reduced in to the north, south and west of the NAPS, and in all direction around the OEAP as compared to the no action scenario at a timeframe of approximately 40 years following closure scenario implementation. The greatest reduction in footprint was observed in the central and north portions of the OEAP. The footprint continued to extend to the Middle Fork to the east of the NAPS and southern portion of the OEAP. The concentrations that continued to contribute to the plume extent to the east of the NAPS were associated with saturated ash beneath the capped NAPS. Residual boron concentrations that continued to contribute to the plume extent in the southern portion of the OEAP in this scenario were typically found in layers of the model containing geologic materials that had lower hydraulic conductivities than the MGU and LGU resulting in a lower leachate depletion rates (e.g. Upper Confining Unit).

5.2.6 Closure Scenario 5 Predicted Hydraulic Heads and Boron Concentrations

The design for closure scenario 5 includes consolidation of ash fill in an area north of the OEAP and within the polishing pond to the NAPS followed by placement of a cap on the NAPS and OEAP (Figure 16, Appendix C). Ash fill sourced from areas outside of the model domain (NEAP) were also consolidated to the NAPS prior to capping, slightly increasing the runoff drainage distance and estimated recharge through the NAPS cap. In this scenario the number of dry cells increased in layers 1 through 4 (Fill Unit and Upper Unit), particularly in the center of the NAPS and OEAP, as compared to the no action scenario at approximately 40 years after closure scenario implementation. This increase in the number of dry cells in closure scenario 5 results from a general decrease in predicted hydraulic heads in the Fill Unit and Upper Unit in response to placement of the caps over the NAPS and OEAP and the resulting decrease in recharge. As the cells become dry within the modeled Fill Unit, saturated ash cells (constant concentration cells) also become inactive and no longer contribute boron source concentrations to the model domain. There was also a decrease in predicted hydraulic heads in the primary water-bearing hydrogeologic units, layers 5 (MGU) and 7 (LGU), as indicated by an approximate 1.1-foot and 1.8-foot decrease in head at MGU well 08R and LGU well 03R, respectively, when compared to the no action scenario at approximately 40 years after closure implementation. Predicted groundwater flow direction in the MGU and LGU did not change significantly when compared to the no action scenario and was primarily toward the Middle Fork.

At all MGU wells, concentrations in scenario 5 were predicted to decrease rapidly following completion of remedial construction 3 years after closure scenario implementation (Figure 22). The concentrations typically continue to decrease for a time then reach their minimum once equilibrium is reached, primarily due to the continued transport of ash leachate from areas of potentially saturated ash underneath the cap. The initial decrease in concentration is in response to reduced infiltration (recharge) after placement of the caps. Following the initial decrease after cap placement, boron leachate derived from infiltration through unsaturated ash reaches its minimum and the groundwater concentration at each well asymptotically reaches equilibrium with concentrations released from saturated ash source areas beneath the cap. The time needed for boron concentrations in groundwater to reach equilibrium with leachate from saturated ash is dependent on the position of the well relative to groundwater flow and distance from the source. As discussed above, well 03R takes longer to respond to remedial options due to the separation distance between the LGU and the sources of boron in the model.

Three of the six wells that exceeded the 2 mg/L Class I groundwater quality standard for boron in 2017 and 2018 are predicted to reach equilibrium at a concentration below the Class I standard within 34 years of implementation of closure scenario 5 (Figure 22), including wells, 04, 05 and 17. Only a slight decrease (about 1 mg/L) in concentration is predicted at well 18, likely due to its vertical proximity to the source concentrations. Well 08R is predicted to decrease initially from the calibrated concentration of 43 mg/L and then reach equilibrium approximately 66 years after closure scenario implementation at a concentration above the Class I groundwater quality standard (approximately 28 mg/L). Based on the model prediction for closure scenario 5,

monitoring well 03R is not predicted to reach equilibrium below the Class I standard for boron. However, the calibration model is over calibrated at monitoring well 03R by approximately 11 mg/L when compared to the upper limit of observed boron concentrations in 2017 and 2018, indicating concentrations may stabilize below the Class I standard, although the timeframe for this to occur would be significantly greater than other monitoring well locations. The predicted extent of the footprint of the boron plume over 2 mg/L in closure scenario 5 was reduced in the north, south and west directions as compared to the no action scenario at a timeframe of approximately 40 years following closure scenario implementation. The greatest reduction in footprint was observed to the northeast of the NAPS near the polishing pond. The footprint continued to extend to the Middle Fork to the east of the NAPS and OEAP as predicted 40 years after closure implementation.

6 SUMMARY

Groundwater flow and analytical data was collected at the Site from six bimonthly groundwater monitoring events in 2017 and 2018. The data was summarized and evaluated for significant changes in groundwater conditions since the previous monitoring events completed in 2011 (Kelron, 2012a and Kelron, 2012b). The updated groundwater data was used to calibrate the existing groundwater model, developed in 2012 and later updated in 2014, to current hydraulic head and boron concentrations. The updated model was then used to evaluate the five closure scenarios included in the November 2017 Response Letter.

The results of the groundwater evaluation are:

- Groundwater flow direction and gradients have not changed significantly since the hydrogeologic investigation report was completed in 2012.
- Groundwater elevations were within ranges of previously reported with the exception of well 07, where water elevations have decreased below the screened interval and the well could not be sampled.
- Groundwater statistical analysis and concentration versus time plots indicate concentration trends are stable or decreasing over time with the following exceptions:
  - Boron concentrations from the recent six rounds have increased compared to previous results at wells 03R, 05, and 08R;
  - Manganese concentrations from the recent six rounds have increased compared to previous results at wells 06R and 18; and,
  - The lowest pH value from the recent six rounds was observed at well 10, where values have decreased compared to previous results.

The results of the modeling are:

- The no action scenario prediction model indicates boron concentrations at monitoring wells that currently exceed the Class I groundwater quality standard for boron will continue to exceed the Class I standard.
- The five closure scenario prediction models demonstrate boron concentrations in all monitoring wells with Class I exceedances in 2017 and 2018 will rapidly begin to decrease in the MGU following completion of remedial construction. The general decrease in concentrations will result in decreased plume extent of boron concentrations over 2 mg/L. All closure scenarios will reach their maximum potential for reducing boron concentrations in wells 04, 05, 08R, 18 and 17 within a period of 66 years following closure scenario implementation.
- Because the LGU is further away from the source areas (deeper below the ground surface than the MGU) and overlain by the Middle Confining Unit, changes in source concentration take longer to appear in this unit, as indicated by the delayed reduction in concentrations. The calibration model also over-predicts concentrations at well 03R, so the simulated concentrations are expected to be greater than what will likely be observed in the future.

REFERENCES

Anderson , Mary P., and Woessner, William W., 1992, Applied Groundwater Modeling: Simulation of Flow and Advective Transport, Academic Press, Inc., San Diego, CA.

Fetter, C.W., 1988, Applied Hydrogeology, Merrill Publishing Company, Columbis, Ohio.

Kelron Environmental (Kelron), 2003, Regional and Local Hydrogeology and Geochemistry, Vermilion Power Plant, Illinois, Dynegy Midwest Generation, Inc., November 30, 2003.

Kelron Environmental (Kelron), 2012a, Hydrogeology and Groundwater Quality of the North Ash Pond System, Vermilion Power Station, Oakwood, Illinois, Dynegy Midwest Generation, LLC, March 15, 2012.

Kelron Environmental (Kelron), 2012b, Hydrogeology and Groundwater Quality of the Old East Ash Pond, Vermilion Power Station, Oakwood, Illinois, Dynegy Midwest Generation, LLC, March 15, 2012.

Natural Resource Technology, Inc. (NRT), 2012a, Corrective Action Plan, North Ash Pond System, Vermilion Power Station, Oakwood, Illinois, Dynegy Midwest Generation, LLC, March 27, 2012.

Natural Resource Technology, Inc. (NRT), 2012b, Corrective Action Plan, Old East Ash Pond, Vermilion Power Station, Oakwood, Illinois, Dynegy Midwest Generation, LLC, March 27, 2012.

Natural Resource Technology, Inc. (NRT), 2012c, Application for Groundwater Management Zone, North Ash Pond System and Old East Ash Pond, Vermilion Power Station, Oakwood, Illinois, Dynegy Midwest Generation, LLC, March 27, 2012.

Natural Resource Technology, Inc. (NRT), 2014a, Corrective Action Plan, North Ash Pond System, Vermilion Power Station, Oakwood, Illinois, Dynegy Midwest Generation, LLC, April 2, 2014.

Natural Resource Technology, Inc. (NRT), 2014b, Corrective Action Plan, Old East Ash Pond, Vermilion Power Station, Oakwood, Illinois, Dynegy Midwest Generation, LLC, April 2, 2014.

URS, Geotechnical Report, North ash Pond and Old East Ash Pond, Vermilion Site, Embankment Evaluations, Oakwood, Illinois, Dynegy Midwest Generation, LLC, November 18, 2013.

Tables

Table 1. Groundwater Levels and Elevations 2017-2018

2018 Groundwater Monitoring and Modeling Report
North Ash Pond System and Old East Ash Pond
Vermilion Site, Oakwood, Illinois

Monitoring Well ID	Ground Surface Elevation (feet NAVD88)	Measuring Point Elevation (feet NAVD88)	Monitored Hydrogeologic Unit	Monitoring Well Location[1]	Groundwater Depth (feet below Measuring Point)						Groundwater Elevation (feet NAVD88)					
					Round 1 7/12-13/17	Round 2 9/13-14/17	Round 3 11/08/17	Round 4 01/24/18	Round 5 03/22/18	Round 6 05/09/18	Round 1 7/12-13/17	Round 2 9/13-14/17	Round 3 11/08/17	Round 4 01/24/18	Round 5 03/22/18	Round 6 05/09/18
01	660.20	661.61	Upland Groundwater Unit*	Upgradient	77.67	78.92	79.40	79.67	79.37	78.75	583.94	582.69	582.21	581.94	582.24	582.86
02	590.40	594.00	Lower Groundwater Unit	Downgradient	18.60	19.19	18.84	18.19	18.90	18.47	575.40	574.81	575.16	575.81	575.10	575.53
03R	587.80	589.90	Lower Groundwater Unit	Downgradient	7.10	8.17	8.71	5.50	7.71	7.03	582.80	581.73	581.19	584.40	582.19	582.87
04	587.40	590.91	Middle Groundwater Unit	Downgradient	7.40	8.34	7.53	6.76	6.35	6.36	583.51	582.57	583.38	584.15	584.56	584.55
05	592.20	595.64	Middle Groundwater Unit	Downgradient	6.89	9.73	7.31	6.38	6.43	6.25	588.75	585.91	588.33	589.26	589.21	589.39
06R	589.60	592.43	Upper Unit	Background	7.58	9.79	9.45	5.15	4.12	3.95	584.85	582.64	582.98	587.28	588.31	588.48
07	589.10	591.41	Middle Groundwater Unit	Downgradient	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
08R	588.00	590.11	Middle Groundwater Unit	Downgradient	12.70	13.80	13.65	12.74	12.67	12.44	577.41	576.31	576.46	577.37	577.44	577.67
09	589.10	592.91	Middle Groundwater Unit	Background	7.93	10.09	9.77	5.66	4.60	4.40	584.98	582.82	583.14	587.25	588.31	588.51
10	656.30	659.10	Upland Confining Unit	Background	49.89	50.95	51.76	52.00	50.84	49.13	609.21	608.15	607.34	607.10	608.26	609.97
17	619.60	623.21	Middle Groundwater Unit	Intermediate	38.54	39.55	39.65	38.98	39.05	38.38	584.67	583.66	583.56	584.23	584.16	584.83
18	619.20	622.82	Middle Groundwater Unit	Intermediate	23.47	25.70	26.80	27.80	24.26	22.93	599.35	597.12	596.02	595.02	598.56	599.89
19	593.10	595.83	Middle Groundwater Unit	Downgradient	7.10	10.13	8.67	6.28	6.23	nm	588.73	585.70	587.16	589.55	589.60	nm
20	590.20	592.30	Middle Groundwater Unit	Downgradient	14.31	15.47	15.06	14.36	13.09	13.21	577.99	576.83	577.24	577.94	579.21	579.09
21	670.40	672.76	Upland Groundwater Unit**	Background	89.55	90.04	91.09	91.40	91.25	90.31	583.21	582.72	581.67	581.36	581.51	582.45
34	590.00	592.52	Lower Groundwater Unit	Downgradient	14.12	14.71	14.57	15.15	13.99	13.55	578.40	577.81	577.95	577.37	578.53	578.97

Notes:

[O: JJW, QC: KLT 7/12/18]

All depth and elevation measurements are in feet.

Dry	Groundwater level below bottom of screened interval of monitoring well.
NAVD88	North American Vertical Datum of 1988
nm	No access to monitoring well, groundwater elevation not measured.

[1]Intermediate well locations refer to wells located on berm between the North Ash Pond System and Old East Ash Pond.

* Hydraulically connected with Lower Groundwater Unit.

** Suspected hydraulic connection with Lower Groundwater Unit.

Table 2. Vertical Hydraulic Gradients 2017-2018

2018 Groundwater Monitoring and Modeling Report
North Ash Pond System and Old East Ash Pond
Vermilion Site, Oakwood, Illinois

Monitoring Wells for Gradient Calculations across Screened Hydrogeologic Units		Saturated Screen Midpoint Elevations (feet NAVD88)		Groundwater Elevations (feet NAVD88)											
				7/12-13/17		9/13-14/17		11/8/2017		1/24/2018		3/22/2018		5/9/2018	
Upper Unit	Middle Groundwater Unit	UU	MGU	UU	MGU	UU	MGU	UU	MGU	UU	MGU	UU	MGU	UU	MGU
06R	09	578.65	560.30	584.85	584.98	582.64	582.82	582.98	583.14	587.28	587.25	588.31	588.31	588.48	588.51
Groundwater Gradient Between Designated Units (feet/feet)				-0.007		-0.010		-0.009		0.002		0.000		-0.002	
Middle Groundwater Unit	Middle Groundwater Unit	MGU	MGU	MGU	MGU	MGU	MGU	MGU	MGU	MGU	MGU	MGU	MGU	MGU	MGU
18	17	578.20	563.10	599.35	584.67	597.12	583.66	596.02	583.56	595.02	584.23	598.56	584.16	599.89	584.83
Groundwater Gradient Between Designated Units (feet/feet)				0.97		0.89		0.83		0.71		0.95		1.00	
Middle Groundwater Unit	Lower Groundwater Unit	MGU	LGU	MGU	LGU	MGU	LGU	MGU	LGU	MGU	LGU	MGU	LGU	MGU	LGU
08R	03R	576.00	556.30	577.41	582.80	576.31	581.73	576.46	581.19	577.37	584.40	577.44	582.19	577.67	582.87
Groundwater Gradient Between Designated Units (feet/feet)				-0.27		-0.28		-0.24		-0.36		-0.24		-0.26	
20	34	575.20	538.39	577.99	578.40	576.83	577.81	577.24	577.95	577.94	577.37	579.21	578.53	579.09	578.97
Groundwater Gradient Between Designated Units (feet/feet)				-0.011		-0.027		-0.019		0.015		0.018		0.003	

Notes:

-0.02	Vertical gradient is upward between the screened well intervals and formations indicated.
0.04	Vertical gradient is downward between the screened well intervals and formations indicated.
- -	No data collected on date or insufficient data to calculate vertical gradients.
NAVD88	North American Vertical Datum of 1988
UU	Upper Unit Well
MGU	Middle Groundwater Unit Well
LGU	Lower Groundwater Unit Well

Table 3. Groundwater Quality Data Summary 2017-2018

2018 Groundwater Monitoring and Modeling Report
North Ash Pond System and Old East Ash Pond
Vermilion Site, Oakwood, Illinois

				Hydrogeologic Units: Upper Unit and Middle Groundwater Unit																	
Parameter	**Method Used**	**Standard Limit***	**Units**	**04**						**05**						**06R**					
Sampling Round				1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Sampling Date				07/13/17	9/13/2017	11/08/17	01/24/18	03/22/18	05/09/18	07/13/17	09/14/17	11/08/17	01/24/18	03/22/18	05/09/18	07/13/17	09/13/17	11/08/17	01/24/18	03/22/18	05/09/18
Temperature	Field	na	C°	19.49	15.54	14.99	10.08	10.09	12.16	16.27	15.21	14.66	9.97	10.73	11.83	16.48	15.19	14.71	10.58	10.95	11.63
Turbidity	Field	na	NTU	1.3	<1	<1	<1	<1	<1.0	<1	<1	<1	<1	<1	<1.0	2.3	<1	<1	<1	1.5	<1.0
ORP	Field	na	mV	116	115	93	2	126	94	49	68	17	35	-16	-27	-74	-44	-101	-69	-121	-66
Specific Conductivity	Field	na	micromhos/cm	448	507	535	736	640	640	600	696	815	1,050	888	923	558	698	845	1,200	1,040	868
Dissolved Oxygen	Field	na	mg/L	1.15	<1.00	<1.00	<1.00	<1.00	<1.00	1.09	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
pH	Field	6.5-9.0	s.u.	7.72	7.50	7.52	6.91	7.54	7.24	7.61	7.26	7.29	6.99	7.43	7.15	7.25	6.93	7.00	6.76	7.09	6.82
Total Dissolved Solids	M2540 C	1,200	mg/L	452	428	330	338	370	430	618	634	362	588	624	674	524	546	606	578	590	568
Nitrate as N (total)	M4500-NO3 F	10.0	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.163	0.062	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chloride (total)	SW9251	200.0	mg/L	12	11	9	10	9	11	11	12	12	11	11	9	7	12	7	7	6	<5
Sulfate (total)	SW9036	400.0	mg/L	95	69	44	32	47	99	268	262	291	261	281	283	87	68	160	103	135	166
Fluoride (dissolved)	SW9214	4.0	mg/L	0.29	0.3	0.32	0.29	0.54	0.28	0.51	0.51	0.46	0.46	0.67	0.44	0.12	0.17	0.15	0.15	0.22	0.1
Arsenic (dissolved)	SW6020A	0.01	mg/L	0.0053	0.0056	0.0056	0.0052	0.0047	0.006	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0010
Barium (dissolved)	SW6020A	2.0	mg/L	0.261	0.271	0.260	0.274	0.246	0.320	0.0259	0.0248	0.0286	0.0245	0.0234	0.0283	0.0637	0.0807	0.0764	0.0757	0.0948	0.0679
Boron (dissolved)	SW6020A	2.0	mg/L	6.68	6.48	6.20	5.48	4.80	5.87	17.9	17.2	17.8	18.3	16.7	14.5	0.19	0.23	0.20	0.17	0.166	0.139
Iron (dissolved)	SW6020A	5.0	mg/L	0.98	0.915	0.88	1.01	0.974	1.31	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	0.0942	0.0924	0.194	0.185	0.118	<0.025
Manganese (dissolved)	SW6020A	0.15	mg/L	0.551	0.547	0.547	0.629	0.595	0.750	0.332	0.325	0.456	0.362	0.358	0.408	0.220	0.225	0.258	0.228	0.149	0.166
Selenium (dissolved)	SW6020A	0.05	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0027	0.0027	<0.001
Groundwater Elevation	Field		NAVD88 (feet)	583.51	582.57	583.38	584.15	584.56	584.55	588.75	585.91	588.33	589.26	589.21	589.39	584.85	582.64	582.98	587.28	588.31	588.48

Notes:

Monitoring well 07 was dry for all groundwater monitoring events.
Groundwater samples were not collected or analyzed in 2017 or 2018.

na	Not Applicable. No Illinois Class I groundwater standard for parameter indicated.
*	Illinois Class I Groundwater Standard
3.4	Parameter with exceedance of Class I standard
ORP	Oxidation-Reduction Potential
C°	Degrees Centigrade
NTU	Nephelometric Turbidity Units
mV	milliVolts
micromhos/cm	micromhos per centimeter
mg/L	milligrams per liter
s.u.	standard units
NAVD88	North American Vertical Datum of 1988

Table 3. Groundwater Quality Data Summary 2017-2018

2018 Groundwater Monitoring and Modeling Report
North Ash Pond System and Old East Ash Pond
Vermilion Site, Oakwood, Illinois

				Hydrogeologic Units: Upper Unit and Middle Groundwater Unit																					
Parameter	Method Used	Standard Limit*	Units	08R						17						18						20					
Sampling Round				1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Sampling Date				07/13/17	09/14/17	11/08/17	01/24/18	03/22/18	05/09/18	07/12/17	09/13/17	11/08/17	01/24/18	03/22/18	05/09/18	07/12/17	09/13/17	11/08/17	01/24/18	03/22/18	05/09/18	07/13/17	09/13/17	11/08/17	01/24/18	03/22/18	05/09/18
Temperature	Field	na	C°	14.99	14.73	14.28	10.61	11.79	13.30	17.28	17.68	11.81	9.97	12.44	15.16	15.28	13.32	12.17	12.03	13.34	14.47	20.54	13.56	15.08	10.95	10.55	11.41
Turbidity	Field	na	NTU	27	<1	<1	<1	1.6	4.00	9.5	3.2	20.7	7.7	12.4	23.20	8.7	<1	<1	<1	<1	1.90	55.5	10	3.3	<1	8.1	9.30
ORP	Field	na	mV	-231	-159	-97	-20	-54	-47	-31	-48	48	97	18	2	25	27	32	79	47	36	34	27	20	0	-31	-21
Specific Conductivity	Field	na	micromhos/cm	1,780	1,980	2,020	1,610	2,200	1,720	1,800	1,880	1,910	2,490	2,850	2,490	1,510	1,620	1,900	2,700	2,310	1,940	364	487	527	849	585	550
Dissolved Oxygen	Field	na	mg/L	<1.00	4.96	<1.00	<1.00	<1.00	<1.00	1.66	1.39	6.48	<1.00	<1.00	2.78	1.75	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
pH	Field	6.5-9.0	s.u.	8.78	8.37	8.56	6.88	7.67	7.16	6.89	6.95	6.84	6.56	6.86	6.69	6.83	6.88	6.85	6.55	6.87	6.66	7.25	7.07	7.22	6.66	7.18	6.96
Total Dissolved Solids	M2540 C	1,200	mg/L	2,040	2,080	2,040	1,110	1,700	1,400	2,030	1,970	2,020	1,630	2,090	1,980	1,600	1,650	1,710	1,590	1,540	1,420	368	392	372	366	312	352
Nitrate as N (total)	M4500-NO3 F	10.0	mg/L	<0.05	<0.05	<0.05	<0.05	<0.055	0.06	0.399	0.275	0.092	<0.05	0.086	<0.05	<0.05	<0.05	0.058	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chloride (total)	SW9251	200.0	mg/L	16	18	17	7	15	9	31	35	6	13	26	13	27	23	21	25	24	17	<5	<5	<5	<5	<5	<5
Sulfate (total)	SW9036	400.0	mg/L	1,140	1,210	1,140	378	1,010	754	1,100	1,020	1,200	976	1,270	1,150	754	784	835	749	795	700	61	60	58	73	46	53
Fluoride (dissolved)	SW9214	4.0	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.17	0.17	0.13	0.14	0.23	0.15	0.13	0.12	0.12	0.12	0.14	0.12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic (dissolved)	SW6020A	0.01	mg/L	0.007	0.0098	0.0106	0.0134	0.0029	0.0017	0.001	0.0012	<0.001	0.0015	0.0018	0.0021	0.0016	0.0014	0.0023	0.0013	<0.001	0.0013	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium (dissolved)	SW6020A	2.0	mg/L	0.0757	0.0464	0.0476	0.0684	0.124	0.0965	0.0254	0.024	0.0299	0.0286	0.0275	0.0285	0.0155	0.0161	0.0163	0.0171	0.015	0.0142	0.0149	0.0229	0.017	0.0192	0.0133	0.0132
Boron (dissolved)	SW6020A	2.0	mg/L	47.7	52.8	51.6	20.7	38.4	32.4	4.74	5.24	1.33	2.25	3.25	3.3	8.22	4.42	3.40	5.06	7.95	10.9	0.377	0.422	0.531	0.456	0.262	0.362
Iron (dissolved)	SW6020A	5.0	mg/L	0.48	0.061	0.0377	1.03	0.0406	<0.025	2.31	2.11	1.03	1.66	3.92	4.52	0.116	0.0749	0.156	0.0909	0.0573	0.108	0.247	0.321	0.178	0.316	0.0991	0.163
Manganese (dissolved)	SW6020A	0.15	mg/L	0.419	0.072	0.113	0.343	0.244	0.145	0.511	0.601	0.0633	0.108	0.132	0.128	1.60	1.47	1.52	1.43	1.33	1.23	0.0159	0.0293	0.0283	0.0265	0.0159	0.0180
Selenium (dissolved)	SW6020A	0.05	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0031	<0.001	0.0012	0.0011	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Groundwater Elevation	Field		NAVD88 (feet)	577.41	576.31	576.46	577.37	577.44	577.67	584.67	583.66	583.56	584.23	584.16	584.83	599.35	597.12	596.02	595.02	598.56	599.89	577.99	576.83	577.24	577.94	579.21	579.09

Notes:

Monitoring well 07 was dry for all groundwater monitoring events.
Groundwater samples were not collected or analyzed in 2017 or 2018.

na	Not Applicable. No Illinois Class I groundwater standard for parameter indicated.
*	Illinois Class I Groundwater Standard
3.4	Parameter with exceedance of Class I standard
ORP	Oxidation-Reduction Potential
C°	Degrees Centigrade
NTU	Nephelometric Turbidity Units
mV	milliVolts
micromhos/cm	micromhos per centimeter
mg/L	milligrams per liter
s.u.	standard units
NAVD88	North American Vertical Datum of 1988

Table 3. Groundwater Quality Data Summary 2017-2018

2018 Groundwater Monitoring and Modeling Report
North Ash Pond System and Old East Ash Pond
Vermilion Site, Oakwood, Illinois

				Hydrogeologic Unit: Lower Groundwater Unit																	
Parameter	Method Used	Standard Limit*	Units	02						03R						34					
Sampling Round				1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Sampling Date				07/13/17	09/14/17	11/08/17	01/24/18	03/22/18	05/09/18	07/13/17	09/14/17	11/08/17	01/24/18	03/22/18	05/09/18	07/13/17	09/13/17	11/08/17	01/24/18	03/22/18	05/09/18
Temperature	Field	na	C°	16.32	14.66	13.66	12.66	14.22	14.45	14.57	16.65	14.91	11.97	13.49	13.98	14.25	12.71	12.31	10.87	12.27	13.08
Turbidity	Field	na	NTU	1	<1	<1	<1	<1	<1.0	5.5	<1	5.2	<1	1.5	<1.0	48.7	102.0	126.0	33.4	52.1	32.40
ORP	Field	na	mV	141	110	139	88	144	-124	-142	-108	-137	-58	-128	-106	-115	-111	-132	-44	-153	-101
Specific Conductivity	Field	na	micromhos/cm	623	699	796	1,090	862	821	803	806	816	1,180	1,070	1,060	618	679	772	1,120	954	864
Dissolved Oxygen	Field	na	mg/L	1.86	<1.00	<1.00	3.33	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	6.17	<1.00	<1.00	<1.00	<1.00	<1.00
pH	Field	6.5-9.0	s.u.	7.83	7.72	7.72	7.40	7.60	7.40	7.62	7.23	7.37	6.95	7.34	7.16	7.29	7.00	6.94	6.58	7.18	6.87
Total Dissolved Solids	M2540 C	1,200	mg/L	514	530	506	432	506	502	742	698	606	542	606	678	510	494	488	456	484	472
Nitrate as N (total)	M4500-NO3 F	10.0	mg/L	<0.05	<0.05	0.067	0.065	0.085	<0.05	<0.05	<0.05	0.13	0.053	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chloride (total)	SW9251	200.0	mg/L	49	49	47	45	33	37	27	27	25	26	25	24	33	33	33	33	34	32
Sulfate (total)	SW9036	400.0	mg/L	13	20	14	19	85	46	179	144	70	55	101	167	<10	<10	<10	<10	<10	<10
Fluoride (dissolved)	SW9214	4.0	mg/L	0.56	0.62	0.62	0.57	0.66	0.53	0.5	0.5	0.5	0.48	0.69	0.48	0.68	0.67	0.69	0.61	0.81	0.65
Arsenic (dissolved)	SW6020A	0.01	mg/L	0.0083	0.0077	0.0062	0.0097	0.0107	0.0088	0.0074	0.0077	0.0074	0.0068	0.0061	0.0073	0.023	0.0232	0.0229	0.0233	0.0223	0.0221
Barium (dissolved)	SW6020A	2.0	mg/L	0.156	0.182	0.178	0.174	0.174	0.171	0.187	0.179	0.168	0.162	0.167	0.187	0.147	0.146	0.147	0.147	0.142	0.141
Boron (dissolved)	SW6020A	2.0	mg/L	0.289	0.26	0.309	0.338	0.273	0.249	5.02	3.70	3.15	2.90	3.33	4.36	0.435	0.472	0.518	0.557	0.453	0.493
Iron (dissolved)	SW6020A	5.0	mg/L	0.412	0.283	0.211	0.245	0.982	0.358	2.67	2.39	2.04	1.51	1.49	1.96	5.22	5.34	5.45	5.12	5.01	5.02
Manganese (dissolved)	SW6020A	0.15	mg/L	0.0909	0.0920	0.0903	0.0811	0.109	0.0847	0.0465	0.0413	0.0407	0.0369	0.0366	0.0412	0.0629	0.0619	0.0618	0.0618	0.0614	0.0620
Selenium (dissolved)	SW6020A	0.05	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Groundwater Elevation	Field		NAVD88 (feet)	575.4	574.81	575.16	575.81	575.10	575.53	582.8	581.73	581.19	584.40	582.19	582.87	578.4	577.81	577.95	577.37	578.53	578.97

Notes:

Monitoring well 07 was dry for all groundwater monitoring events.
Groundwater samples were not collected or analyzed in 2017 or 2018.

na	Not Applicable. No Illinois Class I groundwater standard for parameter indicated.
*	Illinois Class I Groundwater Standard
3.4	Parameter with exceedance of Class I standard
ORP	Oxidation-Reduction Potential
C°	Degrees Centigrade
NTU	Nephelometric Turbidity Units
mV	milliVolts
micromhos/cm	micromhos per centimeter
mg/L	milligrams per liter
s.u.	standard units
NAVD88	North American Vertical Datum of 1988

Table 3. Groundwater Quality Data Summary 2017-2018
2018 Groundwater Monitoring and Modeling Report
North Ash Pond System and Old East Ash Pond
Vermilion Site, Oakwood, Illinois

				Hydrogeologic Unit: Upland Groundwater Unit												Hydrogeologic Unit: Upland Confining Unit					
Parameter	Method Used	Standard Limit*	Units	01						21						10					
Sampling Round				1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Sampling Date				07/13/17	09/13/17	11/08/17	01/24/18	03/22/18	05/09/18	07/13/17	09/13/17	11/08/17	01/24/18	03/22/18	05/09/18	07/12/17	09/14/17	11/08/17	01/24/18	03/22/18	05/09/18
Temperature	Field	na	C°	19.34	18.57	12.99	11.75	14.09	14.27	16.18	17.49	12.82	11.58	13.49	14.64	17.22	14.80	13.11	10.74	14.26	15.30
Turbidity	Field	na	NTU	<1	<1	<1	<1	3.3	<1.0	1.6	<1	<1	<1	<1	1.10	<1	<1	<1	9.5	2.9	1.20
ORP	Field	na	mV	83	105	139	64	77	96	-88	-46	-105	-53	-134	-75	121	137	84	50	74	73.00
Specific Conductivity	Field	na	micromhos/cm	2,000	1,910	2,210	3,450	2,820	2,500	573	516	591	843	732	654	991	1,110	1,150	1,490	1,480	1,610
Dissolved Oxygen	Field	na	mg/L	7.4	5.97	6.89	<1.00	1.02	4.99	2.6	2.49	<1.00	<1.00	<1.00	1.40	4.46	6.63	4.26	<1.00	<1.00	1.34
pH	Field	6.5-9.0	s.u.	7.18	7.18	7.00	6.93	6.92	6.63	7.61	7.33	7.38	7.26	7.40	7.02	6.73	6.68	6.86	7.01	6.81	6.42
Total Dissolved Solids	M2540 C	1,200	mg/L	2,060	2,040	2,070	2,080	2,240	2,090	440	400	382	346	390	394	1,030	1,020	900	826	890	1,010
Nitrate as N (total)	M4500-NO3 F	10.0	mg/L	0.348	0.356	0.376	0.349	0.289	<0.05	<0.05	0.052	0.503	<0.05	<0.05	<0.05	0.501	0.208	0.404	0.122	0.115	<0.05
Chloride (total)	SW9251	200.0	mg/L	22	22	20	21	22	14	<5	<5	<5	<5	<5	<5	7	0	7	12	9	8
Sulfate (total)	SW9036	400.0	mg/L	1,070	995	1,000	1,040	1,280	1,070	44	18	<10	12	22	25	332	281	269	233	296	337
Fluoride (dissolved)	SW9214	4.0	mg/L	0.13	0.13	0.13	0.13	0.15	0.13	1.1	1.16	1.17	1.1	1.1	1.08	0.13	0.15	0.14	0.15	0.2	0.14
Arsenic (dissolved)	SW6020A	0.01	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0247	0.0305	0.0313	0.0357	0.0322	0.026	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium (dissolved)	SW6020A	2.0	mg/L	0.012	0.0122	0.0118	0.0128	0.0137	0.0131	0.0825	0.0898	0.0932	0.1010	0.0909	0.0957	0.0604	0.0704	0.0697	0.0701	0.089	0.082
Boron (dissolved)	SW6020A	2.0	mg/L	1.10	1.06	1.05	1.49	1.98	1.7	0.801	0.773	0.823	0.919	0.758	0.758	0.0877	0.0861	0.0943	0.108	0.081	0.0862
Iron (dissolved)	SW6020A	5.0	mg/L	0.0601	<0.025	<0.025	0.0542	0.248	0.223	0.274	0.327	0.258	0.418	0.683	0.177	0.04	<0.025	<0.025	<0.025	0.0272	<0.025
Manganese (dissolved)	SW6020A	0.15	mg/L	<0.001	<0.001	<0.001	0.0058	0.0268	0.0332	0.109	0.113	0.113	0.111	0.110	0.107	0.0722	0.131	0.0954	0.0783	0.0327	0.0284
Selenium (dissolved)	SW6020A	0.05	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Groundwater Elevation	Field		NAVD88 (feet)	583.94	582.69	582.21	581.94	582.24	582.86	583.21	582.72	581.67	581.36	581.51	582.45	609.21	608.15	607.34	607.10	608.26	609.97

[O: JJW, QC: KLT 7/12/18]

Notes:
Monitoring well 07 was dry for all groundwater monitoring events.
Groundwater samples were not collected or analyzed in 2017 or 2018.

na	Not Applicable. No Illinois Class I groundwater standard for parameter indicated.
*	Illinois Class I Groundwater Standard
3.4	Parameter with exceedance of Class I standard
ORP	Oxidation-Reduction Potential
C°	Degrees Centigrade
NTU	Nephelometric Turbidity Units
mV	milliVolts
micromhos/cm	micromhos per centimeter
mg/L	milligrams per liter
s.u.	standard units
NAVD88	North American Vertical Datum of 1988

Table 4. Wilcoxon Rank Sum Results Summary

2018 Groundwater Monitoring and Modeling Report
North Ash Pond System and Old East Ash Pond
Vermilion Site, Oakwood, Illinois

Well	Parameter	Historic Data Range	Wilcoxon Rank Sum Result[4]
01	Total Dissolved Solids	1996-2011	Historic Greater
	Sulfate	1996-2011	Historic Greater
02	Arsenic	2011	Historic Greater
03R	Boron	1994-2011	Recent 6 Rounds Greater
04	Boron	1988-2011	Historic Greater
	Manganese	1988-2011	Historic Greater
05	Boron	1988-2011	Recent 6 Rounds Greater
	Manganese	1988-2011	Historic Greater
06R	Manganese	2000-2011	Recent 6 Rounds Greater
08R	Arsenic	2011	Same
	Boron	1994-2011	Recent 6 Rounds Greater
	Manganese	1994-2011	Same
	Total Dissolved Solids	1994-2011	Historic Greater
	Sulfate	1994-2011	Historic Greater
10	pH	1994-2013	Historic Greater
17	Boron	1994-2011	Historic Greater
	Manganese	1994-2011	Same
	Total Dissolved Solids	1994-2011	Historic Greater
	Sulfate	1994-2011	Same
18	Boron	1994-2011	Same
	Manganese	1994-2011	Recent 6 Rounds Greater
	Total Dissolved Solids	1994-2011	Historic Greater
	Sulfate	1994-2011	Historic Greater
21	Arsenic	2011	Historic Greater
34	Arsenic	2011	Same
	Iron	2011	Same

[O: JJW, C: KLT 7/12/18][U: KLT 7/13/18, C: JJW]

Notes:

1. Same = historic data and the recent six rounds of data are from the same population
2. Historic Greater = historic data has higher concentrations than the recent six rounds of data
3. Recent 6 Rounds Greater = the recent six rounds of data has higher concentrations than historic data
4. Wilcoxon Rank Sum results were only determined for parameters that exceeded the Illinois Class I groundwater quality standards as observed during 2017 and 2018 sampling events

Table 5. Flow Model Input Values (calibration and sensitivity)

2018 Groundwater Monitoring and Modeling Report
North Ash Pond System and Old East Ash Pond
Vermilion Site, Oakwood, Illinois

			Calibration Model				
Horizontal Hydraulic Conductivity							
	Hydrostratigraphic Unit	*Materials*	*ft/d*	*cm/s*		*Value Source*	*Sensitivity*[1]
zone 1	Upper Unit (western)	mixed alluvial deposits	1.4	4.94E-04		Geomean of Field Test Results (Kelron, 2012)	high
zone 2	Fill Unit	coal combustion residuals	1.6	5.64E-04		Kh Estimated from Geomean of Vertical Hydraulic Conductivity Laboratory Test Results (Kelron, 2012)	high
zone 3	Upland Confining Unit	clay and silt	0.1	3.53E-05		Calibrated	high
zone 4	Upper Unit (eastern)	mixed alluvial deposits	14.2	5.01E-03		Calibrated	high
zone 5	Middle Groundwater Unit	alluvial deposits	6.1	2.15E-03		Geomean of Field Test Results (Kelron, 2012)	high
zone 6	Lower Groundwater Unit	sand, gravel, silt	2.4	8.47E-04		Geomean of Field Test Results (Kelron, 2012)	high
zone 7	Lower Confining Unit	clay and silt	0.0085	3.00E-06		Calibrated	high
zone 8	Bedrock Confining Unit	shale	0.0085	3.00E-06		Geomean of Field Test Results (Kelron, 2003)	high
zone 9	Middle confining unit	alluvial and re-worked glacial	0.0045	1.59E-06		Geomean of Field Test Results (Kelron, 2003)	moderate
zone 10	Upland Groundwater Unit	sand and silty sand	2.4	8.47E-04		Calibrated	high
Vertical Hydraulic Conductivity							
	Hydrostratigraphic Unit	*Materials*	*ft/d*	*cm/s*	*Kh/Kv*	*Value Source*	*Sensitivity*[1]
zone 1	Upper Unit (western)	mixed alluvial deposits	0.0014	4.94E-07	1000	Kh/Kv Estimated from Field and Laboratory Test Results (Kelron, 2012)	high
zone 2	Fill Unit	coal combustion residuals (CCR)	0.16	5.64E-05	10	Geomean of Vertical Hydraulic Conductivity Laboratory Test Results (Kelron, 2012)	moderately high
zone 3	Upland Confining Unit	clay and silt	0.0001	3.53E-08	1000	Calibrated	high
zone 4	Upper Unit (eastern)	mixed alluvial deposits	14.2	5.01E-03	1	Calibrated	high
zone 5	Middle Groundwater Unit	alluvial deposits	0.61	2.15E-04	10	Calibrated	high
zone 6	Lower Groundwater Unit	sand, gravel, silt	0.024	8.47E-06	100	Calibrated	high
zone 7	Lower Confining Unit	clay and silt	0.00085	3.00E-07	10	Calibrated	moderately high
zone 8	Bedrock Confining Unit	shale	0.00085	3.00E-07	10	Calibrated	high
zone 9	Middle confining unit	alluvial and re-worked glacial	0.00045	1.59E-07	10	Calibrated	high
zone 10	Upland Groundwater Unit	sand and silty sand	2.4	8.47E-04	1	Calibrated	moderate
Recharge							
	Hydrostratigraphic Unit	*Materials*	*ft/d*	*in/yr*		*Value Source*	*Sensitivity*[1]
zone 1	Upper Unit (western)	mixed alluvial deposits	1.00E-03	4.38		Calibrated	high
zone 2	Fill Unit	CCR NAPS	9.50E-04	4.16		Calibrated	moderate
zone 3	Upland Confining Unit	clay and silt	1.50E-04	0.66		Calibrated	high
zone 4	Upper Unit (eastern)	mixed alluvial deposits	1.40E-04	0.61		Calibrated	high
zone 5	Fill Unit	CCR NAPS Pond	6.00E-03	26.28		Calibrated	high
zone 6	Fill Unit	CCR center of impoundments	3.50E-03	15.33		Calibrated	high
zone 7	Fill Unit	CCR OSAP	1.80E-03	7.88		Calibrated	moderately high
Storage							
	Hydrostratigraphic Unit	*Materials*	*Not used in steady-state calibration model*				
zone 1	Upper Unit (western)	mixed alluvial deposits					
zone 2	Fill Unit	CCR (all)					
zone 3	Upland Confining Unit	clay and silt					
zone 4	Upper Unit (eastern)	mixed alluvial deposits					
zone 5	Middle Groundwater Unit	alluvial deposits					
zone 6	Lower Groundwater Unit	sand, gravel, silt					
zone 7	Lower Confining Unit	clay and silt					
zone 8	Bedrock Confining Unit	shale					
zone 9	Middle confining unit	alluvial and re-worked glacial					
zone 10	Upland Groundwater Unit	sand and silty sand					
River Parameters							
			Reach 1	*Sensitivity*[1]	*Reach 2*	*Value Source*	*Sensitivity*[1]
Location			upstream of TW-1		downstream of TW-1		
Stage (ft)			577.94 - 572.46	high	572.42 - 563.63	Modified from Field Data (Kelron, 2003)	high
Bed Thickness (ft)			1	not tested	1	Calibrated	not tested
Hydraulic Conductivity (ft/d)			1	not tested	1	Calibrated	not tested
Conductance (ft^2/c, normalized[1])			2,500	moderate	2,500	Calibrated	moderate
River Width (ft)			100	not tested	100	Calibrated	not tested
River Cell Length (ft)			25	not tested	25	Calibrated	not tested

Notes:
1. Sensitivity Explanation
   Negligible - SSR changed by less than 1%
   Low - SSR change between 1% and 10%
   Moderate - SSR change between 10% and 50%
   Moderately High - SSR change between 50% and 100%
   High - SSR change greater than 100%
nc = no change
-- = no data

References:

Fetter, C.W., 1988, Applied Hydrogeology, Merrill Publishing Company, Columbs, Ohio.
Kelron Environmental (Kelron), 2003, Regional and Local Hydrogeology and Geochemistry, Vermilion Power Plant, Illinois, Dynegy Midwest Generation, Inc., November 30, 2003.
Kelron Environmental (Kelron), 2012a, Hydrogeology and Groundwater Quality of the North Ash Pond System, Vermilion Power Station, Oakwood, Illinois, Dynegy Midwest Generation, LLC, March 15, 2012.
Kelron Environmental (Kelron), 2012b, Hydrogeology and Groundwater Quality of the Old East Ash Pond, Vermilion Power Station, Oakwood, Illinois, Dynegy Midwest Generation, LLC, March 15, 2012.

Table 6. Flow and Transport Model Calibration Targets

2018 Groundwater Monitoring and Modeling Report
North Ash Pond System and Old East Ash Pond
Vermilion Site, Oakwood, Illinois

Monitoring Well ID	Monitored Hydrogeologic Unit	Modeled Target Location (Layer Number)	Flow Model Target Groundwater Elevation (feet NAVD88)	Transport Model Target Boron Concentrations (mg/L)		
			September 2017	Minimum Boron Concentration 2017-2018	Median Boron Concentration 2017-2018	Maximum Boron Concentration 2017-2018
01	Upland Groundwater Unit*	7	582.69	*No Target*		
02	Lower Groundwater Unit	7	574.81	0.2	0.3	0.3
03R	Lower Groundwater Unit	7	581.73	2.9	3.5	5.0
04	Middle Groundwater Unit	5	582.57	4.8	6.0	6.7
05	Middle Groundwater Unit	5	585.91	14.5	17.5	18.3
06R	Upper Unit	4	582.64	*No Target*		
08R	Middle Groundwater Unit	5	576.31	20.7	43.1	52.8
09	Middle Groundwater Unit	5	582.82	*No Target*		
10	Upland Confining Unit	1	608.15	*No Target*		
17	Middle Groundwater Unit	5	583.66	1.3	3.3	5.2
18	Middle Groundwater Unit	3	597.12	3.4	6.5	10.9
19	Middle Groundwater Unit	5	585.70	*No Target*		
20	Middle Groundwater Unit	5	576.83	0.3	0.4	0.5
21	Upland Groundwater Unit**	7	582.72	*No Target*		
34	Lower Groundwater Unit	7	577.81	0.4	0.5	0.6

Notes:

NAVD88 North American Vertical Datum of 1988

* Hydraullcally connected with Lower Groundwater Unit.

** Suspected hydraulic connection with Lower Groundwater Unit.

Table 7. Transport Model Input Values (calibration)

2018 Groundwater Monitoring and Modeling Report
North Ash Pond System and Old East Ash Pond
Vermilion Site, Oakwood, Illinois

Initial Concentration						**Calibration Model**	
					mg/L	*Value Source*	*Sensitivity*
entire domain					0	na	not tested
Source Concentration (recharge)							
	Description				*mg/L*	*Value Source*	*Sensitivity*
zone 1	Upper Unit (western)	mixed alluvial deposits			0	na	not tested
zone 2	Fill Unit	CCR NAPS			45	calibrated	not tested
zone 3	Upland Confining Unit	clay and silt			0	na	not tested
zone 4	Upper Unit (eastern)	mixed alluvial deposits			0	na	not tested
zone 5	Fill Unit	CCR NAPS Pond			4	calibrated	not tested
zone 6	Fill Unit	CCR center of impoundments			5	calibrated	not tested
zone 7	Fill Unit	CCR OEAP			8	calibrated	not tested
Source Concentration (constant concentration cells)							
	Description				*mg/L*	*Value Source*	*Sensitivity*
reach 1	Fill Unit	CCR NAPS			45	calibrated	not tested
reach 2	Fill Unit	CCR center of impoundments			5	calibrated	not tested
reach 3	Fill Unit	CCR OEAP			8	calibrated	not tested
Storage, Specific Yield and Effective Porosity							
	Description		*Storage*	*Specific Yield*	*Effective Porosity*	*Value Source*	*Sensitivity*
zone 1	Upper Unit (western)	mixed alluvial deposits	0.003	0.1	0.1	Estimated from literature (Fetter, 1988)	see Table 8
zone 2	Fill Unit	CCR (all)	0.003	0.1	0.1	Estimated from literature (Fetter, 1988)	see Table 8
zone 3	Upland Confining Unit	clay and silt	0.003	0.1	0.1	Estimated from literature (Fetter, 1988)	see Table 8
zone 4	Upper Unit (eastern)	mixed alluvial deposits	0.003	0.2	0.2	Estimated from literature (Fetter, 1988)	see Table 8
zone 5	Middle Groundwater Unit	alluvial deposits	0.003	0.2	0.2	Estimated from literature (Fetter, 1988)	see Table 8
zone 6	Lower Groundwater Unit	sand, gravel, silt	0.003	0.2	0.2	Estimated from literature (Fetter, 1988)	see Table 8
zone 7	Lower Confining Unit	clay and silt	0.003	0.1	0.1	Estimated from literature (Fetter, 1988)	see Table 8
zone 8	Bedrock Confining Unit	shale	0.003	0.1	0.1	Estimated from literature (Fetter, 1988)	see Table 8
zone 9	Middle confining unit	alluvial and re-worked glacial till	0.003	0.01	0.01	Estimated from literature (Fetter, 1988)	see Table 8
zone 10	Upland Groundwater Unit	sand and silty sand	0.003	0.2	0.2	Estimated from literature (Fetter, 1988)	see Table 8
Dispersivity							
			Longitudinal (ft)	*Transverse (ft)*	*Vertical (ft)*	*Value Source*	*Sensitivity*
entire domain			3	0.3	0.03	calibrated	not tested
Retardation							
				Kd (mL/g)	*Bulk Density (g/cm^3)*	*Value Source*	*Sensitivity*
entire domain				0.0	1.57	na	see Table 8

Notes:
1. The concentrations from the end of the calibrated transport model were imported as initial concentrations for the prediction model runs.

Table 8. Transport Model Input Values (sensitivity)

2018 Groundwater Monitoring and Modeling Report
North Ash Pond System and Old East Ash Pond
Vermilion Site, Oakwood, Illinois

		Storage and Specific Yield				Retardation		Effective Porosity				Diffusion Zones	
	Calibration	REV400_21_cal_4_s_sy_low_CC		REV400_21_cal_4_s_sy_high_CC		REV400_cal_5_Kd_high_CC		REV400_cal_5_Por_low_CC		REV400_cal_5_Por_high_CC		REV400_21_cal_4	
Well ID	Concentration	Concentration	Sensitivity[1]	Concentration	Sensitivity[1]	Concentration	Sensitivity[1]	Concentration	Sensitivity[1]	Concentration	Sensitivity[1]	Concentration	Sensitivity[1]
05	18.1	18.8	low	18.3	low	18.1	negligible	18.1	negligible	18.0	negligible	18.0	negligible
04	4.6	4.6	negligible	4.6	negligible	4.6	negligible	4.6	negligible	4.5	negligible	4.6	negligible
08R	43.0	43.0	negligible	43.0	negligible	43.0	negligible	43.1	negligible	42.6	negligible	43.0	negligible
17	4.4	4.4	negligible	4.3	low	4.4	negligible	4.4	negligible	4.3	negligible	4.3	negligible
18	5.0	5.0	negligible	5.0	negligible	5.0	negligible	5.0	negligible	5.0	negligible	5.0	negligible
20	1.8	1.8	negligible	1.8	negligible	1.8	negligible	1.8	negligible	1.8	low	1.8	negligible
02	0.3	0.3	negligible	0.3	low	0.3	negligible	0.3	low	0.3	moderate	0.3	low
03R	15.9	16.0	negligible	15.6	low	15.9	negligible	21.8	moderate	8.2	moderate	17.0	low
34	0.3	0.3	low	0.3	low	0.3	negligible	0.5	moderate	0.1	moderately high	0.4	low
		S*0.1 Sy*0.5		S*10 Sy*2		Kd=0.5		Porosity-0.05		Porosity+0.05		Zone 10 Inactive Transport Cells	

Notes:

1. Sensitivity Explanation
Negligible - concentration changed by less than 1%
Low - concentration change between 1% and 10%
Moderate - concentration change between 10% and 50%
Moderately High - concentration change between 50% and 100%
High - concentration change greater than 100%

Effective Porosity Zone 9 value at 0.01 in calibration model, no change to Zone 9 was applied in the low effective porosity sensitivity test.

Table 9. HELP Model Input and Output Values

2018 Groundwater Monitoring and Modeling Report

North Ash Pond System and Old East Ash Pond

Vermilion Site, Oakwood, Illinois

	NAPS - CAP	OEAP - CAP	
Closure Scenario Number (Drainage Length)	Scenario 1 (1585); Scenario 3 (1000); Scenarios 4 & 5 (3730)	Scenarios 1 & 5 (1610)	
Input Parameter			Notes
Climate-General			
City	Indianapolis, IN	Indianapolis, IN	Nearby city to the Site within HELP database
Latitude	40.18	40.18	Site latitude
Evap Zone	21	21	21 - fair grass
Leaf Index	2	2	2 - fair stand of grass (Schroeder, 1994)
Growing Season Period, Average Wind Speed, and Quarterly Relative Humidity	Indianapolis, IN	Indianapolis, IN	Nearby city to the Site within HELP database
Number of Years for Synthetic Data Generation	30	30	
Temperature, Evapotranspiration, and Precipitation	Synthetically generated using 30 year monthly averages for Danville, IL	Synthetically generated using 30 year monthly averages for Danville, IL	
Soils-General			
% where runoff possible	100	100	
Area (acres)	1	1	Unit area
Specify Initial MC	No	No	
Surface Water/Snow	Model Caclulated	Model Caclulated	
Soils-Layers			
1	Vegetative Cover	Vegetative Cover	
2	Soil Rooting Zone	Soil Rooting Zone	
3	Geocomposite Drainage Layer	Geocomposite Drainage Layer	
4	40-mil HDPE geomembrane	40-mil HDPE geomembrane	
5	Fly Ash	Fly Ash	
Soil Parameters--top soil			
Type	1	1	vertical percolation layer
Thickness (in)	6	6	
Texture	9	9	defaults used
Description	SiL	SiL	Silty Loam
Soil Parameters--rooting zone			
Type	1	1	vertical percolation layer
Thickness (in)	18	18	
Texture	12	12	defaults used
Description	SiCL	SiCL	Silty Clay

Table 9. HELP Model Input and Output Values

2018 Groundwater Monitoring and Modeling Report

North Ash Pond System and Old East Ash Pond

Vermilion Site, Oakwood, Illinois

	NAPS - CAP	OEAP - CAP	
Closure Scenario Number (Drainage Length)	Scenario 1 (1585); Scenario 3 (1000); Scenarios 4 & 5 (3730)	Scenarios 1 & 5 (1610)	
Input Parameter			Notes
Soil Parameters--soil fill			
Type			vertical percolation layer
Thickness (in)			
Texture			defaults used
Description			Silty Clay
Soil Parameters--drainage			
Type	2	2	drainage layer
Thickness (in)	0.2	0.2	
Drainage Length	1585; 1000; 3730	1610	
Drainage Slope	3	3	
Texture	20	20	defaults used
Soil Parameters--geomembrane			
Type	4	4	geomembrane
Thickness (in)	0.04	0.04	
Texture	35	35	HDPE, defaults used
Pinhole density	1	1	holes/acre
Installation Defects	4	4	holes/acre
Placement Quality	3	3	Good
Soil Parameters--ash layers			
Type	1	1	vertical percolation layer
Thickness (in)	256	514	
Texture	30	30	coal fly ash, defaults used
Soils--Runoff			
Equation	HELP CN	HELP CN	HELP-calculated
Slope	3.0%	3.0%	
Length (ft)	1585; 1000; 3730	1610	
Texture	9	9	
Vegetation	fair	fair	
Execution Parameters			
Years	30	30	
Report Daily	n	n	
Report Monthly	n	n	
Report Annual	y	y	
Output Parameter			
Percolation Rate (in/yr)	**0.02341; 0.01094; 0.12883**	**0.024**	

Table 9. HELP Model Input and Output Values
2018 Groundwater Monitoring and Modeling Report
North Ash Pond System and Old East Ash Pond
Vermilion Site, Oakwood, Illinois

	NAPS - Consolidation/Removal Area	OEAP - Consolidation/Removal Area	
Closure Scenario Number (Drainage Length)	Scenarios 2 & 3 (1585)	Scenarios 1 & 5 (150); Scenarios 2 & 3 (1610); Scenario 4 (760)	
Input Parameter			Notes
Climate-General			
City	Indianapolis, IN	Indianapolis, IN	Nearby city to the Site within HELP database
Latitude	40.18	40.18	Site latitude
Evap Zone	21	21	21 fair grass
Leaf Index	2	2	2 - fair stand of grass (Schroeder, 1994)
Growing Season Period, Average Wind Speed, and Quarterly Relative Humidity	Indianapolis, IN	Indianapolis, IN	Nearby city to the Site within HELP database
Number of Years for Synthetic Data Generation	30	30	
Temperature, Evapotranspiration, and Precipitation	Synthetically generated using 30 year monthly averages for Danville, IL	Synthetically generated using 30 year monthly averages for Danville, IL	
Soils-General			
% where runoff possible	100	100	
Area (acres)	1	1	Unit area
Specify Initial MC	No	No	
Surface Water/Snow	Model Caclulated	Model Caclulated	
Soils-Layers			
1	Vegetative Cover	Vegetative Cover	
2	Soil Rooting Zone	Soil Rooting Zone	
3	Silty Clay	Silty Clay	
4			
5			
Soil Parameters--top soil			
Type	1	1	vertical percolation layer
Thickness (in)	6	6	
Texture	9	9	defaults used
Description	SiL	SiL	Silty Loam
Soil Parameters--rooting zone			
Type	1	1	vertical percolation layer
Thickness (in)	18	18	
Texture	12	12	defaults used
Description	SiCL	SiCL	Silty Clay

Table 9. HELP Model Input and Output Values

2018 Groundwater Monitoring and Modeling Report
North Ash Pond System and Old East Ash Pond
Vermilion Site, Oakwood, Illinois

	NAPS - Consolidation/Removal Area	OEAP - Consolidation/Removal Area	
Closure Scenario Number (Drainage Length)	Scenarios 2 & 3 (1585)	Scenarios 1 & 5 (150); Scenarios 2 & 3 (1610); Scenario 4 (760)	
Input Parameter			Notes
Soil Parameters--soil fill			
Type	1	1	vertical percolation layer
Thickness (in)	196	454	
Texture	12	12	defaults used
Description	SiCL	SiCL	Silty Clay
Soil Parameters--drainage			
Type			drainage layer
Thickness (in)			
Drainage Length			
Drainage Slope			
Texture			defaults used
Soil Parameters--geomembrane			
Type			geomembrane
Thickness (in)			
Texture			HDPE, defaults used
Pinhole density			holes/acre
Installation Defects			holes/acre
Placement Quality			Good
Soil Parameters--ash layers			
Type			vertical percolation layer
Thickness (in)			
Texture			coal fly ash, defaults used
Soils--Runoff			
Equation	HELP CN	HELP CN	HELP-calculated
Slope	2.0%	2.0%	
Length (ft)	1585	150; 1610; 760	
Texture	9	9	
Vegetation	fair	fair	
Execution Parameters			
Years	30	30	
Report Daily	n	n	
Report Monthly	n	n	
Report Annual	y	y	
Output Parameter			
Percolation Rate (in/yr)	7.05754	6.27105; 6.94935; 6.36367	

Table 10. HELP Model Sensitivity Analysis Summary
2018 Groundwater Monitoring and Modeling Report
North Ash Pond System and Old East Ash Pond
Vermilion Site, Oakwood, Illinois

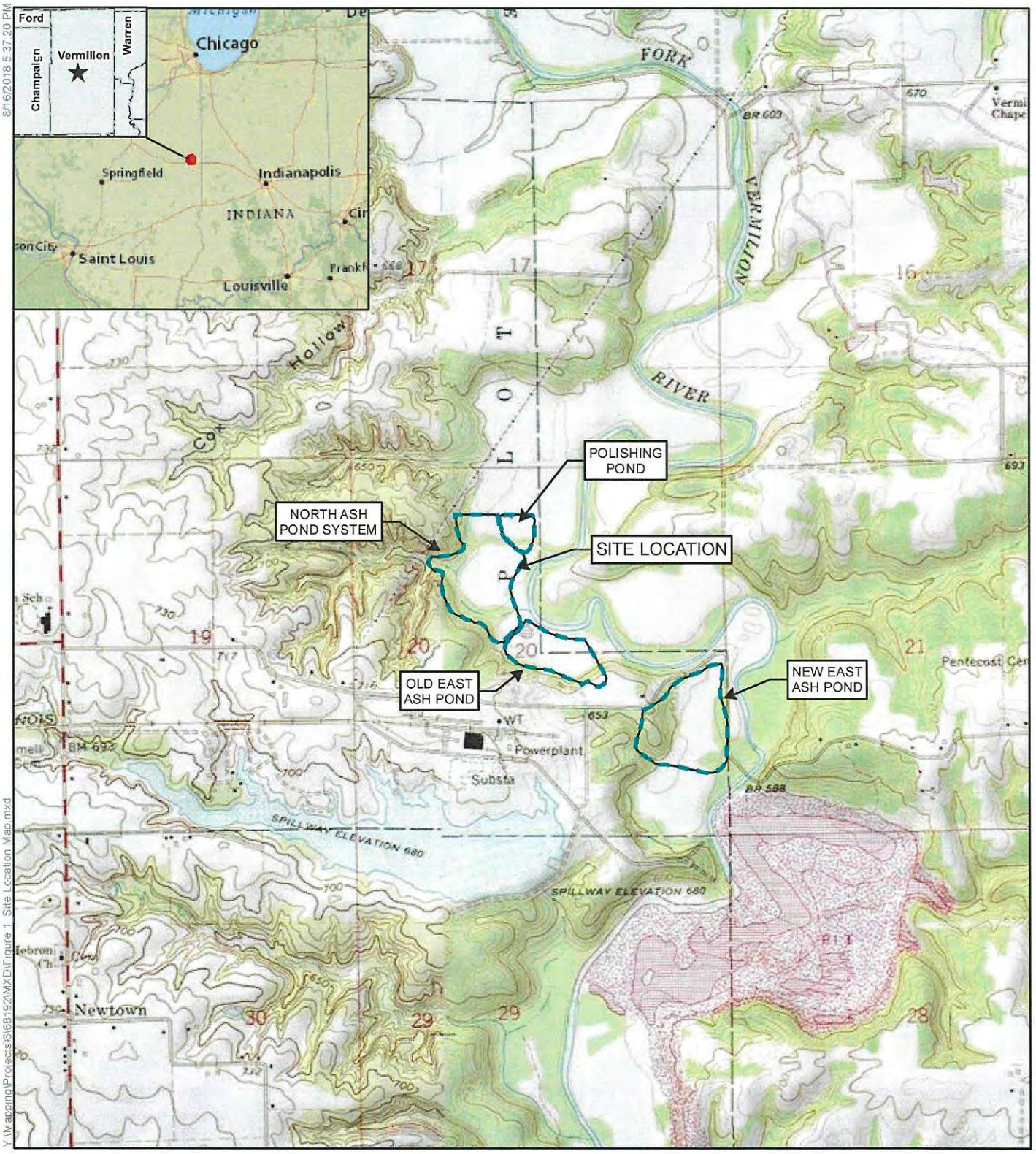
Parameter	Anticipated Closure Condition	Sensitivity Values Evaluated	Area Location and Conditions (anticipated drainage length, feet)	Sensitivity to Percolation Rate[1]
Soil Layers--top soil and rooting zone	top soil and rooting zone present	top soil and rooting zone absent	NAPS Consolidation/Removal Area (1585)	moderate
			OEAP Consolidation/Removal Area (150)	moderate
			OEAP Consolidation/Removal Area (1610)	moderate
			OEAP Consolidation/Removal Area (760)	moderate
Soil Parameters--soil fill thickness (inches)	196	258	NAPS Consolidation/Removal Area (1585)	negligible
		136		negligible
	454	514	OEAP Consolidation/Removal Area (150)	negligible
		394		negligible
	454	514	OEAP Consolidation/Removal Area (1610)	negligible
		394		negligible
	454	514	OEAP Consolidation/Removal Area (760)	negligible
		394		negligible
Soil Parameters--capping area drainage length (feet)	1585	2085	NAPS Capping Area (1585)	high
		1085		moderate
	1000	500	NAPS Capping Area (1000)	moderately high
		1500		moderately high
	3730	3230	NAPS Capping Area (3730)	moderate
		4230		moderate
	1610	2110	OEAP Capping Area (1610)	high
		1110		moderate
Soil Parameters--capping area drainage slope (percentage)	3	1	NAPS Capping Area (1585)	moderately high
		5		high
	3	1	NAPS Capping Area (1000)	moderately high
		5		high
	3	1	NAPS Capping Area (3730)	moderately high
		5		high
	3	1	OEAP Capping Area (1610)	moderately high
		5		high
Soil Parameters--geomembrane placement quality (good/poor)	good	poor	NAPS Capping Area (1585)	high
	good	poor	NAPS Capping Area (1000)	high
	good	poor	NAPS Capping Area (3730)	high
	good	poor	OEAP Capping Area (1610)	high
Soil Parameters--ash fill thickness (inches)	256	316	NAPS Capping Area (1585)	negligible
		196		negligible
	256	316	NAPS Capping Area (1000)	negligible
		196		negligible
	256	316	NAPS Capping Area (3730)	negligible
		196		negligible
	514	574	OEAP Capping Area (1610)	negligible
		454		negligible
Soil Parameters--ash fill texture (bottom ash/fly ash)	fly ash	bottom ash	NAPS Capping Area (1585)	moderately high
	fly ash	bottom ash	NAPS Capping Area (1000)	moderately high
	fly ash	bottom ash	NAPS Capping Area (3730)	high
	fly ash	bottom ash	OEAP Capping Area (1610)	moderately high
Soil Layers--Consolidation/Removal area drainage length (feet)	2	1	NAPS Consolidation/Removal Area (1585)	low
		3		negligible
	2	1	OEAP Consolidation/Removal Area (150)	negligible
		3		negligible
	2	1	OEAP Consolidation/Removal Area (1610)	low
		3		negligible
	2	1	OEAP Consolidation/Removal Area (760)	low
		3		negligible
Soil Layers--Consolidation/Removal area drainage slope (percentage)	1585	2085	NAPS Consolidation/Removal Area (1585)	negligible
		1085		low
	150	650	OEAP Consolidation/Removal Area (150)	negligible
	1610	2110	OEAP Consolidation/Removal Area (1610)	negligible
		1110		low
	760	1360	OEAP Consolidation/Removal Area (760)	negligible
		260		negligible

Notes:
1. Sensitivity Explanation
Negligible - percolation rate changed by less than 1%
Low - percolation change between 1% and 10%
Moderate - percolation rate change between 10% and 50%
Moderately High - percolation rate change between 50% and 100%
High - percolation rate change greater than 100%

Table 11. Prediction Model Recharge and Constant Concentration Input Values (no action and closure scenario prediction)
2018 Groundwater Monitoring and Modeling Report
North Ash Pond System and Old East Ash Pond
Vermilion Site, Oakwood, Illinois

Fill Unit - CCR NAPS Pond						
Prediction Model	Construction Period (years)	Recharge Zone	Recharge Concentration (mg/L)	Recharge (ft/day)	Recharge (in/yr)	Constant Concentration (mg/L)
No Action	0	5	4	6.0E-03	26.28	
Closure Scenario 1	2	14	0	6.0E-03	26.28	--
Closure Scenario 2	10	14	0	6.0E-03	26.28	--
Closure Scenario 3	20	14	0	6.0E-03	26.28	
Closure Scenario 4	5	14	0	6.0E-03	26.28	--
Closure Scenario 5	3	14	0	6.0E-03	26.28	--
Fill Unit - CCR NAPS						
Prediction Model	Construction Period (years)	Recharge Zone	Recharge Concentration (mg/L)	Recharge (ft/day)	Recharge (in/yr)	Constant Concentration (mg/L)
No Action	0	2	45	9.5E-04	4.16	45
Closure Scenario 1	2	8	45	5.3E-06	0.02	45
Closure Scenario 2	10	12	0	1.6E-03	7.01	--
Closure Scenario 3	20	8	45	2.5E-06	0.01	45
Closure Scenario 4	5	8	45	2.9E-05	0.13	45
Closure Scenario 5	3	8	45	2.9E-05	0.13	45
Fill Unit - CCR center of impoundments (North)						
Prediction Model	Construction Period (years)	Recharge Zone	Recharge Concentration (mg/L)	Recharge (ft/day)	Recharge (in/yr)	Constant Concentration (mg/L)
No Action	0	6	5	3.5E-03	15.33	5
Closure Scenario 1	2	9	5	5.3E-06	0.02	5
Closure Scenario 2	10	12	0	1.6E-03	7.01	--
Closure Scenario 3	20	9	5	2.5E-06	0.01	5
Closure Scenario 4	5	9	5	2.9E-05	0.13	5
Closure Scenario 5	3	9	5	2.9E-05	0.13	5
Fill Unit - CCR center of impoundments (South))						
Prediction Model	Construction Period (years)	Recharge Zone	Recharge Concentration (mg/L)	Recharge (ft/day)	Recharge (in/yr)	Constant Concentration (mg/L)
No Action	0	6	5	3.5E-03	15.33	5
Closure Scenario 1	2	10	5	5.5E-06	0.02	5
Closure Scenario 2	10	13	0	1.6E-03	7.01	--
Closure Scenario 3	20	13	0	1.6E-03	7.01	--
Closure Scenario 4	5	13	0	1.5E-03	6.57	--
Closure Scenario 5	3	10	5	5.5E-06	0.02	5
Fill Unit - CCR OEAP						
Prediction Model	Construction Period (years)	Recharge Zone	Recharge Concentration (mg/L)	Recharge (ft/day)	Recharge (in/yr)	Constant Concentration (mg/L)
No Action	0	7	8	1.8E-03	7.88	8
Closure Scenario 1	2	11	8	5.5E-06	0.02	8
Closure Scenario 2	10	13	0	1.6E-03	7.01	--
Closure Scenario 3	20	13	0	1.6E-03	7.01	--
Closure Scenario 4	5	13	0	1.5E-03	6.57	--
Closure Scenario 5	3	11	8	5.5E-06	0.02	8
Fill Unit - Consolidation/Removal NAPS						
Prediction Model	Construction Period (years)	Recharge Zone	Recharge Concentration (mg/L)	Recharge (ft/day)	Recharge (in/yr)	Constant Concentration (mg/L)
No Action	0	--	--	--	--	--
Closure Scenario 1	2	12	0	1.6E-03	7.01	--
Closure Scenario 2	10	12	0	1.6E-03	7.01	--
Closure Scenario 3	20	12	0	1.6E-03	7.01	--
Closure Scenario 4	5	12	0	1.6E-03	7.01	--
Closure Scenario 5	3	12	0	1.6E-03	7.01	--
Fill Unit - Consolidation/Removal OEAP						
Prediction Model	Construction Period (years)	Recharge Zone	Recharge Concentration (mg/L)	Recharge (ft/day)	Recharge (in/yr)	Constant Concentration (mg/L)
No Action	0	--	--	--	--	
Closure Scenario 1	2	13	0	1.4E-03	6.13	--
Closure Scenario 2	10	13	0	1.6E-03	7.01	--
Closure Scenario 3	20	13	0	1.6E-03	7.01	--
Closure Scenario 4	5	13	0	1.5E-03	6.57	--
Closure Scenario 5	3	13	0	1.4E-03	6.13	--

Figures



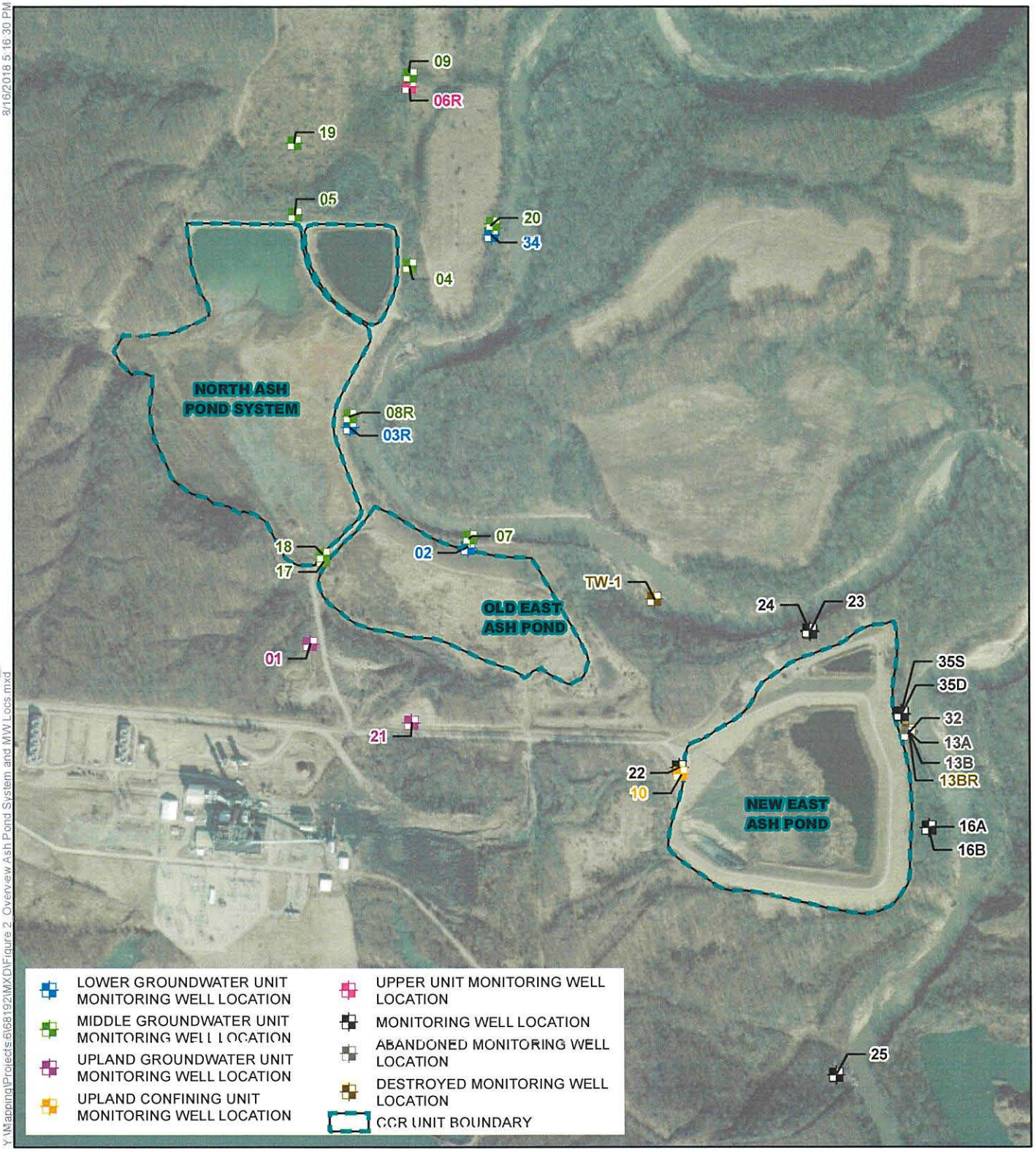
SITE LOCATION MAP

GROUNDWATER MONITORING AND MODELING REPORT
NORTH ASH POND SYSTEM AND OLD EAST ASH POND
VERMILION SITE
OAKWOOD, ILLINOIS

N

0 1,000 2,000 4,000
Feet

O'BRIEN & GERE ENGINEERS, INC.



3/16/2018 5:16:30 PM

Y:\Mapping\Projects\668192\MXD\Figure 2_Overview Ash Pond System and MW Locs.mxd

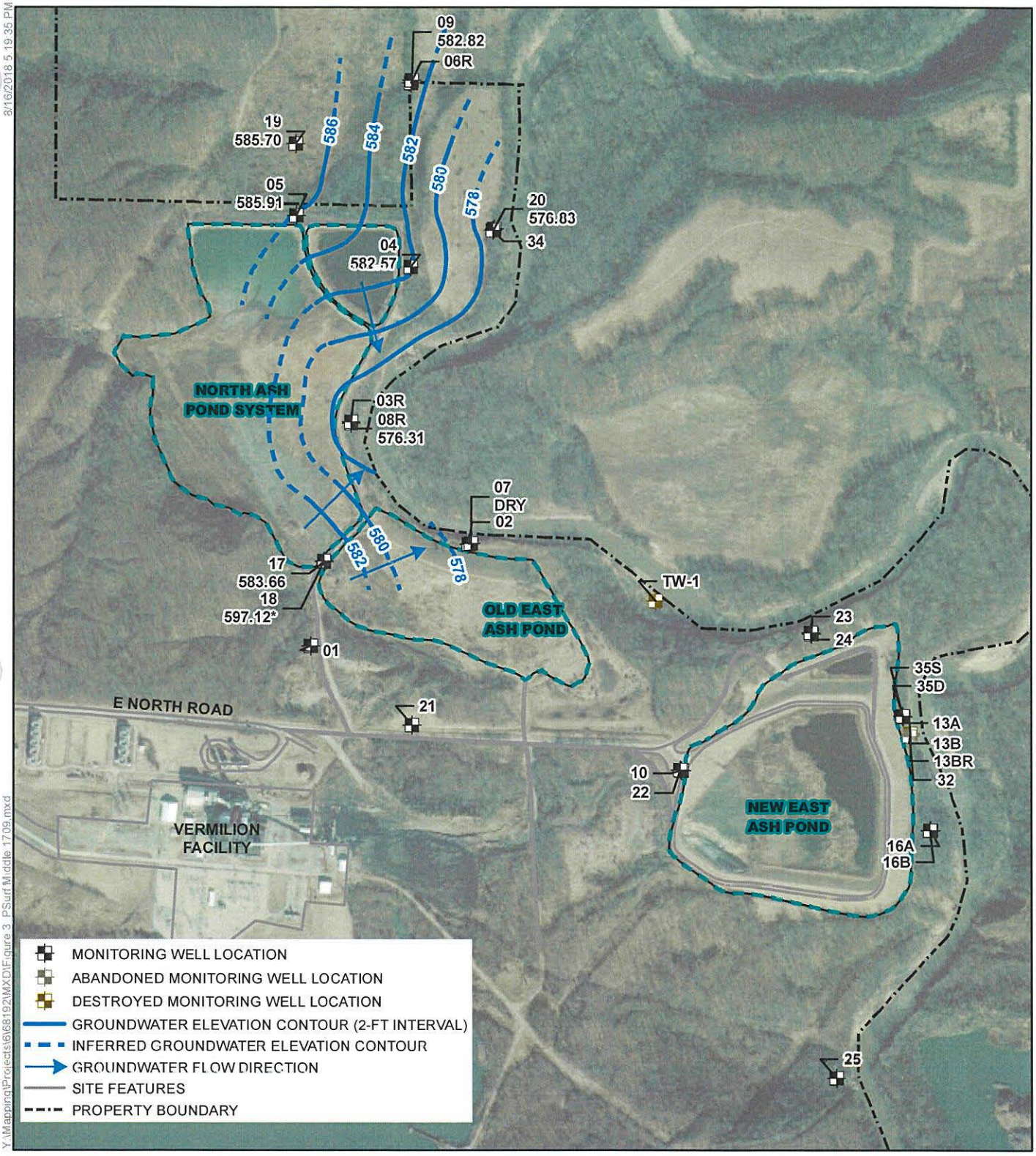
OVERVIEW OF ASH POND SYSTEM AND SITE MONITORING WELL LOCATIONS

GROUNDWATER MONITORING AND MODELING REPORT
NORTH ASH POND SYSTEM AND OLD EAST ASH POND
VERMILION SITE
OAKWOOD, ILLINOIS

N

0 375 750 1,500
Feet

O'BRIEN & GERE ENGINEERS, INC.



8/16/2018 5:19:35 PM

Y:\Mapping\Projects\68192\MXD\Figure 3_PSurf Middle 1709.mxd

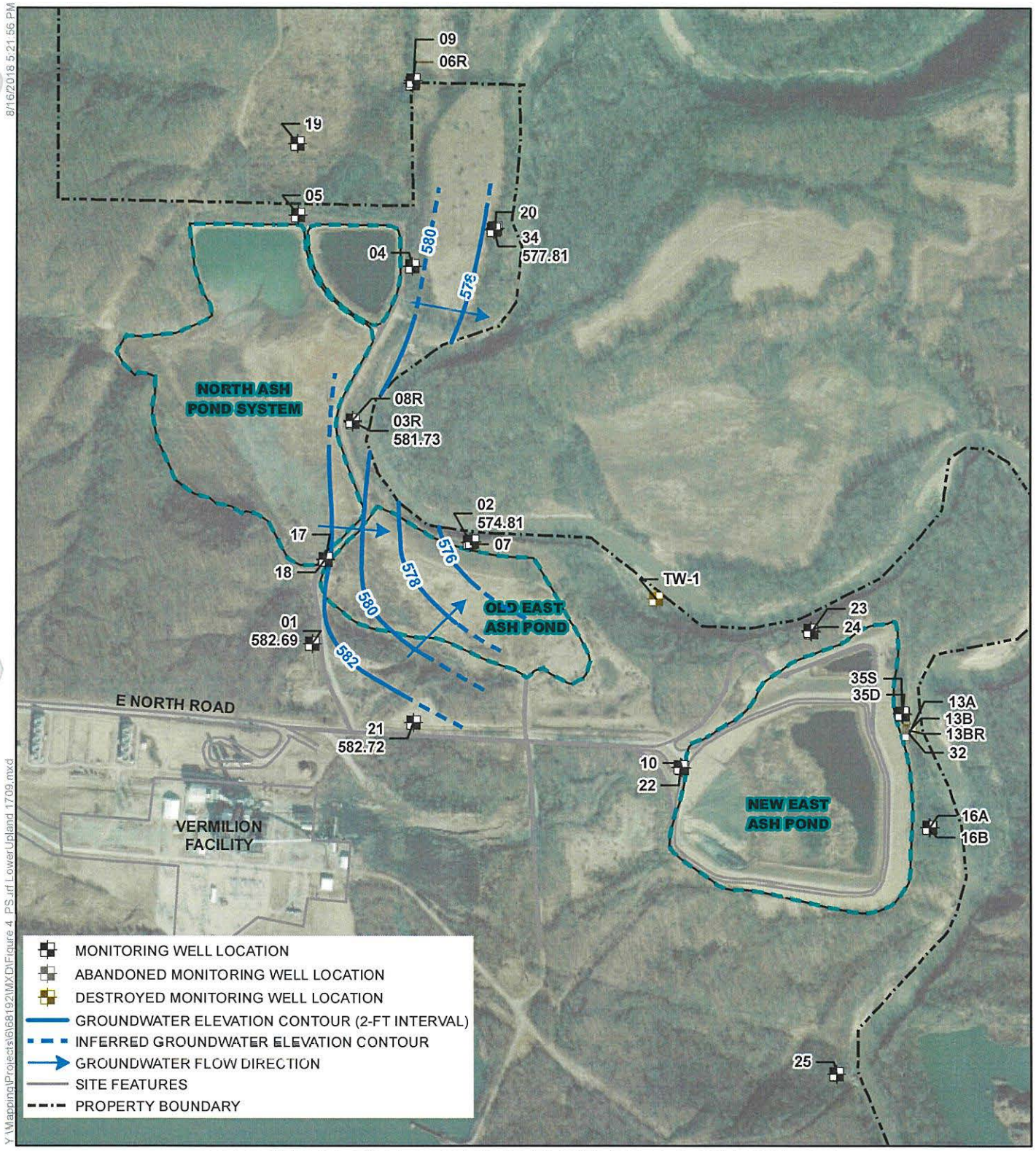
POTENTIOMETRIC SURFACE ELEVATION CONTOUR MAP
MIDDLE GROUNDWATER UNIT
SEPTEMBER 2017

GROUNDWATER MONITORING AND MODELING REPORT
NORTH ASH POND SYSTEM AND OLD EAST ASH POND
VERMILION SITE
OAKWOOD, ILLINOIS

N

0 375 750 1,500
Feet

O'BRIEN & GERE ENGINEERS, INC.



8/16/2018 5:21:56 PM

Y:\Mapping\Projects\168192\MXD\Figure 4_PS.mxd LowerUpland 1709.mxd

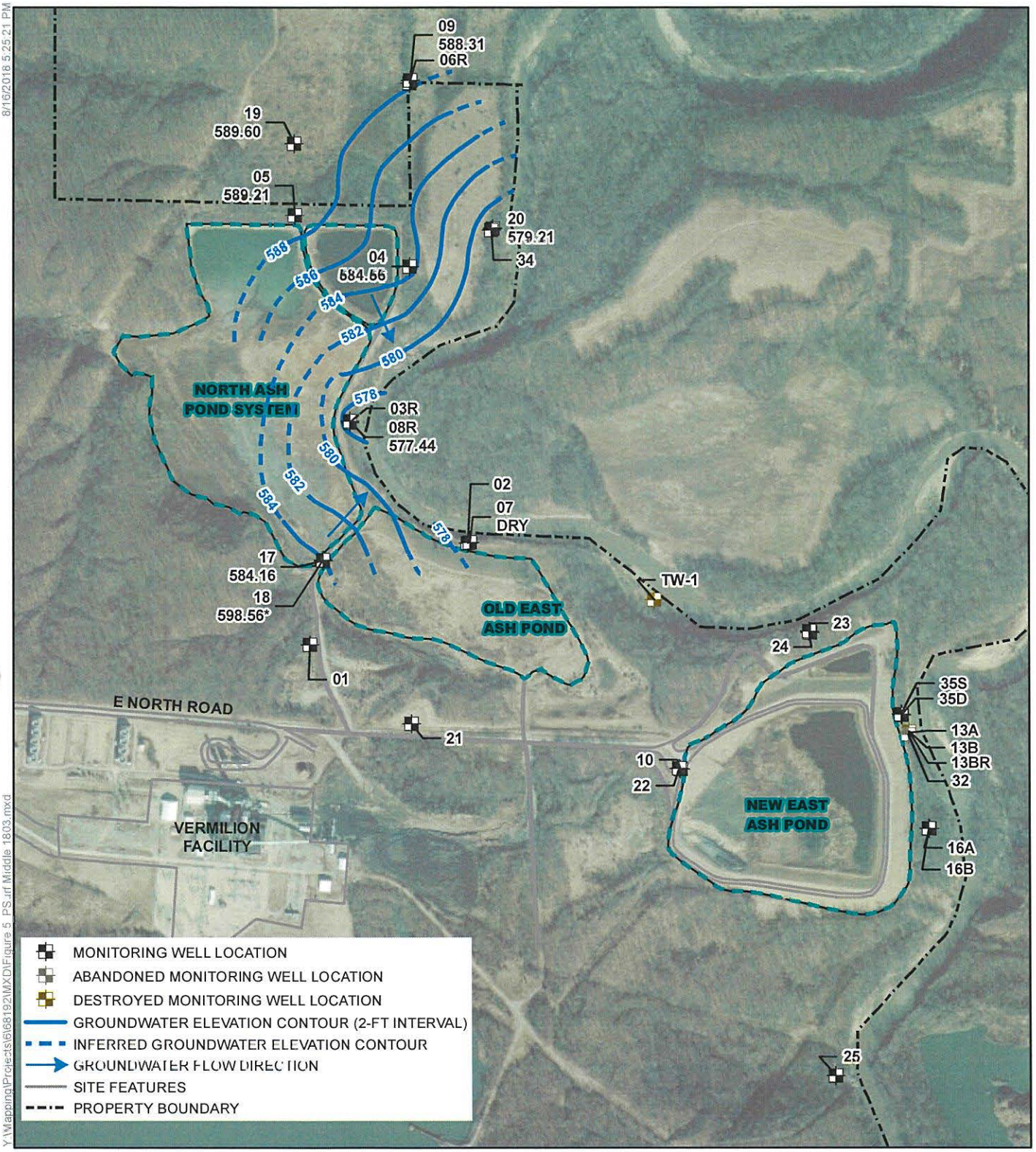
POTENTIOMETRIC SURFACE ELEVATION CONTOUR MAP
LOWER AND UPLAND GROUNDWATER UNIT
SEPTEMBER 2017

GROUNDWATER MONITORING AND MODELING REPORT
NORTH ASH POND SYSTEM AND OLD EAST ASH POND
VERMILION SITE
OAKWOOD, ILLINOIS

N

0 375 750 1,500
Feet

O'BRIEN & GERE ENGINEERS, INC.



8/16/2018 5:25:21 PM

Y:\Wapping\Projects\66192\MXD\Figure 5_PS.mxd Middle 1803.mxd

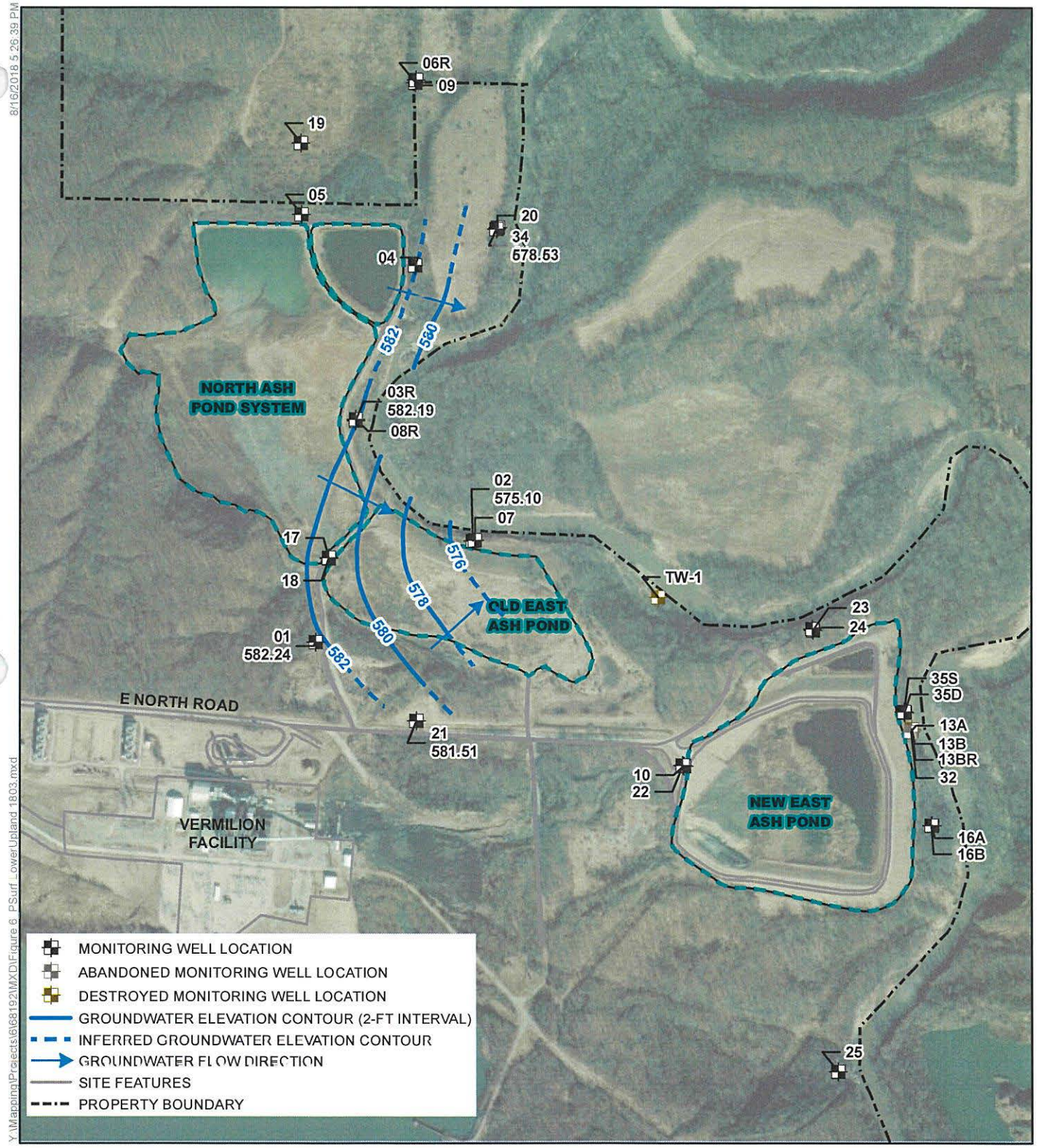
POTENTIOMETRIC SURFACE ELEVATION CONTOUR MAP
MIDDLE GROUNDWATER UNIT
MARCH 2018

GROUNDWATER MONITORING AND MODELING REPORT
NORTH ASH POND SYSTEM AND OLD EAST ASH POND
VERMILION SITE
OAKWOOD, ILLINOIS

N

0 375 750 1,500
Feet

O'BRIEN & GERE ENGINEERS, INC.



8/16/2018 5:26:39 PM

Y:\Mapping\Projects\68192\MXD\Figure 6_PSurf_LowerUpland 1803.mxd

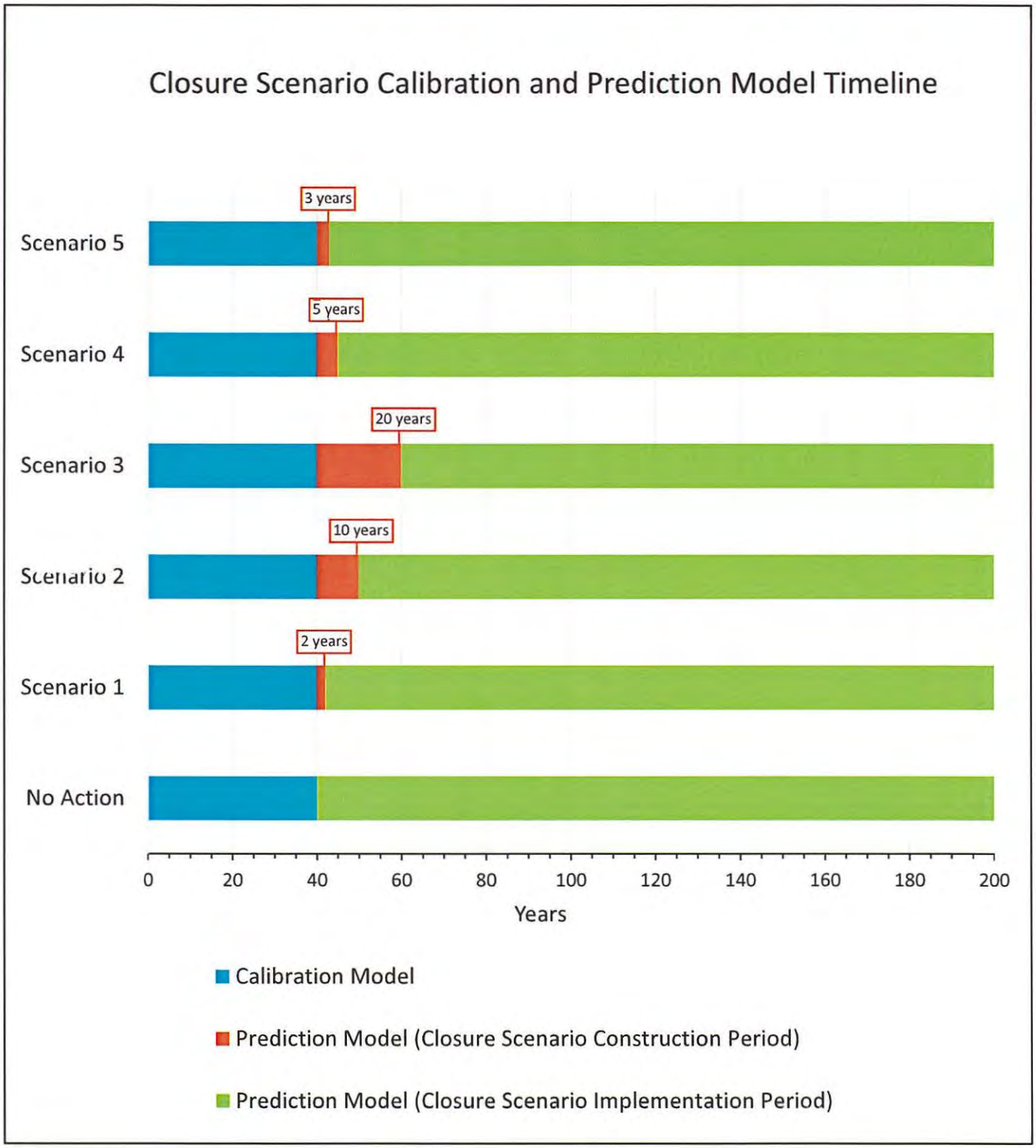
POTENTIOMETRIC SURFACE ELEVATION CONTOUR MAP
LOWER AND UPLAND GROUNDWATER UNIT
MARCH 2018

GROUNDWATER MONITORING AND MODELING REPORT
NORTH ASH POND SYSTEM AND OLD EAST ASH POND
VERMILION SITE
OAKWOOD, ILLINOIS

N

0 375 750 1,500
Feet

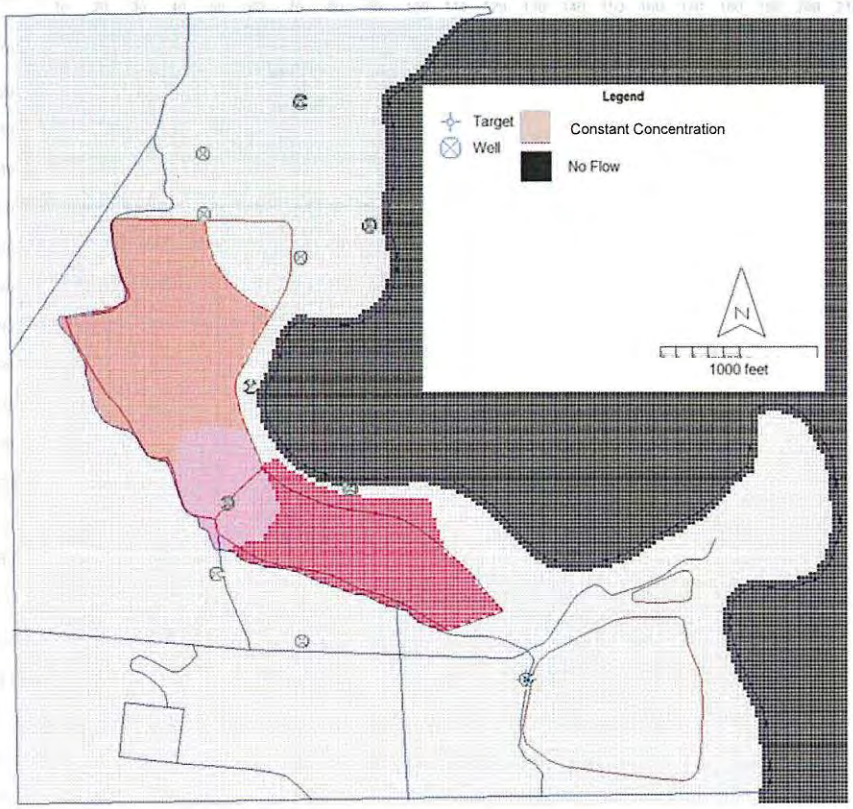
O'BRIEN & GERE ENGINEERS, INC.

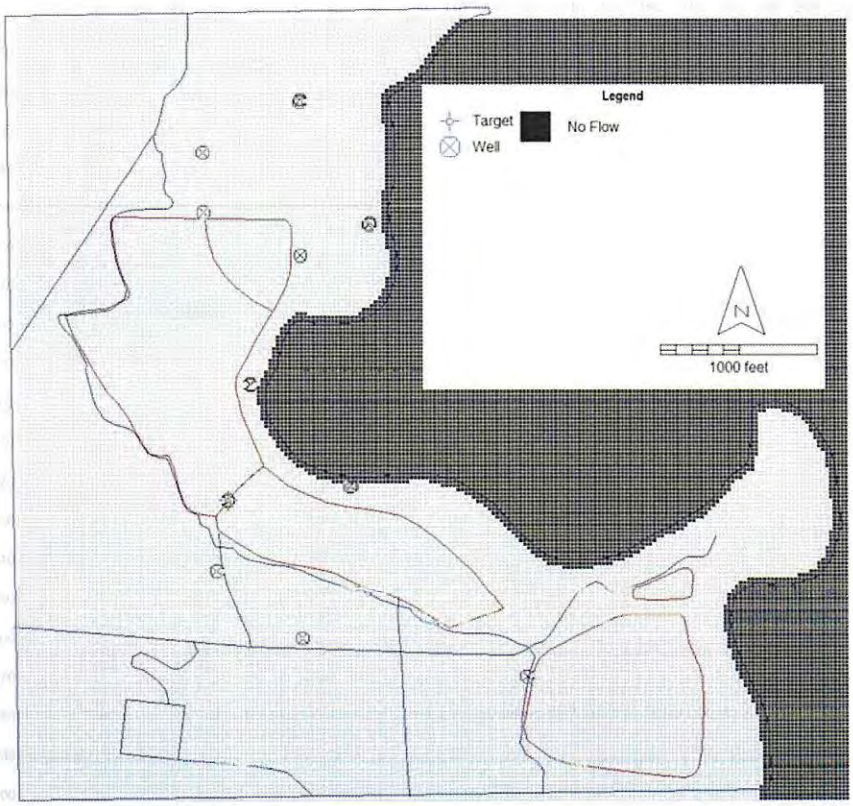


CLOSURE SCENARIO CALIBRATION AND PREDICTION MODEL TIMELINE

GROUNDWATER MONITORING AND MODELING REPORT
NORTH ASH POND SYSTEM AND OLD EAST ASH POND
VERMILION SITE
OAKWOOD, ILLINOIS

O'BRIEN & GERE ENGINEERS, INC.





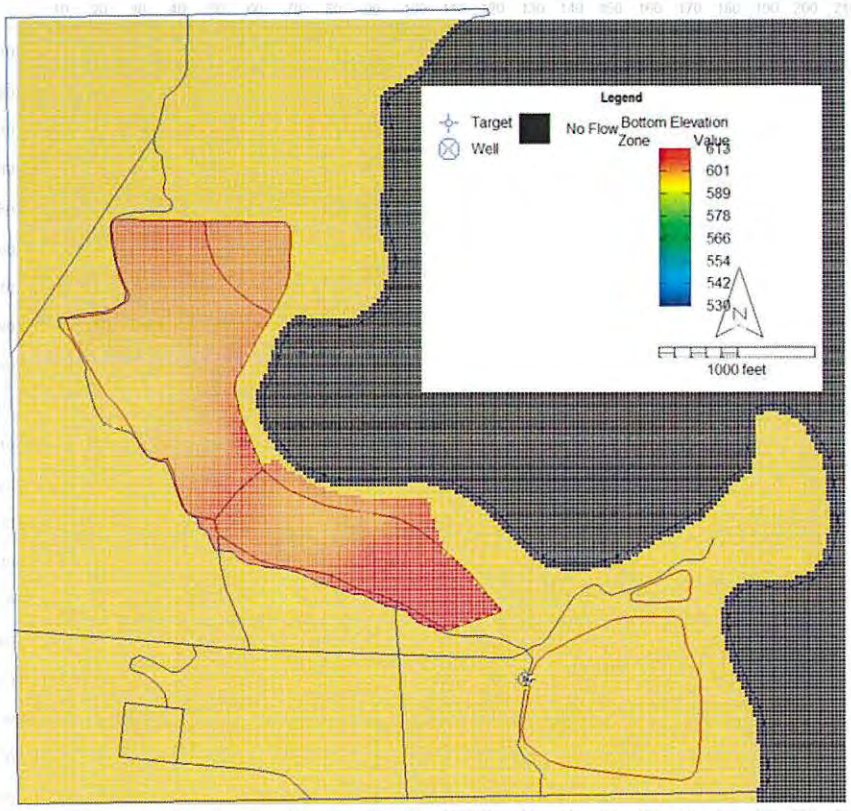
MODFLOW AND MT3DMS GRID AND BOUNDARY CONDITIONS FOR LAYERS 1-2 (TOP) AND LAYERS 3-4 (BOTTOM)

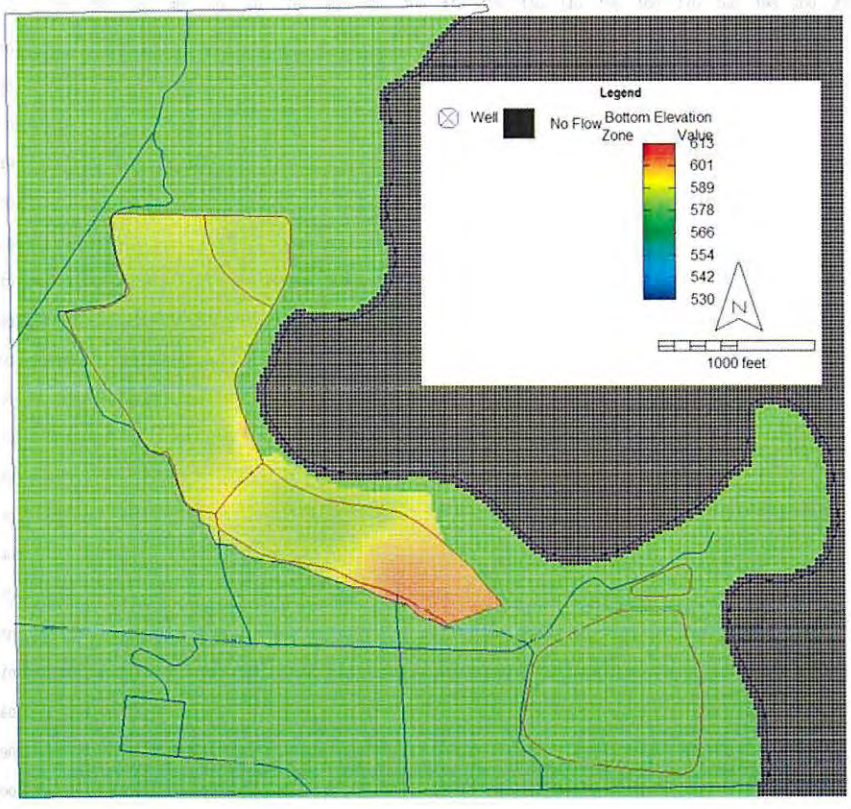
The following are attachments to the testimony of Andrew Rehn.

ATTACHMENT 20b



MODFLOW AND MT3DMS GRID AND BOUNDARY CONDITIONS FOR LAYERS 5 (TOP) AND LAYERS 6-8 (BOTTOM)

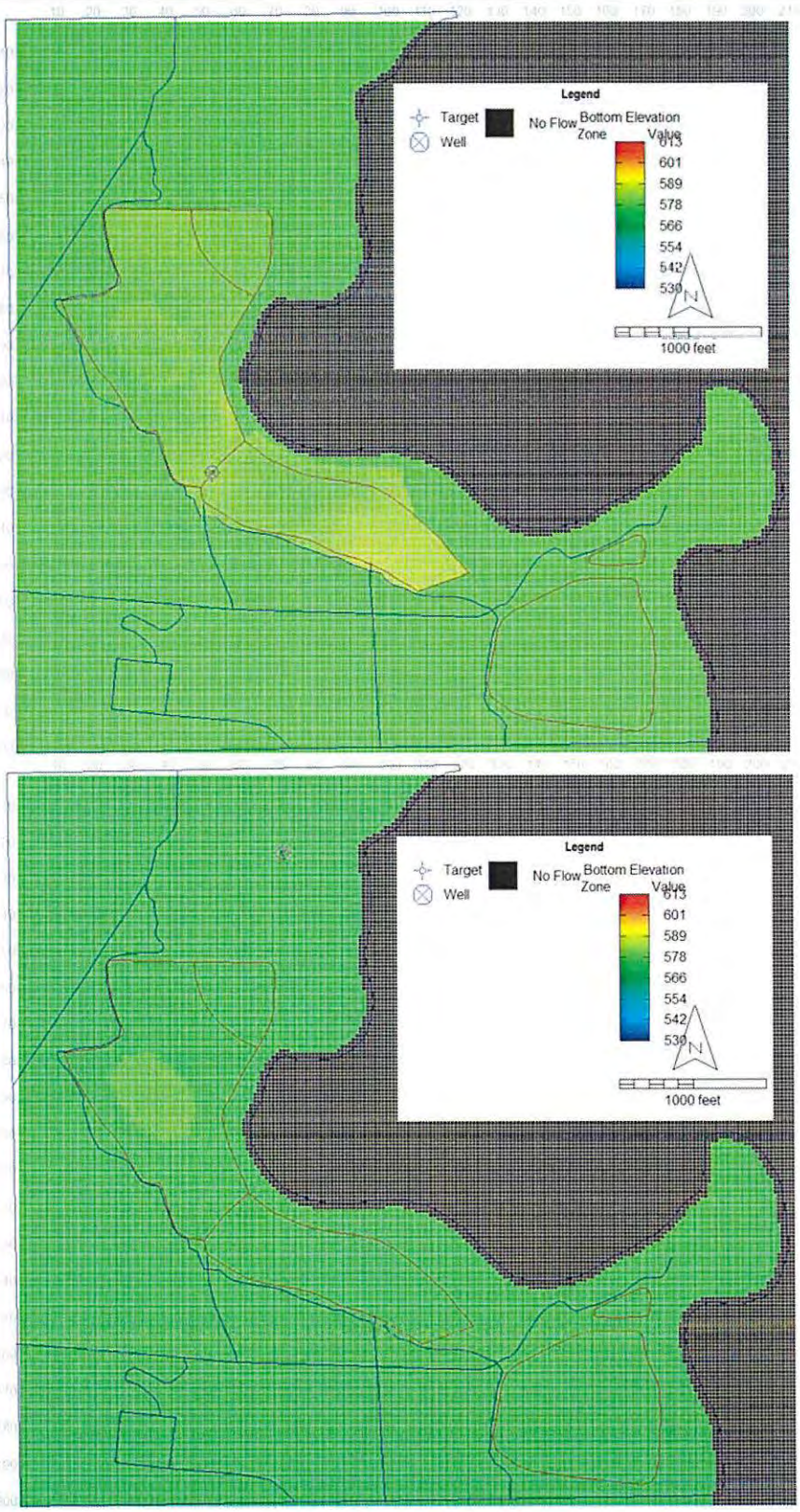




BOTTOM ELEVATION (feet) ARRAY FOR LAYERS 1 (TOP) AND LAYERS 2 (BOTTOM)

GROUNDWATER MONITORING AND MODELING REPORT
NORTH ASH POND SYSTEM AND OLD EAST ASH POND
VERMILION SITE
OAKWOOD, ILLINOIS

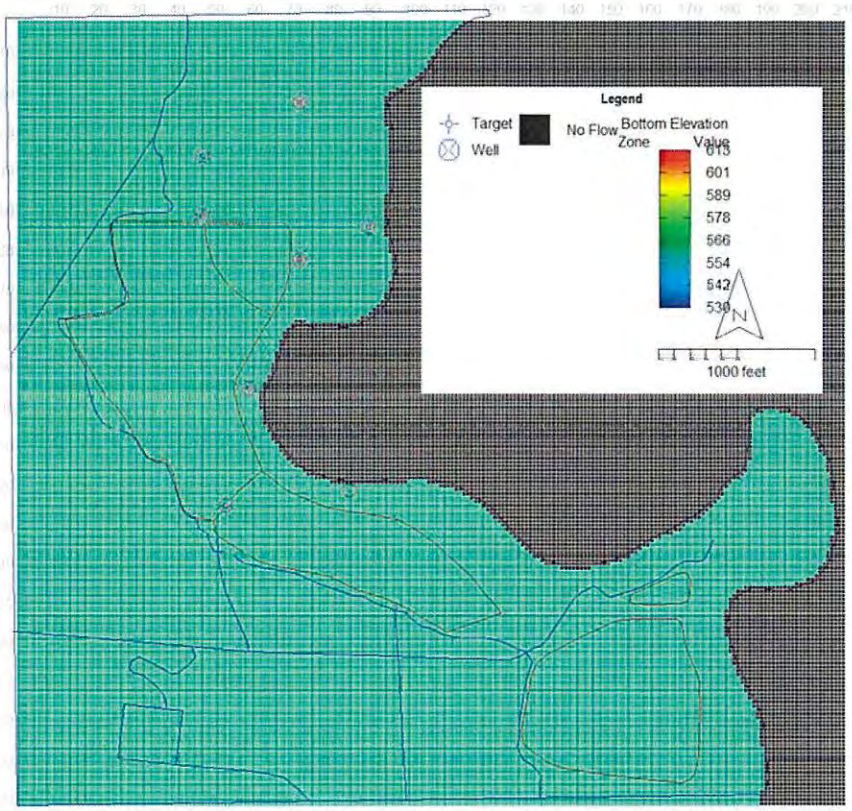
O'BRIEN & GERE ENGINEERS, INC.

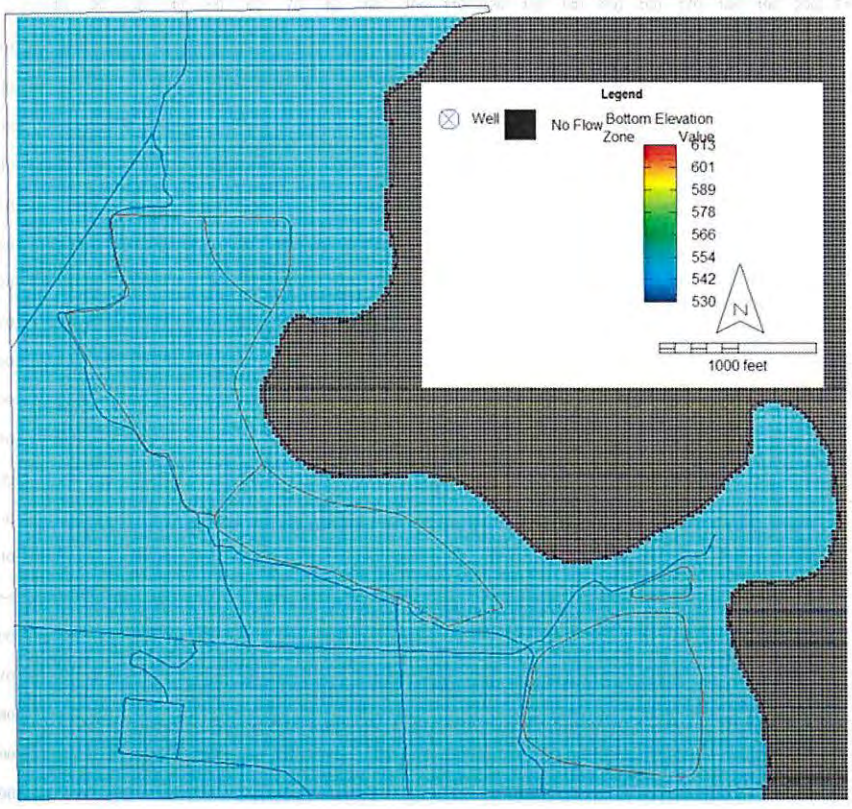


BOTTOM ELEVATION (feet) ARRAY FOR LAYERS 3 (TOP) AND LAYERS 4 (BOTTOM)

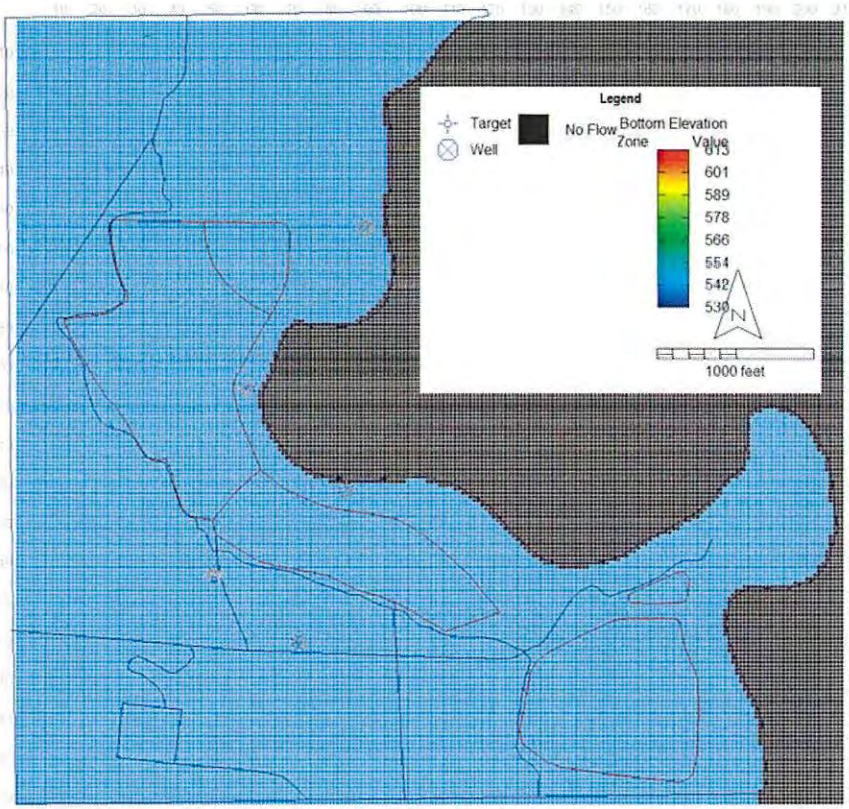
GROUNDWATER MONITORING AND MODELING REPORT
NORTH ASH POND SYSTEM AND OLD EAST ASH POND
VERMILION SITE
OAKWOOD, ILLINOIS

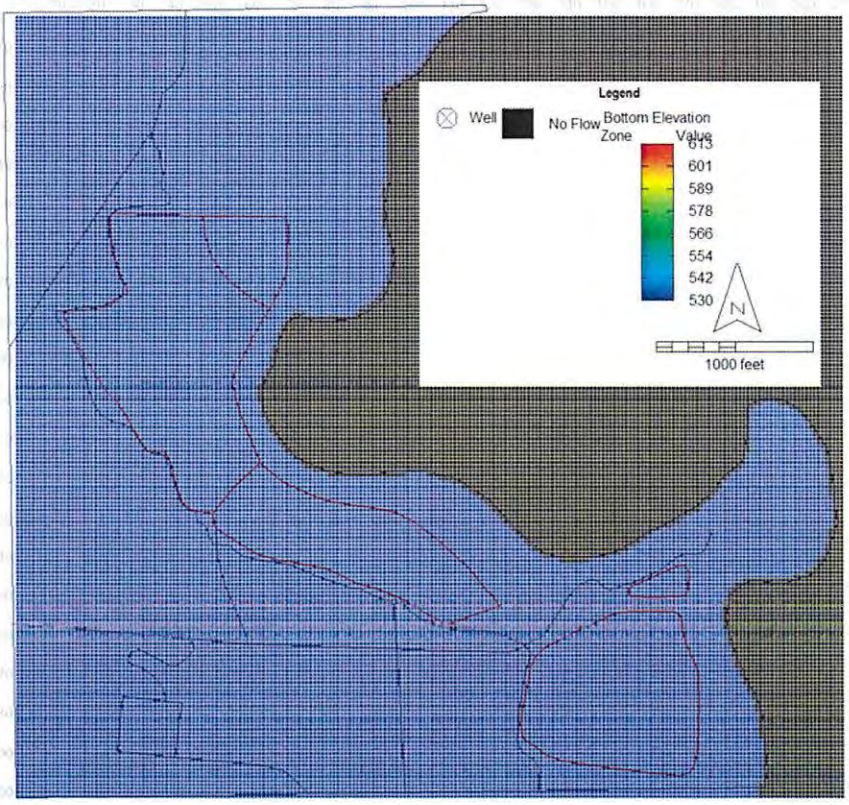
O'BRIEN & GERE ENGINEERS, INC.





BOTTOM ELEVATION (feet) ARRAY FOR LAYERS 5 (TOP) AND LAYERS 6 (BOTTOM)

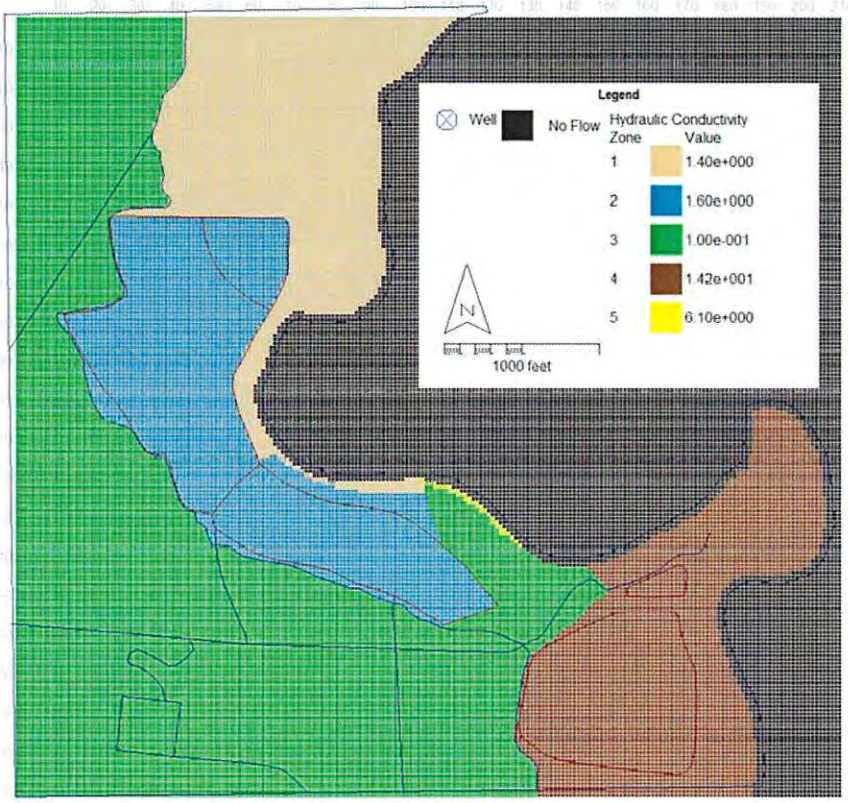


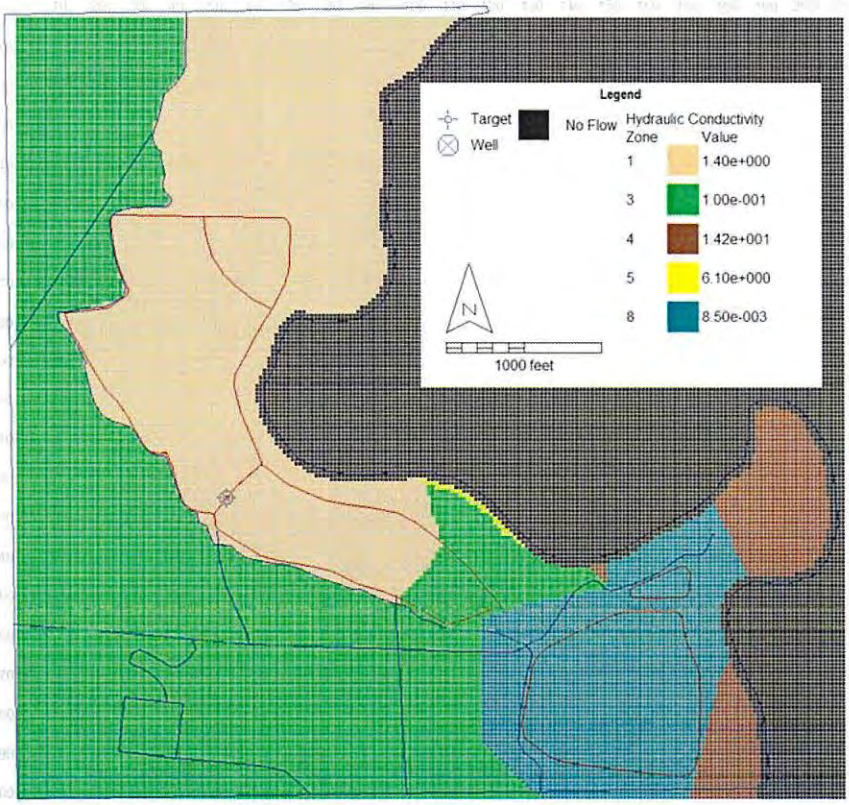


BOTTOM ELEVATION (feet) ARRAY FOR LAYERS 7 (TOP) AND LAYERS 8 (BOTTOM)

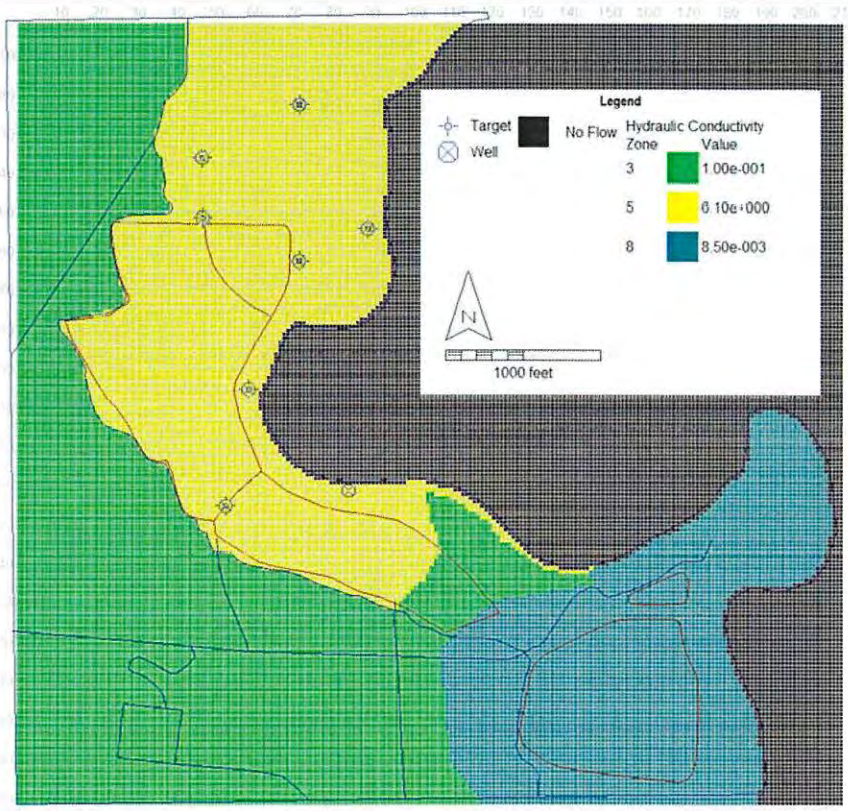
GROUNDWATER MONITORING AND MODELING REPORT
NORTH ASH POND SYSTEM AND OLD EAST ASH POND
VERMILION SITE
OAKWOOD, ILLINOIS

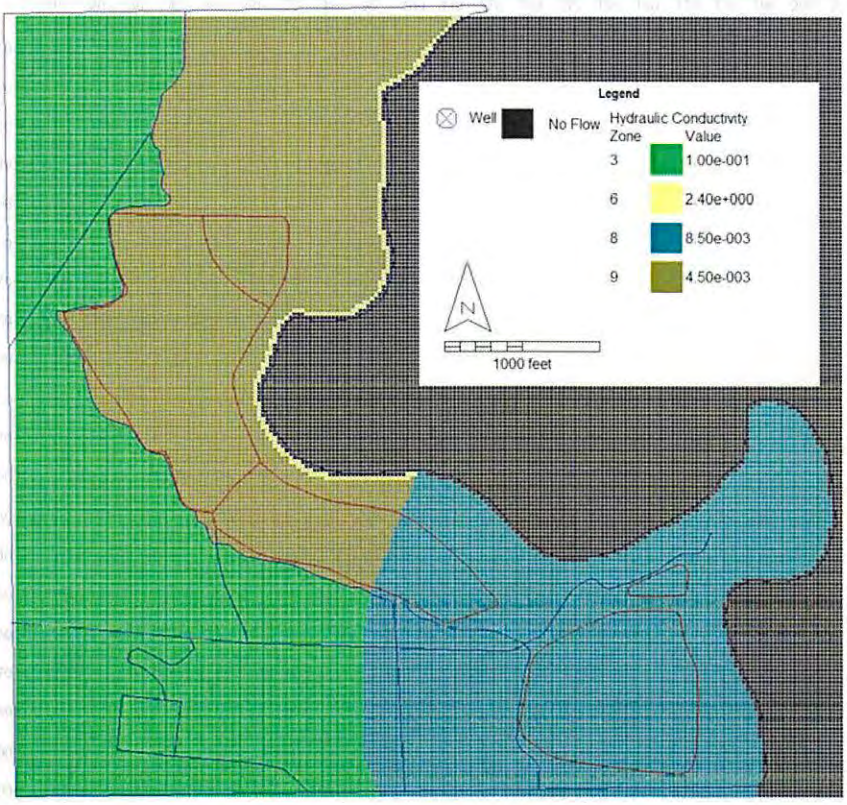
O'BRIEN & GERE ENGINEERS, INC.



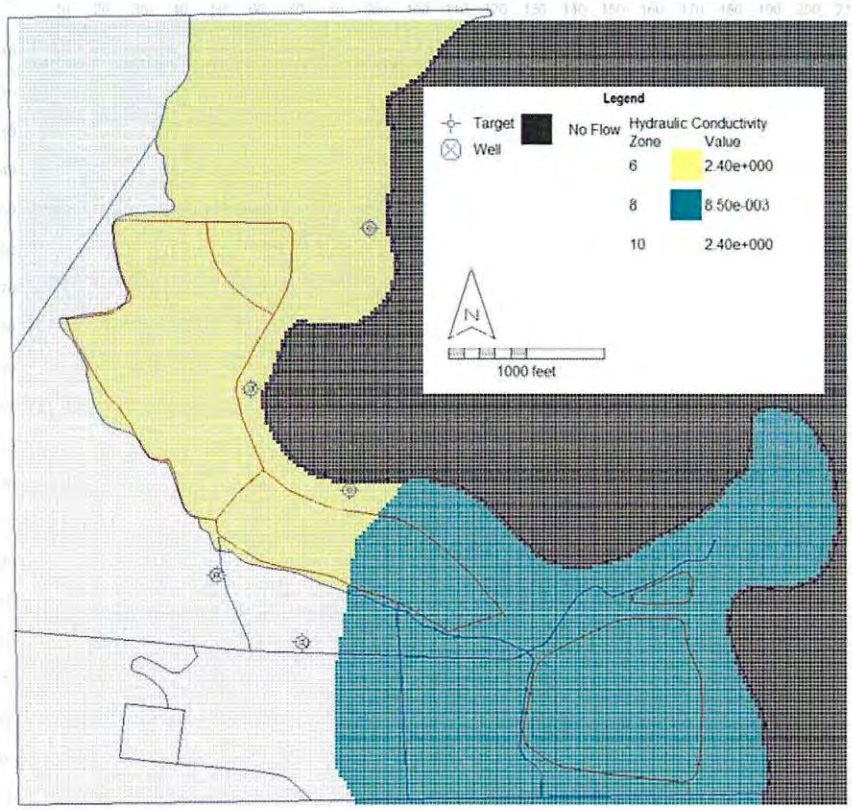


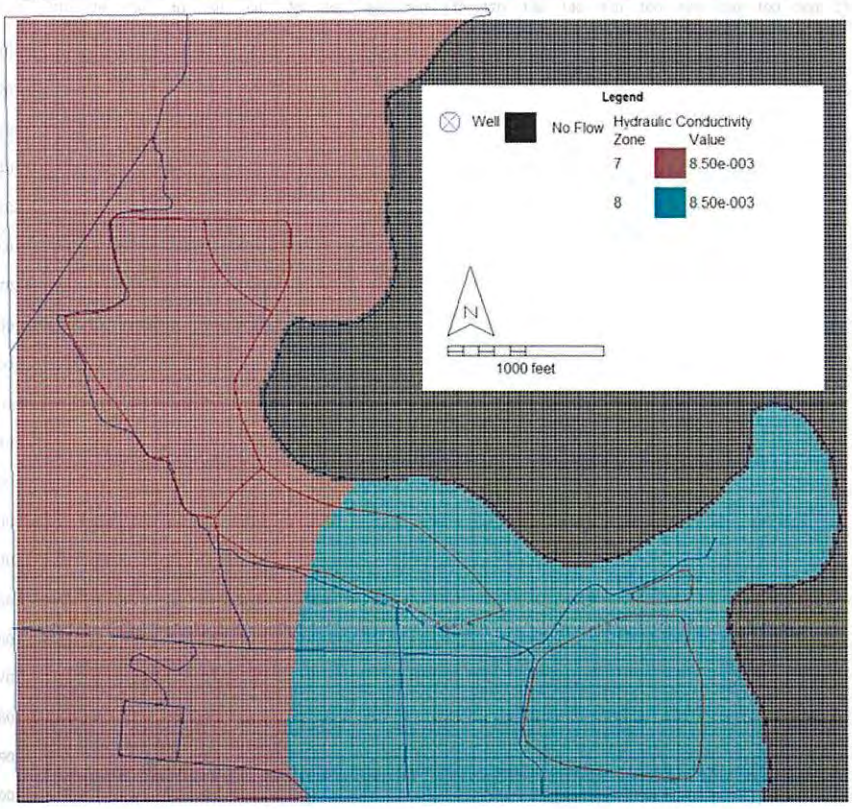
HYDRAULIC CONDUCTIVITY (feet/day) ARRAY FOR LAYERS 1-2 (TOP) AND LAYERS 3-4 (BOTTOM)



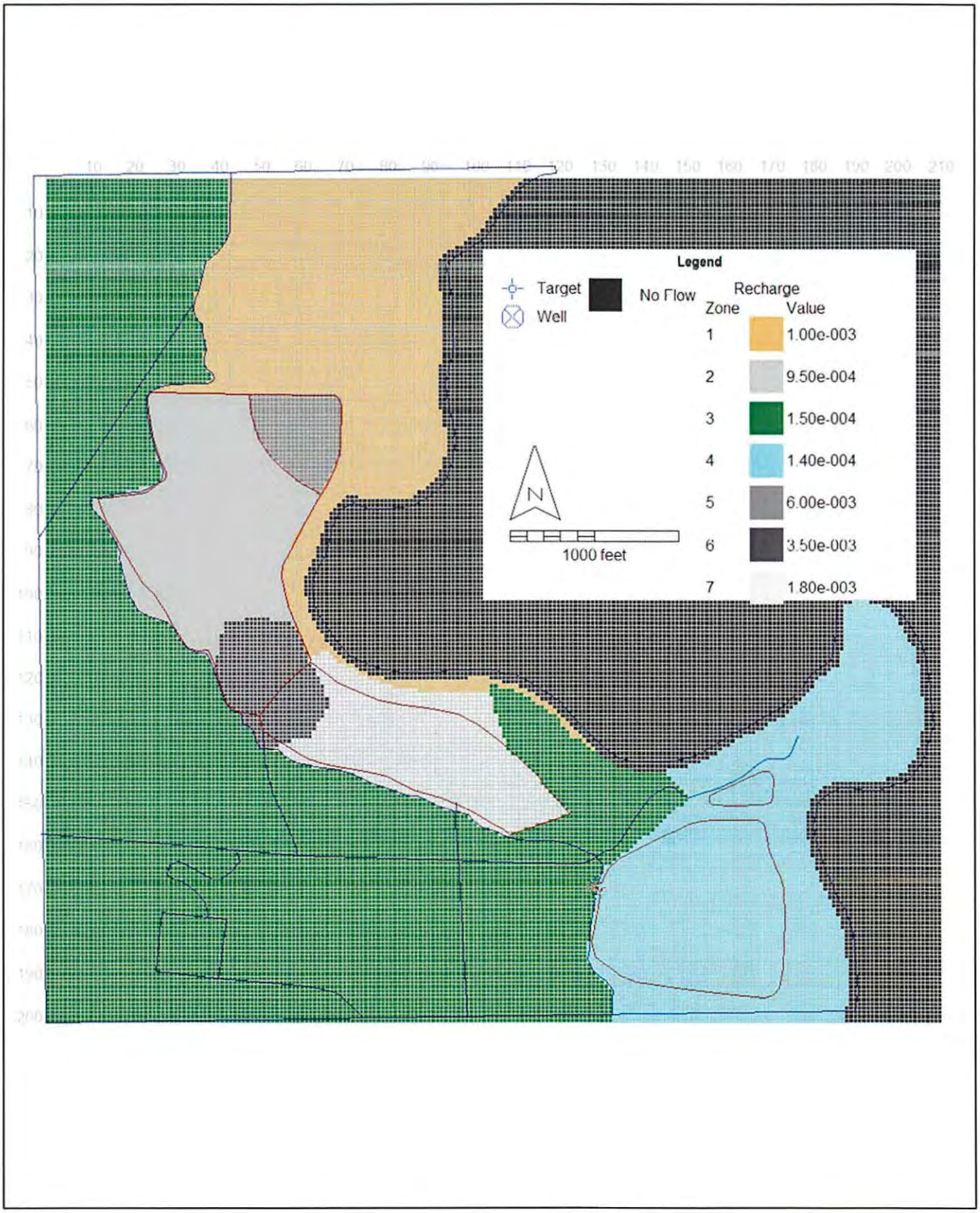


HYDRAULIC CONDUCTIVITY (feet/day) ARRAY FOR LAYER 5 (TOP) AND LAYER 6 (BOTTOM)





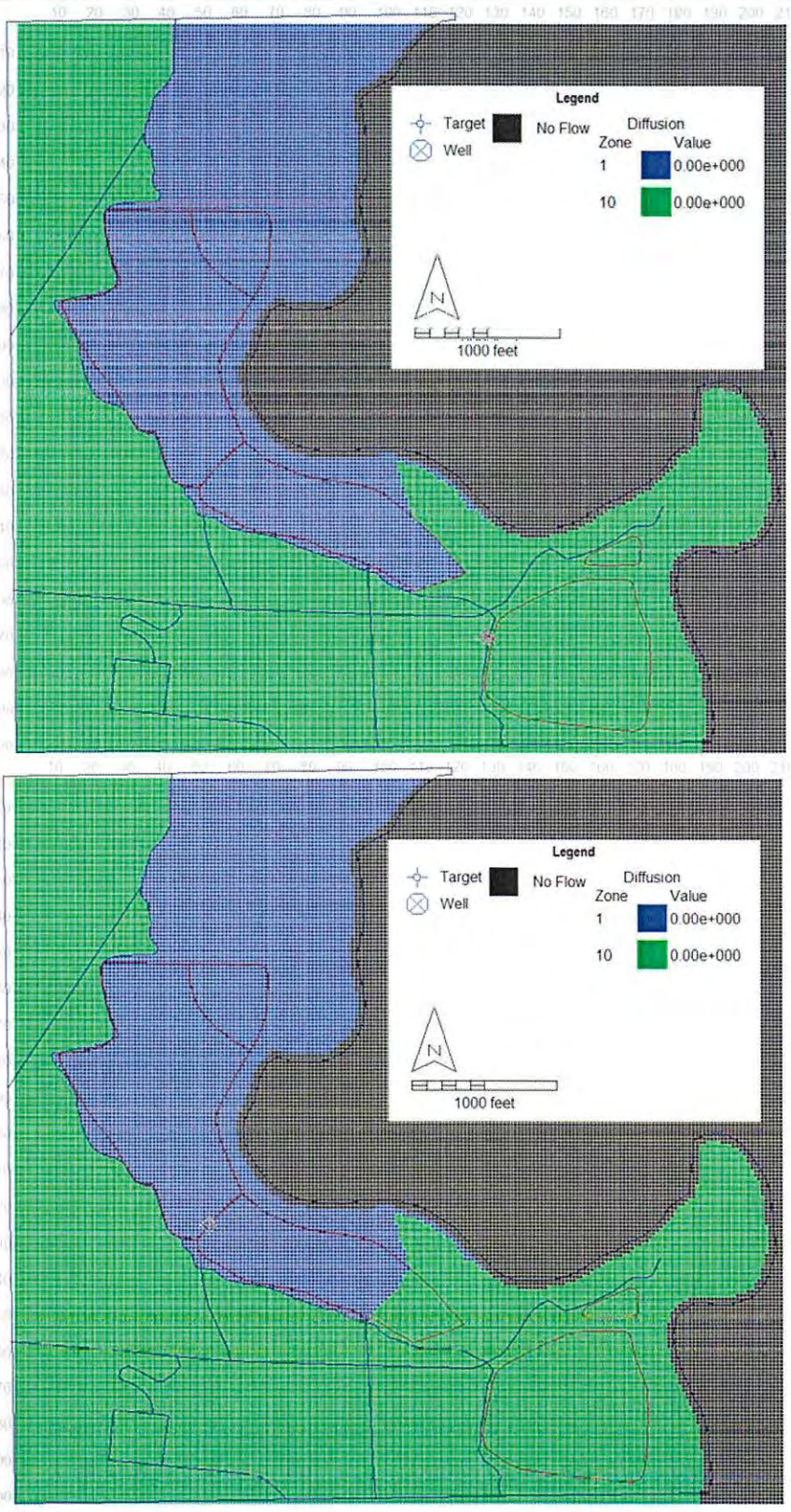
HYDRAULIC CONDUCTIVITY (feet/day) ARRAY FOR LAYER 7 (TOP) AND LAYER 8 (BOTTOM)



RECHARGE (feet/day) ARRAY FOR LAYER 1

GROUNDWATER MONITORING AND MODELING REPORT
NORTH ASH POND SYSTEM AND OLD EAST ASH POND
VERMILION SITE
OAKWOOD, ILLINOIS

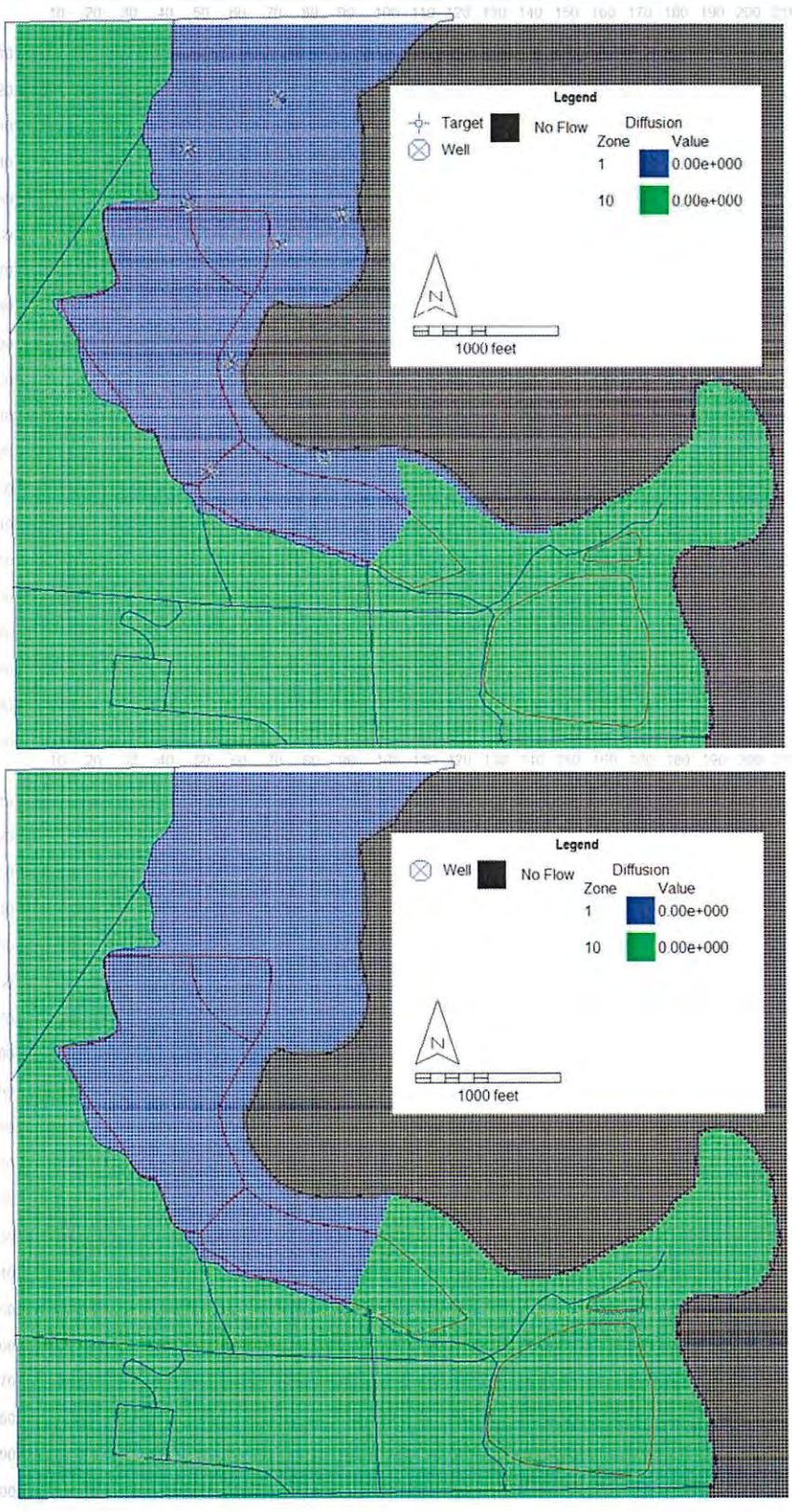
O'BRIEN & GERE ENGINEERS, INC.



DIFFUSION ARRAY FOR LAYERS 1-2 (TOP) AND LAYERS 3-4 (BOTTOM)

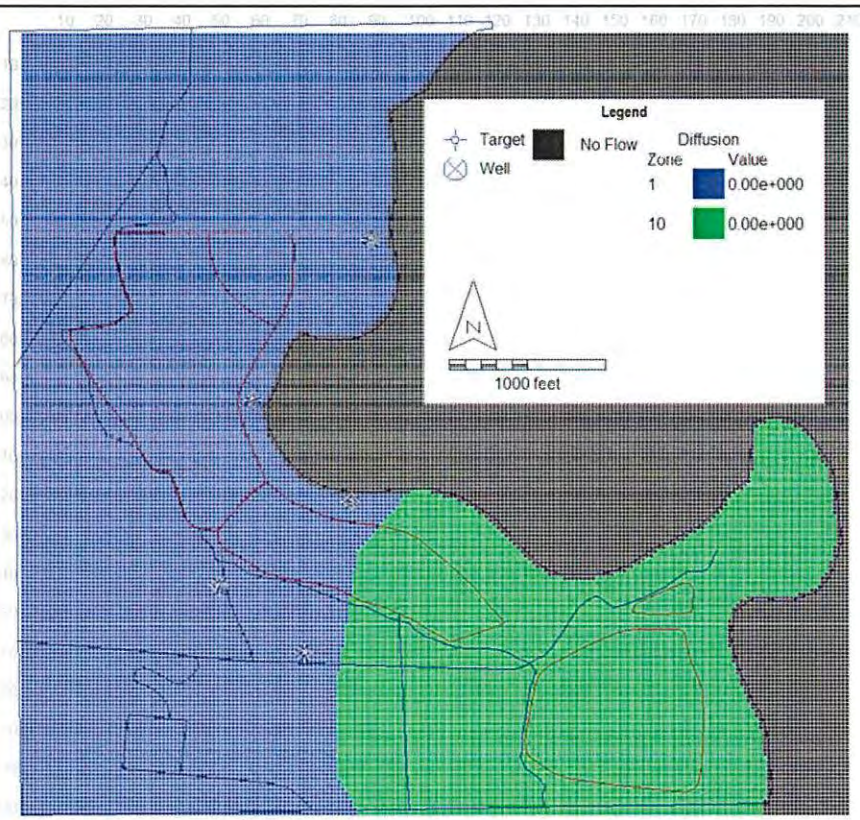
GROUNDWATER MONITORING AND MODELING REPORT
NORTH ASH POND SYSTEM AND OLD EAST ASH POND
VERMILION SITE
OAKWOOD, ILLINOIS

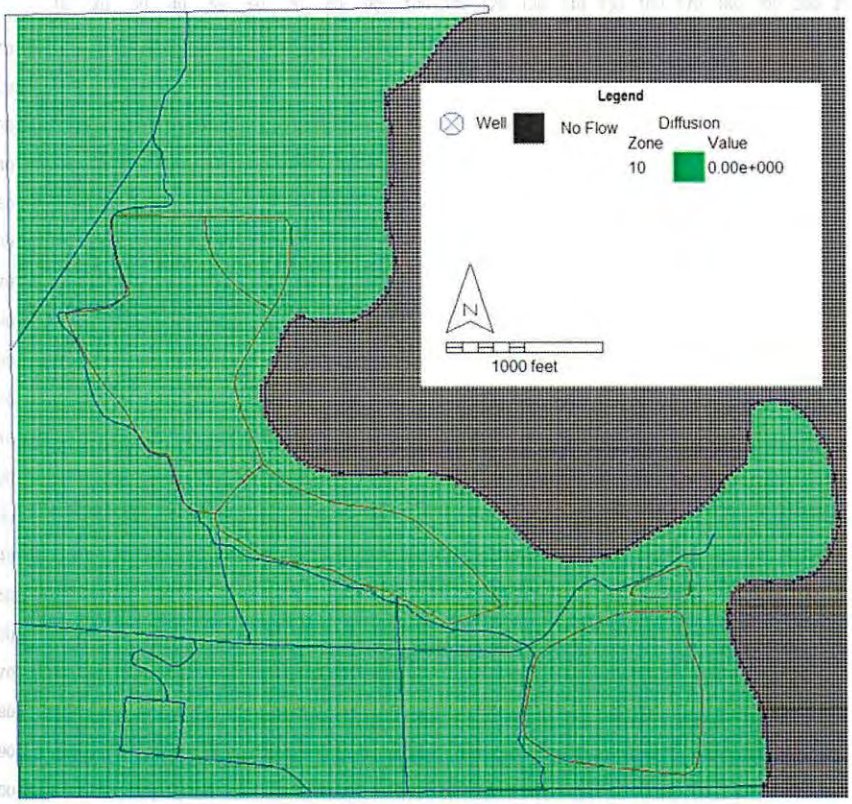
O'BRIEN & GERE ENGINEERS, INC.



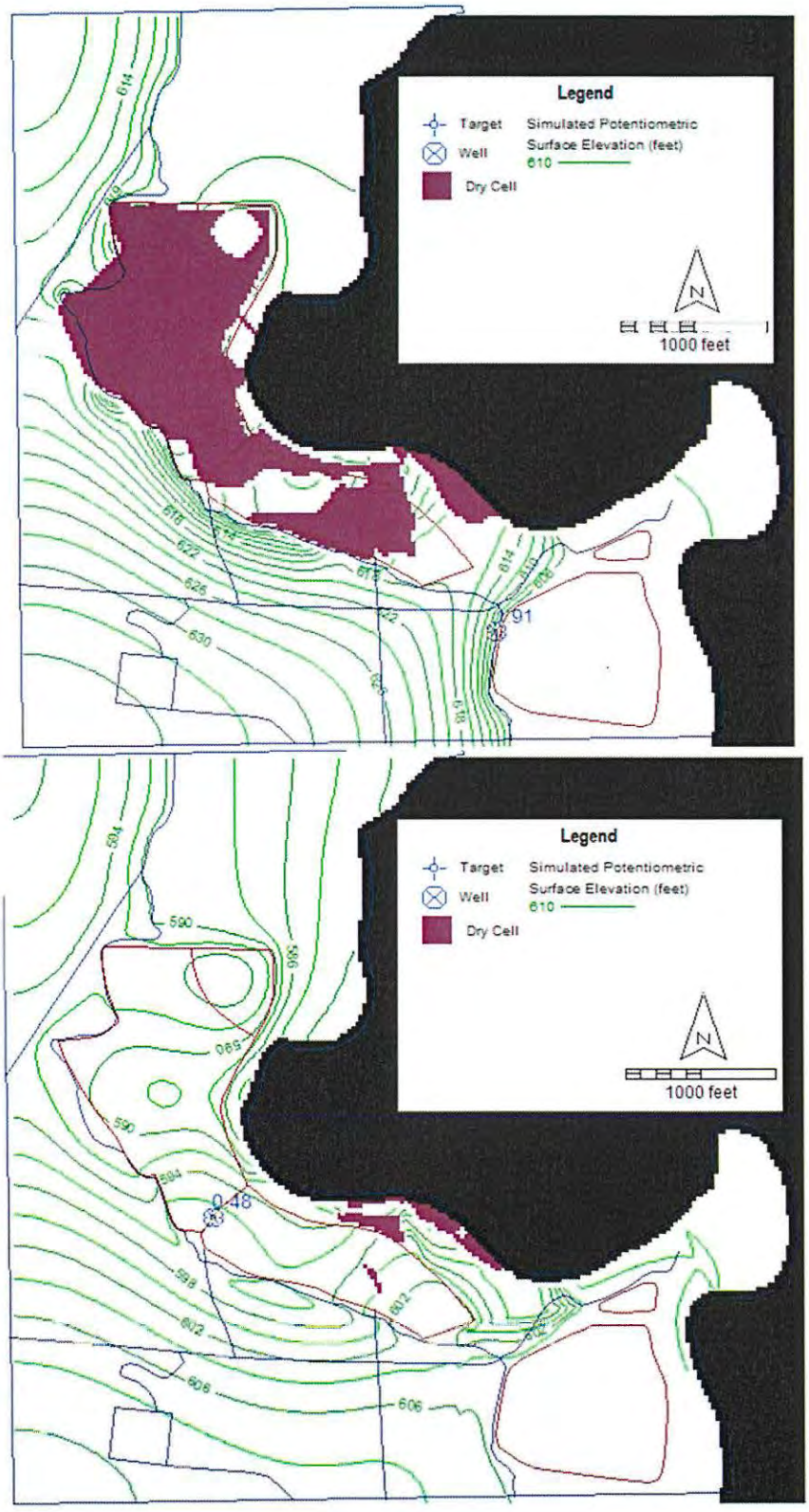
DIFFUSION ARRAY FOR LAYER 5 (TOP) AND LAYER 6 (BOTTOM)

GROUNDWATER MONITORING AND MODELING REPORT
NORTH ASH POND SYSTEM AND OLD EAST ASH POND
VERMILION SITE
OAKWOOD, ILLINOIS





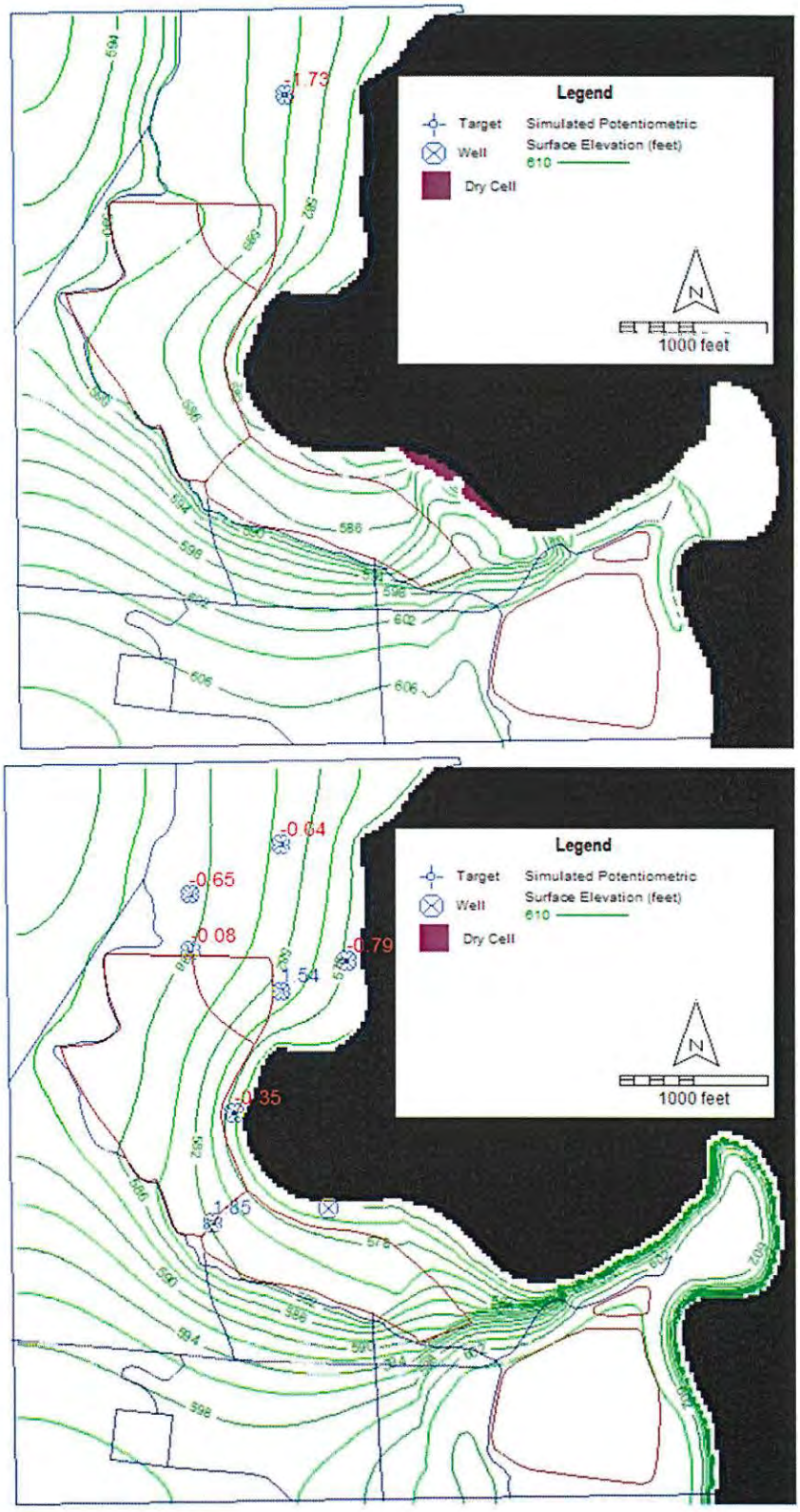
DIFFUSION ARRAY FOR LAYER 7 (TOP) AND LAYER 8 (BOTTOM)



COMPARISON BETWEEN SIMULATED HEADS AND FIELD MEASUREMENTS
FOR LAYER 1 (TOP) AND LAYER 3 (BOTTOM)

GROUNDWATER MONITORING AND MODELING REPORT
NORTH ASH POND SYSTEM AND OLD EAST ASH POND
VERMILION SITE
OAKWOOD, ILLINOIS

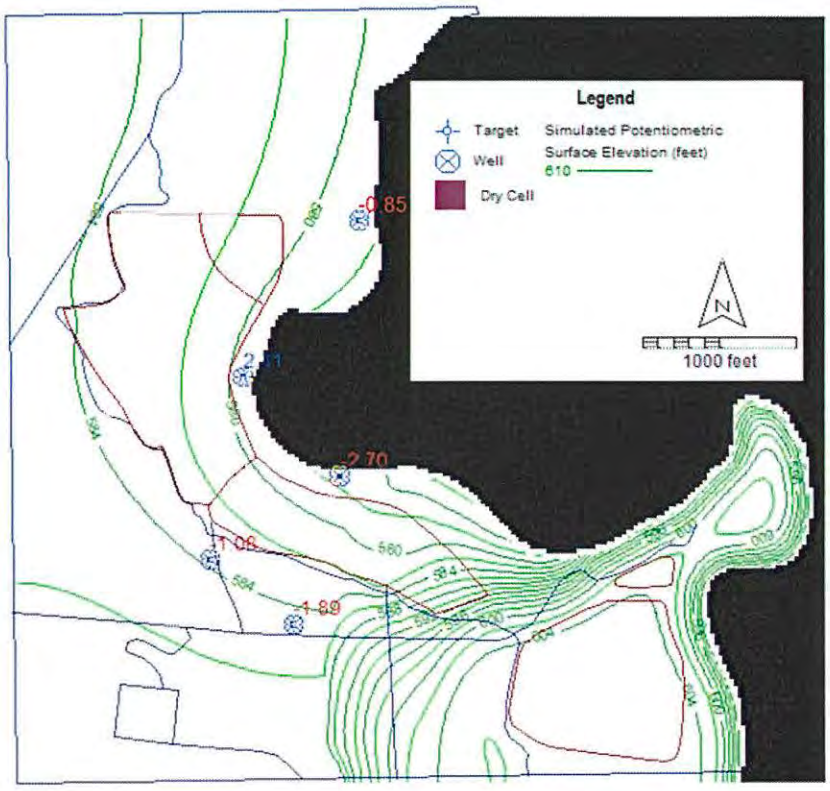
O'BRIEN & GERE ENGINEERS, INC.



COMPARISON BETWEEN SIMULATED HEADS AND FIELD MEASUREMENTS
FOR LAYER 4 (TOP) AND LAYER 5 (BOTTOM)

GROUNDWATER MONITORING AND MODELING REPORT
NORTH ASH POND SYSTEM AND OLD EAST ASH POND
VERMILION SITE
OAKWOOD, ILLINOIS

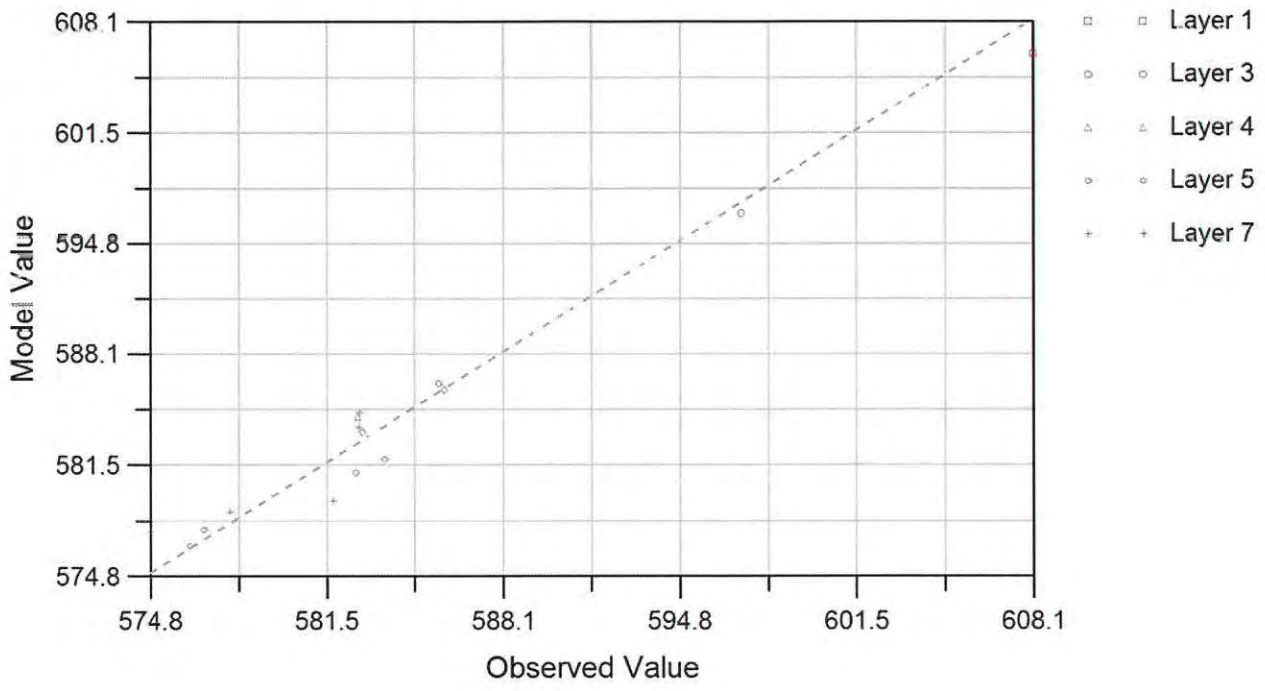
O'BRIEN & GERE ENGINEERS, INC.

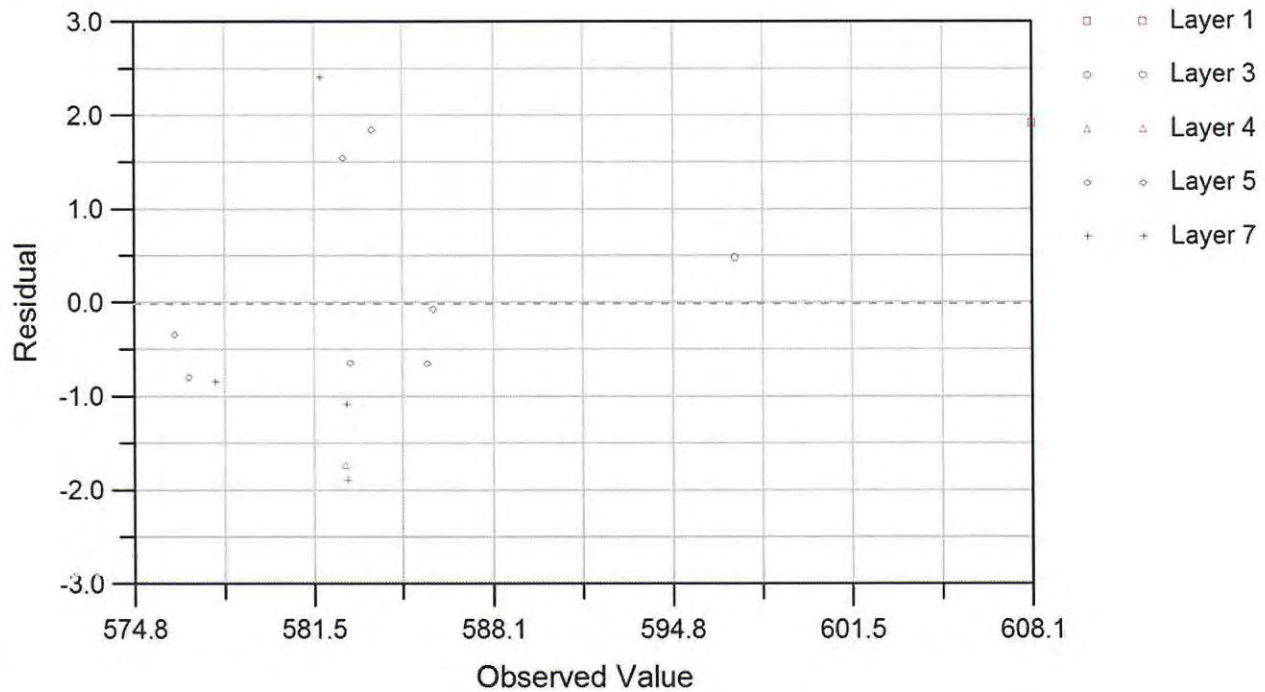


COMPARISON BETWEEN SIMULATED HEADS AND FIELD MEASUREMENTS
FOR LAYER 7

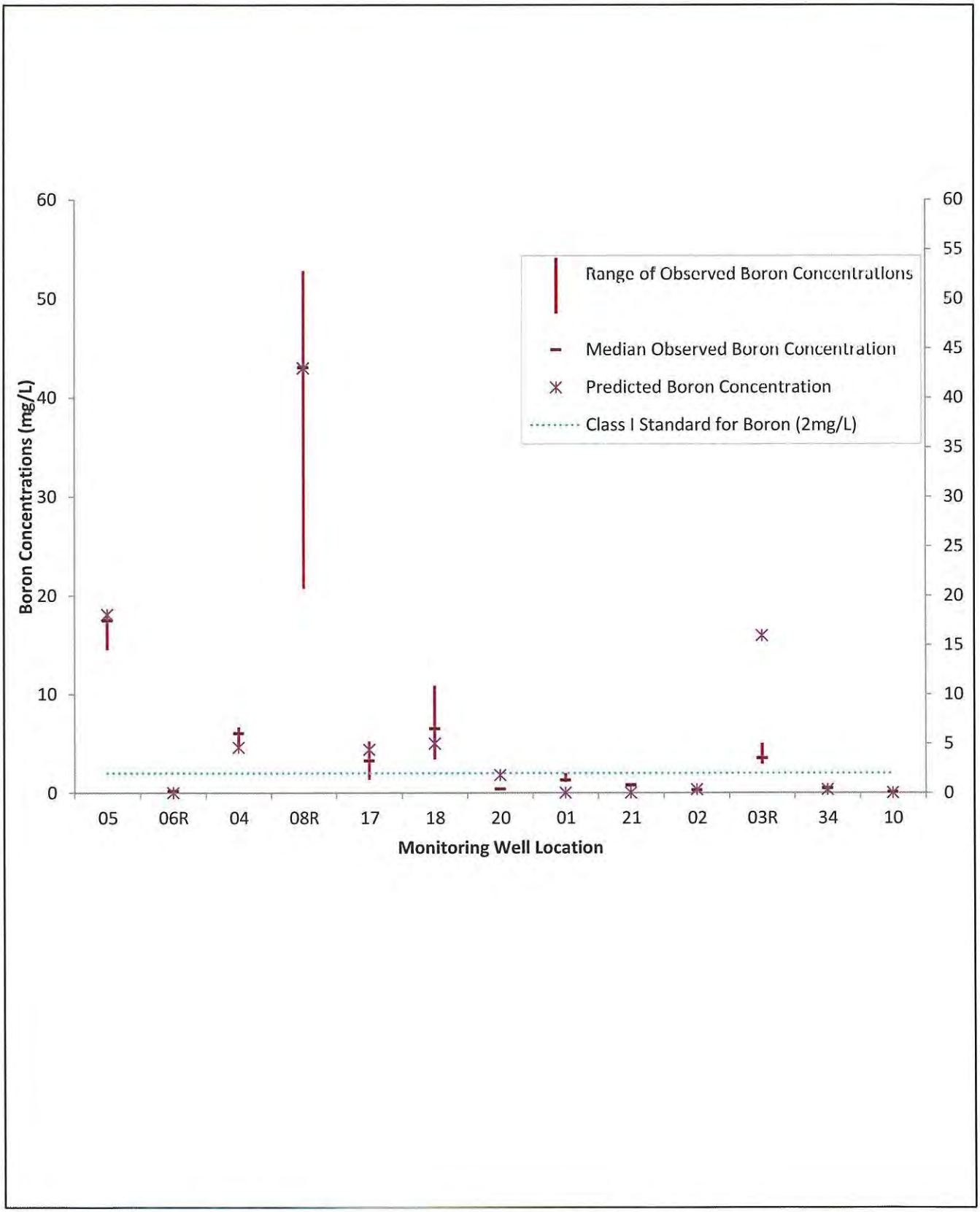
GROUNDWATER MONITORING AND MODELING REPORT
NORTH ASH POND SYSTEM AND OLD EAST ASH POND
VERMILION SITE
OAKWOOD, ILLINOIS

O'BRIEN & GERE ENGINEERS, INC.





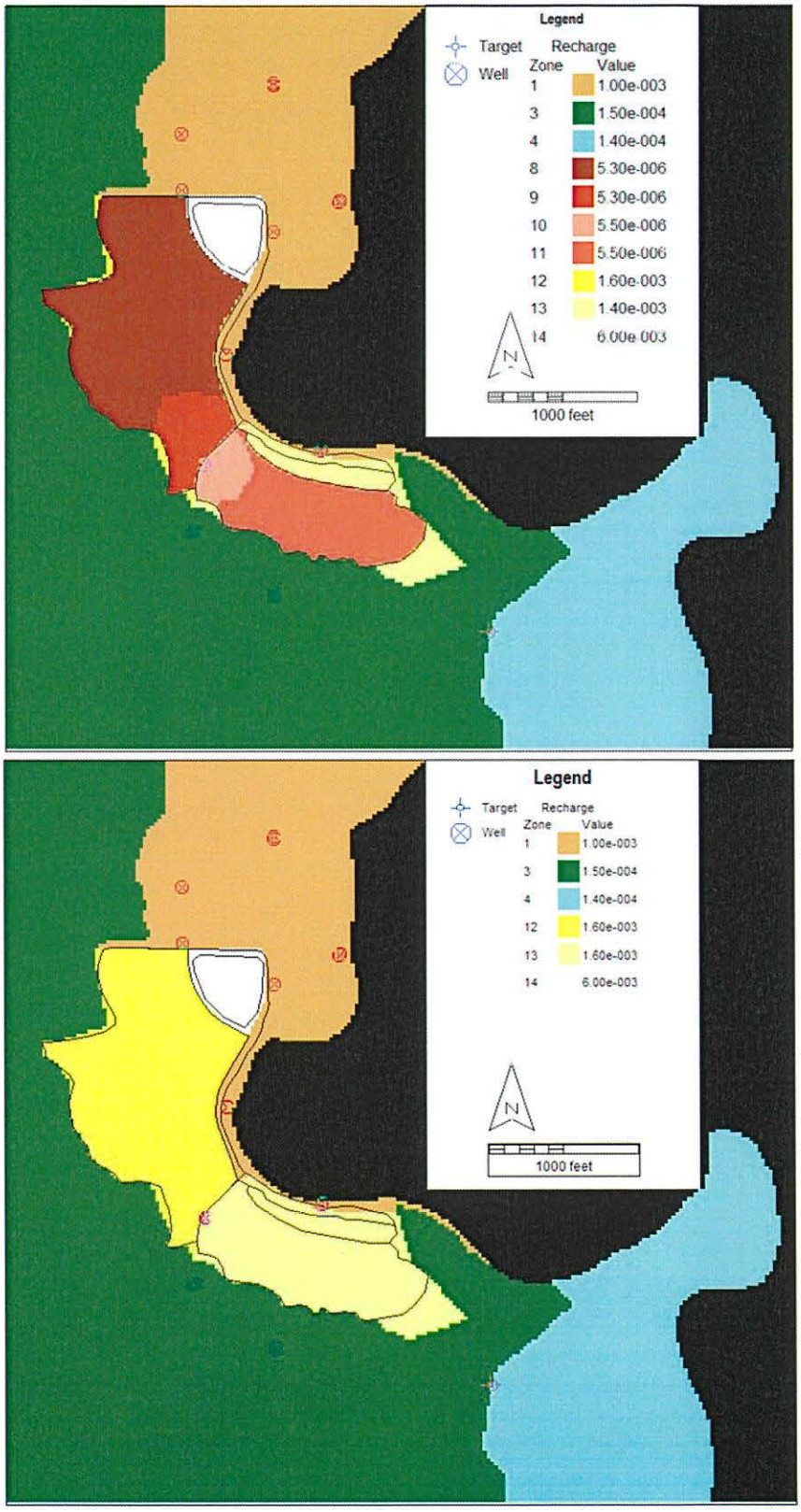
STEADY-STATE MODFLOW MODEL CALIBRATION RESULTS FOR SEPTEMBER 2017



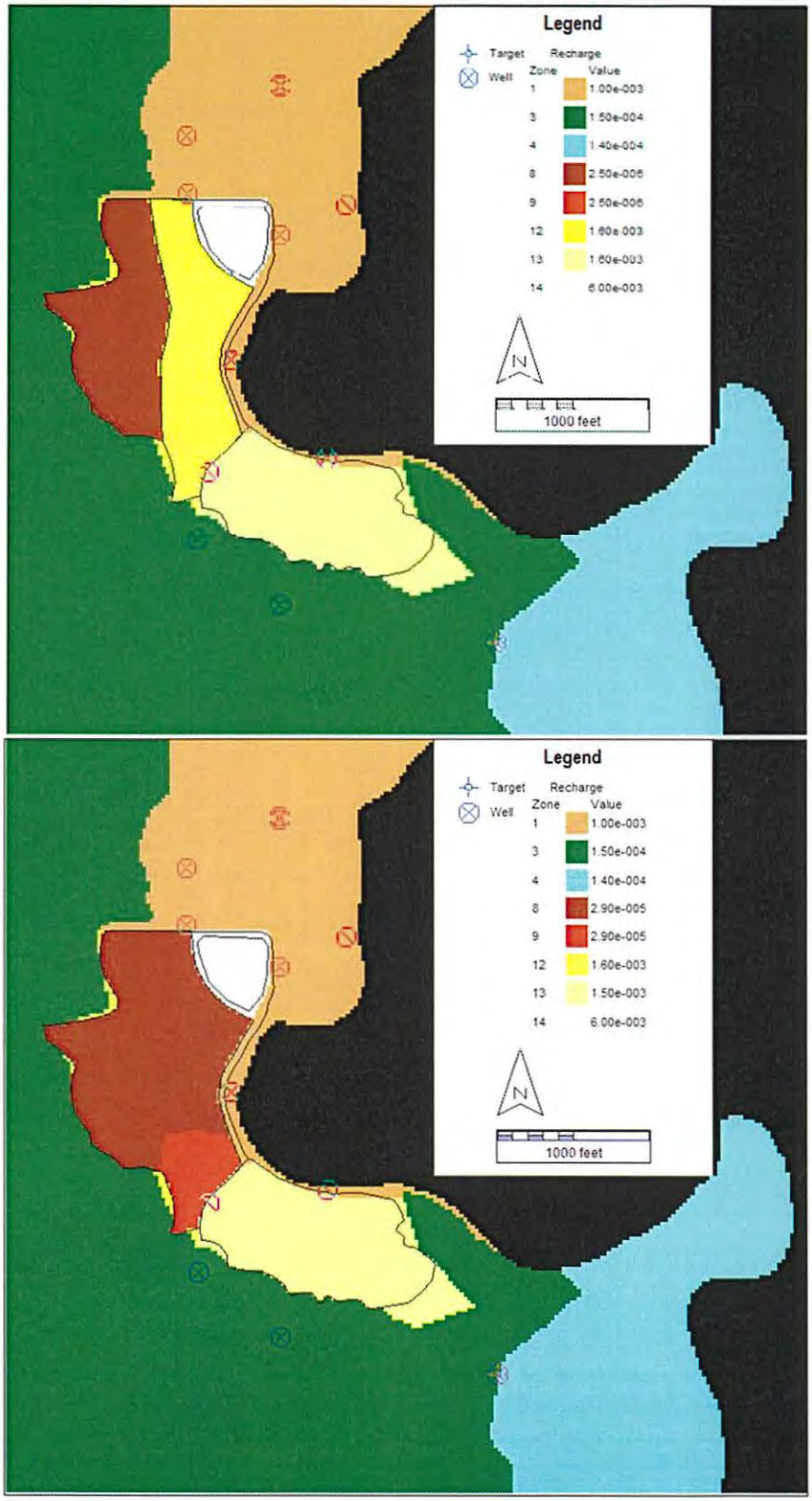
PREDICTED AND OBSERVED BORON CONCENTRATION (mg/L) 2017-2018

GROUNDWATER MONITORING AND MODELING REPORT
NORTH ASH POND SYSTEM AND OLD EAST ASH POND
VERMILION SITE
OAKWOOD, ILLINOIS

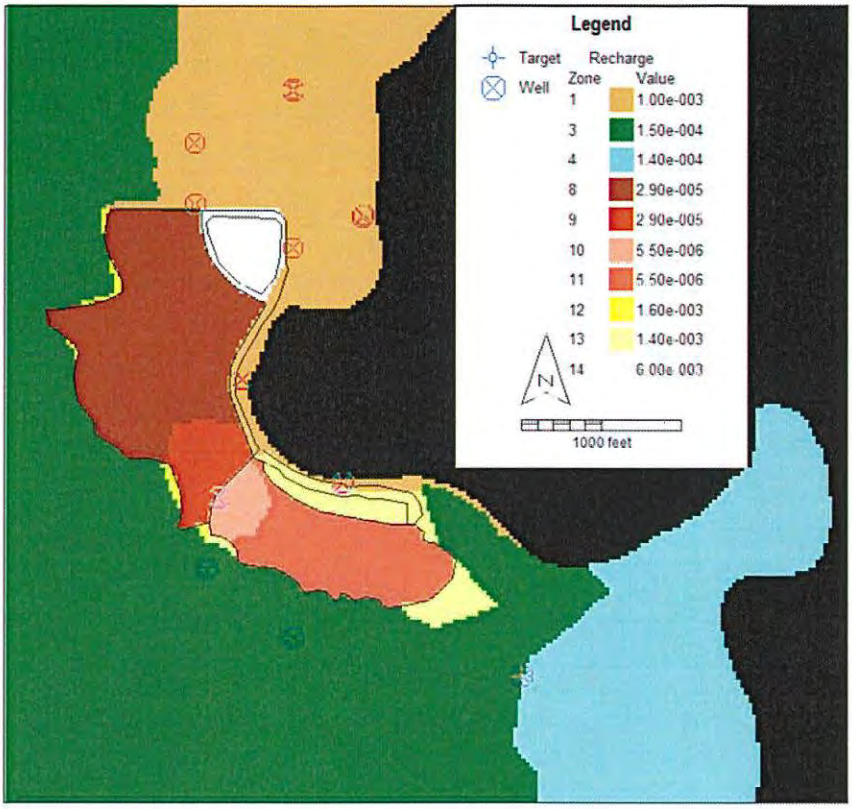
O'BRIEN & GERE ENGINEERS, INC.



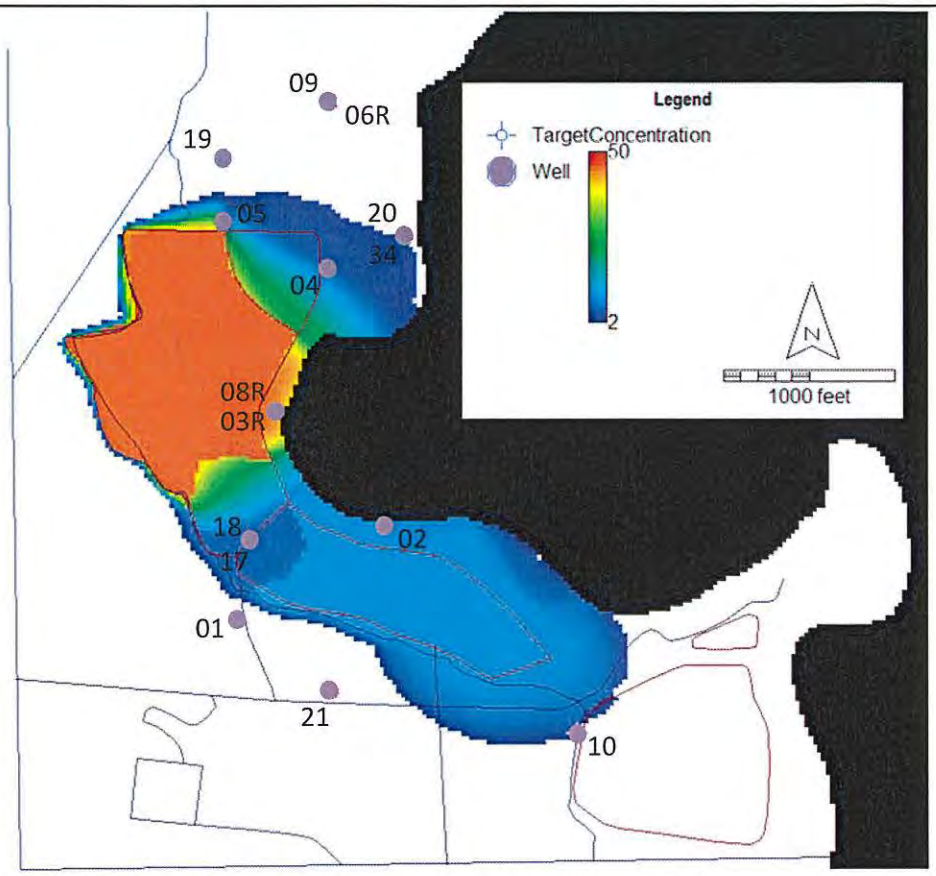
RECHARGE (feet/day) ARRAY FOR CLOSURE SCENARIO 1 LAYER 1 (TOP) AND CLOSURE SCENARIO 2 LAYER 1 (BOTTOM)



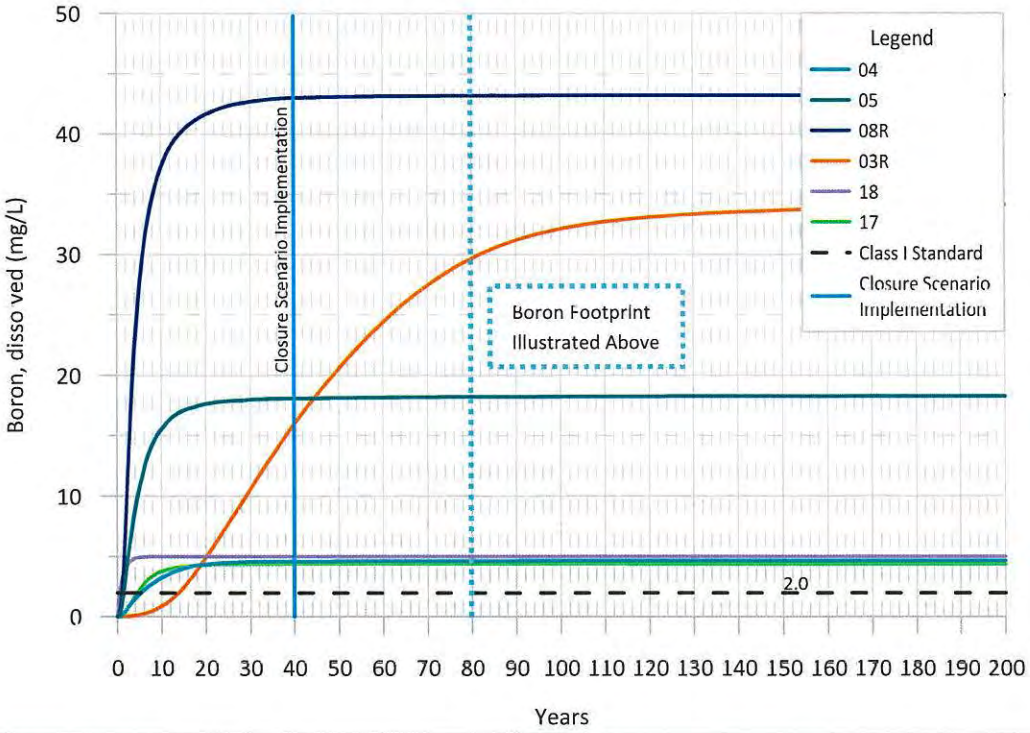
RECHARGE (feet/day) ARRAY FOR CLOSURE SCENARIO 3 LAYER 1 (TOP) AND CLOSURE SCENARIO 4 LAYER 1 (BOTTOM)



RECHARGE (feet/day) ARRAY FOR CLOSURE SCENARIO 5 LAYER 1



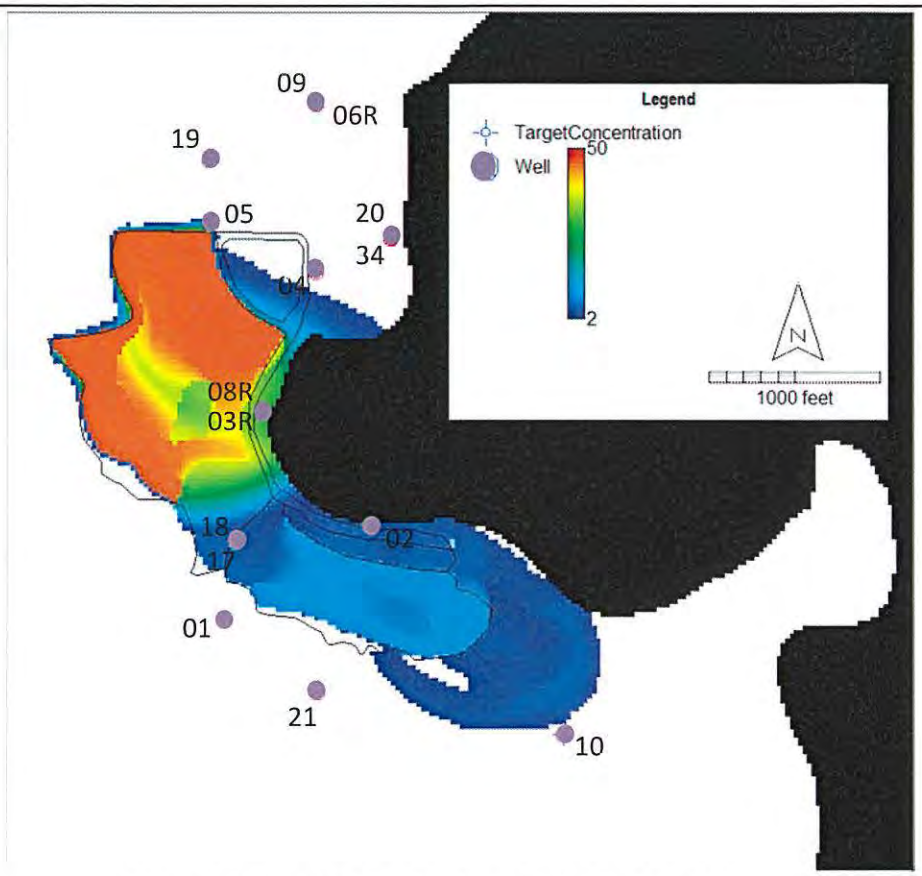
No Action - Model Predicted Boron Concentration



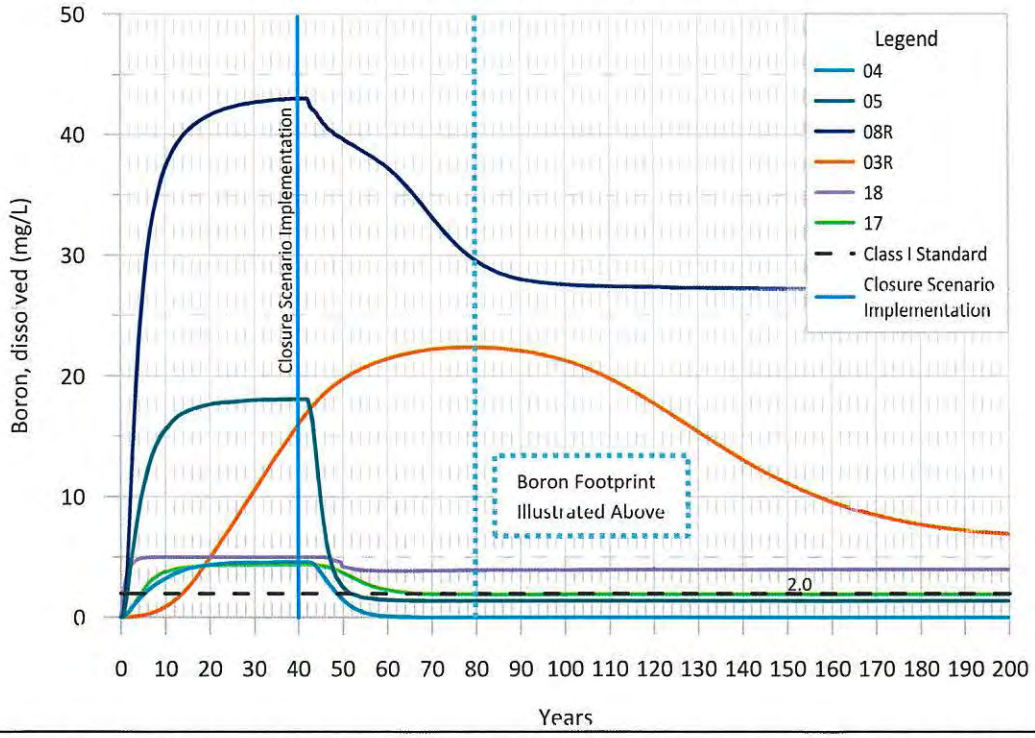
NO ACTION SCENARIO FOOTPRINT OF BORON PLUME OVER 2 mg/L INTO THE FUTURE WITH PREDICTED CONCENTRATIONS AT WELLS 04, 05, 08R, 03R, 17 AND 18

GROUNDWATER MONITORING AND MODELING REPORT
NORTH ASH POND SYSTEM AND OLD EAST ASH POND
VERMILION SITE
OAKWOOD, ILLINOIS

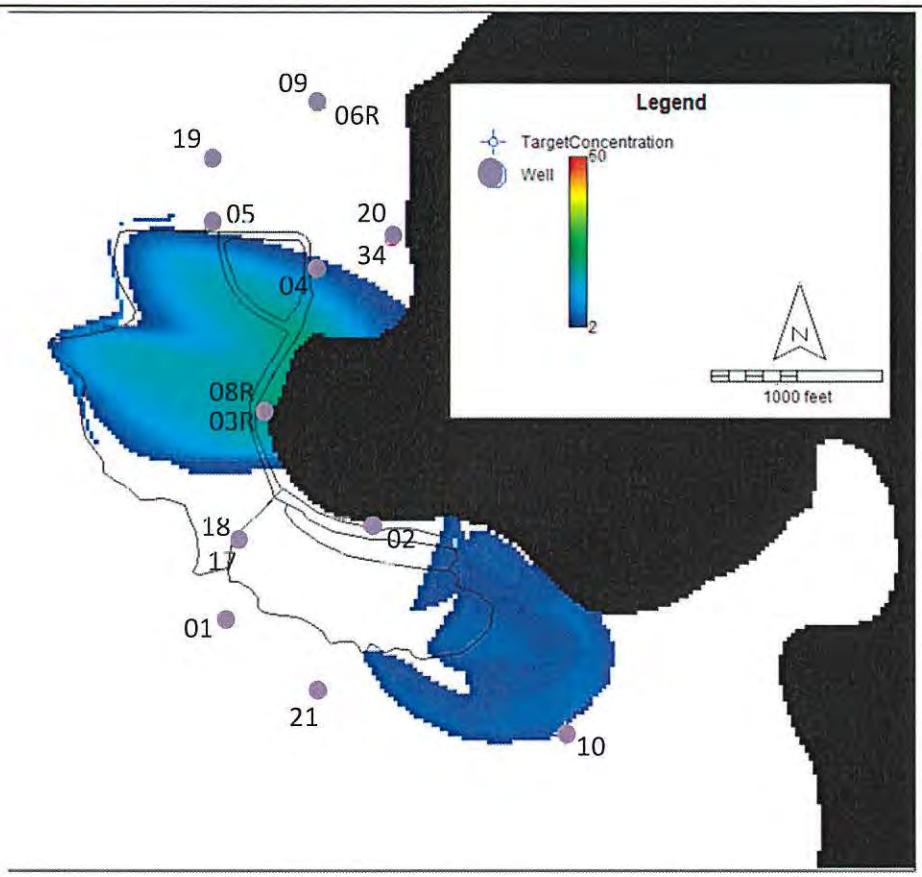
O'BRIEN & GERE ENGINEERS, INC.



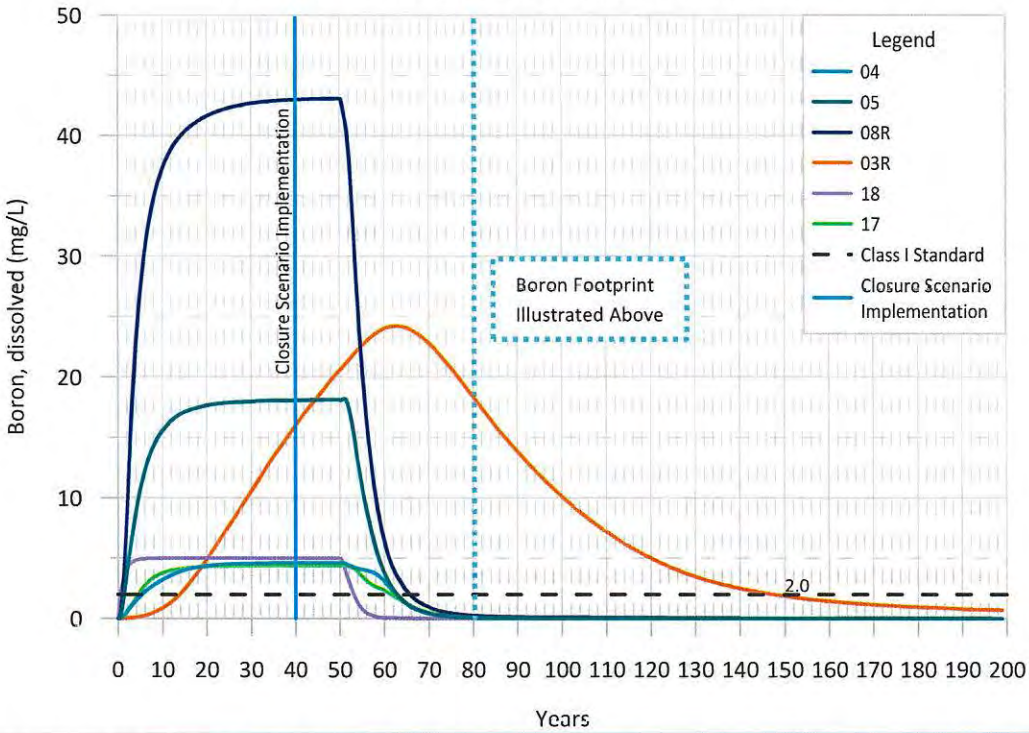
Scenario 1 - Model Predicted Boron Concentration



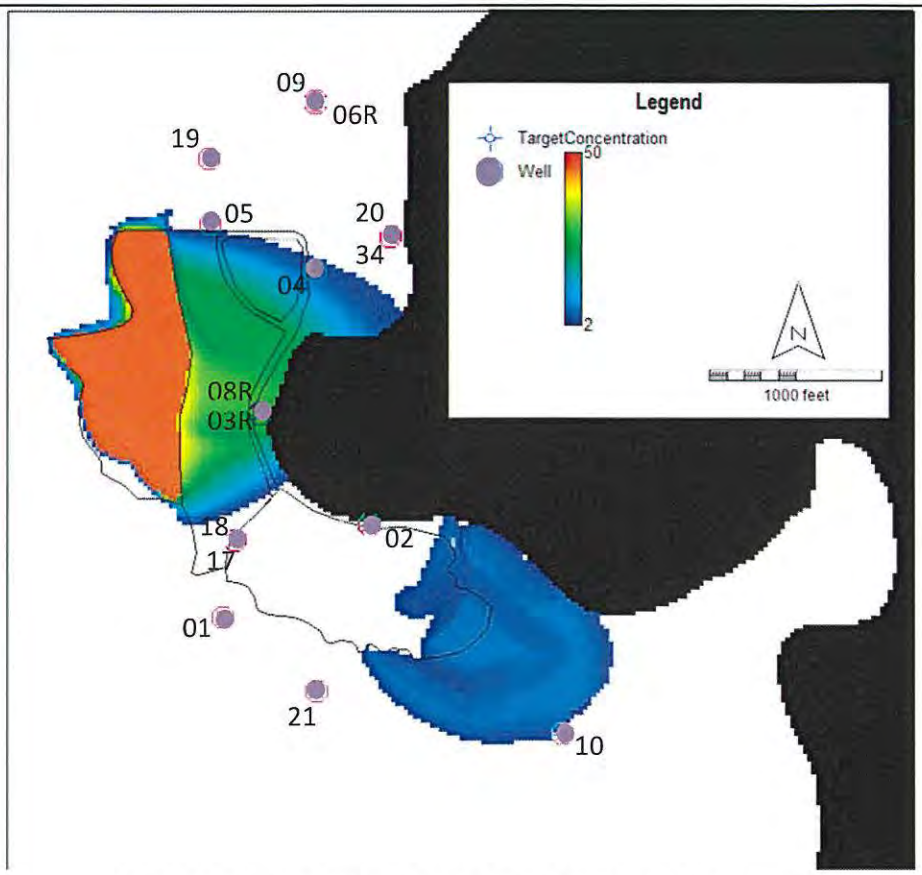
SCENARIO 1 FOOTPRINT OF BORON PLUME OVER 2 mg/L 40 YEARS AFTER IMPLEMENTATION WITH PREDICTED CONCENTRATIONS AT WELLS 04, 05, 08R, 03R, 17 AND 18



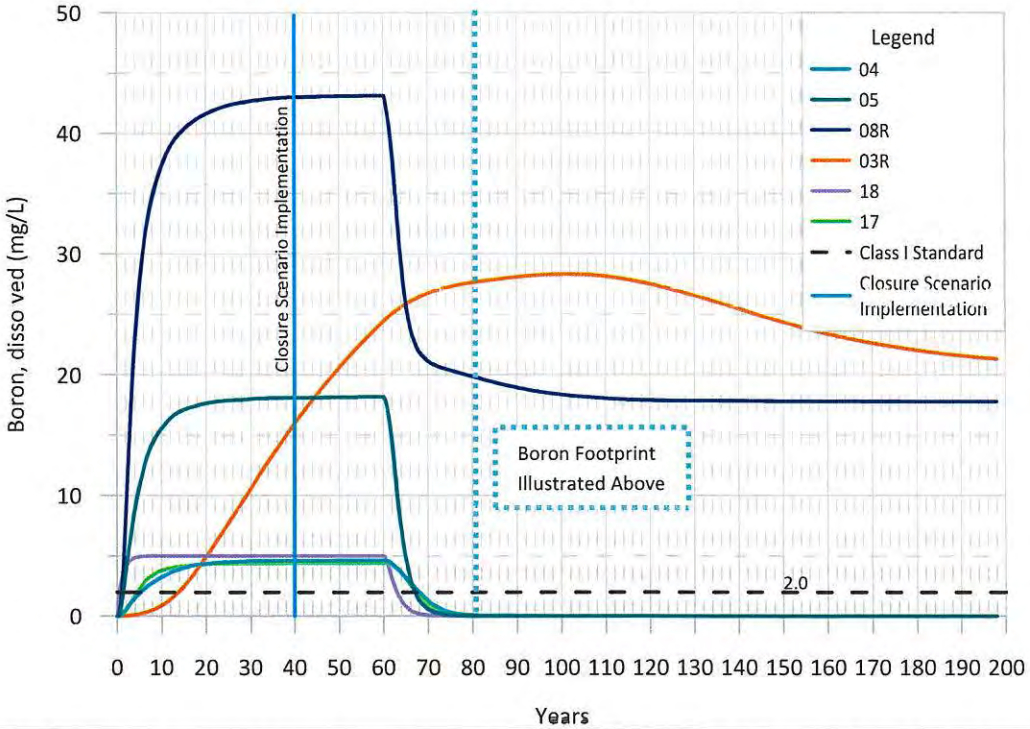
Scenario 2 - Model Predicted Boron Concentration



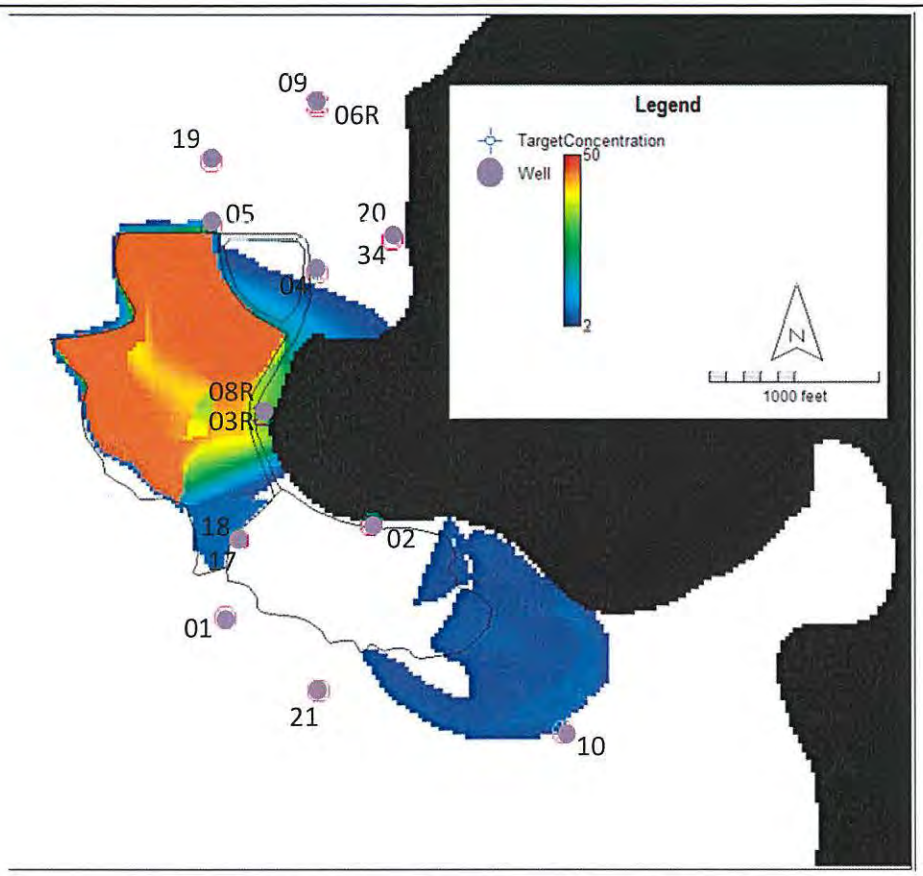
SCENARIO 2 FOOTPRINT OF BORON PLUME OVER 2 mg/L 40 YEARS AFTER IMPLEMENTATION WITH PREDICTED CONCENTRATIONS AT WELLS 04, 05, 08R, 03R, 17 AND 18



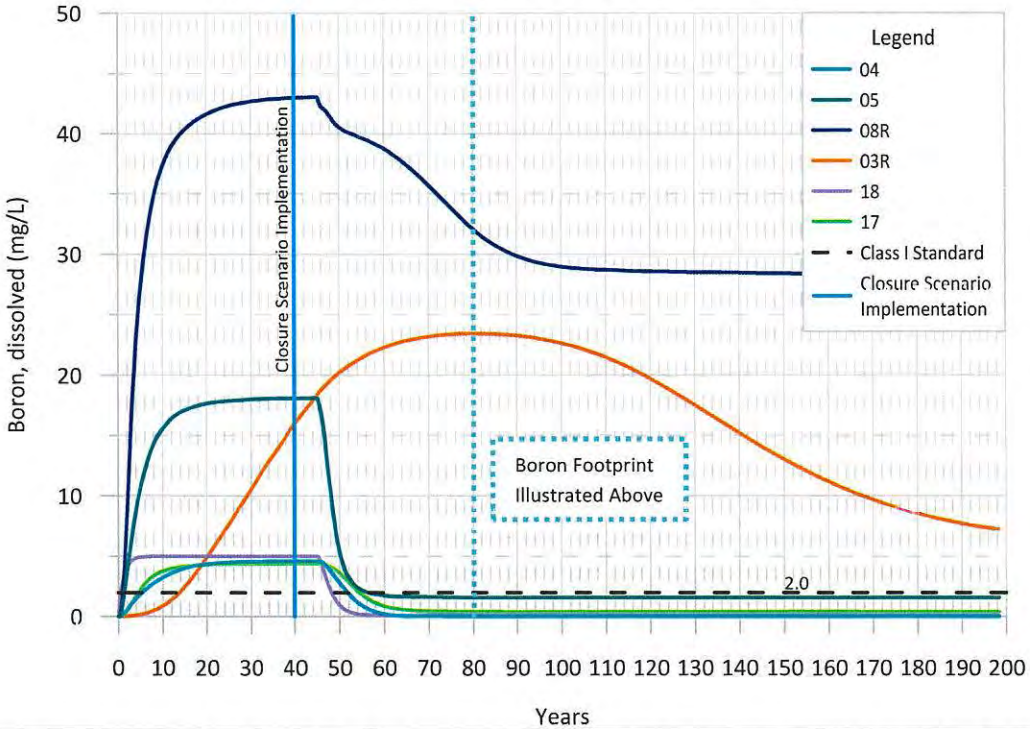
Scenario 3 - Model Predicted Boron Concentration



SCENARIO 3 FOOTPRINT OF BORON PLUME OVER 2 mg/L 40 YEARS AFTER IMPLEMENTATION WITH PREDICTED CONCENTRATIONS AT WELLS 04, 05, 08R, 03R, 17 AND 18



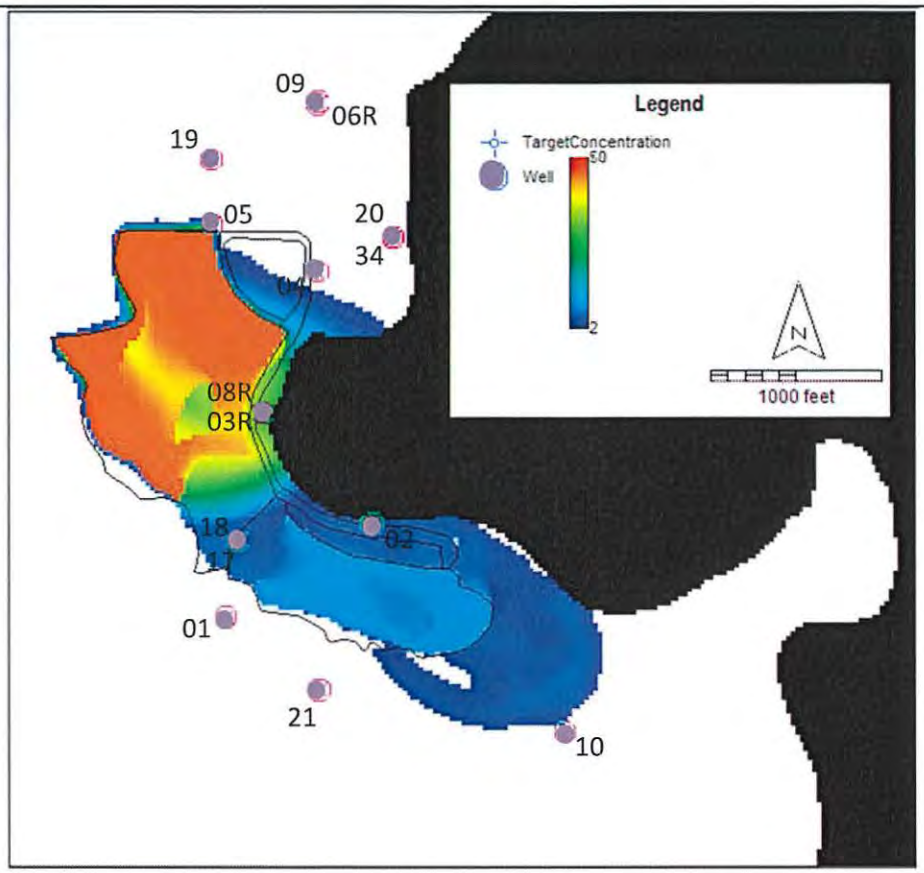
Scenario 4 - Model Predicted Boron Concentration



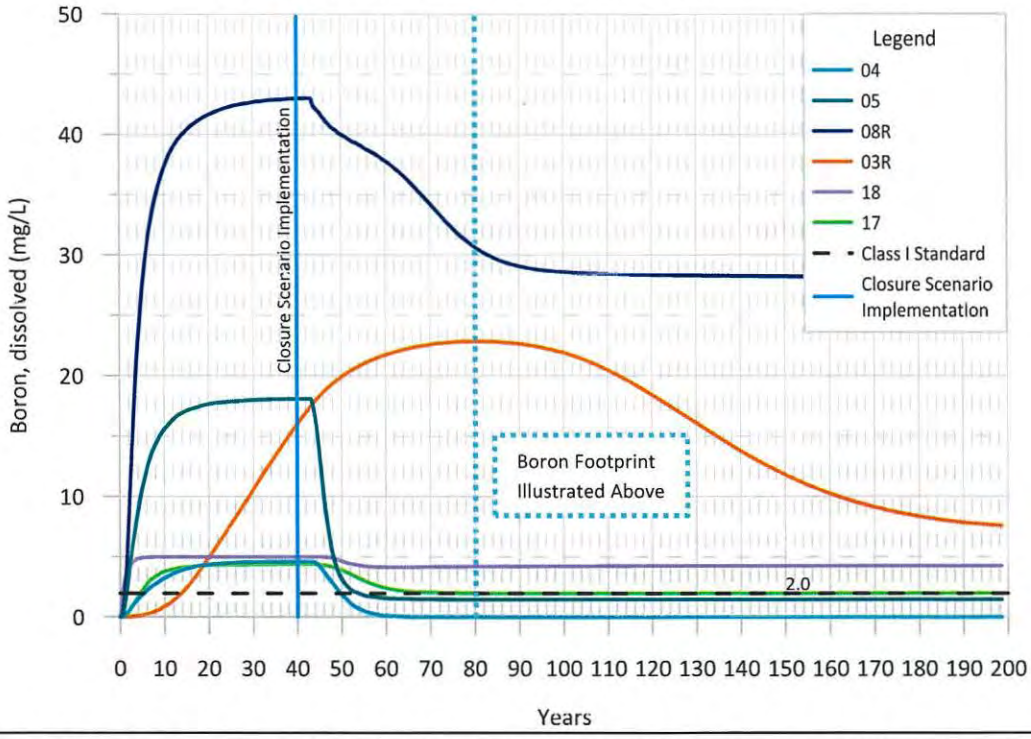
SCENARIO 4 FOOTPRINT OF BORON PLUME OVER 2 mg/L 40 YEARS AFTER IMPLEMENTATION WITH PREDICTED CONCENTRATIONS AT WELLS 04, 05, 08R, 03R, 17 AND 18

GROUNDWATER MONITORING AND MODELING REPORT
NORTH ASH POND SYSTEM AND OLD EAST ASH POND
VERMILION SITE
OAKWOOD, ILLINOIS

O'BRIEN & GERE ENGINEERS, INC.



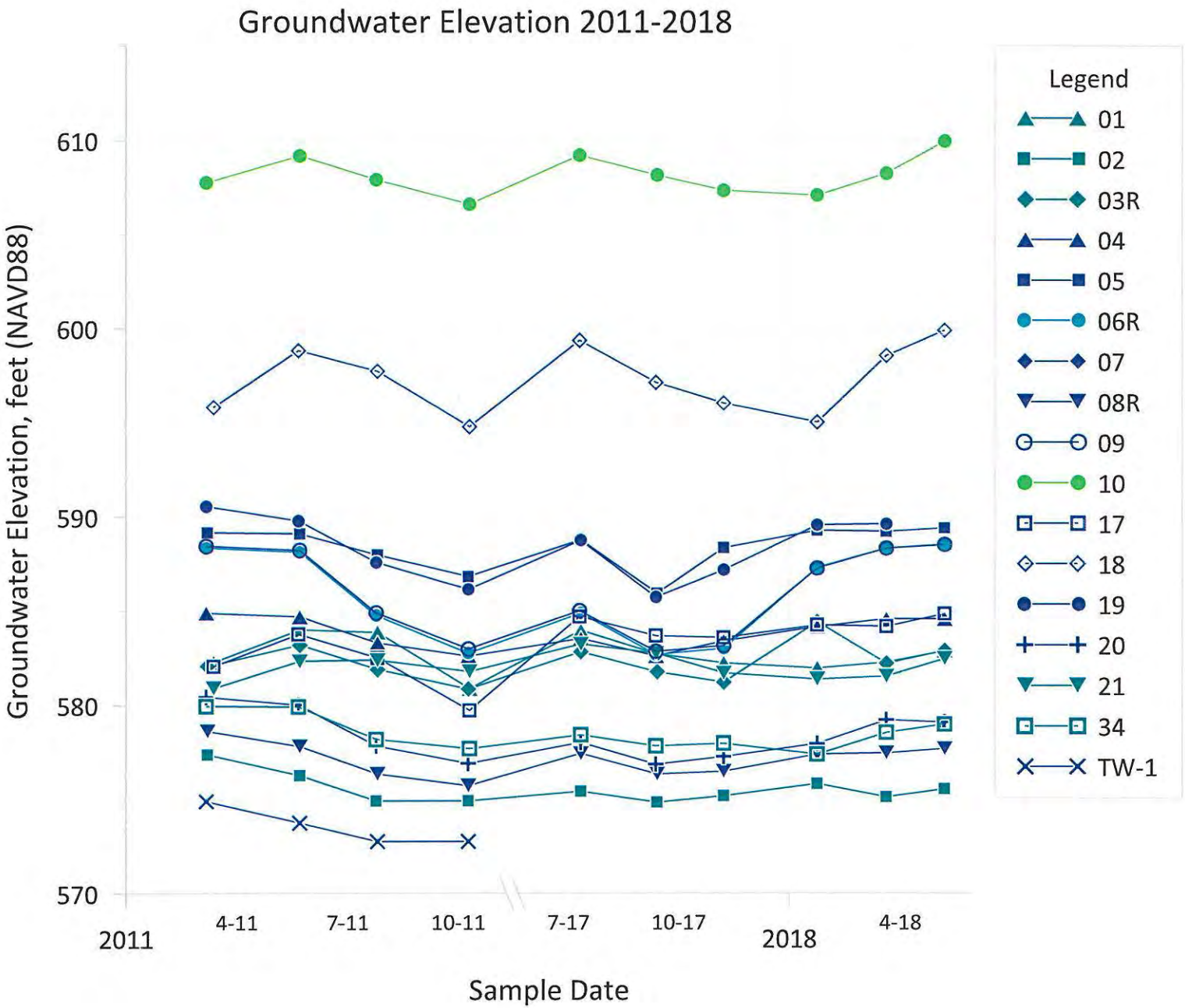
Scenario 5 - Model Predicted Boron Concentration

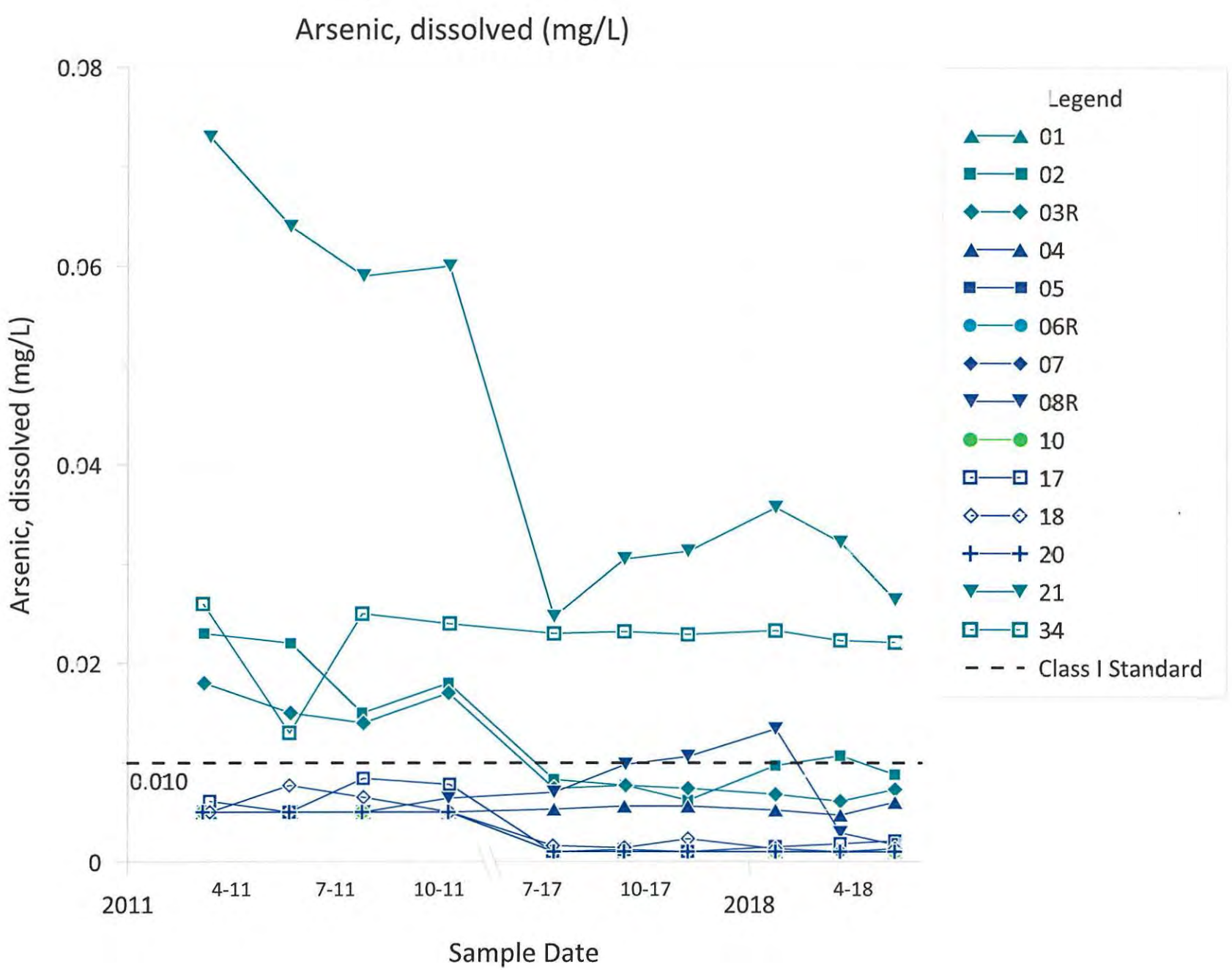


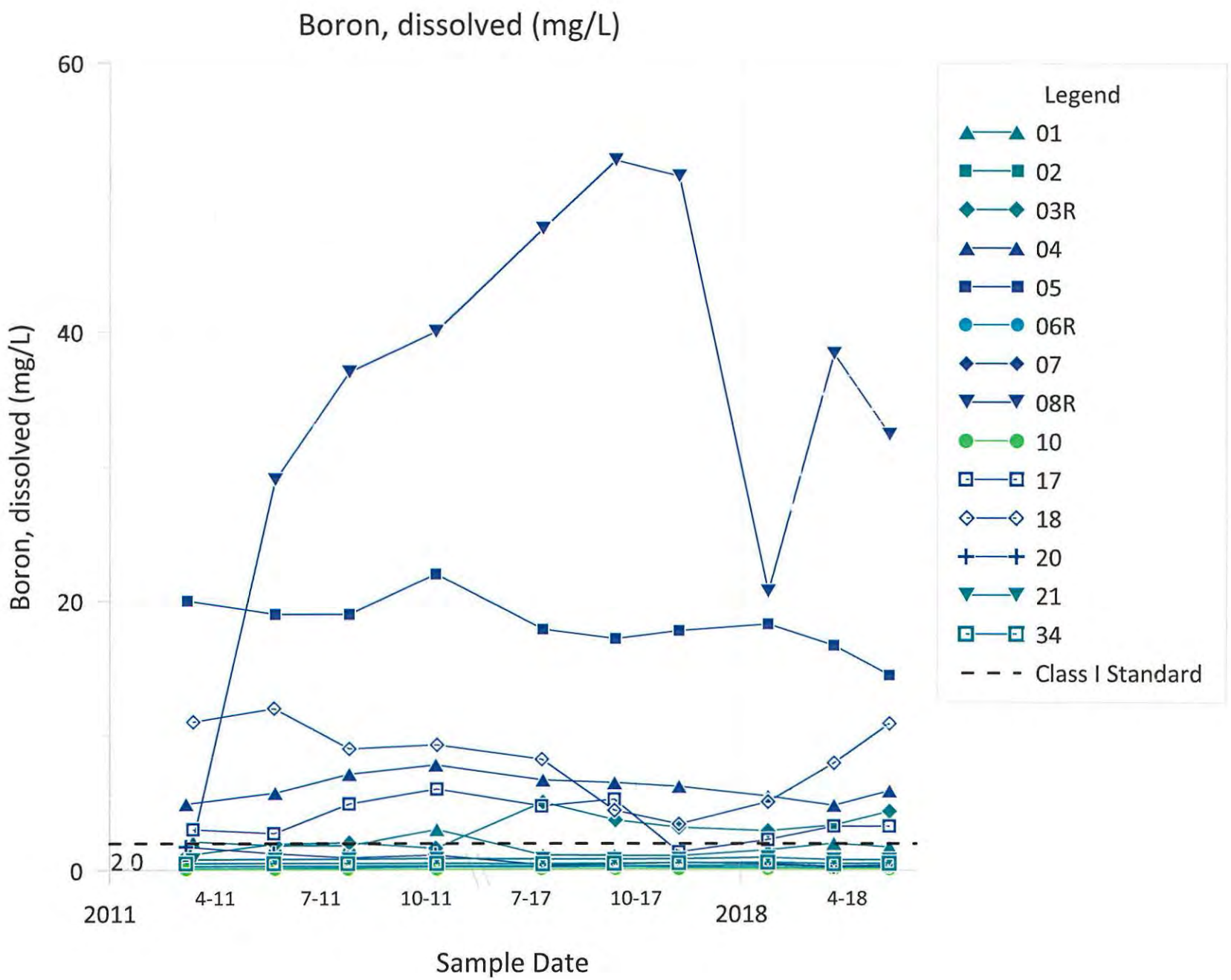
SCENARIO 5 FOOTPRINT OF BORON PLUME OVER 2 mg/L 40 YEARS AFTER IMPLEMENTATION WITH PREDICTED CONCENTRATIONS AT WELLS 04, 05, 08R, 03R, 17 AND 18

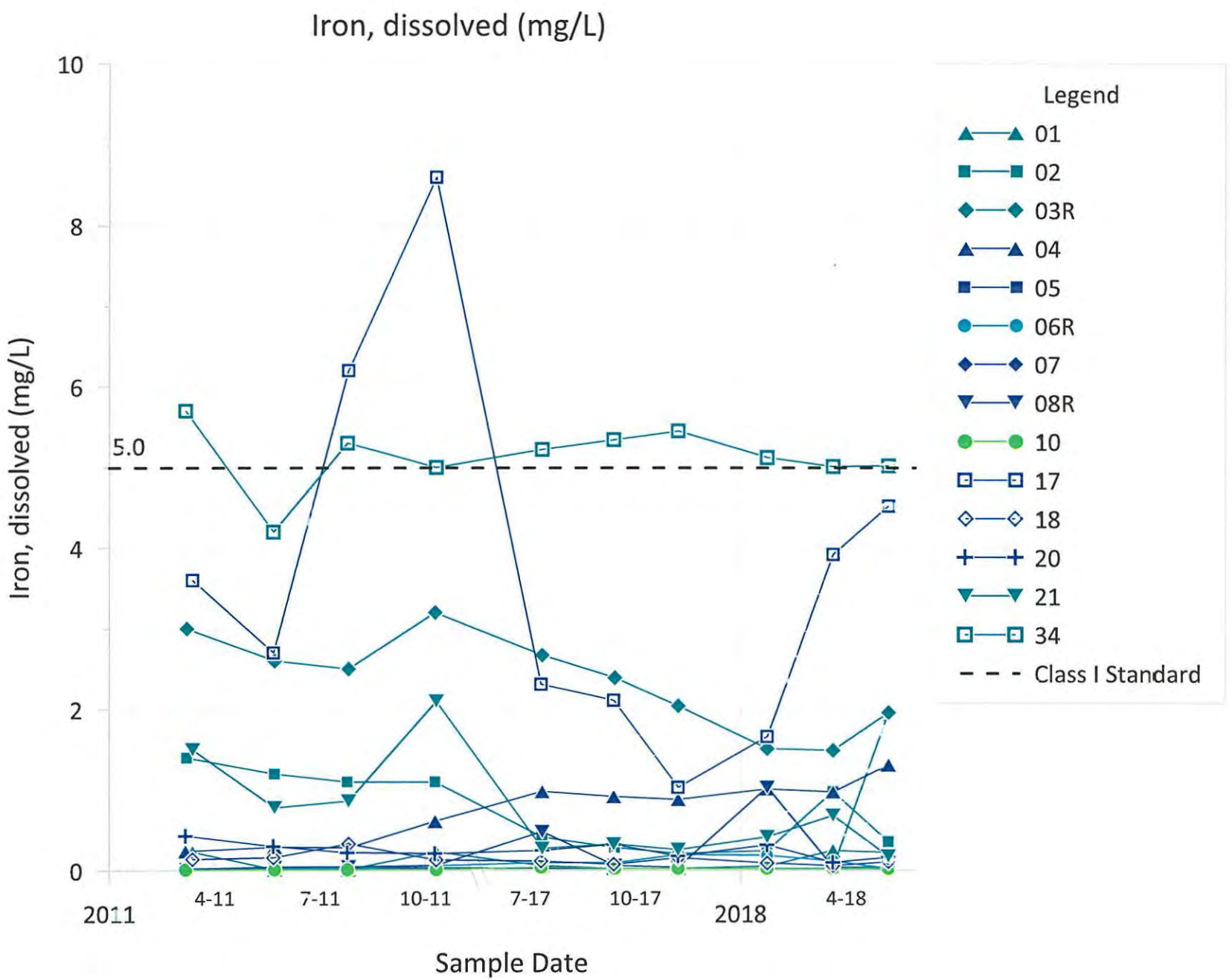
Appendix A

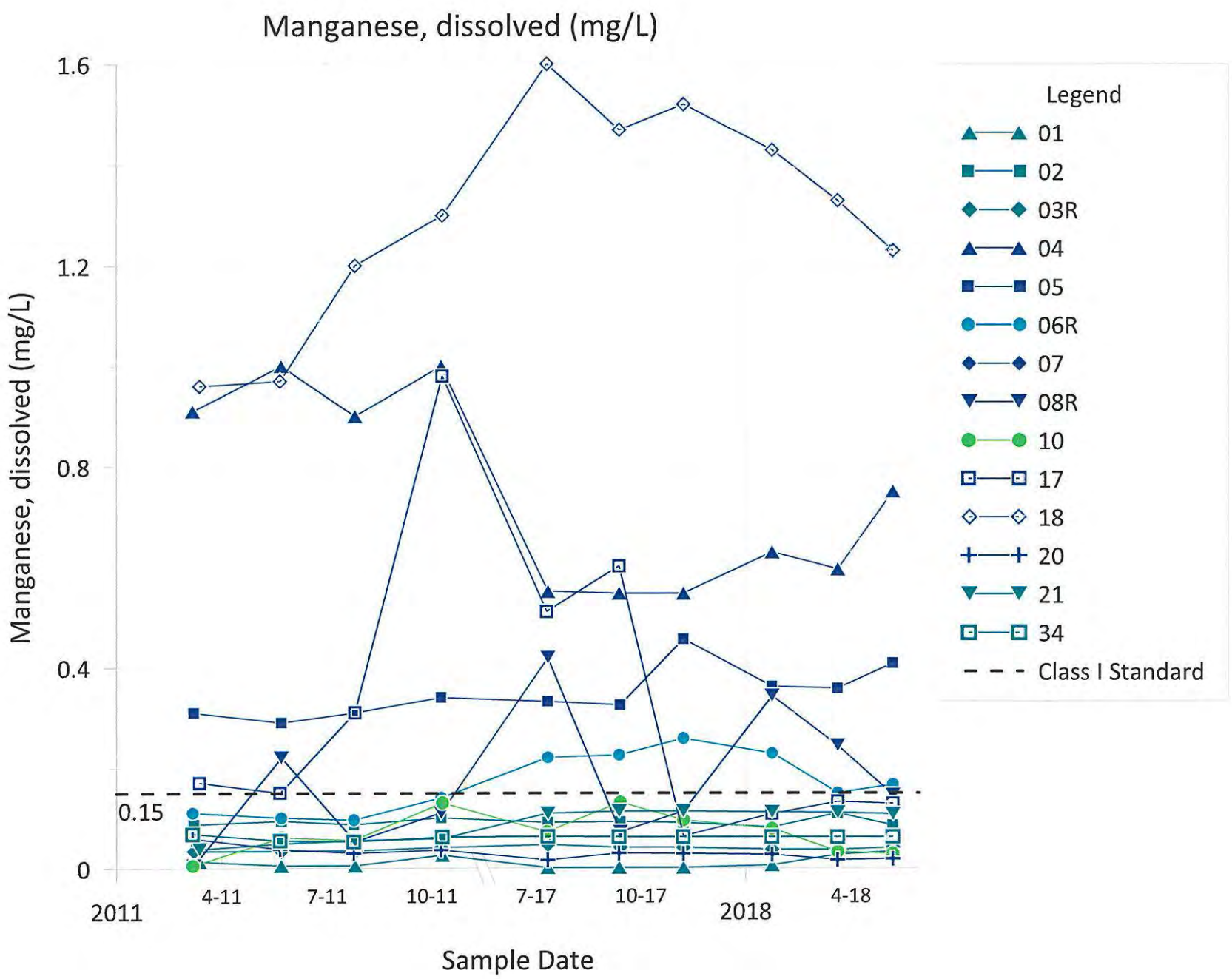
2011-2018 Time Series Graphs

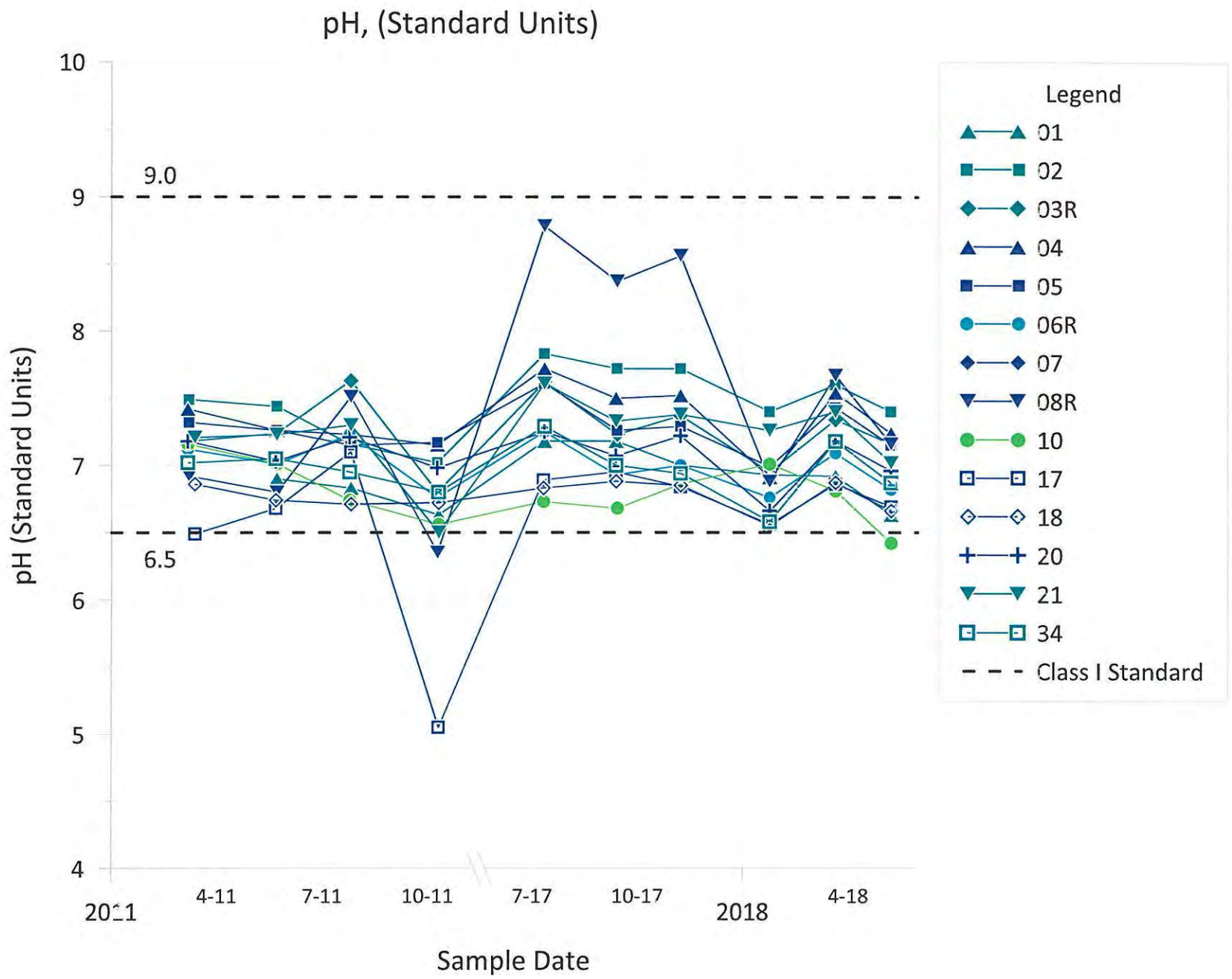

Groundwater Elevation 2011-2018
Groundwater Elevation, feet (NAVD88)
610
600
590
580
570
2011
4-11
7-11
10-11
7-17
10-17
2018
4-18
Sample Date
Legend
01
02
03R
04
05
06R
07
08R
09
10
17
18
19
20
21
34
TW-1

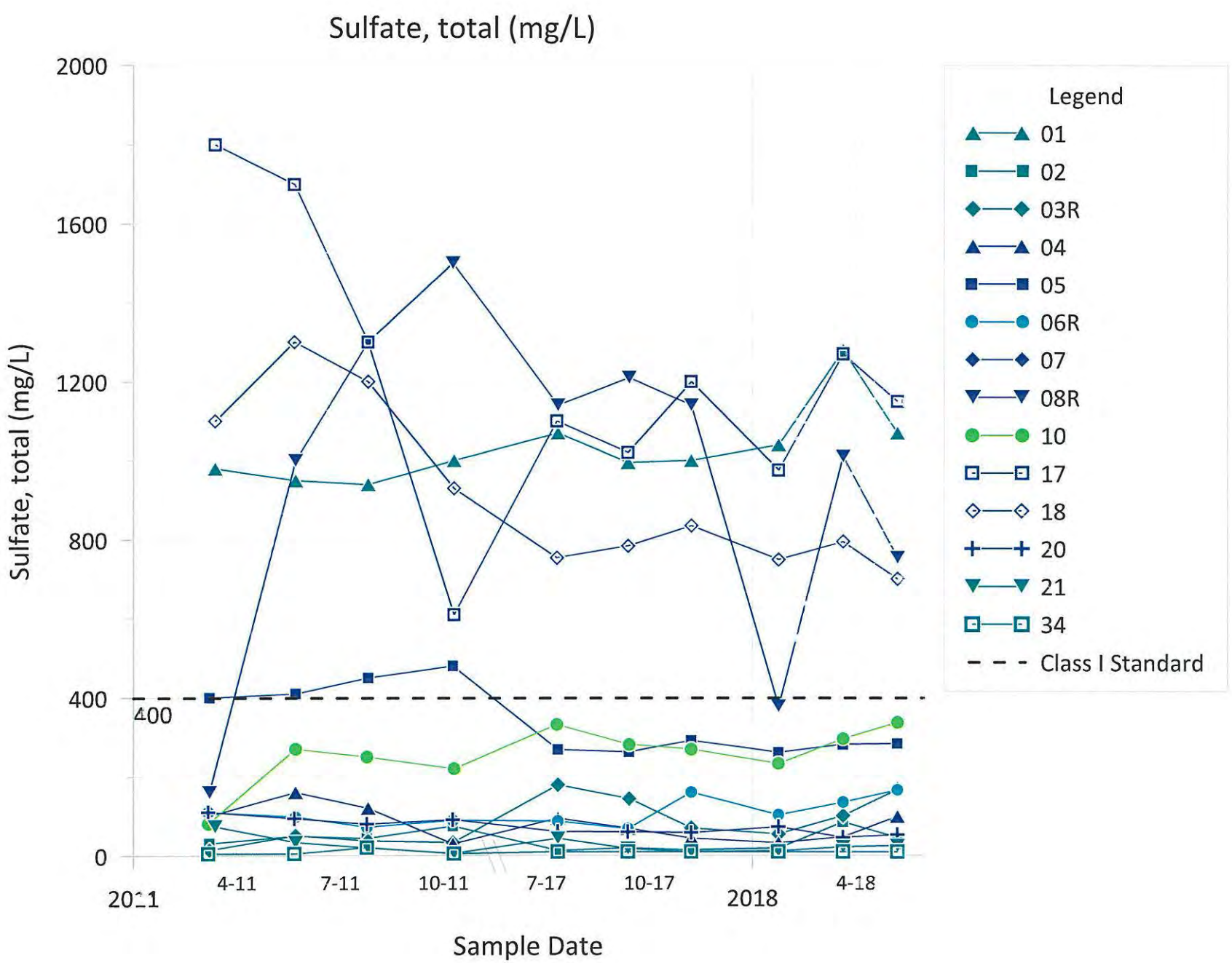

Arsenic, dissolved (mg/L)
0.08
0.06
0.04
0.02
0
0.010
Arsenic, dissolved (mg/L)
2011
4-11
7-11
10-11
7-17
10-17
2018
4-18
Sample Date
Legend
01
02
03R
04
05
06R
07
08R
10
17
18
20
21
34
Class I Standard

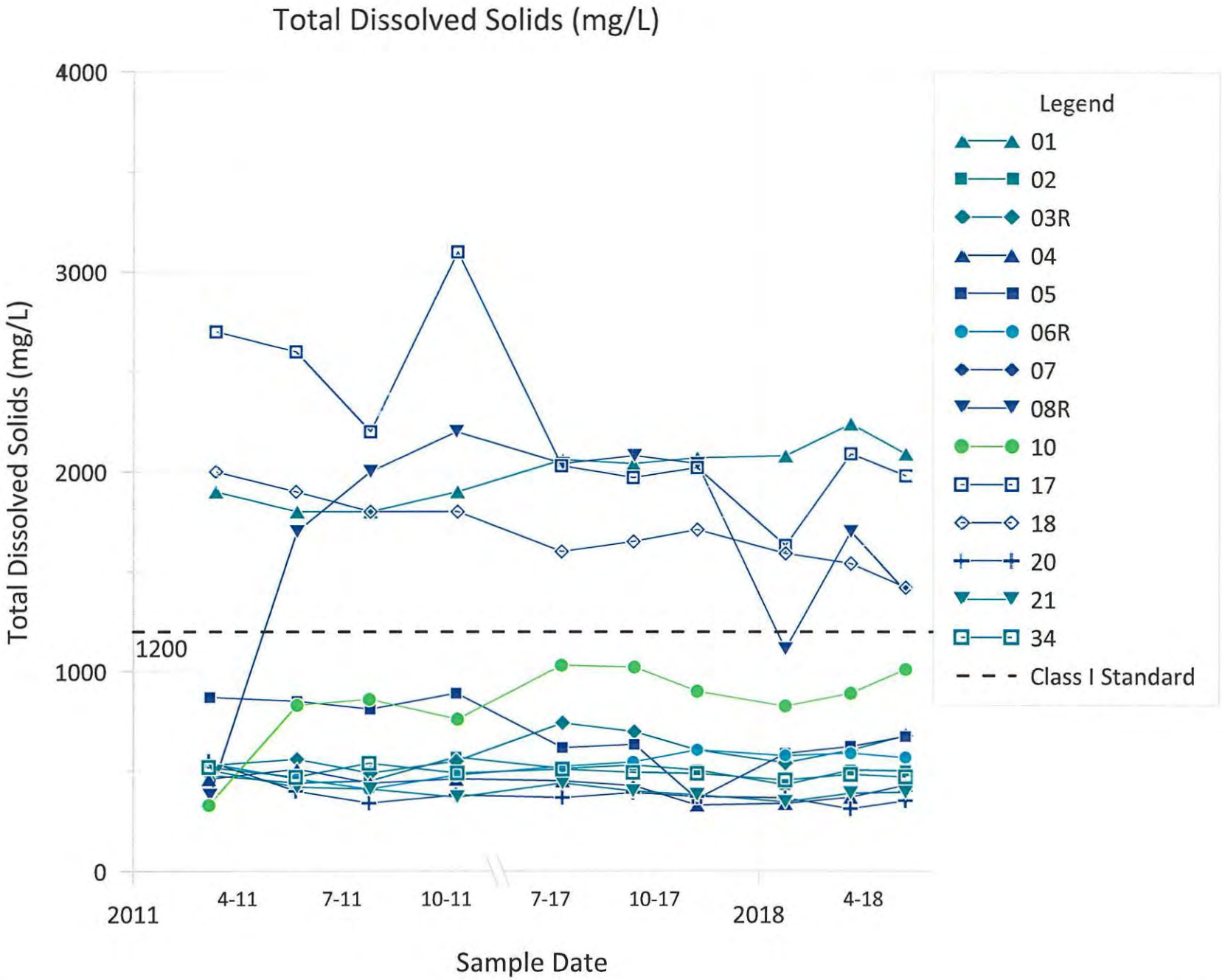

Boron, dissolved (mg/L)
60
40
20
0
Boron, dissolved (mg/L)
2.0
2011
4-11
7-11
10-11
7-17
10-17
2018
4-18
Sample Date
Legend
01
02
03R
04
05
06R
07
08R
10
17
18
20
21
34
Class I Standard


Iron, dissolved (mg/L)
10
8
6
4
2
0
5.0
Iron, dissolved (mg/L)
2011
4-11
7-11
10-11
7-17
10-17
2018
4-18
Sample Date
Legend
01
02
03R
04
05
06R
07
08R
10
17
18
20
21
34
Class I Standard


Manganese, dissolved (mg/L)
1.6
1.2
0.8
0.4
0.15
0
Manganese, dissolved (mg/L)
2011
4-11
7-11
10-11
7-17
10-17
2018
4-18
Sample Date
Legend
01
02
03R
04
05
06R
07
08R
10
17
18
20
21
34
Class I Standard


pH, (Standard Units)
10
9
8
7
6
5
4
9.0
6.5
pH (Standard Units)
4-11
7-11
10-11
7-17
10-17
4-18
2011
2018
Sample Date
Legend
01
02
03R
04
05
06R
07
08R
10
17
18
20
21
34
Class I Standard


Sulfate, total (mg/L)
2000
1600
1200
800
400
0
400
Sulfate, total (mg/L)
4-11
7-11
10-11
7-17
10-17
4-18
2018
Sample Date
Legend
01
02
03R
04
05
06R
07
08R
10
17
18
20
21
34
Class I Standard


Total Dissolved Solids (mg/L)
Total Dissolved Solids (mg/L)
4000
3000
2000
1000
0
1200
2011
4-11
7-11
10-11
7-17
10-17
2018
4-18
Sample Date
Legend
01
02
03R
04
05
06R
07
08R
10
17
18
20
21
34
Class I Standard

Appendix B

2017-2018 Field and Laboratory Data

August 02, 2017

Steve Wiskes
Natural Resource Technology, Inc.
2422 East Washington Street
Suite 104
Bloomington, IL 61704
TEL: (414) 837-3614
FAX: (414) 837-3608

RE: Dynegy - Vermillion Power Station **WorkOrder:** 17070059

Dear Steve Wiskes:

TEKLAB, INC received 20 samples on 7/13/2017 7:45:00 PM for the analysis presented in the following report.

Samples are analyzed on an as received basis unless otherwise requested and documented. The sample results contained in this report relate only to the requested analytes of interest as directed on the chain of custody. NELAP accredited fields of testing are indicated by the letters NELAP under the Certification column. Unless otherwise documented within this report, Teklab Inc. analyzes samples utilizing the most current methods in compliance with 40CFR. All tests are performed in the Collinsville, IL laboratory unless otherwise noted in the Case Narrative.

All quality control criteria applicable to the test methods employed for this project have been satisfactorily met and are in accordance with NELAP except where noted. The following report shall not be reproduced, except in full, without the written approval of Teklab, Inc.

If you have any questions regarding these tests results, please feel free to call.

Sincerely,

Michael L. Austin
Project Manager
(618)344-1004 ex 16
MAustin@teklabinc.com

Client: Natural Resource Technology, Inc.
Work Order: 17070059

Client Project: Dynegy - Vermillion Power Station
Report Date: 02-Aug-17

This reporting package includes the following:

Cover Letter	1
Report Contents	2
Definitions	3
Case Narrative	4
Accreditations	5
Laboratory Results	6
Sample Summary	24
Dates Report	25
Quality Control Results	34
Receiving Check List	40
Chain of Custody	Appended

Client: Natural Resource Technology, Inc. **Work Order:** 17070059

Client Project: Dynegy - Vermillion Power Station **Report Date:** 02-Aug-17

Abbr Definition

CCV	Continuing calibration verification is a check of a standard to determine the state of calibration of an instrument between recalibration.
DF	Dilution factor is the dilution performed during analysis only and does not take into account any dilutions made during sample preparation. The reported result is final and includes all dilutions factors
DNI	Did not ignite
DUP	Laboratory duplicate is an aliquot of a sample taken from the same container under laboratory conditions for independent processing and analysis independently of the original aliquot.
ICV	Initial calibration verification is a check of a standard to determine the state of calibration of an instrument before sample analysis is initiated.
IDPH	IL Dept. of Public Health
LCS	Laboratory control sample, spiked with verified known amounts of analytes, is analyzed exactly like a sample to establish intra-laboratory or analyst specific precision and bias or to assess the performance of all or a portion of the measurement system. The acceptable recovery range is in the QC Package (provided upon request).
LCSD	Laboratory control sample duplicate is a replicate laboratory control sample that is prepared and analyzed in order to determine the precision of the approved test method. The acceptable recovery range is listed in the QC Package (provided upon request).
MBLK	Method blank is a sample of a matrix similar to the batch of associated sample (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures, and in which no target analytes or interferences should present at concentrations that impact the analytical results for sample analyses.
MDL	Method detection limit means the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero.
MS	Matrix spike is an aliquot of matrix fortified (spiked) with known quantities of specific analytes that is subjected to the entire analytical procedures in order to determine the effect of the matrix on an approved test method's recovery system. The acceptable recovery range is listed in the QC Package (provided upon request).
MSD	Matrix spike duplicate means a replicate matrix spike that is prepared and analyzed in order to determine the precision of the approved test method. The acceptable recovery range is listed in the QC Package (provided upon request).
MW	Molecular weight
ND	Not Detected at the Reporting Limit
NELAP	NELAP Accredited
PQL	Practical quantitation limit means the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operation conditions. The acceptable recovery range is listed in the QC Package (provided upon request).
RL	The reporting limit the lowest level that the data is displayed in the final report. The reporting limit may vary according to customer request or sample dilution. The reporting limit may not be less than the MDL.
RPD	Relative percent difference is a calculated difference between two recoveries (ie. MS/MSD). The acceptable recovery limit is listed in the QC Package (provided upon request).
SPK	The spike is a known mass of target analyte added to a blank sample or sub-sample; used to determine recovery deficiency or for other quality control purposes.
Surr	Surrogates are compounds which are similar to the analytes of interest in chemical composition and behavior in the analytical process, but which are not normally found in environmental samples.
TIC	Tentatively identified compound: Analytes tentatively identified in the sample by using a library search. Only results not in the calibration standard will be reported as tentatively identified compounds. Results for tentatively identified compounds that are not present in the calibration standard, but are assigned a specific chemical name based upon the library search, are calculated using total peak areas from reconstructed ion chromatograms and a response factor of one. The nearest Internal Standard is used for the calculation. The results of any TICs must be considered estimated, and are flagged with a "T". If the estimated result is above the calibration range it is flagged "ET"
TNTC	Too numerous to count (> 200 CFU)

Qualifiers

- # - Unknown hydrocarbon
- B - Analyte detected in associated Method Blank
- E - Value above quantitation range
- H - Holding times exceeded
- I - Associated Internal standard was outside method criteria
- M - Manual Integration used to determine area response
- ND - Not Detected at the Reporting Limit
- R - RPD outside accepted recovery limits
- S - Spike Recovery outside recovery limits
- T - TIC(Tentatively identified compound)
- X - Value exceeds Maximum Contaminant Level

Client: Natural Resource Technology, Inc.
Client Project: Dynegy - Vermillion Power Station

Work Order: 17070059
Report Date: 02-Aug-17

Cooler Receipt Temp: 1.02 °C

An employee of Teklab, Inc. collected the sample(s).

MW1 could not be collected; the well was dry TW1 could not be collected JMS/TWM 7/13/17

Locations

Collinsville

Address	5445 Horseshoe Lake Road Collinsville, IL 62234-7425
Phone	(618) 344-1004
Fax	(618) 344-1005
Email	jhriley@teklabinc.com

Springfield

Address	3920 Pintail Dr Springfield, IL 62711-9415
Phone	(217) 698-1004
Fax	(217) 698-1005
Email	KKlostermann@teklabinc.com

Kansas City

Address	8421 Nieman Road Lenexa, KS 66214
Phone	(913) 541-1998
Fax	(913) 541-1998
Email	jhriley@teklabinc.com

Collinsville Air

Address	5445 Horseshoe Lake Road Collinsville, IL 62234 7425
Phone	(618) 344-1004
Fax	(618) 344-1005
Email	EHurley@teklabinc.com

Chicago

Address	1319 Butterfield Rd. Downers Grove, IL 60515
Phone	(630) 324-6855
Fax	
Email	jhriley@teklabinc.com

Client: Natural Resource Technology, Inc. **Work Order:** 17070059

Client Project: Dynegy - Vermillion Power Station **Report Date:** 02-Aug-17

State	Dept	Cert #	NELAP	Exp Date	Lab
Illinois	IEPA	100226	NELAP	1/31/2018	Collinsville
Kansas	KDHE	E-10374	NELAP	4/30/2018	Collinsville
Louisiana	LDEQ	166493	NELAP	6/30/2018	Collinsville
Louisiana	LDEQ	166578	NELAP	6/30/2018	Collinsville
Texas	TCEQ	T104704515-12-1	NELAP	7/31/2018	Collinsville
Arkansas	ADEQ	88-0966		3/14/2018	Collinsville
Illinois	IDPH	17584		5/31/2017	Collinsville
Indiana	ISDH	C-IL-06		1/31/2018	Collinsville
Kentucky	KDEP	98006		12/31/2017	Collinsville
Kentucky	UST	0073		1/31/2018	Collinsville
Louisiana	LDPH	LA170027		12/31/2017	Collinsville
Missouri	MDNR	930		1/31/2018	Collinsville
Missouri	MDNR	00930		5/31/2017	Collinsville
Oklahoma	ODEQ	9978		8/31/2017	Collinsville

Client: Natural Resource Technology, Inc. **Work Order:** 17070059

Client Project: Dynegy - Vermillion Power Station **Report Date:** 02-Aug-17

Lab ID: 17070059-001 **Client Sample ID:** MW1

Matrix: GROUNDWATER **Collection Date:** 07/13/2017 9:38

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
FIELD ELEVATION MEASUREMENTS								
Depth to water from measuring point		0		**77.67**	ft	1	07/13/2017 9:38	R235423
STANDARD METHOD 4500-H B FIELD								
pH		1.00		**7.18**		1	07/13/2017 9:38	R235423
STANDARD METHODS 2130 B FIELD								
Turbidity		1.0		**< 1.0**	NTU	1	07/13/2017 9:38	R235423
STANDARD METHODS 18TH ED. 2580 B FIELD								
Oxidation-Reduction Potential		-300		**83**	mV	1	07/13/2017 9:38	R235423
STANDARD METHODS 2510 B FIELD								
Conductivity		1		**2000**	µS/cm	1	07/13/2017 9:38	R235423
STANDARD METHODS 2550 B FIELD								
Temperature		0		**19.34**	°C	1	07/13/2017 9:38	R235423
STANDARD METHODS 4500-O G FIELD								
Oxygen, Dissolved		1.00		**7.40**	mg/L	1	07/13/2017 9:38	R235423
STANDARD METHODS 2540 C (DISSOLVED)								
Total Dissolved Solids	NELAP	20		**2060**	mg/L	1	07/17/2017 14:58	R235310
STANDARD METHODS 4500-NO3 F (TOTAL)								
Nitrogen, Nitrate (as N)	NELAP	0.050		**0.348**	mg/L	1	07/18/2017 14:30	R235311
SW-846 9036 (TOTAL)								
Sulfate	NELAP	500		**1070**	mg/L	50	07/17/2017 15:46	R235313
SW-846 9214 (DISSOLVED)								
Fluoride	NELAP	0.10		**0.13**	mg/L	1	07/14/2017 13:45	R235182
SW-846 9251 (TOTAL)								
Chloride	NELAP	5		**22**	mg/L	1	07/14/2017 14:59	R235239
SW-846 3005A, 6020A, METALS BY ICPMS (DISSOLVED)								
Arsenic	NELAP	0.0010		**< 0.0010**	mg/L	5	07/17/2017 15:33	132182
Barium	NELAP	0.0010		**0.0120**	mg/L	5	07/18/2017 13:53	132182
Boron	NELAP	0.0250		**1.10**	mg/L	5	07/17/2017 15:33	132182
Iron	NELAP	0.0250		**0.0601**	mg/L	5	07/18/2017 13:53	132182
Manganese	NELAP	0.0010		**< 0.0010**	mg/L	5	07/18/2017 13:53	132182
Selenium	NELAP	0.0010		**< 0.0010**	mg/L	5	07/17/2017 15:33	132182

Client: Natural Resource Technology, Inc. **Work Order:** 17070059

Client Project: Dynegy - Vermillion Power Station **Report Date:** 02-Aug-17

Lab ID: 17070059-002 **Client Sample ID:** MW2

Matrix: GROUNDWATER **Collection Date:** 07/13/2017 10:17

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
FIELD ELEVATION MEASUREMENTS								
Depth to water from measuring point		0		**18.60**	ft	1	07/13/2017 10:17	R235423
STANDARD METHOD 4500-H B FIELD								
pH		1.00		**7.83**		1	07/13/2017 10:17	R235423
STANDARD METHODS 2130 B FIELD								
Turbidity		1.0		**1.0**	NTU	1	07/13/2017 10:17	R235423
STANDARD METHODS 18TH ED. 2580 B FIELD								
Oxidation-Reduction Potential		-300		**-141**	mV	1	07/13/2017 10:17	R235423
STANDARD METHODS 2510 B FIELD								
Conductivity		1		**623**	µS/cm	1	07/13/2017 10:17	R235423
STANDARD METHODS 2550 B FIELD								
Temperature		0		**16.32**	°C	1	07/13/2017 10:17	R235423
STANDARD METHODS 4500-O G FIELD								
Oxygen, Dissolved		1.00		**1.86**	mg/L	1	07/13/2017 10:17	R235423
STANDARD METHODS 2540 C (DISSOLVED)								
Total Dissolved Solids	NELAP	20		**514**	mg/L	1	07/17/2017 14:58	R235310
STANDARD METHODS 4500-NO3 F (TOTAL)								
Nitrogen, Nitrate (as N)	NELAP	0.050		**< 0.050**	mg/L	1	07/18/2017 14:32	R235311
SW-846 9036 (TOTAL)								
Sulfate	NELAP	10		**13**	mg/L	1	07/15/2017 1:10	R235238
SW-846 9214 (DISSOLVED)								
Fluoride	NELAP	0.10		**0.56**	mg/L	1	07/14/2017 13:48	R235182
SW-846 9251 (TOTAL)								
Chloride	NELAP	5		**49**	mg/L	1	07/14/2017 15:08	R235239
SW-846 3005A, 6020A, METALS BY ICPMS (DISSOLVED)								
Arsenic	NELAP	0.0010		**0.0083**	mg/L	5	07/17/2017 18:33	132182
Barium	NELAP	0.0010		**0.156**	mg/L	5	07/17/2017 18:33	132182
Boron	NELAP	0.0250		**0.289**	mg/L	5	07/17/2017 18:33	132182
Iron	NELAP	0.0250		**0.412**	mg/L	5	07/17/2017 18:33	132182
Manganese	NELAP	0.0010		**0.0909**	mg/L	5	07/17/2017 18:33	132182
Selenium	NELAP	0.0010		**< 0.0010**	mg/L	5	07/17/2017 18:33	132182

Client: Natural Resource Technology, Inc. **Work Order:** 17070059

Client Project: Dynegy - Vermillion Power Station **Report Date:** 02-Aug-17

Lab ID: 17070059-004 **Client Sample ID:** MW10

Matrix: GROUNDWATER **Collection Date:** 07/12/2017 18:07

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
FIELD ELEVATION MEASUREMENTS								
Depth to water from measuring point		0		**49.89**	ft	1	07/12/2017 18:07	R235423
STANDARD METHOD 4500-H B FIELD								
pH		1.00		**6.73**		1	07/12/2017 18:07	R235423
STANDARD METHODS 2130 B FIELD								
Turbidity		1.0		**< 1.0**	NTU	1	07/12/2017 18:07	R235423
STANDARD METHODS 18TH ED. 2580 B FIELD								
Oxidation-Reduction Potential		-300		**121**	mV	1	07/12/2017 18:07	R235423
STANDARD METHODS 2510 B FIELD								
Conductivity		1		**991**	µS/cm	1	07/12/2017 18:07	R235423
STANDARD METHODS 2550 B FIELD								
Temperature		0		**17.22**	°C	1	07/12/2017 18:07	R235423
STANDARD METHODS 4500-O G FIELD								
Oxygen, Dissolved		1.00		**4.46**	mg/L	1	07/12/2017 18:07	R235423
STANDARD METHODS 2540 C (DISSOLVED)								
Total Dissolved Solids	NELAP	20		**1030**	mg/L	1	07/17/2017 14:59	R235310
STANDARD METHODS 4500-NO3 F (TOTAL)								
Nitrogen, Nitrate (as N)	NELAP	0.100		**0.501**	mg/L	2	07/18/2017 14:34	R235311
SW-846 9036 (TOTAL)								
Sulfate	NELAP	100		**332**	mg/L	10	07/14/2017 15:24	R235238
SW-846 9214 (DISSOLVED)								
Fluoride	NELAP	0.10		**0.13**	mg/L	1	07/14/2017 13:50	R235182
SW-846 9251 (TOTAL)								
Chloride	NELAP	5		**7**	mg/L	1	07/14/2017 15:16	R235239
SW-846 3005A, 6020A, METALS BY ICPMS (DISSOLVED)								
Arsenic	NELAP	0.0010		**< 0.0010**	mg/L	5	07/17/2017 15:41	132182
Barium	NELAP	0.0010		**0.0604**	mg/L	5	07/18/2017 14:02	132182
Boron	NELAP	0.0250		**0.0877**	mg/L	5	07/17/2017 15:41	132182
Iron	NELAP	0.0250		**0.0400**	mg/L	5	07/18/2017 14:02	132182
Manganese	NELAP	0.0010		**0.0722**	mg/L	5	07/18/2017 14:02	132182
Selenium	NELAP	0.0010		**< 0.0010**	mg/L	5	07/17/2017 15:41	132182

Client: Natural Resource Technology, Inc. **Work Order:** 17070059

Client Project: Dynegy - Vermillion Power Station **Report Date:** 02-Aug-17

Lab ID: 17070059-005 **Client Sample ID:** MW17

Matrix: GROUNDWATER **Collection Date:** 07/12/2017 18:47

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
FIELD ELEVATION MEASUREMENTS								
Depth to water from measuring point		0		**38.54**	ft	1	07/12/2017 18:47	R235423
STANDARD METHOD 4500-H B FIELD								
pH		1.00		**6.89**		1	07/12/2017 18:47	R235423
STANDARD METHODS 2130 B FIELD								
Turbidity		1.0		**9.5**	NTU	1	07/12/2017 18:47	R235423
STANDARD METHODS 18TH ED. 2580 B FIELD								
Oxidation-Reduction Potential		-300		**-31**	mV	1	07/12/2017 18:47	R235423
STANDARD METHODS 2510 B FIELD								
Conductivity		1		**1800**	µS/cm	1	07/12/2017 18:47	R235423
STANDARD METHODS 2550 B FIELD								
Temperature		0		**17.28**	°C	1	07/12/2017 18:47	R235423
STANDARD METHODS 4500-O G FIELD								
Oxygen, Dissolved		1.00		**1.66**	mg/L	1	07/12/2017 18:47	R235423
STANDARD METHODS 2540 C (DISSOLVED)								
Total Dissolved Solids	NELAP	20		**2030**	mg/L	1	07/17/2017 14:59	R235310
STANDARD METHODS 4500-NO3 F (TOTAL)								
Nitrogen, Nitrate (as N)	NELAP	0.050		**0.399**	mg/L	1	07/18/2017 14:52	R235311
SW-846 9036 (TOTAL)								
Sulfate	NELAP	500		**1100**	mg/L	50	07/17/2017 15:49	R235313
SW-846 9214 (DISSOLVED)								
Fluoride	NELAP	0.10		**0.17**	mg/L	1	07/14/2017 13:53	R235182
SW-846 9251 (TOTAL)								
Chloride	NELAP	5		**31**	mg/L	1	07/14/2017 15:40	R235239
SW-846 3005A, 6020A, METALS BY ICPMS (DISSOLVED)								
Arsenic	NELAP	0.0010		**0.0010**	mg/L	5	07/17/2017 15:49	132182
Barium	NELAP	0.0010		**0.0254**	mg/L	5	07/17/2017 15:49	132182
Boron	NELAP	0.0250		**4.74**	mg/L	5	07/17/2017 15:49	132182
Iron	NELAP	0.0250		**2.31**	mg/L	5	07/17/2017 15:49	132182
Manganese	NELAP	0.0010		**0.511**	mg/L	5	07/17/2017 15:49	132182
Selenium	NELAP	0.0010		**< 0.0010**	mg/L	5	07/17/2017 15:49	132182

Client: Natural Resource Technology, Inc. **Work Order:** 17070059

Client Project: Dynegy - Vermillion Power Station **Report Date:** 02-Aug-17

Lab ID: 17070059-006 **Client Sample ID:** MW18

Matrix: GROUNDWATER **Collection Date:** 07/12/2017 19:09

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
FIELD ELEVATION MEASUREMENTS								
Depth to water from measuring point		0		**23.47**	ft	1	07/12/2017 19:09	R235423
STANDARD METHOD 4500-H B FIELD								
pH		1.00		**6.83**		1	07/12/2017 19:09	R235423
STANDARD METHODS 2130 B FIELD								
Turbidity		1.0		**8.7**	NTU	1	07/12/2017 19:09	R235423
STANDARD METHODS 18TH ED. 2580 B FIELD								
Oxidation-Reduction Potential		-300		**25**	mV	1	07/12/2017 19:09	R235423
STANDARD METHODS 2510 B FIELD								
Conductivity		1		**1510**	µS/cm	1	07/12/2017 19:09	R235423
STANDARD METHODS 2550 B FIELD								
Temperature		0		**15.28**	°C	1	07/12/2017 19:09	R235423
STANDARD METHODS 4500-O G FIELD								
Oxygen, Dissolved		1.00		**1.75**	mg/L	1	07/12/2017 19:09	R235423
STANDARD METHODS 2540 C (DISSOLVED)								
Total Dissolved Solids	NELAP	20		**1600**	mg/L	1	07/17/2017 15:00	R235310
STANDARD METHODS 4500-NO3 F (TOTAL)								
Nitrogen, Nitrate (as N)	NELAP	0.050		**< 0.050**	mg/L	1	07/18/2017 14:54	R235311
SW-846 9036 (TOTAL)								
Sulfate	NELAP	200		**754**	mg/L	20	07/15/2017 1:37	R235238
SW-846 9214 (DISSOLVED)								
Fluoride	NELAP	0.10		**0.13**	mg/L	1	07/14/2017 13:59	R235182
SW-846 9251 (TOTAL)								
Chloride	NELAP	5		**27**	mg/L	1	07/14/2017 15:48	R235239
SW-846 3005A, 6020A, METALS BY ICPMS (DISSOLVED)								
Arsenic	NELAP	0.0010		**0.0016**	mg/L	5	07/17/2017 16:14	132182
Barium	NELAP	0.0010		**0.0155**	mg/L	5	07/18/2017 14:10	132182
Boron	NELAP	0.0250		**8.22**	mg/L	5	07/17/2017 16:14	132182
Iron	NELAP	0.0250		**0.116**	mg/L	5	07/18/2017 14:10	132182
Manganese	NELAP	0.0010		**1.60**	mg/L	5	07/18/2017 14:10	132182
Selenium	NELAP	0.0010		**< 0.0010**	mg/L	5	07/17/2017 16:14	132182

Client: Natural Resource Technology, Inc. **Work Order:** 17070059

Client Project: Dynegy - Vermillion Power Station **Report Date:** 02-Aug-17

Lab ID: 17070059-007 **Client Sample ID:** MW21

Matrix: GROUNDWATER **Collection Date:** 07/13/2017 9:02

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
FIELD ELEVATION MEASUREMENTS								
Depth to water from measuring point		0		**89.55**	ft	1	07/13/2017 9:02	R235423
STANDARD METHOD 4500-H B FIELD								
pH		1.00		**7.61**		1	07/13/2017 9:02	R235423
STANDARD METHODS 2130 B FIELD								
Turbidity		1.0		**1.6**	NTU	1	07/13/2017 9:02	R235423
STANDARD METHODS 18TH ED. 2580 B FIELD								
Oxidation-Reduction Potential		-300		**-88**	mV	1	07/13/2017 9:02	R235423
STANDARD METHODS 2510 B FIELD								
Conductivity		1		**573**	µS/cm	1	07/13/2017 9:02	R235423
STANDARD METHODS 2550 B FIELD								
Temperature		0		**16.18**	°C	1	07/13/2017 9:02	R235423
STANDARD METHODS 4500-O G FIELD								
Oxygen, Dissolved		1.00		**2.60**	mg/L	1	07/13/2017 9:02	R235423
STANDARD METHODS 2540 C (DISSOLVED)								
Total Dissolved Solids	NELAP	20		**440**	mg/L	1	07/17/2017 15:00	R235310
STANDARD METHODS 4500-NO3 F (TOTAL)								
Nitrogen, Nitrate (as N)	NELAP	0.050		**< 0.050**	mg/L	1	07/18/2017 14:56	R235311
SW-846 9036 (TOTAL)								
Sulfate	NELAP	10		**44**	mg/L	1	07/14/2017 15:59	R235238
SW-846 9214 (DISSOLVED)								
Fluoride	NELAP	0.10		**1.10**	mg/L	1	07/14/2017 14:01	R235182
SW-846 9251 (TOTAL)								
Chloride	NELAP	5		**< 5**	mg/L	1	07/14/2017 15:56	R235239
SW-846 3005A, 6020A, METALS BY ICPMS (DISSOLVED)								
Arsenic	NELAP	0.0010		**0.0247**	mg/L	5	07/17/2017 16:22	132182
Barium	NELAP	0.0010		**0.0825**	mg/L	5	07/17/2017 16:22	132182
Boron	NELAP	0.0250		**0.801**	mg/L	5	07/17/2017 16:22	132182
Iron	NELAP	0.0250		**0.274**	mg/L	5	07/17/2017 16:22	132182
Manganese	NELAP	0.0010		**0.109**	mg/L	5	07/17/2017 16:22	132182
Selenium	NELAP	0.0010		**< 0.0010**	mg/L	5	07/17/2017 16:22	132182

Client: Natural Resource Technology, Inc. **Work Order:** 17070059

Client Project: Dynegy - Vermillion Power Station **Report Date:** 02-Aug-17

Lab ID: 17070059-009 **Client Sample ID:** MW3R

Matrix: GROUNDWATER **Collection Date:** 07/13/2017 11:43

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
FIELD ELEVATION MEASUREMENTS								
Depth to water from measuring point		0		**7.10**	ft	1	07/13/2017 11:43	R235423
STANDARD METHOD 4500-H B FIELD								
pH		1.00		**7.62**		1	07/13/2017 11:43	R235423
STANDARD METHODS 2130 B FIELD								
Turbidity		1.0		**5.5**	NTU	1	07/13/2017 11:43	R235423
STANDARD METHODS 18TH ED. 2580 B FIELD								
Oxidation-Reduction Potential		-300		**-142**	mV	1	07/13/2017 11:43	R235423
STANDARD METHODS 2510 B FIELD								
Conductivity		1		**803**	µS/cm	1	07/13/2017 11:43	R235423
STANDARD METHODS 2550 B FIELD								
Temperature		0		**14.57**	°C	1	07/13/2017 11:43	R235423
STANDARD METHODS 4500-O G FIELD								
Oxygen, Dissolved		1.00		**< 1.00**	mg/L	1	07/13/2017 11:43	R235423
STANDARD METHODS 2540 C (DISSOLVED)								
Total Dissolved Solids	NELAP	20		**742**	mg/L	1	07/17/2017 15:00	R235310
STANDARD METHODS 4500-NO3 F (TOTAL)								
Nitrogen, Nitrate (as N)	NELAP	0.050		**< 0.050**	mg/L	1	07/18/2017 14:58	R235311
SW-846 9036 (TOTAL)								
Sulfate	NELAP	100		**179**	mg/L	10	07/14/2017 16:12	R235238
SW-846 9214 (DISSOLVED)								
Fluoride	NELAP	0.10		**0.50**	mg/L	1	07/14/2017 14:02	R235182
SW-846 9251 (TOTAL)								
Chloride	NELAP	5		**27**	mg/L	1	07/14/2017 16:04	R235239
SW-846 3005A, 6020A, METALS BY ICPMS (DISSOLVED)								
Arsenic	NELAP	0.0010		**0.0074**	mg/L	5	07/17/2017 16:30	132182
Barium	NELAP	0.0010		**0.187**	mg/L	5	07/17/2017 16:30	132182
Boron	NELAP	0.0250		**5.02**	mg/L	5	07/17/2017 16:30	132182
Iron	NELAP	0.0250		**2.67**	mg/L	5	07/17/2017 16:30	132182
Manganese	NELAP	0.0010		**0.0465**	mg/L	5	07/17/2017 16:30	132182
Selenium	NELAP	0.0010		**< 0.0010**	mg/L	5	07/17/2017 16:30	132182

Client: Natural Resource Technology, Inc. **Work Order:** 17070059

Client Project: Dynegy - Vermillion Power Station **Report Date:** 02-Aug-17

Lab ID: 17070059-010 **Client Sample ID:** MW4

Matrix: GROUNDWATER **Collection Date:** 07/13/2017 15:27

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
FIELD ELEVATION MEASUREMENTS								
Depth to water from measuring point		0		**7.40**	ft	1	07/13/2017 15:27	R235423
STANDARD METHOD 4500-H B FIELD								
pH		1.00		**7.72**		1	07/13/2017 15:27	R235423
STANDARD METHODS 2130 B FIELD								
Turbidity		1.0		**1.3**	NTU	1	07/13/2017 15:27	R235423
STANDARD METHODS 18TH ED. 2580 B FIELD								
Oxidation-Reduction Potential		-300		**-116**	mV	1	07/13/2017 15:27	R235423
STANDARD METHODS 2510 B FIELD								
Conductivity		1		**448**	µS/cm	1	07/13/2017 15:27	R235423
STANDARD METHODS 2550 B FIELD								
Temperature		0		**19.49**	°C	1	07/13/2017 15:27	R235423
STANDARD METHODS 4500-O G FIELD								
Oxygen, Dissolved		1.00		**1.15**	mg/L	1	07/13/2017 15:27	R235423
STANDARD METHODS 2540 C (DISSOLVED)								
Total Dissolved Solids	NELAP	20		**452**	mg/L	1	07/17/2017 15:01	R235310
STANDARD METHODS 4500-NO3 F (TOTAL)								
Nitrogen, Nitrate (as N)	NELAP	0.050		**< 0.050**	mg/L	1	07/18/2017 15:00	R235311
SW-846 9036 (TOTAL)								
Sulfate	NELAP	50		**95**	mg/L	5	07/15/2017 1:39	R235238
SW-846 9214 (DISSOLVED)								
Fluoride	NELAP	0.10		**0.29**	mg/L	1	07/14/2017 14:04	R235182
SW-846 9251 (TOTAL)								
Chloride	NELAP	5		**12**	mg/L	1	07/14/2017 16:12	R235239
SW-846 3005A, 6020A, METALS BY ICPMS (DISSOLVED)								
Arsenic	NELAP	0.0010		**0.0053**	mg/L	5	07/17/2017 16:39	132182
Barium	NELAP	0.0010		**0.261**	mg/L	5	07/17/2017 16:39	132182
Boron	NELAP	0.0250		**6.68**	mg/L	5	07/17/2017 16:39	132182
Iron	NELAP	0.0250		**0.980**	mg/L	5	07/17/2017 16:39	132182
Manganese	NELAP	0.0010		**0.551**	mg/L	5	07/17/2017 16:39	132182
Selenium	NELAP	0.0010		**< 0.0010**	mg/L	5	07/17/2017 16:39	132182

Client: Natural Resource Technology, Inc. **Work Order:** 17070059

Client Project: Dynegy - Vermillion Power Station **Report Date:** 02-Aug-17

Lab ID: 17070059-011 **Client Sample ID:** MW5

Matrix: GROUNDWATER **Collection Date:** 07/13/2017 12:21

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
FIELD ELEVATION MEASUREMENTS								
Depth to water from measuring point		0		**6.89**	ft	1	07/13/2017 12:21	R235423
STANDARD METHOD 4500-H B FIELD								
pH		1.00		**7.61**		1	07/13/2017 12:21	R235423
STANDARD METHODS 2130 B FIELD								
Turbidity		1.0		**< 1.0**	NTU	1	07/13/2017 12:21	R235423
STANDARD METHODS 18TH ED. 2580 B FIELD								
Oxidation-Reduction Potential		-300		**-49**	mV	1	07/13/2017 12:21	R235423
STANDARD METHODS 2510 B FIELD								
Conductivity		1		**600**	µS/cm	1	07/13/2017 12:21	R235423
STANDARD METHODS 2550 B FIELD								
Temperature		0		**16.27**	°C	1	07/13/2017 12:21	R235423
STANDARD METHODS 4500-O G FIELD								
Oxygen, Dissolved		1.00		**1.09**	mg/L	1	07/13/2017 12:21	R235423
STANDARD METHODS 2540 C (DISSOLVED)								
Total Dissolved Solids	NELAP	20		**618**	mg/L	1	07/17/2017 15:01	R235310
STANDARD METHODS 4500-NO3 F (TOTAL)								
Nitrogen, Nitrate (as N)	NELAP	0.050		**< 0.050**	mg/L	1	07/18/2017 15:05	R235311
SW-846 9036 (TOTAL)								
Sulfate	NELAP	100		**268**	mg/L	10	07/14/2017 16:45	R235238
SW-846 9214 (DISSOLVED)								
Fluoride	NELAP	0.10		**0.51**	mg/L	1	07/14/2017 14:10	R235182
SW-846 9251 (TOTAL)								
Chloride	NELAP	5		**11**	mg/L	1	07/14/2017 16:37	R235239
SW-846 3005A, 6020A, METALS BY ICPMS (DISSOLVED)								
Arsenic	NELAP	0.0010		**< 0.0010**	mg/L	5	07/17/2017 16:47	132182
Barium	NELAP	0.0010		**0.0259**	mg/L	5	07/18/2017 14:18	132182
Boron	NELAP	0.0250		**17.9**	mg/L	5	07/17/2017 16:47	132182
Iron	NELAP	0.0250		**< 0.0250**	mg/L	5	07/18/2017 14:18	132182
Manganese	NELAP	0.0010		**0.332**	mg/L	5	07/18/2017 14:18	132182
Selenium	NELAP	0.0010		**< 0.0010**	mg/L	5	07/17/2017 16:47	132182

Client: Natural Resource Technology, Inc. **Work Order:** 17070059

Client Project: Dynegy - Vermillion Power Station **Report Date:** 02-Aug-17

Lab ID: 17070059-012 **Client Sample ID:** MW6R

Matrix: GROUNDWATER **Collection Date:** 07/13/2017 13:06

Analyses	Certification	RL	Qual	Result	Units	DF	Date Analyzed	Batch
FIELD ELEVATION MEASUREMENTS								
Depth to water from measuring point		0		**7.58**	ft	1	07/13/2017 13:06	R235423
STANDARD METHOD 4500-H B FIELD								
pH		1.00		**7.25**		1	07/13/2017 13:06	R235423
STANDARD METHODS 2130 B FIELD								
Turbidity		1.0		**2.3**	NTU	1	07/13/2017 13:06	R235423
STANDARD METHODS 18TH ED 2580 B FIELD								
Oxidation-Reduction Potential		-300		**-74**	mV	1	07/13/2017 13:06	R235423
STANDARD METHODS 2510 B FIELD								
Conductivity		1		**558**	µS/cm	1	07/13/2017 13:06	R235423
STANDARD METHODS 2550 B FIELD								
Temperature		0		**16.48**	°C	1	07/13/2017 13:06	R235423
STANDARD METHODS 4500-O G FIELD								
Oxygen, Dissolved		1.00		**< 1.00**	mg/L	1	07/13/2017 13:06	R235423
STANDARD METHODS 2540 C (DISSOLVED)								
Total Dissolved Solids	NELAP	20		**524**	mg/L	1	07/17/2017 15:02	R235310
STANDARD METHODS 4500-NO3 F (TOTAL)								
Nitrogen, Nitrate (as N)	NELAP	0.050		**< 0.050**	mg/L	1	07/18/2017 15:07	R235311
SW-846 9036 (TOTAL)								
Sulfate	NELAP	50		**87**	mg/L	5	07/15/2017 1:45	R235238
SW-846 9214 (DISSOLVED)								
Fluoride	NELAP	0.10		**0.12**	mg/L	1	07/14/2017 14:11	R235182
SW-846 9251 (TOTAL)								
Chloride	NELAP	5		**7**	mg/L	1	07/14/2017 16:45	R235239
SW-846 3005A, 6020A, METALS BY ICPMS (DISSOLVED)								
Arsenic	NELAP	0.0010		**< 0.0010**	mg/L	5	07/17/2017 16:55	132182
Barium	NELAP	0.0010		**0.0637**	mg/L	5	07/18/2017 14:26	132182
Boron	NELAP	0.0250		**0.187**	mg/L	5	07/19/2017 14:56	132182
Iron	NELAP	0.0250		**0.0942**	mg/L	5	07/18/2017 14:26	132182
Manganese	NELAP	0.0010		**0.220**	mg/L	5	07/18/2017 14:26	132182
Selenium	NELAP	0.0010		**< 0.0010**	mg/L	5	07/17/2017 16:55	132182