



Structural Stability and Safety Factor Assessment Report

D.E. KARN GENERATING FACILITY

BOTTOM ASH POND STRUCTURAL STABILITY AND SAFETY FACTOR ASSESSMENT REPORT

Essexville, Michigan

Pursuant to 40 CFR 257.73(d, e)

Submitted To: Consumers Energy Company
1945 W. Parnall Road
Jackson, Michigan 49201

Submitted By: Golder Associates Inc.
15851 South US 27, Suite 50
Lansing, Michigan 48906

October 2016

1655284





CERTIFICATION

Professional Engineer Certification Statement [40 CFR 257.73(d)(3) & 257.73(e)(2)]

I hereby certify that, having reviewed the attached documentation and being familiar with the provisions of Title 40 of the Code of Federal Regulations Section 257.73 (40 CFR Part 257.73), I attest that this Structural Stability and Safety Factor Assessment Report is accurate and has been prepared in accordance with good engineering practices, including the consideration of applicable industry standards, and with the requirements of 40 CFR Part 257.73(d) periodic structural stability assessments and 40 CFR Part 257.73(e) periodic safety factor assessments.

Golder Associates Inc.



Signature

October 14, 2016

Date of Report Certification

Matthew Wachholz, PE

Name

6201047513

Professional Engineer Certification Number





Table of Contents

CERTIFICATION..... C-1
Professional Engineer Certification Statement [40 CFR 257.73(d)(3) & 257.73(e)(2)]..... C

1.0 INTRODUCTION..... 1
1.1 Purpose 1
1.2 Background 1
1.3 Previous Evaluations..... 1

2.0 SUBSURFACE CONDITIONS..... 3

3.0 STRUCTURAL STABILITY ASSESSMENT [40 CFR 257.73(d)(1)(I-VII)]..... 4
3.1 Foundations and Abutments [40 CFR 257.73(d)(1)(i)] 4
3.2 Slope Protection [40 CFR 257.73(d)(1)(ii)] 4
3.3 Dikes (Embankment) [40 CFR 257.73(d)(1)(iii)] 5
3.4 Vegetated Slopes [40 CFR 257.73(d)(1)(iv)] 5
3.5 Spillways [40 CFR 257.73(d)(1)(v)]..... 5
3.6 Hydraulic Structures [40 CFR 257.73(d)(1)(v)] 5
3.7 Downstream Slopes Adjacent to Water Body [40 CFR 257.73(d)(1)(vii)]..... 5
3.8 Structural Stability Deficiencies [40 CFR 257.73(d)(2)] 6

4.0 SAFETY FACTOR ASSESSMENT [40 CFR 257.73(e)]..... 7
4.1 Slope Stability Analysis 7
4.1.1 Cross Sections Analyzed 7
4.1.2 Geotechnical Material Properties..... 8
4.1.3 Pond Elevation and Phreatic Surface/Groundwater 8
4.1.4 Vehicle Loading..... 8
4.1.5 Seismic Loading Conditions..... 8
4.2 Stability Analysis Results 9
4.3 Liquefaction Potential Assessment 9

5.0 SUMMARY 10

6.0 CLOSING 11

7.0 REFERENCES..... 12



List of Tables

Table 1.3.1	Previous Reviewed Documents Related to Structural Stability Assessment
Table 4.2.1	Slope Stability Analysis Results

List of Figures

Figure 1	Site Location Map
Figure 2	Borehole Location and Cross Section Location Map

List of Appendices

Appendix A	Summary Inspection Checklist
Appendix B	Slope Stability Analysis Results
Appendix C	Liquefaction Potential Analysis Results



1.0 INTRODUCTION

1.1 Purpose

On April 17, 2015, the United States Environmental Protection Agency (EPA) issued the Coal Combustion Residual (CCR) Resource Conservation and Recovery Act (RCRA) Rule (40 CFR 257 Subpart D) (“CCR RCRA Rule”) to regulate the beneficial use and disposal of CCR materials generated at coal-fired electrical power generating complexes. The CCR RCRA Rule requires that existing CCR surface impoundments meeting the requirements of Section 257.73(b) conduct initial and periodic structural stability assessments in accordance with Section 257.73(d) and safety factor assessments in accordance with Section 257.73(e). This report provides the initial structural stability assessment and the safety factor assessment for the Bottom Ash Pond surface impoundment (Bottom Ash Pond) at the D.E. Karn Generating Facility (DE Karn). A hazard potential classification was conducted for the Bottom Ash Pond pursuant to Section 257.73, which resulted in a low hazard potential classification. As a result of the low hazard potential classification, the 100-year flood elevation was used in the models to prepare this report.

1.2 Background

DE Karn is a coal-fired power generation facility located near Essexville, Michigan on the southern shore of Saginaw Bay as shown on Figure 1 – Site Location Map. The DE Karn Bottom Ash Pond is a hydraulically active CCR surface impoundment which receives sluiced bottom ash. The Bottom Ash Pond is located in the south side of the DE Karn ash disposal area (Figure 2), just north of DE Karn. Topographic and bathymetric surveys were conducted for the Bottom Ash Pond in May 2016 by Engineering & Environmental Solutions, LLC (E&ES), which were used to develop the assessments contained herein.

Bottom ash is sluiced from the DE Karn electrical generating units to the Bottom Ash Pond via an elevated trestle and pipe system. Stored bottom ash is removed via mechanical equipment as required to maintain storage capacity. The Bottom Ash Pond has one outlet located in the northeast corner of the pond that consists of a 24-inch diameter steel pipe. Water is discharged from the Bottom Ash Pond into a series of ditches that conveys the flow to the permitted National Pollutant Discharge Elimination System (NPDES) outfall located along the discharge channel.

1.3 Previous Evaluations

There are no certified records of previous slope stability analyses that have been performed for the Bottom Ash Pond embankments. A Probable Failure Mode Analysis (PFMA) was previously completed for DE Karn (AECOM 2009a) to identify structural (geotechnical) and environmental risks. Additionally, previous site inspections have been conducted to observe and document the structural conditions of the embankment dikes. A list of reviewed documents pertinent to the structural stability assessment is provided in Table 1.3.1.

**Table 1.3.1 - Previous Reviewed Documents Related to Structural Stability Assessment**

Document	Date	Author
D.E. Karn Bottom Ash Pond Annual RCRA CCR Surface Impoundment Inspection Report, January 2016	January 2016	Golder Associates Inc.
D.E. Karn Generating Facility, Triennial Ash Dike Risk Assessment Report – Spring 2014.	December 2014	Barr Engineering
D.E. Karn Ash Disposal Area 2012 Ash Dike Risk Assessment FINAL Inspection Report	August 2012	AECOM Technical Services, Inc.
Inspection Report D.E. Karn Generating Facility Ash Dike Risk Assessment, Essexville, Michigan	October 2009	AECOM Technical Services, Inc.
Potential Failure Mode Analysis (PFMA) Report, D.E. Karn Generating Facility Ash Dike Risk Assessment, Essexville, Michigan	October 2009	AECOM Technical Services, Inc.



2.0 SUBSURFACE CONDITIONS

The site is located at the east side of the confluence of the Saginaw River with Saginaw Bay (part of Lake Huron). Quaternary surficial deposits consist of a mixture of glacial, lacustrine, and alluvial deposits with varying thicknesses and extend to depths of approximately 100 to 120 feet below natural ground surface, where bedrock of the Saginaw formation consisting of gray and black shale is encountered. The glacial deposits generally consist of well sorted (poorly graded) outwash and glacial till. The till is relatively well graded (poorly sorted) and consists of a mixture of sand, silt, and clay. The lacustrine deposits consist of clay, silt, and sand with varying amounts of organics. The alluvial deposits consist of sand that was deposited by the adjacent Saginaw River.

Soil borings and laboratory testing programs were completed in 2015 and 2016 around the Bottom Ash Pond to develop site specific stratigraphy and engineering material properties. Cone penetrometer tests (CPT) were completed around the Bottom Ash Pond in 2008 and 2016. Historic investigations from 1981 and 2009 were also utilized to supplement more recent investigation data. The subsurface investigations and testing identified that the native near surface soils beneath the Bottom Ash Pond consist of alluvial sands, clayey silt, and peat; and the embankments consist primarily of CCR fill (both fly ash and bottom ash) and sand fill.



3.0 STRUCTURAL STABILITY ASSESSMENT [40 CFR 257.73(d)(1)(i-vii)]

The CCR RCRA Rule requires an initial and periodic structural stability assessment be conducted by a qualified professional engineer (QPE) to document whether the design, construction, operation, and maintenance is consistent with recognized and generally accepted good engineering practices for the maximum volume of CCR and CCR wastewater that can be impounded therein. The following sections provide documentation on the initial structural stability assessment and rely mainly on the recent and historic annual inspections performed at the site as well as the weekly field inspections performed by Consumers Energy Company (CEC). The most recent inspection was completed by Golder Associates Inc. (Golder) in May 2016 for the initial structural stability assessment. The summary inspection checklist for the May 2016 site inspection is included in Appendix A.

In accordance with the CCR RCRA Rule, in any calendar year in which both the periodic inspection by a QPE and the quinquennial (occurring every five years) structural stability assessment by a QPE required by Section 257.73(d) are required to be completed, the annual inspection is not required. If the annual inspection is not conducted in a year as provided by this paragraph, the deadline for completing the next annual inspection is one year from the date of completing the quinquennial structural stability assessment. As a result, a certified annual inspection report for the Bottom Ash Pond will not be required until October 2017.

3.1 Foundations and Abutments [40 CFR 257.73(d)(1)(i)]

Certified issued for construction (IFC) drawings were not available on the original design of the Bottom Ash Pond embankments. As previously noted, the foundation soils consist primarily of CCR fill and native sand soils, with occasional occurrences of thin layers of silty clay and peat. There has been no indication of foundational or abutment instability or movement in recent or historic site inspections and; therefore, the foundation soils and abutments are considered stable.

3.2 Slope Protection [40 CFR 257.73(d)(1)(ii)]

The downstream slopes of the embankments for the Bottom Ash Pond are protected from erosion and deterioration by the establishment of a vegetative cover. Existing slopes are inspected weekly for erosion, signs of seepage, animal burrows, sloughing, and plants that could negatively impact the embankment. The May 2016 inspection did not identify items relating to slope protection that required investigation or repair, and the downstream slopes of the Bottom Ash Pond are not subjected to wave or sudden drawdown effects. The existing slope protection measures are considered adequate to provide protection against surface erosion, wave action, and adverse effects of sudden drawdown.



3.3 Dikes (Embankment) [40 CFR 257.73(d)(1)(iii)]

As previously noted, certified IFC drawings were not available on the original design of the Bottom Ash Pond embankments. Based on subsurface investigation information, it is believed that the perimeter dike was constructed with standard earthwork equipment and fill consisting of bottom ash, fly ash, and sand. Results of the safety factor assessment detailed in Section 4.0 provide additional details on the stability of the external dike. Based on the relative density of the material encountered during the subsurface investigations, historic inspections, recent observations, and results of the safety factor assessment; the embankment dikes are considered sufficient to withstand the range or loading conditions in the Bottom Ash Pond.

3.4 Vegetated Slopes [40 CFR 257.73(d)(1)(iv)]

The EPA has vacated the requirement that vegetative cover on surface impoundment dikes be maintained at no more than six inches. A new rule establishing requirements relating to the use of vegetation as slope protection for CCR surface impoundments is still pending.

3.5 Spillways [40 CFR 257.73(d)(1)(v)]

There are no spillways on the Bottom Ash Pond. Flow is conveyed out of the Bottom Ash Pond via the outflow pipe as described in Section 3.6.

3.6 Hydraulic Structures [40 CFR 257.73(d)(1)(v)]

The Bottom Ash Pond has one outlet located in the northeast corner of the pond and consists of a 24-inch diameter steel pipe with an upstream invert of 591.6 feet (NAVD88). As a result, the normal operating level of the Bottom Ash Pond has been determined to be at elevation 591.6 feet (NAVD88).

The outflow pipe was identified as the only hydraulic structure that is underlying the base or passing through the external dike of the CCR unit. The Bottom Ash Pond outflow pipe was reported to be in good to fair condition in the 2014 Pipe Condition Assessment Report (Barr 2014b), which was based on a closed circuit television (CCTV) inspection of the hydraulic structures. No change to the conditions of the pipe was noted in the May 2016 inspection by Golder.

Based on review of the Barr Triennial Ash Dike Assessment Report and May 2016 inspection, the hydraulic structure that was inspected is free of significant deterioration, deformation, distortion, bedding deficiencies, sedimentation, and debris which may negatively affect the operation of the hydraulic structure.

3.7 Downstream Slopes Adjacent to Water Body [40 CFR 257.73(d)(1)(vii)]

The downstream slopes of the Bottom Ash Pond are not adjacent to water bodies and; therefore, rapid-drawdown was not considered a potential mechanism for structural instability of the exterior slope.



3.8 Structural Stability Deficiencies [40 CFR 257.73(d)(2)]

Based on the 2016 site inspection and structural stability assessment contained herein, no structural stability deficiencies were identified.



4.0 SAFETY FACTOR ASSESSMENT [40 CFR 257.73(e)]

According to Section 257.73(e)(1) of the CCR RCRA Rule, periodic safety factor assessments must be conducted for each CCR unit. The safety factor assessment must document the calculated factor of safety for the dike slopes under the following scenarios:

- Maximum Pool Storage - Section 257.73(e)(1)(i) – Defined as the long-term, maximum storage pool (or operating) elevation and approximately equal to the outlet elevation (elevation = 591.6 feet NAVD88) for this facility; static factor of safety must equal or exceed 1.50
- Maximum Pool Surcharge - Section 257.73(e)(1)(ii) – Defined as the temporary raised pond level above the maximum pool storage elevation due to an inflow design flood (594.0 feet NAVD88); static factor of safety must equal or exceed 1.40
- Seismic Loading Conditions - Section 257.73(e)(1)(iii) – Seismic factor of safety must equal or exceed 1.00
- Liquefaction Potential - Section 257.73(e)(1)(iv) – Only necessary for dikes constructed of soils that have susceptibility to liquefaction; factor of safety must equal or exceed 1.20

The following sections provide details on the factor of safety assessment and methods used to calculate the slope factor of safety and results of the analysis.

4.1 Slope Stability Analysis

Slope stability analyses were performed to evaluate the slope factor of safety for each of the maximum pool storage, maximum pool surcharge, and seismic loading scenarios. In the Preamble to Sections 257 and 261 of the CCR RCRA Rule *General Safety Factor Assessment Considerations* [VI (E)(3)(b)(ii)(a)], limit equilibrium methods are identified as conventional analysis procedures for calculating the factor of safety and specific common methods are identified, including the Morgenstern and Price method of slices (Abramson et al. 2002), which was used for this stability analysis.

4.1.1 Cross Sections Analyzed

Critical sections of the exterior dike were determined by using the existing topography (2016) and considering the interpreted soil profile from the subsurface investigations and estimated steady state seepage phreatic surface. The critical cross section is anticipated to be the most susceptible of all cross sections to structural failure based on appropriate engineering considerations, including loading conditions.

The critical section used for the slope stability analysis was located along the northern dike of the Bottom Ash Pond and is shown as Section A-A' on Figure 2.



4.1.2 Geotechnical Material Properties

Representative material properties based on subsurface investigations and laboratory testing were selected for use in the stability analysis for the critical section as follows: 1) loose to medium dense embankment fill consisting of CCR; 2) dense embankment fill consisting of CCR; and 3) lower sand (native foundation soil).

4.1.3 Pond Elevation and Phreatic Surface/Groundwater

The phreatic surface for the stability models was developed based on a steady state seepage model. Two upstream water boundary conditions were considered in the analyses; the maximum pool storage and the maximum pool surcharge conditions. For the maximum pool storage scenario, the upstream water boundary condition was set to pond water surface elevation of 591.6 feet (NAVD88). The maximum pool surcharge scenario considers the temporary rise of the pond water elevation due to rainfall and collection of site stormwater runoff during the design event. Bottom Ash Pond water elevations were calculated for the 100-year storm event, resulting in an increase in pond elevations to an elevation of 594.0 feet (NAVD88) which is slightly higher than the modeled elevation (593.97 NAVD88) provided in Golder's D.E. Karn Generating Facility Bottom Ash Pond, Inflow Design Flood Control System Plan (Golder 2016b).

The phreatic surface was estimated inside the embankment using steady state seepage module in Slide™ v7.017.

4.1.4 Vehicle Loading

The crest of the embankments are periodically used by maintenance vehicles as access roads around the pond and; therefore, a vehicle load was applied to the critical cross section for the maximum pool storage and maximum pool surcharge cases to model the loading effects of vehicle traffic. The vehicle load was applied based on American Association of State Highway and Transportation Officials (AASHTO) recommended loading for truck loads acting perpendicular to traffic (AASHTO 2012).

4.1.5 Seismic Loading Conditions

Factors of safety for stability under seismic conditions were calculated using the pseudo-static method. The peak ground acceleration (PGA) based on the 2008 United States Geological Survey (USGS) seismic hazard maps (Peterson et al. 2008) with a two percent probability of exceedance in 50 years (2,475-year return period) is 0.028g; however, the Natural Resources Conservation Service (NRCS) recommends a minimum seismic coefficient of 0.05g for Michigan, so a seismic coefficient of 0.05g was used in seismic analyses.



4.2 Stability Analysis Results

Slope stability analyses were performed for long-term static conditions for the critical cross section considered under maximum pool storage and maximum pool surcharge scenarios as well as pseudo-static seismic conditions. The results of the safety factor assessment are presented in Table 4.2.1, and critical failure surface result outputs are contained in Appendix B. The results indicate that the calculated factor of safety through the critical cross section in the Bottom Ash Pond surface impoundment meet or exceed the minimum values listed in Section 257.73(e)(1)(i-iv).

Table 4.2.1 - Slope Stability Analysis Results

Scenarios	Maximum Pool Storage	Maximum Pool Surcharge	Seismic
Required Safety Factor	1.50	1.40	1.00
Section	Calculated Safety Factor		
Section A-A'	1.52	1.52	1.35

4.3 Liquefaction Potential Assessment

Embankment and foundation soils were screened for seismically-induced liquefaction susceptibility using methods recommended by the National Center for Earthquake Research (NCEER), which uses CPT data (Youd et al. 2001; Robertson and Wride 1998). The calculated factor of safety against seismically-induced liquefaction is shown in Appendix C and was calculated to be greater than 1.20 throughout the depth of the embankments and underlying foundation in the evaluated CPT soundings for the considered earthquake loading. These screening-level results indicate that the embankments and foundation soils for the Bottom Ash Pond are not susceptible to seismically-induced liquefaction for the seismic loading considered.



5.0 SUMMARY

Based on our review of the information provided by CEC, onsite observations, and the results of the structural stability assessment; no structural stability deficiencies were identified in the Bottom Ash Pond surface impoundment during this assessment. Based on this same information and on our safety factor assessment, the calculated factor of safety through the critical cross section in the Bottom Ash Pond surface impoundment meets or exceeds the minimum values listed in Section 257.73(e)(1)(i-iv).



6.0 CLOSING

This report summarizes the results of the structural stability and factor of safety assessment to fulfill the provisions of Title 40 of the Code of Federal Regulations Section 257.73 (40 CFR Part 257.73) for the Bottom Ash Pond at DE Karn.

GOLDER ASSOCIATES INC.

Handwritten signature of Jeffrey Piaskowski in blue ink.

Jeffrey Piaskowski, P.E.
Project Engineer

Handwritten signature of Jeffrey Schneider in blue ink.

Jeffrey Schneider, P.E.
Senior Project Engineer

Handwritten signature of Matt Wachholz in blue ink.

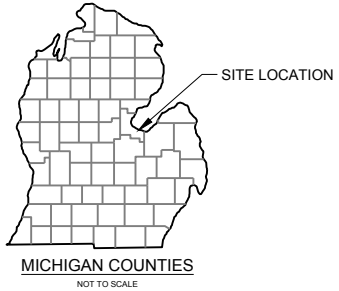
Matt Wachholz, P.E.
Senior Engineer



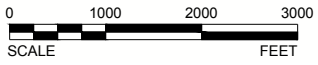
7.0 REFERENCES

- AASHTO, 2012. American Association of State Highway and Transportation Officials, Load Resistant Factor Design (LFRD) Bridge Design Specifications, 2012.
- Abramson, L.W., T.S. Lee, S. Sharma, and G.M. Boyce (2002). Slope Stability and Stabilization Methods, 2nd edition, John Wiley & Sons, New York.
- AECOM, 2009a. Potential Failure Mode Analysis (PFMA) Report, D.E. Karn Generating Facility Ash Dike Risk Assessment, Essexville, Michigan, AECOM Technical Services, Inc., October 2009.
- AECOM, 2009b. Inspection Report D.E. Karn Generating Facility Ash Dike Risk Assessment, Essexville, Michigan, AECOM Technical Services, Inc., October 2009.
- AECOM, 2012. D.E. Karn Ash Disposal Area 2012 Ash Dike Risk Assessment FINAL Inspection Report, AECOM Technical Services, Inc., August 2012.
- Barr, 2014a. D.E. Karn Ash Disposal Area, Triennial Ash Dike Risk Assessment Report – Spring 2014, Barr Engineering Company, December 8, 2014.
- Barr, 2014b. D.E. Karn Ash Disposal Area, Pipe Condition Assessment Report – Fall 2014. Barr Engineering Company, December 8, 2014.
- Golder, 2016a. D.E. Karn Bottom Ash Pond Annual RCRA CCR Surface Impoundment Inspection Report, January 2016.
- Golder, 2016b. D.E. Karn Generating Facility Bottom Ash Pond, Inflow Design Flood Control System Plan Golder Associates, Inc., report, October 2016.
- Petersen, Mark D., Arthur D. Frankel, Stephen C. Harmsen, Charles S. Mueller, Kathleen M. Haller, Russell L. Wheeler, Robert L. Wesson, Yuehua Zeng, Oliver S. Boyd, David M. Perkins, Nicolas Luco, Edward H. Field, Chris J. Wills, Kenneth S. Rukstales, (2008). Documentation for the 2008 Update of the United States National Seismic Hazard Maps, Open File Report 2008-1128, U.S. Department of the Interior, U.S. Geological Survey.
- Robertson, R. and Wride, C. 1998. Evaluating Cyclic Liquefaction Potential Using the Cone Penetration Test, Canadian Geotechnical Journal, vol. 35, pp. 442-459.
- “Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments,” Title 40 – Protection of the Environment Part 257 – Criteria for Classification of Solid Waste Disposal Facilities and Practices Subpart D – Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments.
- Youd, T., and Idriss, I., 2001. Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils, Journal of Geotechnical and Geoenvironmental Engineering, April 2001, pp. 297-313.

FIGURES



REFERENCE(S)
 BASE MAP TAKEN FROM USGS 7.5 MINUTE QUADRANGLE
 BAY CITY NE, MICHIGAN
 DATED 2014



CLIENT
CONSUMERS ENERGY COMPANY
 2742 NORTH WEADOCK HIGHWAY
 ESSEXVILLE, MI. 48732

PROJECT
D.E. KARN UNITS #1 AND #2
 BOTTOM ASH POND

CONSULTANT	YYYY-MM-DD	2016-08-22
	DESIGNED	MAL
	PREPARED	MAL
	REVIEWED	JRP
	APPROVED	MAB

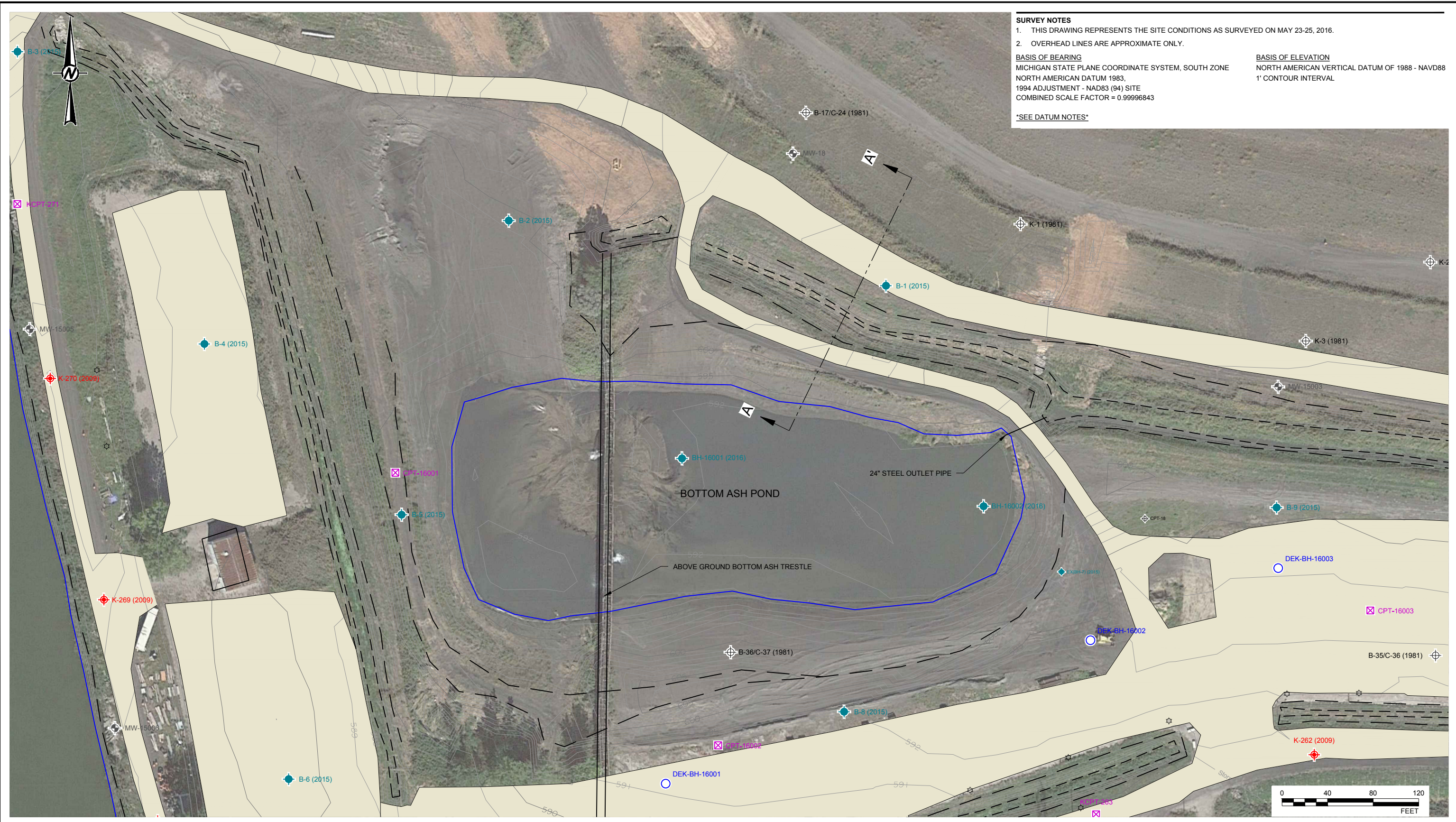


TITLE
SITE LOCATION MAP

PROJECT NO. 1655284 REV. 0 FIGURE 1

Path: \\sacramento\asad\Stiles\Work for Other Offices\Karn & Weadock\PRODUCTION_1\ File Name: 1655284_Karn_Location_Map.dwg

1 in IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A



SURVEY NOTES
 1. THIS DRAWING REPRESENTS THE SITE CONDITIONS AS SURVEYED ON MAY 23-25, 2016.
 2. OVERHEAD LINES ARE APPROXIMATE ONLY.

BASIS OF BEARING
 MICHIGAN STATE PLANE COORDINATE SYSTEM, SOUTH ZONE
 NORTH AMERICAN DATUM 1983,
 1994 ADJUSTMENT - NAD83 (94) SITE
 COMBINED SCALE FACTOR = 0.99996843

BASIS OF ELEVATION
 NORTH AMERICAN VERTICAL DATUM OF 1988 - NAVD88
 1' CONTOUR INTERVAL

SEE DATUM NOTES

MONITORING WELL	TOP OF BANK	B-35/C-36 (1981) HISTORIC BOREHOLE/ CPT
GRAVEL SURFACE / TRAVELED PATHWAY	TOE OF SLOPE	K-262 (2009) HISTORIC AECOM BOREHOLE/ CPT
ASPHALT SURFACE		B-9 (2015) GOLDER BOREHOLE
CONCRETE SURFACE		DEK-CPT-16003 HISTORIC CONETEC PIEZOCONE PENETRATION TESTING (CPT)
		KCPT HISTORIC CPT LOCATION (BY AECOM, 2)
		DEK-BH-16001 2016 GOLDER BOREHOLE

CLIENT
 CONSUMERS ENERGY COMPANY
 2742 NORTH WEADOCK HIGHWAY
 ESSEXVILLE, MI. 48732

CONSULTANT

YYYY-MM-DD	2016-09-16
DESIGNED	JS
PREPARED	CMN
REVIEWED	JS
APPROVED	MW

PROJECT
 D.E. KARN BOTTOM ASH POND
 2016 RCRA COMPLIANCE FACTOR OF SAFETY ASSESSMENT

TITLE
BOREHOLE LOCATION & CROSS SECTION MAP

PROJECT NO.
 1655284

REV. _____

FIGURE
2

Path: \\nasarament\share\Share_Work\Other Offices\1655284_DE Karn Bottom Ash Pond\CIVIL_3D_1\Fig Name_1655284_2016-08_Survey.dwg

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B

APPENDIX A
SUMMARY INSPECTION CHECKLIST

CCR SURFACE IMPOUNDMENT VISUAL INSPECTION CHECKLIST

Facility Name: D.E. Karn Bottom Ash Pond

Owner: Consumers Energy Company (CEC)

Purpose of Facility: Detention and settlement of sluiced bottom ash

County, State: Bay County, Michigan

Inspected By: Tiffany Johnson

Inspection Date: 05/18/16

Weather: Sunny, 65-degrees F

ITEM					REMARKS
	Acceptable	Monitor/Maintain	Investigate	Repair	
1. General Conditions					
a. Year Minimum Water Elevation					Elevation: 583.0 NAVD88
b. Year Average Water Elevation					Elevation: 591.6 NAVD88
c. Year Maximum Water Elevation					Elevation: 596.2 NAVD88
d. Current water level					Elevation: 591.6 NAVD88
e. Current storage capacity					Volume: 25,500 CY (see note 1)
f. Current volume of impounded water and CCR					Volume: 60,200 CY (see note 1)
g. Alterations	X				
h. Development of downstream plain	X				
i. Grass cover	X				
j. Settlement/misalignment/cracks	X				
k. Sudden drops in water level?					NA – No drop in water level observed.
2. Inflow Structure					
a. Settlement	X				
b. Cracking	X				
c. Corrosion		X			Perform routine maintenance of inflow piping and supports. See Note 2.
d. Obstacles in inlet	X				
e. Riprap/erosion control					NA – Bottom ash discharged from vertical trestle.
3. Outflow Structure					
a. Settlement	X				
b. Cracking	X				
c. Corrosion	X				
d. Obstacles in outlet	X				
e. Riprap/erosion control		X			Observed erosion around outlet pipe and missing riprap, maintain erosion and grading controls. See Note 2.
f. Seepage	X				
4. Upstream slope					
a. Erosion	X				Observed erosion rills along south exterior slope near trestles. Rills likely caused by ongoing leaks from trestle pipes. Maintain erosion and pipe maintenance controls. See Note 2.
b. Rodent burrows	X				
c. Vegetation		X			Phragmites located along interior slopes, maintain vegetation controls. See Note 2.
d. Cracks/settlement	X				
e. Riprap/other erosion protection	X				
f. Slide, Slough, Scarp	X				
5. Crest					
a. Soil condition	X				
b. Comparable to width from previous inspection	X				
c. Vegetation		X			Lack of vegetation along the crest, maintain erosion and vegetation controls. See Note 2.
d. Rodent burrows	X				
e. Exposed to heavy traffic	X				
f. Damage from vehicles/machinery	X				
6. Downstream slope					
a. Erosion		X			Observed interior erosion rills along north and southwest slopes and steep slopes on the south, maintain erosion controls. See Note 2.
b. Vegetation		X			Phragmites located along interior slopes, maintain vegetation controls. See Note 2.
c. Rodent burrows		X			Small burrows located on northern and western slopes, maintain animal control procedures. See Note 2.
d. Slide, Slough, Scarp	X				

ITEM					REMARKS
	Acceptable	Monitor/Maintain	Investigate	Repair	
e. Drain conditions	X				
f. Seepage	X				
7. Toe					
a. Vegetation		X			Phragmites located along west and southwest toes, maintain vegetation controls. See Note 2.
b. Rodent burrows	X				
c. Settlement	X				
d. Drainage conditions	X				
e. Seepage	X				

Notes:

- 1) Current volume of impounded water and CCR is based on an approximate bottom elevation of 583.0 feet (NAVD88) and normal operating level of 591.6 feet (NAVD88). The unit's storage capacity is based on an approximate pond bottom elevation of 583.0 feet NAVD88 and elevation 596.2 feet (NAVD88), which corresponds to the 2 feet below the lowest elevation of the exterior berm. Elevations used in this calculation are based off a May 2016 topographic and bathymetric survey completed by Engineering and Environmental Solutions, LLC (EES).
- 2) Features observed and documented in this checklist were not considered a deficiency or release as classified under 40 CFR 257.83(b)(5) and required no immediate action beyond periodic inspection in accordance with the SMP and typical maintenance.

PROFESSIONAL ENGINEER SEAL

Name of Engineer: Tiffany Johnson, P.E.

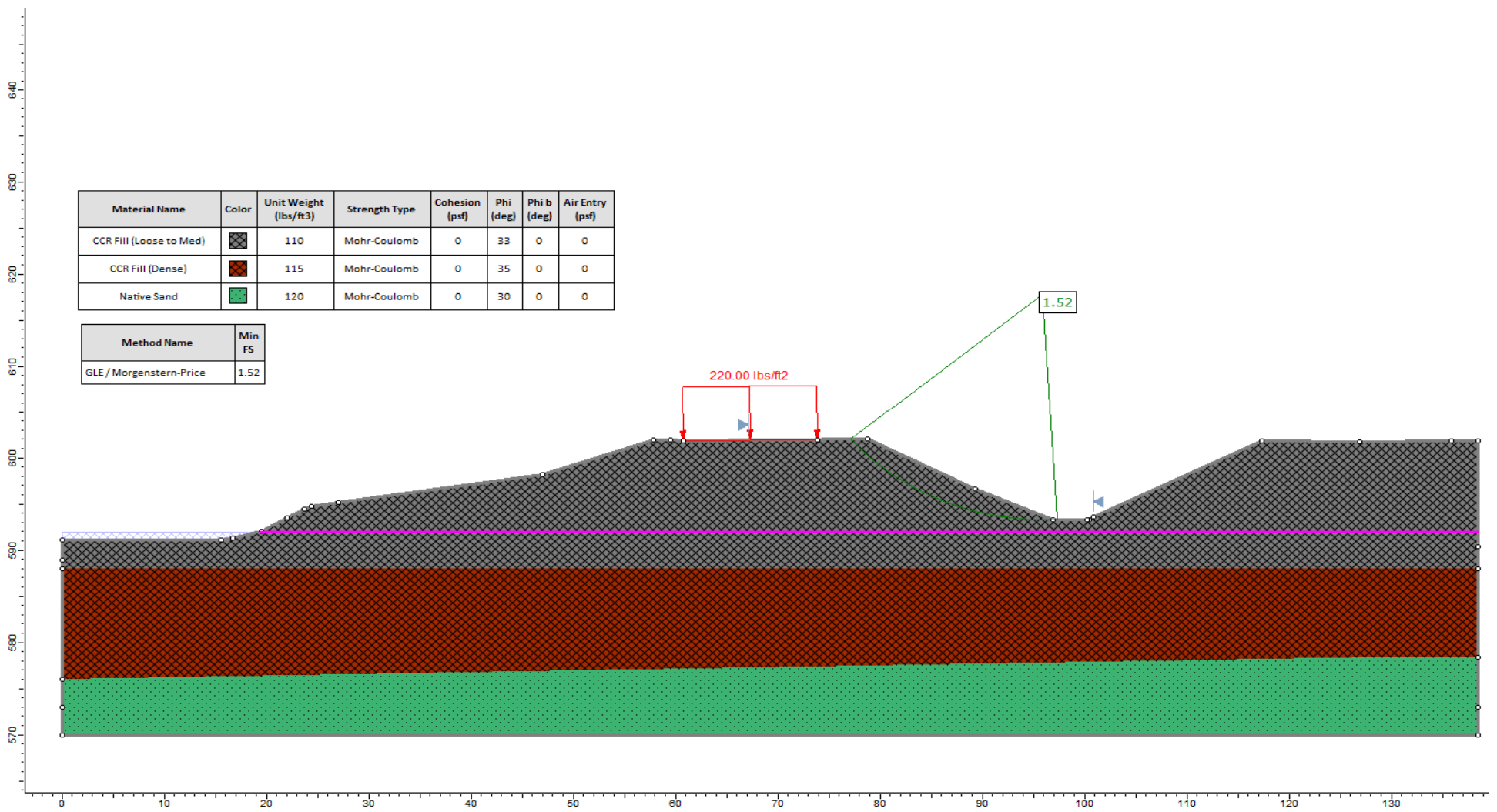
Date: 10/14/2016

Engineering Firm: Golder Associates Inc.

Signature:



APPENDIX B
SLOPE STABILITY ANALYSIS RESULTS



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Phi b (deg)	Air Entry (psf)
CCR Fill (Loose to Med)		110	Mohr-Coulomb	0	33	0	0
CCR Fill (Dense)		115	Mohr-Coulomb	0	35	0	0
Native Sand		120	Mohr-Coulomb	0	30	0	0

Method Name	Min FS
GLE / Morgenstern-Price	1.52



SCALE	AS SHOWN
DATE	Sep 2016
MADE BY	BF
CAD	-

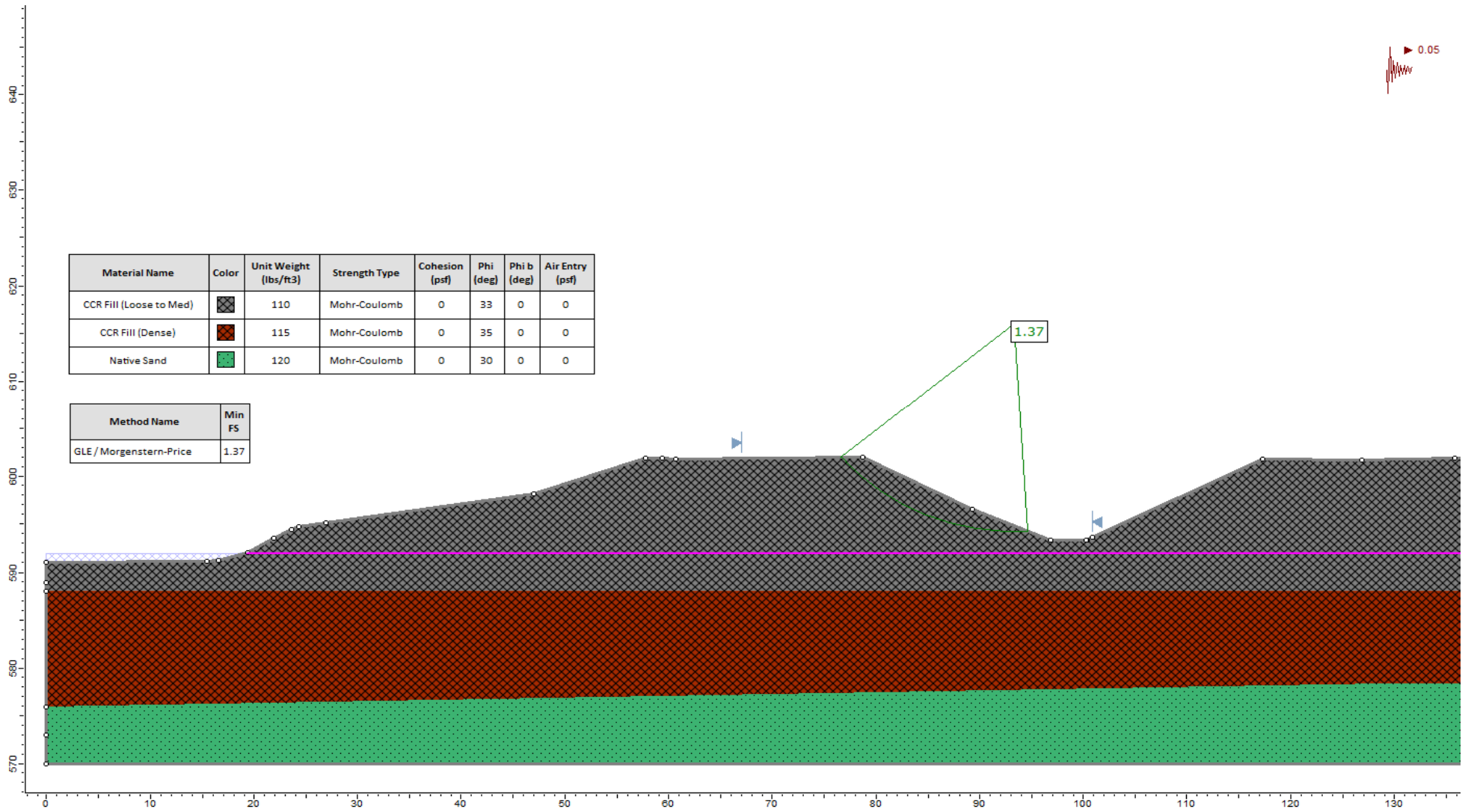
PROJECT	D.E. Karn Structural Stability Assessments	
TITLE	Bottom Ash Pond Section A-A' (North Slope)	
	Slope Factor of Safety	
	Max Pool Storage Scenario	

FILE	Karn_Bottom_Ash_Pond_Stability	
PROJECT No.	1655284	REV. 0

CHECK	JMS
REVIEW	MJW

CLIENT	Consumers Energy Company
--------	---------------------------------

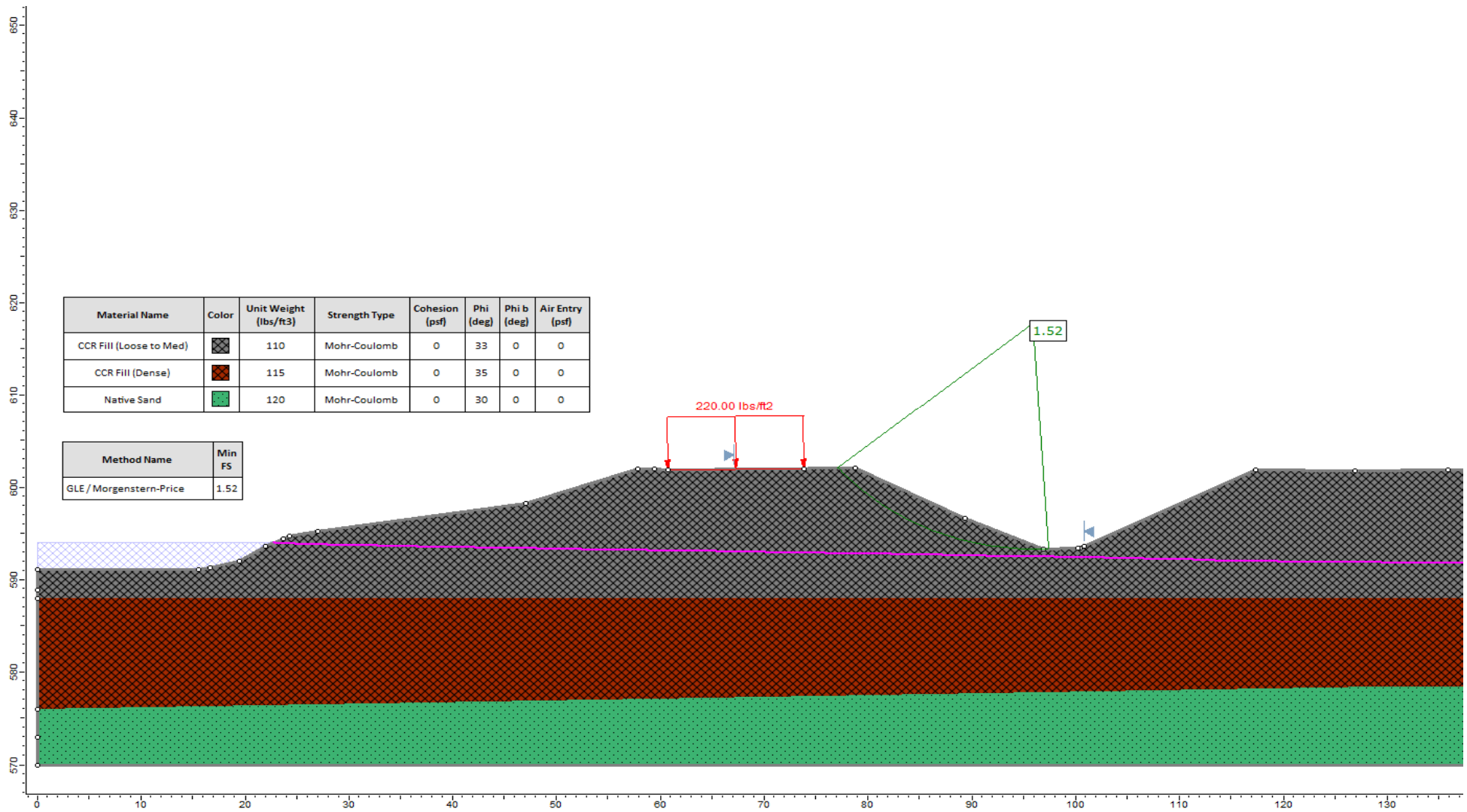
FIGURE	B-A1
--------	-------------



SCALE	AS SHOWN
DATE	Sep 2016
MADE BY	BF
CAD	-
CHECK	JMS
REVIEW	MJW

PROJECT	D.E. Karn Structural Stability Assessments	
TITLE	Bottom Ash Pond Section A-A' (North Slope)	
	Slope Factor of Safety	
	Max Pool Surcharge Scenario	
CLIENT	Consumers Energy Company	FIGURE
		B-A2

FILE	Karn_Bottom_Ash_Pond_Stability	
PROJECT No.	1654923	REV. 0



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Phi b (deg)	Air Entry (psf)
CCR Fill (Loose to Med)	Grey cross-hatch	110	Mohr-Coulomb	0	33	0	0
CCR Fill (Dense)	Brown cross-hatch	115	Mohr-Coulomb	0	35	0	0
Native Sand	Green cross-hatch	120	Mohr-Coulomb	0	30	0	0

Method Name	Min FS
GLE / Morgenstern-Price	1.52



	SCALE	AS SHOWN	PROJECT	D.E. Karn Structural Stability Assessments	
	DATE	Sep 2016	TITLE	Bottom Ash Pond Section A-A' (North Slope)	
	MADE BY	BF		Slope Factor of Safety	
	CAD	-		Seismic Scenario	
FILE	Karn_Bottom_Ash_Pond_Stability	CHECK	JMS	CLIENT	Consumers Energy Company
PROJECT No.	1654923	REVIEW	MJW	FIGURE	
	REV. 0				B-A3

APPENDIX C
LIQUEFACTION ANALYSIS RESULTS

Project: DE Karn RCRA
Location: Essexville, MI
Client: CEC
Proj No.: 1655284
Termination: Target Depth

Test Type: CPTU
Device: 15 cm², Type 2 filter
Standard: ASTM D5778
Push Co.: ConeTec
Operator: Thomas Carpenter

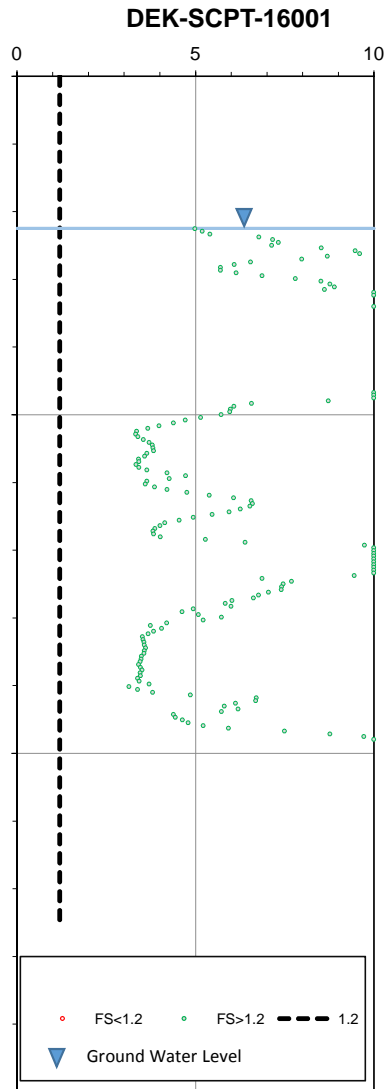
Golder Eng: AK
Check: AF
Review: JS
Max Depth: 50.0 ft

Design EQ 1
Magnitude: 6.8



CPT ID: DEK-SCPT-16001
Test Date: 5/19/2016
Northing: 783008
Easting: 13262522
Elevation: 599.0 ft
a_{max}: 0.04 g
Water Table: 9.0 ft

FACTOR OF SAFETY AGAINST LIQUEFACTION



Notes: Factors of safety (FS) greater than 10 are shown equal to 10.

NCEER (2001) method was used to calculate factors of safety against liquefaction.

The ground water levels shown here are the interpreted ground water levels at the time of CPT investigation.

No liquefaction assumed to be possible above the water table or if $qc1Ncs > 160$.

Established in 1960, Golder Associates is a global, employee-owned organization that helps clients find sustainable solutions to the challenges of finite resources, energy and water supply and management, waste management, urbanization, and climate change. We provide a wide range of independent consulting, design, and construction services in our specialist areas of earth, environment, and energy. By building strong relationships and meeting the needs of clients, our people have created one of the most trusted professional services organizations in the world.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Inc.
15851 South US 27, Suite 50
Lansing, MI 48906 USA
Tel: (517) 482-2262
Fax: (517) 482-2460



Engineering Earth's Development, Preserving Earth's Integrity

Golder, Golder Associates and the GA globe design are trademarks of Golder Associates Corporation