Structural Stability and Safety Factor Assessment Report

# J.H. CAMPBELL GENERATING FACILITY

# BOTTOM ASH PONDS 1-2 STRUCTURAL STABILITY AND SAFETY FACTOR ASSESSMENT REPORT

**West Olive, 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 USA

**October 2016** **1654923**

Golder Associates

# 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

STATE OF MICHIGAN
MATTHEW J. WACHHOLZ
ENGINEER
No.
47513
LICENSED PROFESSIONAL ENGINEER

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# 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 Bottom Ash Ponds 1-2 surface impoundment (Bottom Ash Ponds 1-2) at the J.H. Campbell Generating Facility (JH Campbell). A hazard potential classification was conducted for Bottom Ash Ponds 1-2 pursuant to Section 257.73, which resulted in a significant hazard classification. As a result of the hazard classification potential, the 1000-year flood elevation was used in the models to prepare this report.

## 1.2 Site Description and Background

JH Campbell is a coal-fired power generation facility located near West Olive, Michigan as presented on Figure 1 – Site Location Map. JH Campbell Bottom Ash Ponds 1-2 are hydraulically active CCR surface impoundments which receive sluiced bottom ash and coal pile runoff. Bottom Ash Ponds 1-2 consist of one northern pond (Bottom Ash Pond 1-2 North) and one southern pond (Bottom Ash Pond 1-2 South) separated by an internal dike. The ponds together are considered one CCR surface impoundment and are located in the southwestern side of the JH Campbell ash disposal area (Figure 2). Topographic and bathymetric surveys were conducted for Bottom Ash Ponds 1-2 in May and September 2016 by Engineering & Environmental Solutions, LLC (E&ES); which were used to develop the assessments contained herein.

Sluiced ash enters Bottom Ash Ponds 1-2 via an above-ground trestle, and coal pile runoff enters through two 6-inch diameter polyvinyl chloride (PVC) pipes located in the southwest and northwest corners of Bottom Ash Pond 1-2 North and Bottom Ash Pond 1-2 South, respectively. Bottom Ash Pond 1-2 North and Bottom Ash Pond 1-2 South have one outlet each and a connector pipe between the two ponds. Bottom Ash Pond 1-2 North outlet is located in the northeast corner of the pond and consists of a 24-inch diameter corrugated metal pipe (CMP). Bottom Ash Pond 1-2 South has an overflow outlet located in the southeast corner that consists of a 24-inch diameter CMP. Water is conveyed between the ponds via two 12-inch diameter steel pipes that pass through the center embankment.

## 1.3 Previous Evaluations

A slope stability analysis on the western embankment of Bottom Ash Pond 1-2 North was performed by STS in 1993. However, re-grading of the exterior slope has occurred since that report, and it is not considered to represent current conditions. A Probable Failure Mode Analysis (PFMA) was previously completed for JH Campbell (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 |
|---|---|---|
| J.H. Campbell Bottom Ash Pond 1-2 Annual RCRA CCR Surface Impoundment Inspection Report – January 2016 | January 2016 | Golder Associates Inc. |
| J.H. Campbell Ash Disposal Area Triennial Ash Dike Risk Assessment Report | December 2014 | Barr Engineering |
| Resource Conservation and Recovery Act Vertical Expansion Feasibility Investigation -2012 | December 2012 | Engineering & Environmental Solutions, LLC |
| J.H. Campbell Ash Disposal Area 2012 Ash Dike Risk Assessment FINAL Inspection Report | July 2012 | AECOM Technical Services, Inc. |
| Inspection Report J.H. Campbell Generating Facility Ash Dike Risk Assessment | November 2009 | AECOM Technical Services, Inc. |
| Potential Failure Mode Analysis (PFMA) Report J.H. Campbell Generating Facility Ash Dike Risk Assessment | November 2009 | AECOM Technical Services, Inc. |

## 2.0 SUBSURFACE CONDITIONS

The site is located near the east shore of Lake Michigan. Quaternary deposits in the area primarily consist of eolian sands extending to depths of approximately 45 to 60 feet below natural ground surface. The sands are underlain by fine-grained silty clay and clayey silt soils which extend down to bedrock. Bedrock of the Coldwater Shale deposits and Marshall Formation consisting of shale, sandstone, limestone, and siltstone exists at depths of approximately 140 feet below natural ground surface (STS 1993).

Soil borings and laboratory testing programs were completed in 2012, 2015, and 2016 around Bottom Ash Ponds 1-2 to develop site specific stratigraphy and engineering material properties. The subsurface investigations and testing identified that the native soil beneath Bottom Ash Ponds 1-2 consists of sand underlain by silty clay; and the embankments consist of compacted CCR fill and, in some locations, sand fill. The May and September 2016 surveys conducted by E&ES was used to develop the slope geometry in the stability analysis.

## 3.0 STRUCTURAL STABILITY ASSESSMENT [CFR 40 257.73(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 are 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 inspections were completed by Golder Associates Inc. (Golder) in May 2016 with a follow up inspection in October 2016 for the initial structural stability assessment. The summary inspection checklist for the May 2016 site inspection and October 2016 follow up 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 Bottom Ash Ponds 1-2 will not be required until October 2017.

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

Certified issued for construction (IFC) drawings were not available on the original design of the Bottom Ash Ponds 1-2 embankments. The foundation soils consist of native sand soils. 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 [CFR 40 257.73(d)(1)(ii)]

The downstream slope of the embankments for Bottom Ash Ponds 1-2 are protected from erosion and deterioration by the establishment of a vegetative cover. Recently regraded slopes have been mulched and reseeded. Existing slopes are inspected weekly for erosion, signs of seepage, animal burrows, sloughing, and plants that could negatively impact the embankment. The May 2016 site inspection and October 2016 follow up site inspection did not identify items relating to slope protection that required investigation or repair, and the downstream slopes of Bottom Ash Ponds 1-2 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) [CFR 40 257.73(d)(1)(iii)]

As previously noted, certified IFC drawings were not available on the original design of the Bottom Ash Ponds 1-2 embankments. Based on subsurface investigation information, it is believed that the perimeter dike was constructed with standard earthwork equipment and comprises of a fill consisting of bottom ash, fly ash and, in some locations, sand. In 1993, a portion of the west dike of Bottom Ash Pond 1-2 North was excavated and re-compacted. Additionally, geotextile and erosion protection block was installed to serve as slope protection beneath the ash conveyance trestle.

Regrading of portions of the exterior slope along the south, west, and northwest sides of Bottom Ash Ponds 1-2 to 2.5H:1V slope was completed in 2016 using Michigan Department of Transportation (MDOT) Class II aggregate sand fill. Results of the external dike stability analysis are provided in Section 4.0. Based on the relative density of the material encountered during the subsurface investigations, historic inspections, recent observations, and results of the stability analysis; the embankment dikes are considered sufficient to withstand the range of loading conditions in Bottom Ash Ponds 1-2.

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

There is one emergency spillway located on the west dike of Bottom Ash Pond 1-2 North beneath the ash conveyance trestle that was constructed in 1993. The emergency spillway is lined with erosion protection block and is underlain with geotextile along the interior and exterior slopes of the embankment. The elevation of the spillway crest is 621.5 feet (NGVD29), which is above the calculated 1000-year storm event elevation. Since the design elevation will not trigger flow out of the spillway structure, the spillway is considered to have been designed or constructed to manage flows from the peak discharge event. Design peak discharge flows are conveyed out of the ponds via outfall pipes as described in Section 3.6.

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

Bottom Ash Pond 1-2 North and Bottom Ash Pond 1-2 South have one outlet each and two connector pipes between the two ponds. Bottom Ash Pond 1-2 North outlet is located in the northeast corner of the pond and consists of a 24-inch diameter CMP with an upstream invert of 619.1 feet (NGVD29). Water is conveyed between the ponds via two 12-inch diameter steel pipes that pass through the center embankment with an invert of approximately 621.7 feet (NGVD29). Bottom Ash Pond 1-2 South has an overflow outlet located in the southeast corner that consists of a 24-inch diameter CMP with an upstream invert of 618.8 feet (NGVD29). As a result, the normal operating level of Bottom Ash Pond 1-2 North has been determined to be at elevation 619.1 feet (NGVD29) and the normal operating level of Bottom Ash Pond 1-2 South has been determined to be at elevation 618.8 feet (NGVD29).

The two outflow pipes and the two coal pile runoff inlet pipes were identified as the hydraulic structures that are underlying the base or passing through the external dike of the CCR unit. There is no record of an inspection of the two 6-inch PVC coal pile runoff inlet pipes; however, inspections of the pipes at their discharge locations indicate that the pipes appear to be functioning properly. These pipes are also planned to be either grouted or removed by the end of 2016.

The two outflow pipes were reported to be in good or good to fair condition in the 2014 Triennial Ash Dike Risk Assessment Report (Barr 2014a), which was based on a closed circuit television (CCTV) inspection of the hydraulic structures. No changes to the conditions of the pipes that were CCTV inspected in 2014 were noted in the October 2016 inspection by Golder.

Based on review of the Barr Triennial Ash Dike Assessment Report and May 2016 and October 2016 site inspection and follow up site inspection, respectively, the hydraulic structures that were inspected are 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 [CFR 40 257.73(d)(1)(vii)]

The downstream slopes of Bottom Ash Ponds 1-2 are not adjacent to water bodies and; therefore, rapid-drawdown was not considered a potential mechanism for structural instability in the exterior slope.

## 3.8 Structural Stability Deficiencies [CFR 40 257.73(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 [CFR 40 257.73(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 equal to the outlet elevation [elevation = 619.1 feet (NGVD29)[ 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 [620.1 feet (NGVD29)]; 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, phreatic surface. The critical cross section 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 western dike of Bottom Ash Ponds 1-2 North and is shown as Section A-A’ in Figure 2.

#### 4.1.2 Geotechnical Material Properties

Representative material properties based on the subsurface investigations and laboratory testing were selected for use in the stability analysis for the critical section as follows: 1) dike fill consisting of CCR (mix of bottom ash and fly ash); 2) sand (native foundation soil); 3) clay (native foundation soil); and 4) drainage channel gravel.

#### 4.1.3 Pond Elevation and Phreatic Surface/Groundwater

The phreatic surface for the stability models was developed based on water level measurements from standpipe piezometers installed within the embankment. Two upstream water boundary conditions were considered in the analyses; the maximum pool storage and the maximum pool surcharge conditions. 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. Pond water elevations were calculated for the 1000-year storm event, resulting in an increase in pond elevations to an elevation of 620.14 feet (NGVD29) for Bottom Ash Pond 1-2 North and 619.32 feet (NGVD29) for Bottom Ash Pond 1-2 South, as provided in Golder's J.H. Campbell Generating Facility Bottom Ash Ponds 1-2, Inflow Design Flood Control System Plan (Golder 2016b).

Downstream water boundary condition was set to water elevations observed in the ditch of approximately 601.0 feet (NGVD29). For the maximum pool storage scenario, upstream water boundary condition was set to pond water surface elevation of 619.1 feet (NGVD29) based on the primary outlet upstream invert elevation. For the maximum pool surcharge scenario, upstream water boundary condition was set to pond water surface elevation of 620.1 feet (NGVD29) based on the 1000-year storm pond water elevation.

The phreatic surface was estimated inside the embankment by using piezometer water level measurements with known pond elevations to calibrate the model.

#### 4.1.4 Vehicle Loading

The crest of the embankments are periodically used by maintenance vehicles as access roads around the ponds 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 0.033g; 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 slope stability analyses cases 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 Bottom Ash Ponds 1-2 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' | 1.53 | 1.49 | 1.36 |

## 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 Cone Penetrometer Test (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 Bottom Ash Ponds 1-2 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 Bottom Ash Ponds 1-2 surface impoundment during this assessment. Based on this same information and on our analyses, the calculated factor of safety through the critical cross section in Bottom Ash Ponds 1-2 surface impoundment meet or exceed 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 Bottom Ash Ponds 1-2 at JH Campbell.

**GOLDER ASSOCIATES INC.**

Jeffrey Piaskowski, P.E.
Project Engineer

Jeffrey Schneider, P.E.
Senior Project Engineer

Matt Wachholz, P.E.
Senior Engineer

## 7.0 REFERENCES


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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 Unites States National Seismic Hazard Maps, Open File Report 2008-1128, U.S. Department of the Interior, U.S. Geological Survey.

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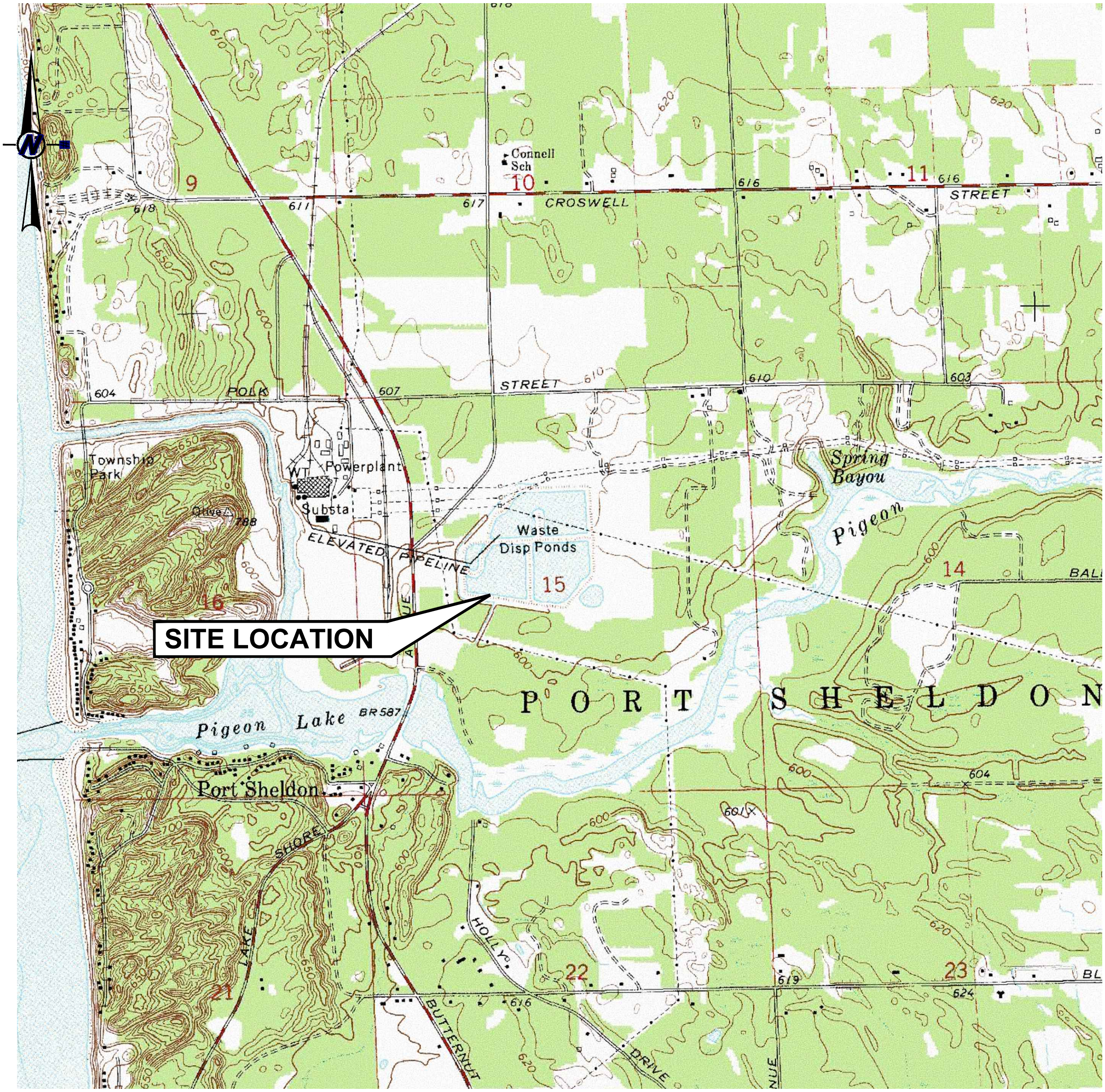
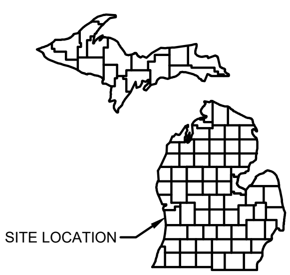
**FIGURES**




MICHIGAN COUNTIES

NOT TO SCALE

**REFERENCE(S)**

1. BASE MAP TAKEN FROM 7.5 MINUTE U.S.G.S. QUADRANGLES OF PORT SHELDON MICHIGAN, DOWNLOADED FROM MICHIGAN DNR WEBSITE JUNE 2016.

0 1000 2000

1" = 2000' FEET

CLIENT

CONSUMERS ENERGY COMPANY
17000 CROSWELL ST.
WEST OLIVE, MI 49460

PROJECT

2016 RCRA COMPLIANCE STRUCTURAL STABILITY & SAFETY FACTOR ASSESSMENT

CONSULTANT

Golder Associates

| | |
|---|---|
| YYYY-MM-DD | 2016-06-06 |
| DESIGNED | JS |
| PREPARED | ARM |
| REVIEWED | DJS |
| APPROVED | MAB |

TITLE

**SITE LOCATION MAP**

| PROJECT NO. | REV. | FIGURE |
|---|---|---|
| 1654923 | # | 1 |

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

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## NOTES

1. CONTOURS SHOWN ARE FROM MAY 2016 AND SEPTEMBER 2016 GROUND SURVEYS.

## LEGEND

- SOIL BORING (2016)
- HISTORICAL SOIL BORING
- PIEZOMETER
- MONITORING WELL
- CPTS (GOLDER 2016)


APPROXIMATE LOCATION OF 10" BURIED PIPE

N

0 40 80

SCALE: 1"=40'

| REFERENCE DRAWINGS | REV | DATE | DESCRIPTION | BY | CHK | APP | REV | DATE | DESCRIPTION | BY | CHK | APP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 10/6/2016 | FILED IN OWNER'S OPERATING RECORD | AM | DS | JP |

Consumers Energy

J.H. CAMPBELL ASH STORAGE FACILITY

2016 RCRA COMPLIANCE FACTOR OF SAFETY ASSESSMENT

BOTTOM ASH PONDS 1-2 PLAN VIEW

BOREHOLE LOCATION AND CROSS SECTION LOCATION MAP

| SCALE | 1" = 40' | DRAWING NO. | UNIT# | FIGURE | REV. |
|---|---|---|---|---|---|
| JOB | 1654923 | ---- | | 2 | A |

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**APPENDIX A**
**SUMMARY INSPECTION CHECKLIST**

# CCR SURFACE IMPOUNDMENT VISUAL INSPECTION CHECKLIST

***Facility Name: J.H. Campbell Bottom Ash Pond 1-2***
***Owner: Consumers Energy Company (CEC)***
***Purpose of Facility: Detention and settlement of sluiced bottom ash from Unit 1-2***
***County, State: Ottawa County, Michigan***
***Inspected By: Tiffany Johnson*** ***Inspection Date: 5/19/2016 and 10/6/2016***
***Weather: Cloudy, 60-degrees F***

| ITEM | | Acceptable | Monitor/Maintain | Investigate | Repair | REMARKS |
|---|---|---|---|---|---|---|
| 1. | General Conditions | | | | | |
| a. | Year Minimum Water Elevation | | | | | Elevation: 618.78 (normal operating level of Bottom Ash Pond 1-2S) |
| b. | Year Average Water Elevation | | | | | Elevation: 618.93 (Average operating level between Bottom Ash Ponds 1-2S and 1-2N) |
| c. | Year Maximum Water Elevation | | | | | Elevation: 619.08 (normal operating level of Bottom Ash Pond 1-2N) |
| d. | Current water level | | | | | Elevation: 619.08 (normal operating level of Bottom Ash Pond 1-2N) |
| e. | Current storage capacity | | | | | Volume: ~40,800 CY Pond 1-2S / ~50,700 CY Pond 1-2N (See Note 1) |
| f. | Current volume of impounded water and CCR | | | | | Volume: ~49,300 CY Pond 1-2S / ~ 60,300 CY Pond 1-2N (See Note 1) |
| g. | Alterations | X | | | | |
| h. | Development of downstream plain | | X | | | Intermittent historical plains observed from active and historical seeps, maintain water level controls and erosion controls. See Note 5. |
| i. | Grass cover | X | | | | |
| j. | Settlement/misalignment/cracks | | X | | | Continue weekly monitoring in accordance with SMP, no change was observed. See Note 2. |
| k. | Sudden drops in water level? | | | | | NA – No drop in water level observed. |
| 2. | Inflow Structure | | | | | |
| a. | Settlement | X | | | | |
| b. | Cracking | | X | | | The inflow piping structure in between Ponds 1-2 north and south was leaking at the time of inspection. Repair cracked area in accordance with the SMP. See Note 5. |
| c. | Corrosion | | X | | | Perform routine maintenance of inflow piping and supports. See Note 5. |
| d. | Obstacles in inlet | X | | | | |
| e. | Riprap/erosion control | | X | | | See Note 3. |
| 3. | Outflow Structure | | | | | |
| a. | Settlement | X | | | | |
| b. | Cracking | X | | | | |
| c. | Corrosion | X | | | | |
| d. | Obstacles in outlet | X | | | | |
| e. | Riprap/erosion control | | X | | | Minor erosion observed around outlet pipe along interior slope of 1-2S, maintain erosion controls in this area. See Note 5. |
| f. | Seepage | X | | | | |
| 4. | Upstream slope | | | | | |
| a. | Erosion | | X | | | Intermittent interior erosion rills noted along interior slopes, maintain erosion controls in this area as needed to protect the outflow pipes. See Note 5. |
| b. | Rodent burrows | X | | | | |
| c. | Vegetation | X | | | | |
| 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 | | | | |
| d. | Rodent burrows | X | | | | |
| e. | Exposed to heavy traffic | X | | | | |
| f. | Damage from vehicles/machinery | X | | | | |
| 6. | Downstream slope | | | | | |
| a. | Erosion | | X | | | Minor erosion noted along west exterior slope, maintain erosion controls in this area. See Note 5. |
| b. | Vegetation | | X | | | Sparse vegetation observed intermittently along west and north slopes, maintain vegetation controls. See Note 5. |
| c. | Rodent burrows | X | | | | |
| d. | Slide, Slough, Scarp | | X | | | See Note 2. |
| e. | Drain conditions | X | | | | |
| f. | Seepage | X | | | | |

| ITEM | Acceptable | Monitor/Maintain | Investigate | Repair | REMARKS |
|---|---|---|---|---|---|
| 7. Toe | | | | | |
| a. Vegetation | | X | | | Observed intermittent woody vegetation, maintain vegetation controls. See Note 5. |
| b. Rodent burrows | X | | | | |
| c. Settlement | X | | | | |
| d. Drainage conditions | | X | | | See Note 4. |
| e. Seepage | | X | | | See Note 4. |

***Notes:***

1) Current storage capacity is based on an approximate bottom of CCR elevation that ranges from an approximate elevation of 594 feet to 602 feet NGVD29 and two feet of freeboard measured from a topographic survey collected in May of 2016 (622.71 NGVD29). Volume of impounded water and CCR are based on an approximate bottom of CCR elevation that ranges from an approximate elevation of 594 feet to 602 feet NGVD29 and pond operating level (618.78 feet and 619.08 feet NGVD29 respectively for Pond 1-2S and Pond 1-2N) based on a topographic survey collected in May of 2016.
2) Evidence of historic sloughing and settlement was observed along areas of the western slope of the Bottom Ash Pond. Areas of historic movement appeared unchanged from previous inspection. Golder recommends weekly observations for visual changes in appearance or further movement. This item is not considered a deficiency or release requiring immediate action per 40 CFR 257.83(b)(5).
3) Erosion controls for the base of support trestles for both ponds should be routinely maintained as required, focusing on the area of inflow pipe that is actively leaking. Suggest reconfiguring discharge pipe or adding additional armoring around the discharge in this area. This item is not considered a deficiency or release requiring immediate action per 40 CFR 257.83(b)(5).
4) Seepage was observed at multiple locations along the toe of the Bottom Ash Pond 1-2. Evidence of historic piping was also observed but was not active. Active sediment transport was not observed at the time of inspection. It appears the seepage has not increased or produced additional sediment loss compared to the previous inspection in 2015. Golder recommends that CEC visually monitor the seeps weekly, per the site's SMP, to identify changes in seep flow, sediment transport, or visible piping. This item is not considered a deficiency or release requiring immediate action per 40 CFR 257.83(b)(5).
5) 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.

***Name of Engineer: Tiffany Johnson, P.E.***

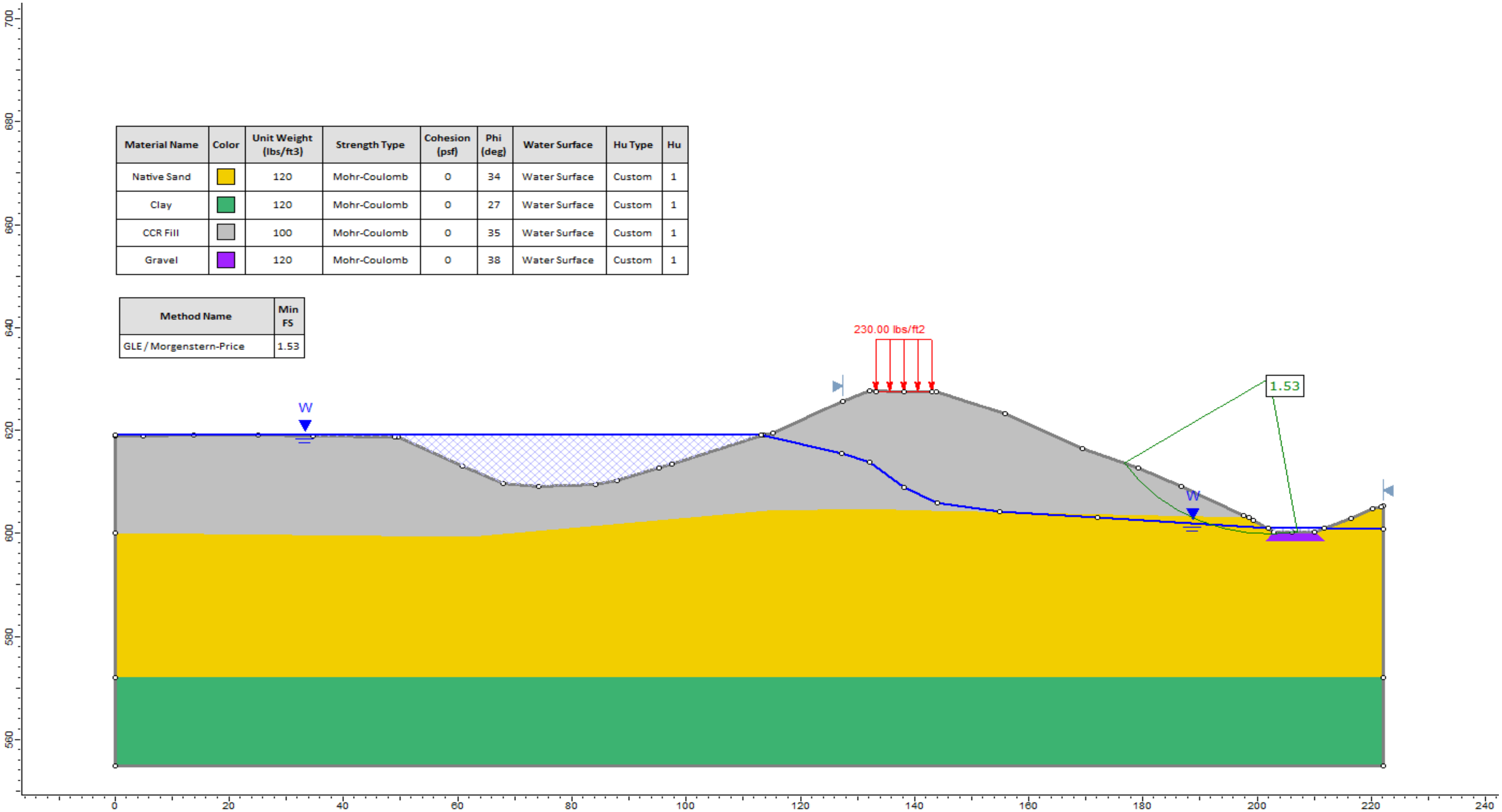
***Date: 10/14/2016***

***Engineering Firm: Golder Associates Inc.***

***Signature:***

PROFESSIONAL ENGINEER SEAL

# APPENDIX B
# SLOPE STABILITY ANALYSIS RESULTS




| Material Name | Color | Unit Weight (lbs/ft3) | Strength Type | Cohesion (psf) | Phi (deg) | Water Surface | Hu Type | Hu |
|---|---|---|---|---|---|---|---|---|
| Native Sand | | 120 | Mohr-Coulomb | 0 | 34 | Water Surface | Custom | 1 |
| Clay | | 120 | Mohr-Coulomb | 0 | 27 | Water Surface | Custom | 1 |
| CCR Fill | | 100 | Mohr-Coulomb | 0 | 35 | Water Surface | Custom | 1 |
| Gravel | | 120 | Mohr-Coulomb | 0 | 38 | Water Surface | Custom | 1 |

| Method Name | Min FS |
|---|---|
| GLE / Morgenstern-Price | 1.53 |

Golder Associates

| | |
|---|---|
| SCALE | AS SHOWN |
| DATE | Aug 2016 |
| MADE BY | AK |
| CAD | - |
| CHECK | JS |
| REVIEW | MW |
| FILE | STABILITY |
| PROJECT No. | 1654923 |
| REV. | 0 |

PROJECT **J.H. Campbell Structural Stability Assessments**

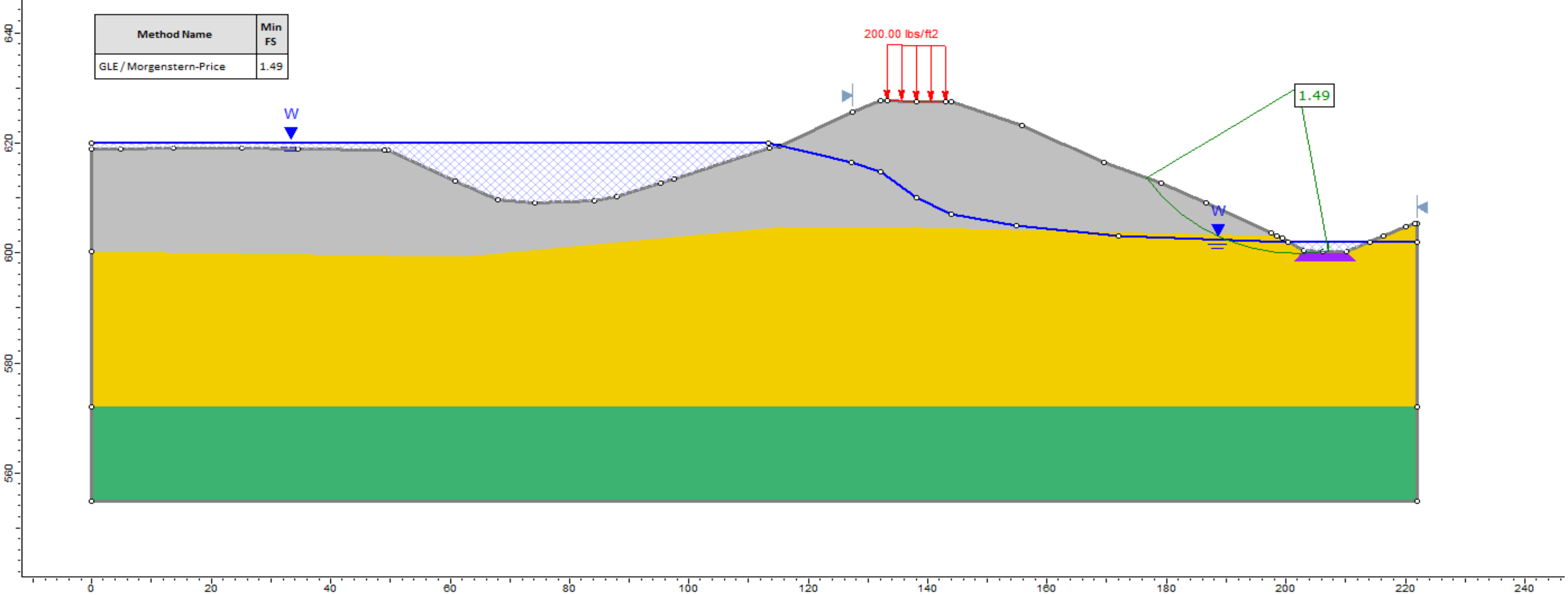
TITLE **Unit 1-2 Bottom Ash Pond Section A-A' Slope Factor of Safety Max Pool Storage Scenario**

CLIENT **Consumers Energy Company**

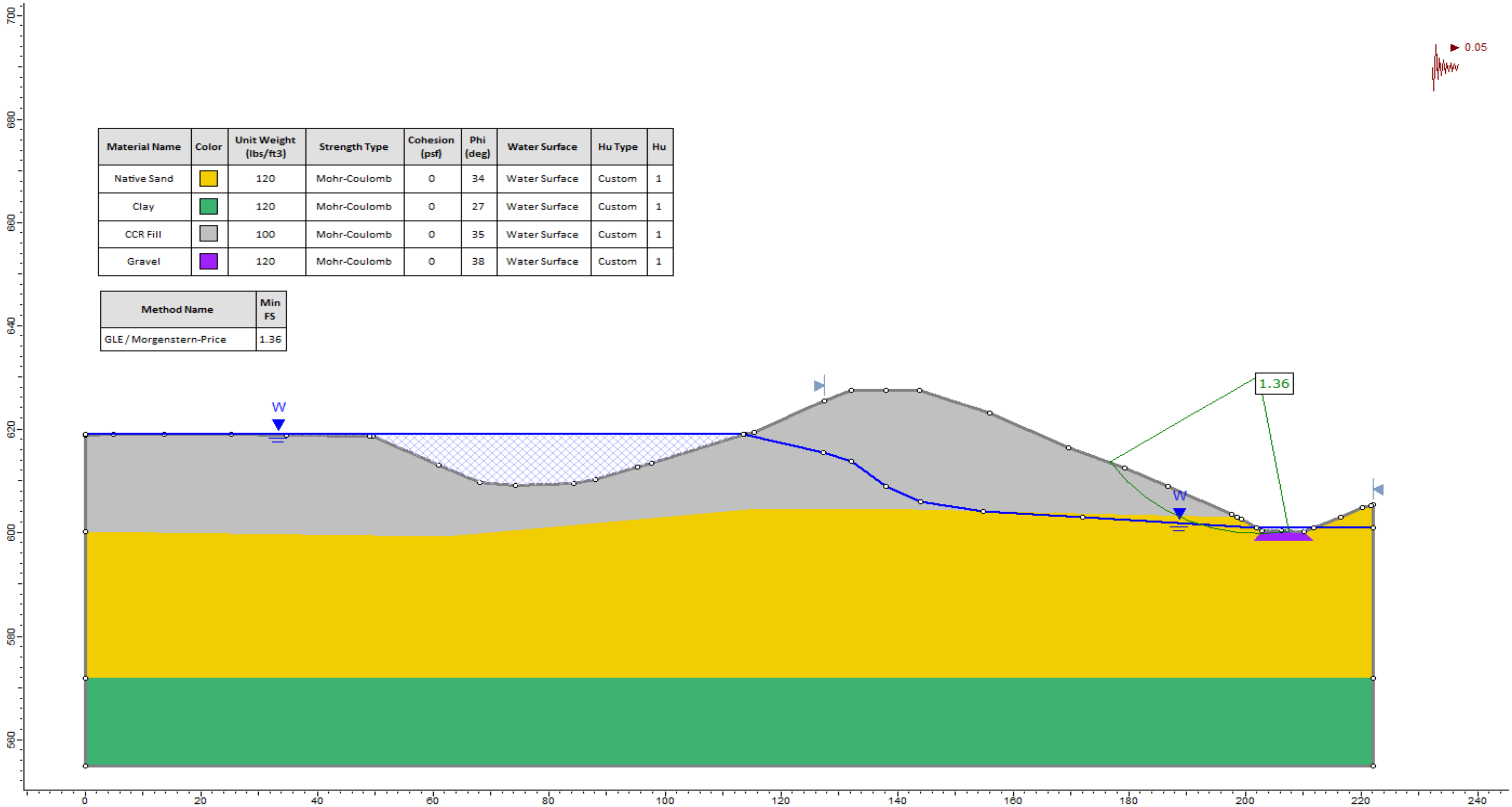
FIGURE **B-A1**

| Material Name | Color | Unit Weight (lbs/ft3) | Strength Type | Cohesion (psf) | Phi (deg) | Water Surface | Hu Type | Hu |
|---|---|---|---|---|---|---|---|---|
| Native Sand | | 120 | Mohr-Coulomb | 0 | 34 | Water Surface | Custom | 1 |
| Clay | | 120 | Mohr-Coulomb | 0 | 27 | Water Surface | Custom | 1 |
| CCR Fill | | 100 | Mohr-Coulomb | 0 | 35 | Water Surface | Custom | 1 |
| Gravel | | 120 | Mohr-Coulomb | 0 | 38 | Water Surface | Custom | 1 |

| Method Name | Min FS |
|---|---|
| GLE / Morgenstern-Price | 1.49 |




| | | | |
|---|---|---|---|
| Golder Associates | SCALE AS SHOWN | PROJECT | J.H. Campbell Structural Stability Assessments |
| | DATE Aug 2016 | TITLE | Unit 1-2 Bottom Ash Pond Section A-A' Slope Factor of Safety Max Pool Surcharge Scenario |
| | MADE BY AK | | |
| | CAD - | | |
| FILE STABILITY | CHECK JS | CLIENT | Consumers Energy Company |
| PROJECT No. 1654923 REV. 0 | REVIEW MW | FIGURE | B-A2 |




| Material Name | Color | Unit Weight (lbs/ft3) | Strength Type | Cohesion (psf) | Phi (deg) | Water Surface | Hu Type | Hu |
|---|---|---|---|---|---|---|---|---|
| Native Sand | | 120 | Mohr-Coulomb | 0 | 34 | Water Surface | Custom | 1 |
| Clay | | 120 | Mohr-Coulomb | 0 | 27 | Water Surface | Custom | 1 |
| CCR Fill | | 100 | Mohr-Coulomb | 0 | 35 | Water Surface | Custom | 1 |
| Gravel | | 120 | Mohr-Coulomb | 0 | 38 | Water Surface | Custom | 1 |

| Method Name | Min FS |
|---|---|
| GLE / Morgenstern-Price | 1.36 |

Golder Associates

| | | | |
|---|---|---|---|
| SCALE | AS SHOWN | PROJECT | J.H. Campbell Structural Stability Assessments |
| DATE | Aug 2016 | TITLE | Unit 1-2 Bottom Ash Pond Section A-A' Slope Factor of Safety Seismic Scenario |
| MADE BY | AK | | |
| CAD | - | | |
| FILE | STABILITY | CHECK | JS |
| PROJECT No. | 1654923 | REV. | 0 |
| REVIEW | MW | CLIENT | Consumers Energy Company |
| FIGURE | B-A3 | | |

**APPENDIX C**
**LIQUIFACTION POTENTIAL ANALYSIS RESULTS**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project:** | JH Campbell RCRA | **Test Type:** | CPTU | **Golder Eng:** | AK | **Design EQ 1** | |
| **Location:** | West Olive, MI | **Device:** | 15 $cm^2$, Type 2 filter | **Check** | AF | **Magnitude:** | 6.4 |
| **Client:** | CEC | **Standard:** | ASTM D5778 | **Review:** | JS | | |
| **Proj No.:** | 1654923 | **Push Co.:** | ConeTec | **Max Depth:** | 50.0 ft | | |
| **Area:** | Ponds 1-2 | **Operator:** | Thomas Carpenter | **Termination:** | Target Depth | | |

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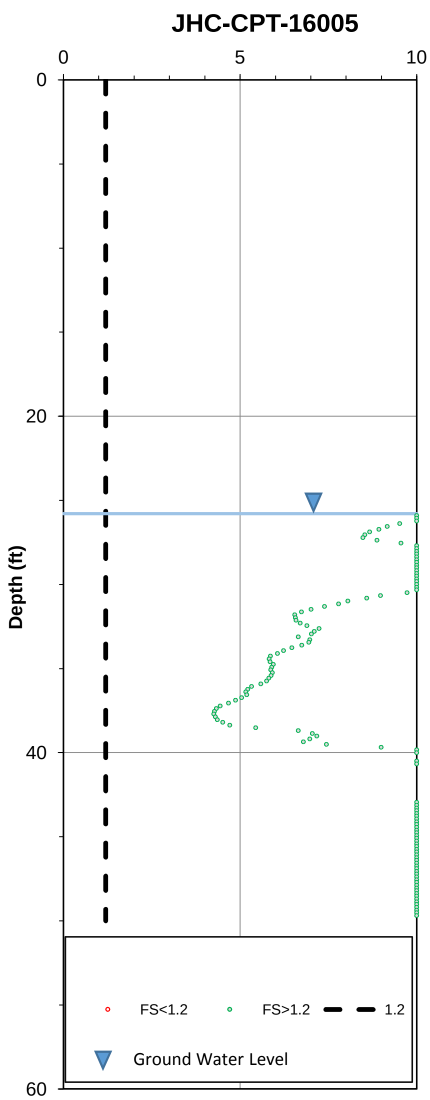
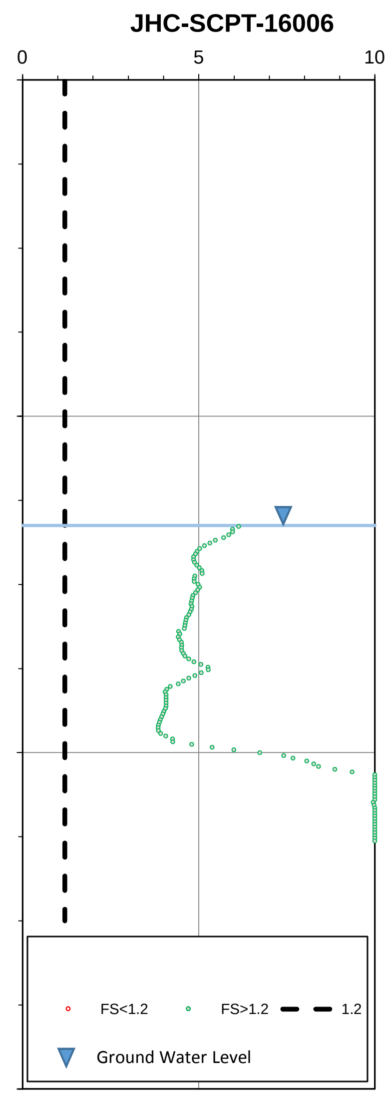
| | | | |
|---|---|---|---|
| **CPT ID:** | JHC-CPT-16005 | **CPT ID:** | JHC-SCPT-16006 |
| **Test Date:** | 5/17/2016 | **Test Date:** | 5/16/2016 |
| **Northing:** | 518471 | **Northing:** | 517983 |
| **Easting:** | 12633629 | **Easting:** | 12633535 |
| **Elevation:** | 628.5 ft | **Elevation:** | 625.0 ft |
| **$a_{max}$:** | 0.06 g | **$a_{max}$:** | 0.06 g |
| **Water Table:** | 25.8 ft | **Water Table:** | 26.5 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.

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Golder Associates

**Engineering Earth's Development, Preserving Earth's Integrity**