J.R. WHITING GENERATING FACILITY

PONDS 1 AND 2 CLOSURE PLAN

Erie, Michigan

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

Submitted By: Golder Associates Inc.
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December 18, 2017 **1667572**

Golder Associates

CERTIFICATION

Professional Engineer Certification Statement [40 CFR 257.102(b)(4)]

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 257.102 (40 CFR Part 257.102), I attest that this Closure Plan 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 257.102.

Golder Associates Inc.

Signature

December 18, 2017

Date of Report Certification

Tiffany D. Johnson

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Professional Engineer Certification Number

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1.0 INTRODUCTION AND SITE DESCRIPTION

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. In accordance with the CCR RCRA Rule, any CCR surface impoundment or CCR landfill that was actively receiving CCR on the effective date of the CCR RCRA Rule (October 19, 2015) was deemed to be an "Existing CCR Unit" on that date and subject to self-implementing compliance standards and schedules. Consumers Energy Company (CEC) identified one existing CCR surface impoundment (Ponds 1 and 2) at the J.R. Whiting Generating Facility (JR Whiting):

This written closure plan for Ponds 1 and 2 at JR Whiting is being generated pursuant to the following applicable closure performance standards when leaving CCR in place:

- RCRA
  - 40 CFR 257.102(d)
- Michigan Department of Environmental Quality (MDEQ)
  - Part 115 R 299.4304
  - Part 115 R 299.4309
  - Part 115 R 299.4317

This plan supports closure of the JR Whiting Ponds 1 and 2 existing CCR surface impoundment in a manner consistent with recognized and generally accepted good engineering practices. Specific requirements for post-closure care, groundwater monitoring, and corrective action are referenced in Section 6.0 Post Closure.

JR Whiting Ponds 1 and 2 are licensed under MDEQ State of Michigan Natural Resources and Environmental Protection Act, 1994 P.A. Part 115 Rules (Part 115 rules) as existing Type III Industrial Waste Surface Impoundments, Facility ID Number 397664, Operating License Number 9403, expiring August 25, 2019. The Ponds 1 and 2 surface impoundment was also permitted as process water treatment units under the National Pollutant Discharge Elimination System (NPDES). An Engineering Plan for Ponds 1 and 2 was approved in 1991 (J.R. Whiting Solid Waste Disposal Area Engineering Plan, February 1, 1991; revised February 7, 1991) in conformance with special condition "J" of the JR Whiting Solid Waste Disposal Area License No. 7759, issued October 25, 1990. JR Whiting Ponds 1 and 2 were constructed prior to Acts 641 and 87; therefore, are not subject to the Act 641 construction permit and engineering plan requirements. The components and configuration of the final cover was designed to address the requirements of Part 115 Rules R 299.4304(1), R 299.4304(5), R 299.4304(6), and R 299.4309(7) for final

covers over Type III landfills; which are understood to also meet the closure performance requirements set forth in 40 CFR 257.102(d)(3)(i)(A) through (D).

Ponds 1 and 2 are located to the east of the former J.R. Whiting Generating Facility and cover approximately 23.82 acres, per the current MDEQ Operating License. Ponds 1 and 2 are bounded by a perimeter berm. Lake Erie is located to the east, the Discharge Channel is located to the south, Erie Road is located to the north, and the Forebay is located to the west of the ponds. Bottom ash and plant process water were hydraulically discharged into Ponds 1 and 2 until JR Whiting ceased electrical generation on April 15, 2016. Occasionally, sluiced fly ash was sent to Ponds 1 and 2 as a backup for the dry ash handling system. Ponds 1 and 2 are hydraulically connected via culverts through the central divider berm. Flow from both ponds was discharged through a common outfall in Pond 1 into the Forebay in accordance with a NPDES permit. This outfall pipe has been grouted and abandoned in place, so there is currently no discharge from Ponds 1 and 2. Discharge from the ponds during construction will be directed through Compliance Monitoring Point 001A/001B into the west end of the Discharge Channel under the active NPDES permit (Permit Number MI0001864). Outfall 001 is located at the east end of the Discharge Channel, south of Ponds 1 and 2, and discharges into Lake Erie. The existing site plan is provided as Sheet 2 (Overall Site Plan) in Appendix A – Engineering Drawings and contains labels for Ponds 1 and 2, Lake Erie, the Discharge Channel, Erie Road, Forebay, and NPDES Outfall 001.

2.0 NARRATIVE DESCRIPTION

Ponds 1 and 2 at JR Whiting will be closed with CCR in place and capped with a final cover system over the CCR surface impoundment area. Prior to construction of the final cover, Ponds 1 and 2 will be dewatered by actively pumping the ponds' contents downstream in a manner that maintains permitted effluent limits. Once dewatered, active pumping will cease; and piping will be permanently capped or removed which will allow Ponds 1 and 2 to be regraded and backfilled to two feet below the final cover grades provided on Sheet 6 of the Engineering Drawings (Appendix A). Final cover design grades will be reached with construction of a two-foot-thick final cover system designed with a 2.0 percent slope to meet performance standard requirements per 40 CFR 257.102(d)(3)(ii). Details of the closure construction are provided in the following sections.

2.1 Ponds 1 and 2 CCR Quantity

Golder characterized CCR in Ponds 1 and 2 in October 2015. The sample characterization results were reported in Golder's Ash Pond Material Characterization, J.R. Whiting Generating Facility dated September 2016 (Golder 2016). Through visual observation, characterization sampling determined that the CCR in Ponds 1 and 2 extended to depths that ranged from 8 to 22 feet below mudline, which correlates to elevations of approximately 570 to 553 (NAVD88). The largest total surface area of Ponds 1 and 2 requiring final cover is approximately 18 acres. The maximum inventory of CCR estimated for Ponds 1 and 2 was approximately 420,850 cubic yards as reported by the Mannik Smith Group in the Ponds 1&2 RCRA Closure Plan dated October 13, 2016.

3.0 CLOSURE CONSTRUCTION SEQUENCE

3.1 Drainage and Stabilization of Ponds 1 and 2

Ponds 1 and 2 will be decanted via pumping downstream through the permitted NPDES outfall in a manner that maintains permitted effluent limits. During decanting, the water level in Ponds 1 and 2 will drop until it reaches the approximate elevation of the lowest ground surface within Ponds 1 and 2 or to the extent practically feasible, as conceptually shown on Sheet 4 (Conceptual Dewatering and Water Treatment Plan) in Appendix A – Engineering Drawings. The lowest ground surface elevation measured within Ponds 1 and 2 is approximately 575 feet above mean sea level (amsl), as measured from the National Geodetic Vertical Datum of 1929 (NGVD29). Existing bathymetry/topography of Ponds 1 and 2 is shown on Sheet 3 (Existing Conditions and Utility Plan) in Appendix A – Engineering Drawings.

After decanting is complete, the Ponds 1 and 2 influent and effluent pipes will be removed and/or abandoned in-place to prevent inflow to the pond. The remaining irregular surface of CCR within Ponds 1 and 2 will be regraded and reworked to facilitate stabilization and placement of fill and geosynthetics. Drainage and stabilization of the remaining wastes and waste residues to support the final cover system, as required by Part 115 R 299.4309(7)(a) and (b), will be achieved by the decanting process and regrading and reworking of the CCR.

3.2 Filling Sequence

Once decanted, the CCR will be regraded and compacted until the surface grading is determined to be acceptable to place structural fill per the Construction Quality Assurance (CQA) Plan (Appendix B). In the event that the CCR is unsuitable for subsequent fill placement or proof-rolling, a bridging layer consisting of three feet of bottom ash or cohesionless structural fill placed over a geotextile or geogrid may be placed, as needed. The strength of the graded CCR surface may also be improved by replacing yielding or rutted areas that do not pass the proof roll with stronger materials, such as sand or riprap, until the surface meets requirements for fill placement per the CQA Plan (Appendix B). Once the graded CCR surface is acceptable, Ponds 1 and 2 will be backfilled with excess onsite material and imported from offsite borrow sources. Fill material will have a maximum particle size of three inches; will be generally void of organic, frozen, or other foreign material; and placed in uniform and generally horizontal lifts across the ponds. Material will be placed in lifts and compacted up to the elevations provided on Sheet 5 (Ash Ponds 1 & 2 Top of Liner Grading Plan) in Appendix A – Engineering Drawings and per the requirements described in the CQA Plan.

The appropriate dust control measures identified in the latest revision of the RCRA J.R. Whiting Fugitive Dust Control Plan for Coal Combustion Residuals that is posted on the publicly accessible website pursuant to 40 CFR 257.107(g)(1) will be followed during earthwork operations. These measures include water trucks

applying water to excavations and haul roads, pausing constructing during high winds, and not overfilling haul trucks during material transport. This plan was developed and certified by a qualified professional engineer. The J.R. Whiting Fugitive Dust Control Plan for Coal Combustion Residuals that was available during development of this closure plan is provided in Appendix C – J.R. Whiting Fugitive Dust Control Plan.

4.0 FINAL COVER DESIGN

4.1 Final Cover Grades

The proposed Ponds 1 and 2 final cover grade is minimum 2.0 percent in accordance with Part 115 R 299.4304(5). The proposed grading plan for Ponds 1 and 2 is depicted on Sheets 6 (Ash Ponds 1 & 2 Top of Final Cover Grading Plan) and 7 (Ash Ponds 1 & 2 Sections A-A', B-B', and C-C') of Appendix A – Engineering Drawings.

Once decanted, the CCR that exists within Ponds 1 and 2 will be regraded and reworked to develop a horizontal and uniform surface capable of bearing the proposed grades presented herein. Once existing CCR in Ponds 1 and 2 is regraded to provide a uniform surface to support fill materials, excess onsite and imported material will be used to fill Ponds 1 and 2 to meet the proposed top of liner grading plan. A 24-inch-thick final cover system will overlay the top of liner grade. It is designed with a proposed minimum 2.0 percent slope to prevent future impoundment of water, sediment, or slurry; prevent/control the release of waste; limit the effects of settlement; and minimize erosion. A final cover settlement assessment was completed to assure positive drainage on the final cover through the post-closure care period. Settlement assessment calculations to support the positive drainage on the final cover in areas with the proposed minimum 2.0 percent grade are included in Appendix D – Geotechnical Calculations.

4.2 Design

The final cover system consists of the following components (from bottom to top):

- CCR with sufficient strength to support final cover per Part 115 R 299.4309(7)(b)
- Structural fill with a maximum particle size of three inches
- Smooth drum-rolled subgrade with no soil particles greater than 0.75-inches on the surface
- 40 mil thick high-density polyethylene (HDPE) geomembrane liner per Part 115 R 299.4304(6)(a)(ii)
- 8 ounce per square yard (oz/sy) non-woven geotextile cushion
- Above-cap drainage collection piping system
- 24-inch final cover material consisting of:
  - 18-inch-thick protective cover per per 40 CFR 257.102(d)(3)(i)(B)
  - 6-inch-thick topsoil per Michigan Department of Transportation (MDOT) 816 – Turf Establishment (erosion layer) and Part 115 R 299.4304(6)(b)
  - Seed, fertilizer, and mulch per Part 115 R 299.4304(6)(b)

The final cover system will be 24 inches thick and consist of a 40 mil HDPE geomembrane (infiltration layer) overlain with an eight oz/sy nonwoven needle-punched geotextile (cushion). The cushion will be overlain with a drainage collection piping system with collection pipes spaced 200 feet apart. The geotextile and

drainage collection piping system will be overlain with an 18-inch-thick protective cover, which is less than the 24-inch thickness required by Part 115 R 299.4304(6)(a)(ii), but supported further in Section 4.2.5. The protective cover will be overlain with a six-inch-thick erosion layer. The erosion layer consists of topsoil, seed, fertilizer, and mulch in accordance with MDOT Standard Specification 816 – Turf Establishment.

The CCR RCRA Rule states in Part 257.102 that the "permeability of the final cover system must be less than or equal to the permeability of any bottom liner system or natural subsoils present, or a permeability no greater than 1×10^{-5} cm/sec, whichever is less." Since Ponds 1 and 2 were constructed without an engineered liner system and the natural subsoils present are clayey soils, it has been conservatively assumed that the subgrade soils have a permeability of 1×10^{-7} centimeters per second (cm/sec). Therefore, the final cover system was designed to have a permeability of 1×10^{-7} cm/sec or less using a combination of the HDPE geomembrane overlain by 18 inches of protective soil. The published permeability of a typical HDPE geomembrane is 1×10^{-12} cm/sec or less (GSE, 2012).

Together, the final cover system is designed to provide a final cover permeability less than 1×10^{-7} cm/sec; minimize the need for maintenance; control, minimize, or eliminate post-closure infiltration of liquids; minimize releases of CCR and leachate into ground and surface waters or the atmosphere; preclude the probability of future impoundment of water, sediment, or slurry; prevent the sloughing or movement of the liner; be completed in the shortest amount of time consistent with recognized and generally accepted good engineering practices.

The final cover system will be constructed, inspected, and tested in accordance with the CQA Plan provided in Appendix B and is summarized in the following sections. Calculations to support the infiltration layer requirement are provided in Appendix E – Hydrologic and Hydraulic Calculations.

4.2.1 Subgrade Layer

Once Ponds 1 and 2 are filled to the top of liner grades provided in Appendix A, the top of liner grade will be smooth drum-rolled, inspected for stones larger than 0.75 inches, and accepted as the geomembrane subgrade. The subgrade surface will be accepted by the owner's representative, the earthwork contractor, and the geosynthetic installer as a surface suitable for geomembrane placement that is free of ruts, soft spots, stones larger than 0.75 inches, dust, and/or excessive moisture in accordance with the CQA Plan.

4.2.2 HDPE Geomembrane Liner

A 40 mil HDPE geomembrane liner is proposed for the final cover system. The HDPE geomembrane will have properties as presented in Appendix B – Construction Quality Assurance Plan or meet current GRI-GM13 Test Methods, Required Properties and Testing Frequencies for HDPE (Geosynthetic Institute, 2016).

4.2.3 Geotextile Cushion

An eight oz/sy nonwoven needle-punched geotextile cushion will prevent puncture when installed above the HDPE geomembrane layer. The above-cap piping system described below will be used to reduce the accumulation of hydrostatic head over the geomembrane liner. The geotextile cushion will have the properties presented in Appendix B – Construction Quality Assurance Plan. Calculations to support the use of an eight oz/sy cushion are provided in Appendix D – Geotechnical Calculations.

4.2.4 Above-Cap Drainage Collection Piping System

An above-cap drainage collection piping system will be installed over the geotextile cushion to capture stormwater infiltrating through the soil cover system and reduce the accumulation of hydrostatic head over the geomembrane liner. Infiltrated water will be collected in 4-inch diameter perforated and socked pipes, spaced 200 feet apart, and conveyed to 4-inch diameter non-perforated outlet pipes. Water captured in the above-cap drainage collection piping system will be conveyed to discharge points located outside of the capped area. Calculations to support the use of the above-cap drainage collection piping system are provided in Appendix E – Hydrologic and Hydraulic Calculations.

4.2.5 24-inch Final Cover Material

The geosynthetic liner system will be covered with an 18-inch-thick protective cover and six inches of topsoil to protect the liner system and allow for establishment of vegetative cover, respectively. The protective cover soil will also surround and cover the above-cap drainage collection piping system. The bottom 18 inches of the final cover system will consist of protective cover soil, which must be classified according to the Unified Soil Classification System (USCS) as either SM, ML, SC, or CL. Since these soils will be placed directly on the geosynthetics, stones larger than 0.75 inches and materials that could harm the geosynthetics will be removed. The 18-inch layer thickness is less than the 24-inch thickness required by Part 115 R 299.4304(6)(a)(ii); however, the layer will appropriately convey drainage, support shallow rooting vegetation, and protect the cover geosynthetics. Further, the thickness requirement is consistent with the CCR RCRA Rule requirement [40 CFR 257.102(d)(3)(i)(B)]. The top six inches of final cover material will consist of available topsoil that meets MDOT Standard Specification 816 - Turf Establishment. Placement of the final cover materials will be performed with low ground pressure construction equipment; and no equipment will be allowed to traverse on the geosynthetics without adequate soil thickness protection, per the CQA Plan.

4.2.6 Seed, Fertilizer, and Mulch

Seed, fertilizer, and mulch have been selected for turf establishment in sand loam. Seeding may be performed by hydroseeding or seed drill. Mulch and fertilizer will be in accordance with MDOT Standard Specifications 816 and 917. The proposed seed mix is as follows:

Table 4.2.1 - Proposed Seed Mix

Seed Variety	Pound/Acre
Kentucky Blue Grass	11
Perennial Rye Grass	55
Hard Fescue	55
Creeping Red Fescue	99
Total:	**220**

Alternative seed mixes may be selected by CEC for a specific final cover project based on the time of year the seed is placed.

4.2.7 Proposed Access Road

A proposed access road around the perimeter of the cap will be used to maintain access to existing facilities at the site [see Sheets 8 (Proposed Access Road Plan and Profile 1 of 2) and 9 (Proposed Access Road Plan and Profile 2 of 2) of Appendix A – Engineering Drawings]. In some areas, the proposed access road will traverse over the liner. The road has been designed to prevent ground pressure at the geomembrane from exceeding the maximum allowable ground pressure of five pounds per square inch (psi). Calculations supporting this design are presented in Appendix D – Geotechnical Calculations. The road section will consist of a 12-inch-thick layer of road base aggregate over a 12-inch-thick layer of clean sand subbase. A 10 oz/sy nonwoven needle-punched geotextile will be placed between the road base aggregate and the clean sand subbase to maintain separation of these materials. In areas where the proposed access road will overlie the final cover geosynthetics, the clean sand subbase will be underlain by a 10 oz/sy nonwoven needle-punched geotextile. This geotextile will serve as a cushion over the HDPE geomembrane liner (where present) and as a separation layer between the clean sand subbase and the subgrade soil (where the HDPE geomembrane is not present).

4.3 Infiltration

The final cover is designed with a minimum 2.0 percent grade to the east and west to promote drainage and reduce water ponding on the final cover system as required by Part 115 R 299.4304(5). Surface water will sheet flow from the cover system to the surrounding ground and, ultimately, to the Forebay, Borrow Pit, or Lake Erie. Seepage through the topsoil layer into the final cover system will be collected by the above-cap drainage collection piping system and discharged at points located outside of the capped area. The site grading and the above-cap drainage collection piping system is anticipated to limit mounding to less than six inches on top of the HDPE geomembrane. This is considered acceptable given the 18-inch-thick protective cover layer and the demonstration to minimize infiltration with this gradient. Calculations to support the mounding are provided in Appendix E – Hydrologic and Hydraulic Calculations. Based on manufacturer's data (GSE, 2012) and the parameters used in the Hydrologic Evaluation of Landfill

Performance (HELP) modelling of the proposed capping system, the lowest permeability layer of the final cover system is the HDPE geomembrane at $1x10^{-12}$ cm/s (or less) which meets the maximum permeability requirement of 1×10^{-7} cm/s. The HELP model results for Ponds 1 and 2 are provided in Appendix E – Hydrologic and Hydraulic Calculations. The above-cap drainage system and protective cover will provide adequate drainage (average head buildup of less than six inches on the geomembrane).

4.4 Stability

A stability analysis was performed for the proposed Ponds 1 and 2 final grades and final cover system. The final grades are proposed minimum 2.0 percent grades with portions of perimeter berm outbound slopes proposed at 2horizontal (H):1vertical (V) (50 percent). The remaining perimeter berm outbound slopes are proposed to remain at their existing slopes of approximately 2.5H:1V (40 percent). Two critical sections were analyzed for global stability using information obtained from subsurface investigations performed during October 2016 and January 2017 and historic investigations during June 1977 and July 2011. The sections analyzed were identified as critical, because they traverse through areas with the steepest slopes or largest amount of fill. Analyses of these sections are provided in Appendix D – Geotechnical Calculations. Drained and undrained material strength properties are provided in Appendix F – Global Material Properties Table and were used to evaluate long- and short-term stability for the proposed grades. A veneer analysis was conducted to assess final cover system stability for various scenarios including equipment forces during construction, seepage forces, and seismic conditions. Details of the stability analysis are provided in Appendix D – Geotechnical Calculations and indicate that the proposed final cover system provides an adequate factor of safety (FoS).

4.5 Final Cover Settlement

Settlement modeling was conducted to confirm that post-settlement cover slopes will maintain long-term positive drainage as required by Part 115 R 299.4304(5). The results indicate that a maximum of 10.4 inches of total long-term settlement is anticipated in the center of Ponds 1 and 2, and negligible long-term settlement can be anticipated along the perimeter of Ponds 1 and 2. These settlement estimates yield a post-settlement slope of 1.8 percent and maintain positive drainage throughout the post-closure care period. The settlement model results are included in Appendix D – Geotechnical Calculations.

4.6 Stormwater and Erosion

Stormwater that falls on the final cover of Ponds 1 and 2 will be managed as sheet flow. The stormwater will flow to the Forebay and the Borrow Pit on the west or to Lake Erie on the east. The stormwater management system consists of the following components, which are outside the limits of the final cover:

- Existing Erie Road ditch
- Proposed culvert beneath the proposed access road to convey water along the existing Erie Road ditch
- Proposed drivable off-cap drainage swale designed to convey water away from a low point west of the cap

The stormwater management system has been designed in accordance with MDEQ Part 115 Rules to manage run-off from the 25-year, 24-hour Soil Conservation Service (SCS) Type II storm event (four inches). Additionally, the drivable off-cap drainage swale was designed to collect and route run-off from the SCS Type II, 100-year, 24-hour storm event without overflow. The channel has been designed to manage the calculated run-off for the final closure grades. Modeling and calculations to support the stormwater management system design are included in Appendix E – Hydrologic and Hydraulic Calculations.

4.6.1 Drainage Swale

A drivable off-cap drainage swale will convey stormwater from a low point west of the Ponds 1 and 2 final cover system north to the Borrow Area. Revegetation of the swale will protect the soils against erosion. A detail of the drivable off-cap drainage swale is shown on Sheet 13 (Miscellaneous Details) of Appendix A – Engineering Drawings. Design calculations to support the designed swale are provided in Appendix E – Hydrologic and Hydraulic Calculations.

4.6.2 Culvert

A culvert beneath the Ponds 1 and 2 access road has been designed to meet Monroe County Road Commission (MCRC) modified commercial access permit conditions (Permit No. 2017-00303). The culvert will be installed in accordance with the conditions of the permit issued by MCRC.

4.7 Erosion Potential

Calculations using the modified universal soil loss equation were used to estimate the erosion potential for the finished grades of Ponds 1 and 2. Per the analysis, after vegetation is established, the average erosion potential will be less than two tons per acre per year. Design calculations are provided in Appendix E – Hydrologic and Hydraulic Calculations.

4.8 Modifications to Existing Monitoring Wells

Regrading of the existing perimeter berms at Ponds 1 and 2 as part of this closure will necessitate adjustments to the existing RCRA monitoring wells JRW-MW-15001 through JRW-MW-15006. The proposed finished grades will be lower than the existing ground surface in the areas of these monitoring wells. As such, these well casings will be shortened to facilitate future sampling activities. Additionally, new protective casings or flush-mount protective covers will be installed to protect the monitoring wells.

The locations of these wells are presented on Sheet 6 (Ash Ponds 1 & 2 Top of Final Cover Grading Plan) of Appendix A – Engineering Drawings. Details of the proposed vaults and protective casings are presented on Sheet 13 (Miscellaneous Details) of Appendix A – Engineering Drawings.

5.0 SCHEDULE

5.1 Introduction

CEC will initiate closure by providing notification pursuant to 40 CFR 257.102(e) by November 30, 2017. In accordance with 40 CFR 257.102(f)(1)(ii), closure activities are expected to be completed within five years of the notification of intent to initiate closure (by November 30, 2022).

5.2 Closure Construction

The volumes, areas, and timeframes presented in this section are representative of the anticipated closure of Ponds 1 and 2 at JR Whiting.

On average, it is anticipated that 5,000 cy of fill can be regraded, hauled, placed, and compacted each day. This yields 27 working days or 6 weeks. Once the grading is complete, the 40 mil geomembrane will be installed. It is assumed that one crew with a daily production of 45,000 square feet will be utilized for this project. Based on these assumptions, it is expected to take 18 working days or approximately four weeks to complete the geosynthetics installation.

Once the geosynthetics are installed, the protective cover can be placed over the nonwoven geotextile cushion. The protective cover will require placement of approximately 90,000 cy. Assuming a placement rate of 5,000 cy per day yields 18 working days or four weeks. The erosion layer will overlay the protective cover. Approximately 20,000 cy of erosion layer is required. Assuming a placement rate of 5,000 cy per day yields four working days or one week.

The erosion layer will require seed, fertilizer, and mulch and should be planted in mid-August so the seed can be established and cut before winter. With proper equipment, the closed area can be seeded, fertilized, and mulched in less than one week. A breakdown of the schedule is provided below in Table 5.2.1 – Closure Schedule Production Estimate.

Table 5.2.1 – Closure Schedule Production Estimate

Closure Component	Quantity	Units	Construction Rate	Rate Units	Required Time in Days
Site regrading and placement of offsite fill	135,000	cubic yards	5,000	cubic yards per day	27
40-mil geomembrane (infiltration layer)	785,000	square feet	45,000	square feet per day	18
18-inch-thick soil (protective cover)	90,000	cubic yards	5,000	cubic yards per day	18
6-inch-thick topsoil (erosion layer)	20,000	cubic yards	5,000	cubic yards per day	4
Seed, fertilizer, mulch (erosion layer)	1 million	square feet	300,000	square feet per day	4
				Workdays Required =	**71**

It is anticipated that closure construction will begin on or before May 1, 2018 in order to comply with the closure schedule. Conservatively assuming a start to finish construction schedule, the final cover construction will take approximately 16 weeks. Using these assumptions results in completion of the final cover construction on August 17, 2018, which complies with the November 30, 2022 closure deadline. Table 5.2.2 – Conceptual Final Cover Construction Schedule Milestones contains a list of milestone dates that were developed as part of the closure construction schedule to demonstrate that closure will be completed within the self-implementing closure schedule per 40 CFR 257.102(f)(1)(ii).

Table 5.2.2 – Conceptual Final Cover Construction Schedule Milestones

Closure Component	Start Date	End Date
Notification of intent to initiate closure	November 30, 2017	November 30, 2017
Dewatering	May 1, 2018	July 6, 2018
Site regrading and placement of offsite fill	May 1, 2018	June 8, 2018
40-mil geomembrane (infiltration layer)	June 11, 2018	July 6, 2018
18-inch-thick soil (protective cover)	July 9, 2018	August 3, 2018
6-inch-thick topsoil (erosion layer)	August 6, 2018	August 10, 2018
Seed, fertilizer, mulch (erosion layer)	August 13, 2018	August 17, 2018
Closure activities complete	NA	August 31, 2018
Certified closure report	NA	December 31, 2018
Post-closure care period	January 1, 2019	December 31, 2048

5.3 Closure Deadline Extension

As previously indicated in Section 5.1, closure of existing CCR surface impoundments must be completed within five years of initiating closure in accordance with 40 CFR 257.102(f)(1)(ii). A deadline extension can be obtained as outlined in 40 CFR 257.102(f)(2) if completion of closure is not feasible within five years (e.g., shortened construction season, significant weather delays during construction, time required for dewatering CCR, delays due to state or local permitting or approval, etc.). An extension must include a narrative description that demonstrates closure is not feasible in the required timeframe in accordance with 40 CFR 257.102(f)(2)(i, iii). The closure deadline for Ponds 1 and 2 may be extended up to two years per 40 CFR 257.102(f)(2)(ii)(A).

6.0 POST-CLOSURE

The RCRA Post-Closure Plan that is posted on the publicly accessible website pursuant to 40 CFR 257.107(i)(12) will be followed, including regular inspections. This plan was developed and certified by a qualified professional engineer to assure that the integrity and effectiveness of the final cover is maintained, including erosion control measures, final cover depths, and vegetative cover over the 30-year post-closure care period. Post-closure care will begin once Ponds 1 and 2 is certified closed and will be in accordance with the latest revision of the JR Whiting Ponds 1 and 2 RCRA Post-Closure Plan.

The RCRA Post-Closure Plan that was available during development of this Closure Plan is provided in Appendix G – J.R. Whiting Generating Facility Ponds 1 and 2 RCRA Post-Closure Plan.

7.0 CONCLUSIONS

This Closure Plan proposes closure with a final cover system over the CCR surface impoundment area pursuant to Part 115 Rules R 299.4304, R 299.4309, and R 299.4317 and 40 CFR 257.102(a). This Closure Plan describes the steps necessary to close the JR Whiting Ponds 1 and 2 CCR surface impoundment in a manner consistent with recognized and generally accepted good engineering practices.

8.0 GENERAL QUALIFICATIONS

This Closure Plan has been prepared in general accordance with normally accepted civil engineering practices. We have prepared this plan for the purpose intended by CEC. No warranty, either expressed or implied, is made. The scope is limited to the specific project and location described herein, and our description of the project represents our understanding of the significant aspects relevant to the site. In the event that any changes in the design or location of the facilities as outlined in this report are planned, we should be informed so that the changes can be reviewed and the conclusions of this report modified, as necessary, in writing by the engineer.

9.0 REFERENCES

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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.

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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

Golder Associates

Engineering Earth's Development, Preserving Earth's Integrity

APPENDIX A
ENGINEERING DRAWINGS

CONSUMERS ENERGY COMPANY
J.R. WHITING GENERATING FACILITY
ASH PONDS 1 & 2 CLOSURE PLAN DRAWINGS

SECTION 14, T8S, R8E

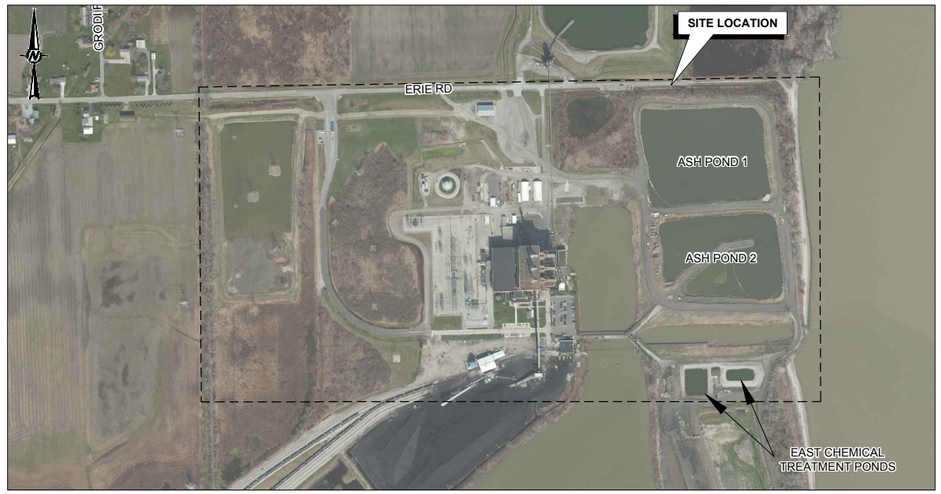
MONROE COUNTY, MICHIGAN

PREPARED FOR:

CONSUMERS ENERGY COMPANY
J. R. WHITING GENERATING FACILITY
4525 E. ERIE ROAD
ERIE, MICHIGAN 48133

PREPARED BY:

GOLDER ASSOCIATES INC.
15851 SOUTH US 27
SUITE 50
LANSING, MICHIGAN 48906



World Topographic Map - Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

SHEET NUMBER	FILE NUMBER	SHEET TITLE
1	1667572H000	TITLE SHEET
2	1667572H001	OVERALL SITE PLAN
3	1667572H002	EXISTING CONDITIONS AND UTILITY PLAN
4	1667572H003	CONCEPTUAL DEWATERING AND WATER TREATMENT PLAN
5	1667572H004	ASH PONDS 1 & 2 TOP OF LINER GRADING PLAN
6	1667572H005	ASH PONDS 1 & 2 TOP OF FINAL COVER GRADING PLAN
7	1667572H006	ASH PONDS 1 & 2 SECTIONS A-A', B-B' AND C-C'
8	1667572H007	PROPOSED ACCESS ROAD PLAN AND PROFILE 1 OF 2
9	1667572H008	PROPOSED ACCESS ROAD PLAN AND PROFILE 2 OF 2
10	1667572H009	FINAL COVER AND BERM DETAILS 1 OF 2
11	1667572H010	FINAL COVER AND BERM DETAILS 2 OF 2
12	1667572H011	PROPOSED ACCESS ROAD DETAILS
13	1667572H012	MISCELLANEOUS DETAILS
14	1667572H013	ABOVE-CAP DRAINAGE COLLECTION PIPING DETAILS

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO
	B	2017-08-29	FINAL FOR SUBMITTAL	DJC	SAM	JRP	TDJ	
	A	2017-07-24	DRAFT FOR REVIEW	DJC	SAM	TDJ	JP	

REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO

SIGNATURE

NAME

MICHIGAN P.E. No.

Consumers Energy

J.R. WHITING PLANT
ERIE, MI

TITLE SHEET

SCALE: NONE
JOB: PT-01851
DRAWING NO. 1667572H000
SHEET 1
REV. B

NOTE
EXISTING CONDITIONS MAY VARY FROM THOSE SHOWN.

REFERENCES
1. SITE LOCATION: SECTION 14, T8S, R8E, MONROE COUNTY, MICHIGAN.
2. EXISTING GROUND TOPOGRAPHY WAS PROVIDED BY SHERIDAN SURVEYING CO. ON 02/23/2017.
3. COORDINATE SYSTEM:
   VERTICAL: NGVD29
   HORIZONTAL: MICHIGAN STATE PLANE SOUTH ZONE NAD83 (2011).

0 150 300
1" = 150' FEET

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO

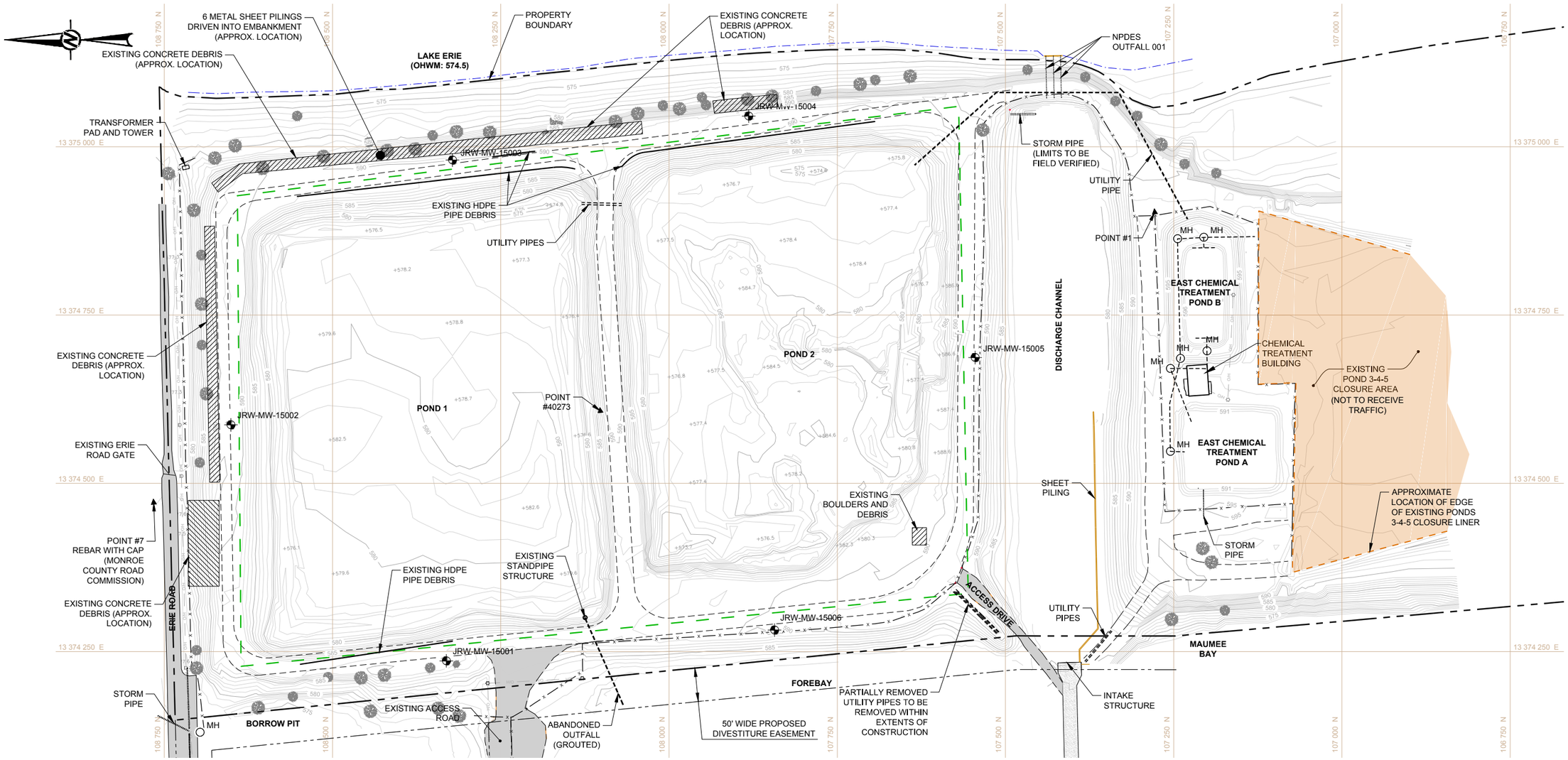
REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO
B	2017-08-29	FINAL FOR SUBMITTAL	DJC	SAM	JRP	TDJ	
A	2017-07-24	DRAFT FOR REVIEW	DJC	SAM	TDJ	JP	

SIGNATURE
NAME
MICHIGAN P.E. No.

Consumers Energy
J.R. WHITING PLANT
ERIE, MI

OVERALL SITE PLAN

SCALE: 1" = 150'
JOB: PT-01851
DRAWING NO. 1667572H001
SHEET 2
REV. B



LEGEND

- PROPERTY BOUNDARY
- PROPOSED DIVESTITURE EASEMENT
- FENCE
- OVERHEAD UTILITY
- UTILITY PIPE
- STORM PIPE
- APPROXIMATE LAKE ERIE WATER LINE
- 590 EXISTING GROUND MAJOR CONTOUR (5' INTERVAL)
- 591 EXISTING GROUND MINOR CONTOUR (1' INTERVAL)
- SHEET PILING
- CONTROL POINT
- MONITORING WELL
- MH MANHOLE
- EXISTING TREES/STUMPS
- PONDS 3-4-5 CLOSURE AREA
- EDGE OF EXISTING ACCESS ROAD
- SOLID WASTE BOUNDARY (SEE REFERENCE 6)

NOTE

EXISTING CONDITIONS MAY VARY FROM THOSE SHOWN.

SURVEY BENCHMARKS

ID	NORTHING	EASTING	POINT ELEV. (NGVD29)
POINT #1	107278.26	13374902.72	590.90
POINT #7	108765.66	13374471.45	577.92
POINT #40273	108102.00	13374607.58	590.56

REFERENCES

1. SITE LOCATION: SECTION 14, T8S, R8E, MONROE COUNTY, MICHIGAN.
2. EXISTING GROUND TOPOGRAPHY WAS PROVIDED BY SHERIDAN SURVEYING CO. ON 02/23/2017.
3. COORDINATE SYSTEM:
   VERTICAL: NGVD29.
   HORIZONTAL: MICHIGAN STATE PLANE SOUTH ZONE NAD83 (2011).
4. MONITORING WELL LOCATIONS AS PRESENTED IN: SUMMARY OF MONITORING WELL DESIGN, INSTALLATION, AND DEVELOPMENT (ARCADIS, 2016).
5. LAKE ERIE ORDINARY HIGH WATER MARK (OHWM) OBTAINED FROM U.S. ARMY CORPS OF ENGINEERS. (www.LRE.USACE.ARMY.MIL/MISSIONS/GREAT-LAKES-INFORMATION/LINES/ORDINARY-HIGH-WATER-MARK-AND-LOW-WATER-DATUM).
6. SOLID WASTE BOUNDARY AS PROVIDED ELECTRONICALLY BY CONSUMERS ENERGY COMPANY.

0 80 160
1" = 80' FEET

REFERENCE DRAWINGS

REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO

REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO
B	2017-08-29	FINAL FOR SUBMITTAL	DJC	SAM	JRP	TDJ	
A	2017-07-24	DRAFT FOR REVIEW	DJC	SAM	TDJ	JP	

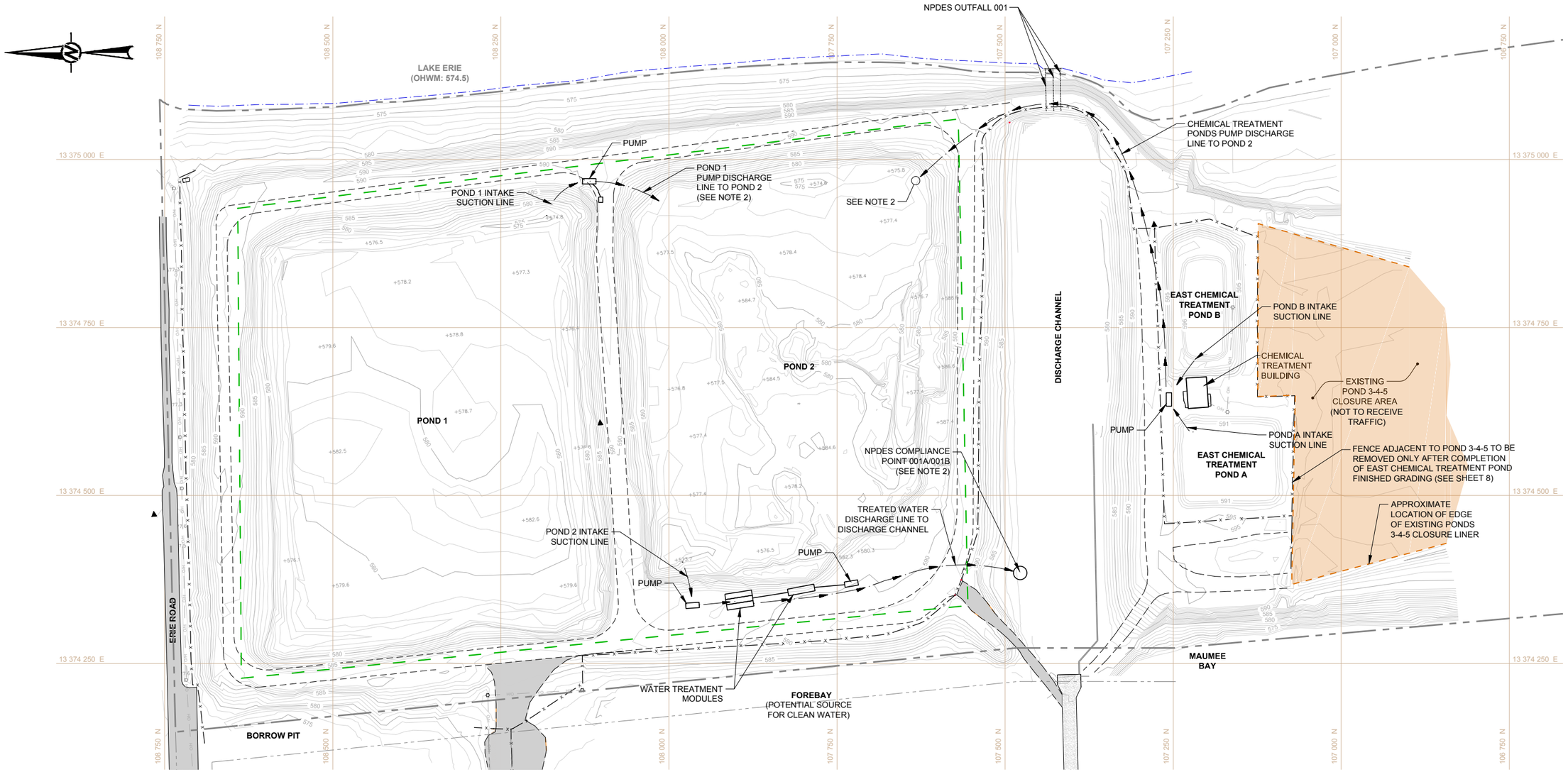
SIGNATURE
NAME
MICHIGAN P.E. No.

Consumers Energy

J.R. WHITING PLANT
ERIE, MI

EXISTING CONDITIONS AND UTILITY PLAN

SCALE: 1" = 80'
JOB: PT-01851
DRAWING NO. 1667572H002
SHEET 3
REV. B



LEGEND

- PROPERTY BOUNDARY
- PROPOSED DIVESTITURE EASEMENT
- FENCE
- OVERHEAD UTILITY
- EXISTING GROUND MAJOR CONTOUR (5' INTERVAL)
- EXISTING GROUND MINOR CONTOUR (1' INTERVAL)
- SHEET PILING
- APPROXIMATE LAKE ERIE WATER LINE
- CONTROL POINT
- PONDS 3-4-5 CLOSURE AREA
- EDGE OF EXISTING ACCESS ROAD
- SOLID WASTE BOUNDARY (SEE REFERENCE 6)

NOTES

1. EXISTING CONDITIONS MAY VARY FROM THOSE SHOWN.
2. CONTRACTOR IS RESPONSIBLE FOR PROVIDING TEMPORARY ARMORING SUFFICIENT TO PREVENT EROSION DAMAGE BY DEWATERING ACTIVITIES. CONTRACTOR IS RESPONSIBLE FOR COSTS ASSOCIATED WITH REPAIRING EROSION DAMAGE CAUSED BY DEWATERING ACTIVITIES.

REFERENCES

1. SITE LOCATION: SECTION 14, T8S, R8E, MONROE COUNTY, MICHIGAN.
2. EXISTING GROUND TOPOGRAPHY WAS PROVIDED BY SHERIDAN SURVEYING CO. ON 02/23/2017.
3. COORDINATE SYSTEM:
   VERTICAL: NGVD29.
   HORIZONTAL: MICHIGAN STATE PLANE SOUTH ZONE NAD83 (2011).
4. MONITORING WELL LOCATIONS AS PRESENTED IN: SUMMARY OF MONITORING WELL DESIGN, INSTALLATION, AND DEVELOPMENT (ARCADIS, 2016).
5. LAKE ERIE ORDINARY HIGH WATER MARK (OHWM) OBTAINED FROM U.S. ARMY CORPS OF ENGINEERS. (www.LRE.USACE.ARMY.MIL/MISSIONS/GREAT-LAKES-INFORMATION/LINES/ORDINARY-HIGH-WATER-MARK-AND-LOW-WATER-DATUM).
6. SOLID WASTE BOUNDARY AS PROVIDED ELECTRONICALLY BY CONSUMERS ENERGY COMPANY.

0 80 160
1" = 80' FEET

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO
	B	2017-08-29	FINAL FOR SUBMITTAL	DJC	SAM	JRP	TDJ	
	A	2017-07-24	DRAFT FOR REVIEW	DJC	SAM	TDJ	JP	
	REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO

SIGNATURE

NAME

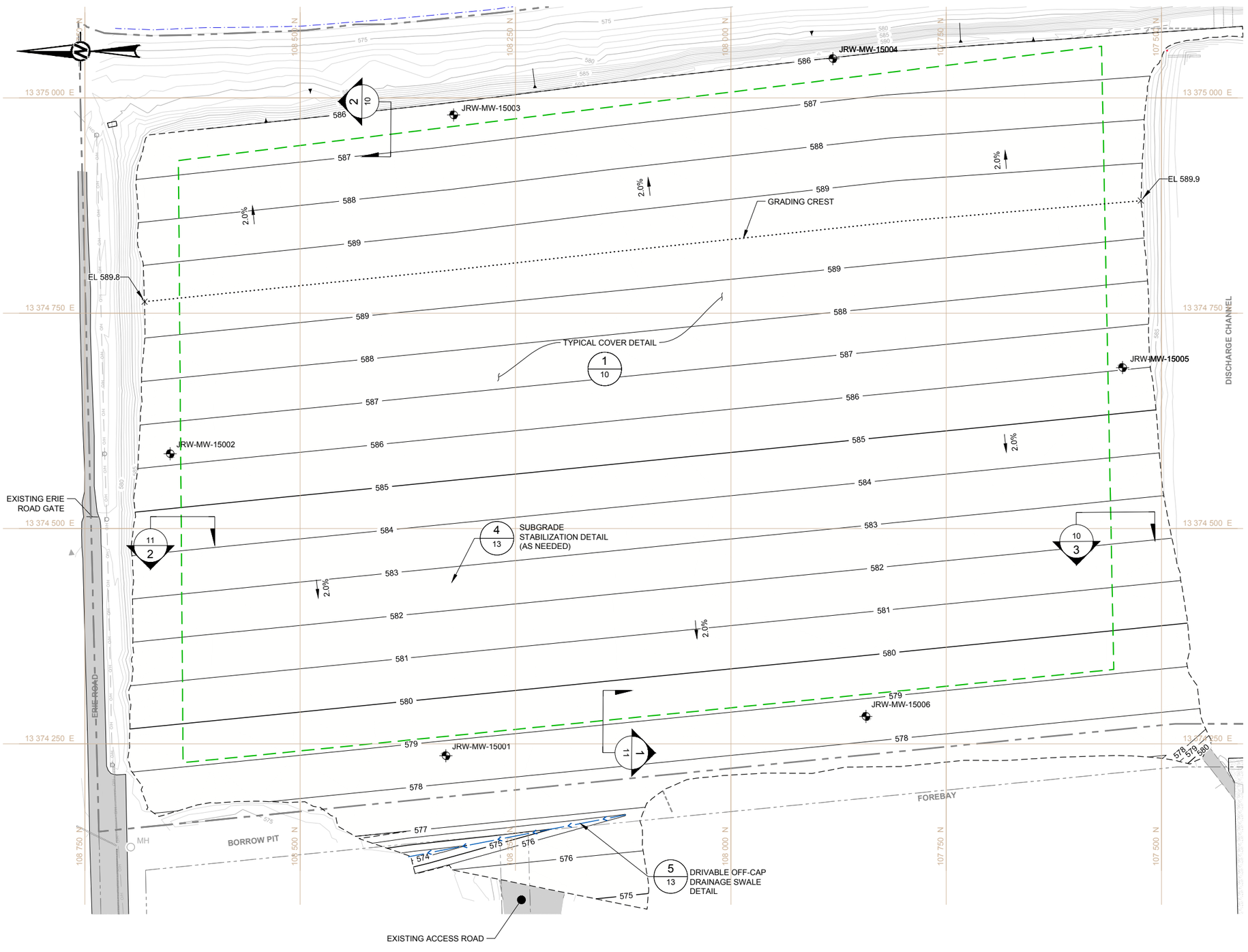
MICHIGAN P.E. No.

Consumers Energy

J.R. WHITING PLANT
ERIE, MI

CONCEPTUAL DEWATERING AND WATER TREATMENT PLAN

SCALE:	1" = 80'	DRAWING NO.	SHEET	REV.
JOB:	PT-01851	1667572H003	4	B



LEGEND

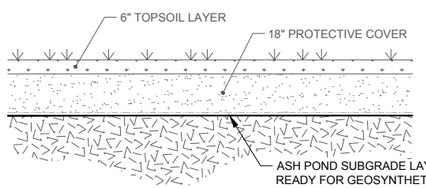
- PROPERTY BOUNDARY
- OVERHEAD UTILITY
- PROPOSED SUBGRADE MAJOR CONTOUR (5' INTERVAL)
- PROPOSED SUBGRADE MINOR CONTOUR (1' INTERVAL)
- PROPOSED DRAINAGE SWALE
- EXISTING GROUND MAJOR CONTOUR (5' INTERVAL)
- EXISTING GROUND MINOR CONTOUR (1' INTERVAL)
- PROPOSED GRADING LIMITS APPROXIMATE
- LAKE ERIE WATER LINE
- SOLID WASTE BOUNDARY (SEE REFERENCE 5)
- CONTROL POINT
- MONITORING WELL

NOTE

EXISTING CONDITIONS MAY VARY FROM THOSE SHOWN.

REFERENCES

1. SITE LOCATION: SECTION 14, T8S, R8E, MONROE COUNTY, MICHIGAN.
2. EXISTING GROUND TOPOGRAPHY WAS PROVIDED BY SHERIDAN SURVEYING CO. ON 02/23/2017.
3. COORDINATE SYSTEM:
   VERTICAL: NGVD29.
   HORIZONTAL: MICHIGAN STATE PLANE SOUTH ZONE NAD83 (2011).
4. MONITORING WELL LOCATIONS AS PRESENTED IN: SUMMARY OF MONITORING WELL DESIGN, INSTALLATION, AND DEVELOPMENT (ARCADIS, 2016).
5. SOLID WASTE BOUNDARY AS PROVIDED ELECTRONICALLY BY CONSUMERS ENERGY COMPANY.



0 60 120
1" = 60' FEET

REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO
B	2017-08-29	FINAL FOR SUBMITTAL	DJC	SAM	JRP	TDJ	
A	2017-07-24	DRAFT FOR REVIEW	DJC	SAM	TDJ	JP	

REFERENCE DRAWINGS

SIGNATURE

NAME

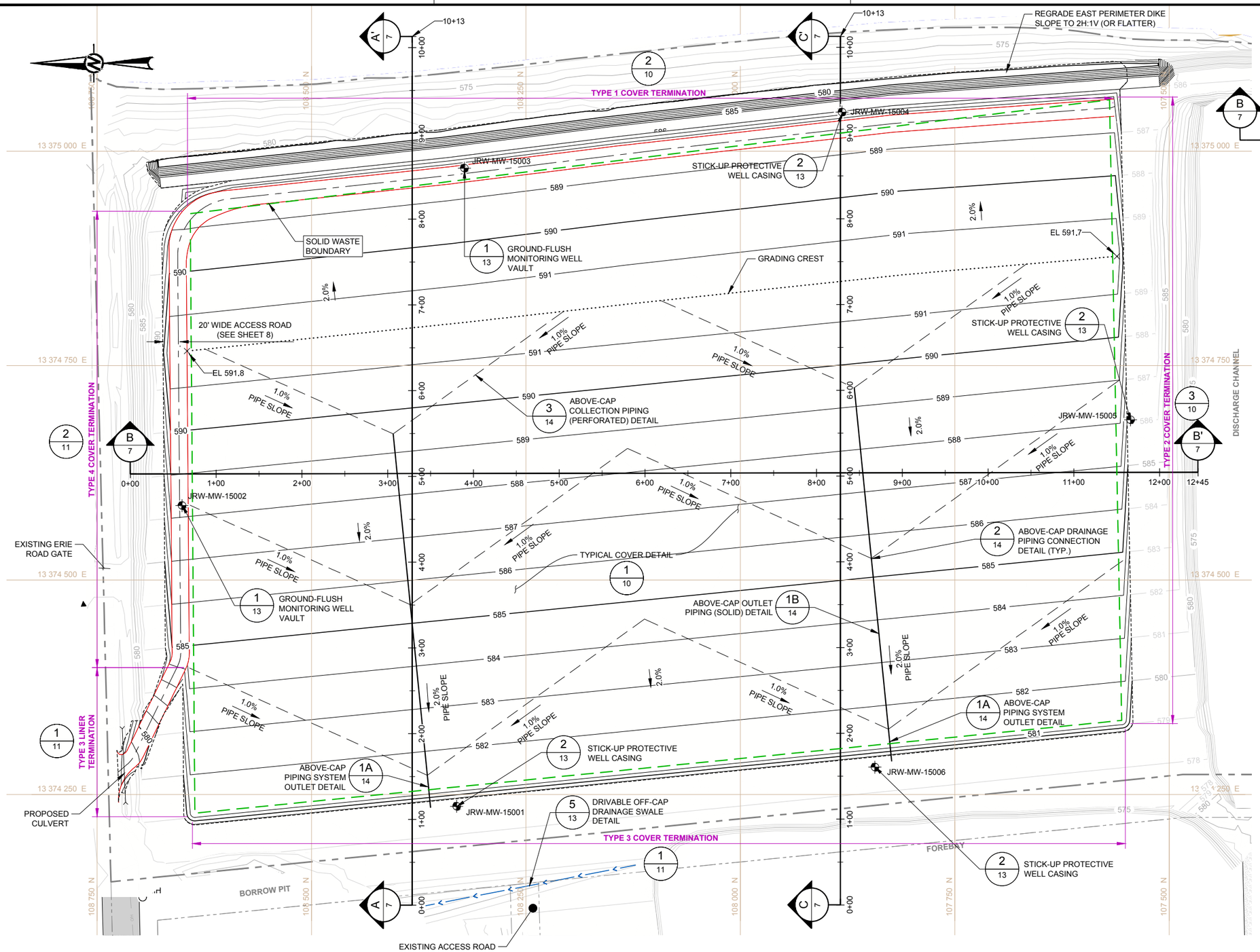
MICHIGAN P.E. No.

Consumers Energy

J.R. WHITING PLANT
ERIE, MI

ASH PONDS 1 & 2 TOP OF LINER GRADING PLAN

SCALE:	1" = 60'	DRAWING NO.	SHEET	REV.
JOB:	PT-01851	1667572H004	5	B



LEGEND

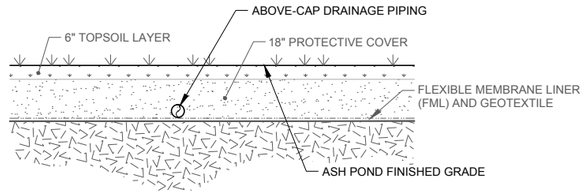
- PROPERTY BOUNDARY
- OVERHEAD UTILITY
- PROPOSED COVER MAJOR CONTOUR (5' INTERVAL)
- PROPOSED COVER MINOR CONTOUR (1' INTERVAL)
- SECTION LOCATION
- PROPOSED DRAINAGE SWALE
- APPROXIMATE LAKE ERIE WATER LINE
- ABOVE-CAP DRAINAGE COLLECTION PIPES (PERFORATED)
- ABOVE-CAP DRAINAGE OUTLET PIPES (SOLID-WALL)
- EXISTING GROUND MAJOR CONTOUR (5' INTERVAL)
- EXISTING GROUND MINOR CONTOUR (1' INTERVAL)
- PROPOSED GRADING LIMITS
- SOLID WASTE BOUNDARY (SEE REFERENCE 5)
- CONTROL POINT
- MONITORING WELL

NOTE

EXISTING CONDITIONS MAY VARY FROM THOSE SHOWN.

REFERENCES

1. SITE LOCATION: SECTION 14, T8S, R8E, MONROE COUNTY, MICHIGAN.
2. EXISTING GROUND TOPOGRAPHY WAS PROVIDED BY SHERIDAN SURVEYING CO. ON 02/23/2017.
3. COORDINATE SYSTEM:
   VERTICAL: NGVD29.
   HORIZONTAL: MICHIGAN STATE PLANE SOUTH ZONE NAD83 (2011).
4. MONITORING WELL LOCATIONS AS PRESENTED IN: SUMMARY OF MONITORING WELL DESIGN, INSTALLATION, AND DEVELOPMENT (ARCADIS, 2016).
5. SOLID WASTE BOUNDARY AS PROVIDED ELECTRONICALLY BY CONSUMERS ENERGY COMPANY.



0 60 120
1" = 60' FEET

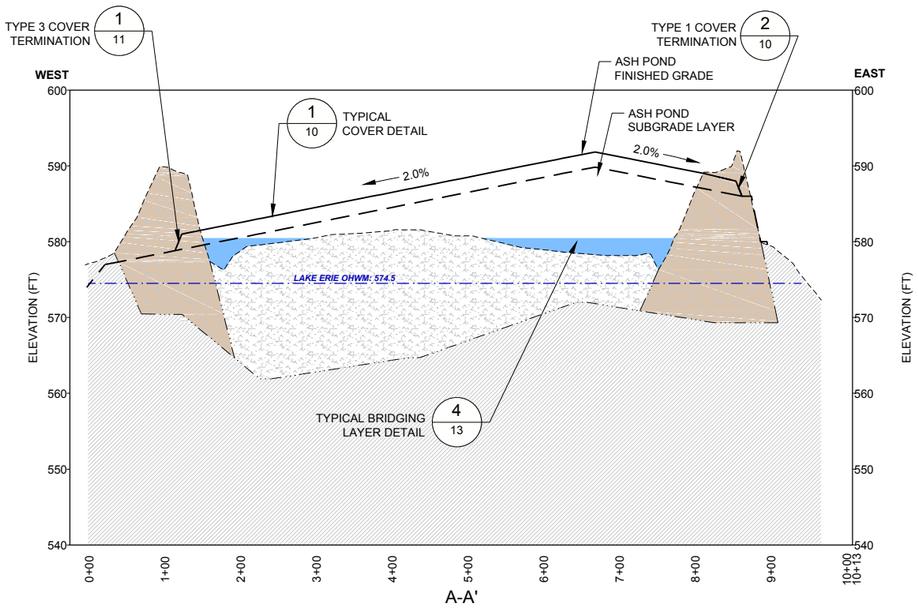
REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO
	B	2017-08-29	FINAL FOR SUBMITTAL	DJC	SAM	JRP	TDJ	
	A	2017-07-24	DRAFT FOR REVIEW	DJC	SAM	TDJ	JP	

SIGNATURE
NAME
MICHIGAN P.E. No.

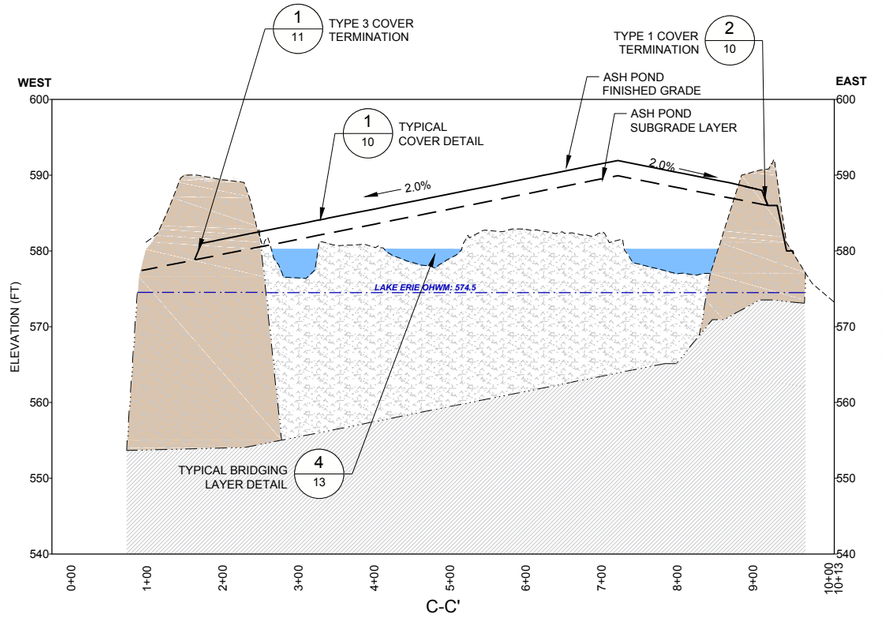
Consumers Energy
J.R. WHITING PLANT
ERIE, MI

ASH PONDS 1 & 2 TOP OF FINAL COVER GRADING PLAN

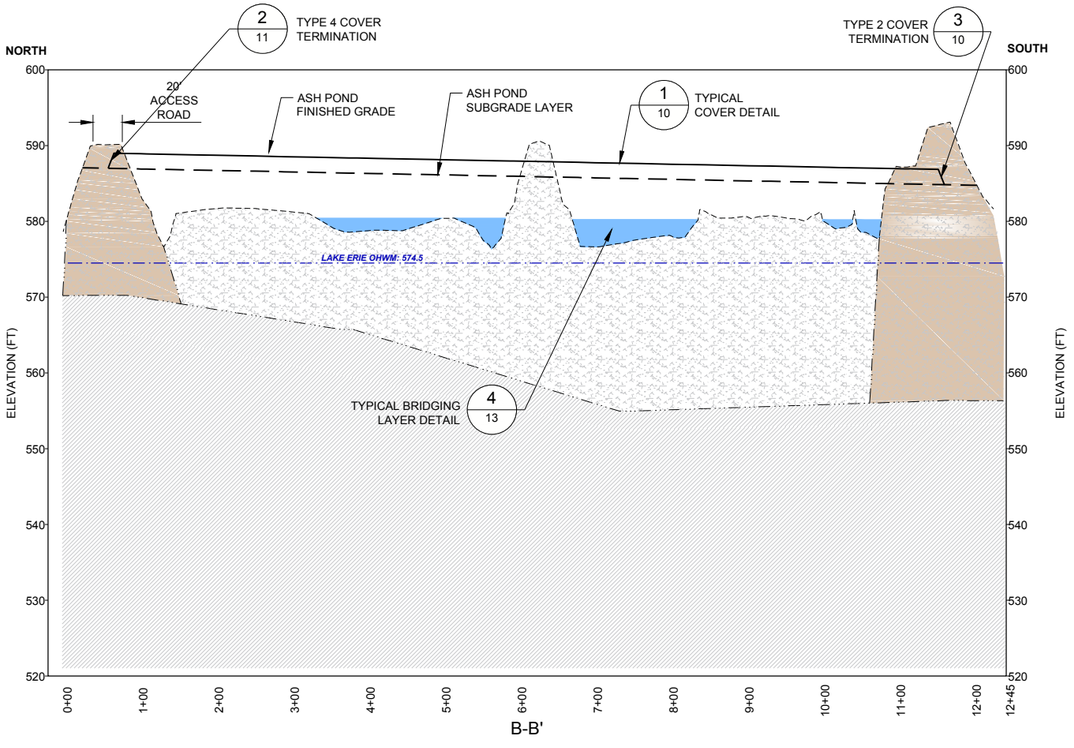
SCALE:	1" = 60'	DRAWING NO.	SHEET	REV.
JOB:	PT-01851	1667572H005	6	B



A-A'



C-C'



B-B'

NOTE
EXISTING CONDITIONS MAY VARY FROM THOSE SHOWN.

REFERENCES
1. SITE LOCATION: SECTION 14, T8S, R8E, MONROE COUNTY, MICHIGAN.
2. EXISTING GROUND TOPOGRAPHY AND WATER LEVEL IN ASH PONDS 1 AND 2 PROVIDED BY SHERIDAN SURVEYING CO. ON 02/23/2017.
3. COORDINATE SYSTEM:
   VERTICAL: NGVD 29.
   HORIZONTAL: MICHIGAN STATE PLANE SOUTH ZONE NAD83 (2011).
4. SEE SHEET 12 FOR SECTION LOCATIONS.
5. LAKE ERIE ORDINARY HIGH WATER MARK (OHWM) OBTAINED FROM U.S. ARMY CORPS OF ENGINEERS. (www.LRE.USACE.ARMY.MIL/MISSIONS/GREAT-LAKES-INFORMATION/LINES/ORDINARY-HIGH-WATER-MARK-AND-LOW-WATER-DATUM)

LEGEND
- COAL COMBUSTION RESIDUALS (CCR)
- EXISTING NATIVE SOIL
- EXISTING PERIMETER DIKE FILL
- EXISTING GROUND (APPROXIMATE)
- INTERPRETED MATERIAL BOUNDARY
- TOP OF GEOMEMBRANE
- FINISHED GRADE
- EXISTING WATER (AS MEASURED FEBRUARY 2017)

0 100 200
1" = 100' FEET

VERTICAL SCALE: 10x EXAGGERATION

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO
	B	2017-08-29	FINAL FOR SUBMITTAL	DJC	SAM	JRP	TDJ	
	A	2017-07-24	DRAFT FOR REVIEW	DJC	SAM	TDJ	JP	

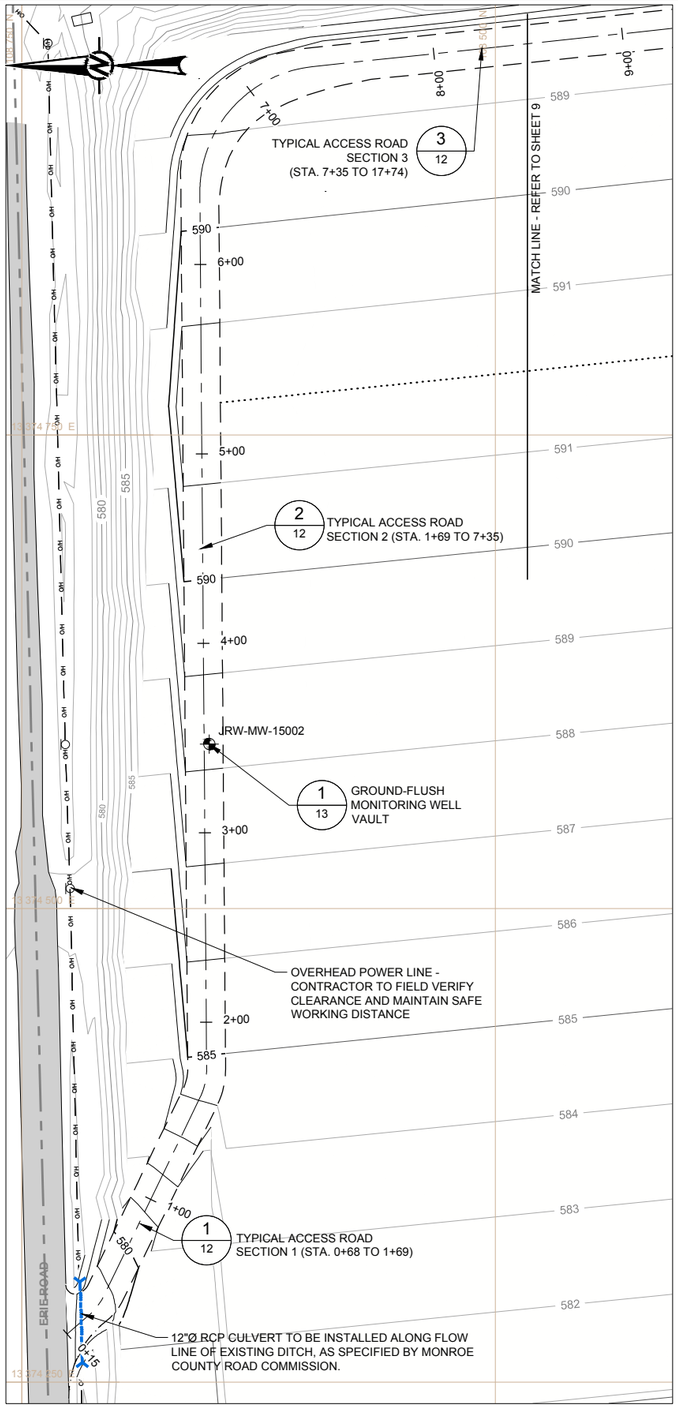
REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO

SIGNATURE
NAME
MICHIGAN P.E. No.

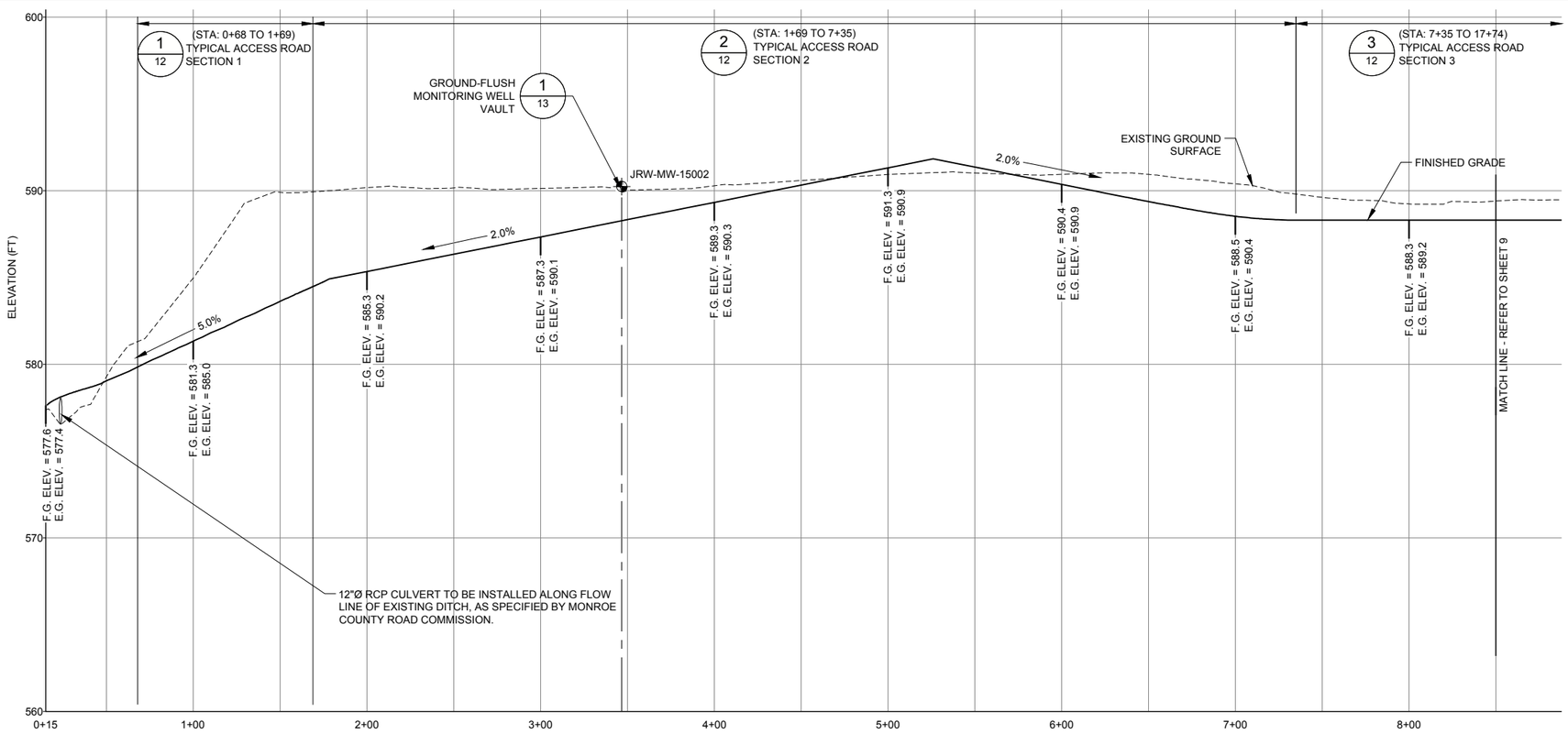
Consumers Energy
J.R. WHITING PLANT
ERIE, MI

ASH PONDS 1 & 2 SECTIONS A-A', B-B' AND C-C'

SCALE:	1" = 100'	DRAWING NO.	SHEET	REV.
JOB:	PT-01851	1667572H006	7	B



PLAN VIEW
SCALE 1"=40'



PROFILE VIEW
HORIZONTAL SCALE: 1"=40'
VERTICAL EXAGGERATION: 10x

LEGEND

- PROPERTY BOUNDARY
- OVERHEAD UTILITY
- UTILITY PIPE
- STORM PIPE
- EXISTING GROUND MAJOR CONTOUR (5' INTERVAL)
- EXISTING GROUND MINOR CONTOUR (1' INTERVAL)
- PROPOSED COVER MAJOR CONTOUR (5' INTERVAL)
- PROPOSED COVER MINOR CONTOUR (1' INTERVAL)
- MONITORING WELL

NOTE
EXISTING CONDITIONS MAY VARY FROM THOSE SHOWN.

REFERENCES
1. SITE LOCATION: SECTION 14, T8S, R8E, MONROE COUNTY, MICHIGAN.
2. EXISTING GROUND TOPOGRAPHY WAS PROVIDED BY SHERIDAN SURVEYING CO. ON 02/23/2017.
3. COORDINATE SYSTEM:
   VERTICAL: NGVD29.
   HORIZONTAL: MICHIGAN STATE PLANE SOUTH ZONE NAD83 (2011).
4. MONITORING WELL LOCATIONS AS PRESENTED IN: SUMMARY OF MONITORING WELL DESIGN, INSTALLATION, AND DEVELOPMENT (ARCADIS, 2016).

0 40 80
1" = 40' FEET

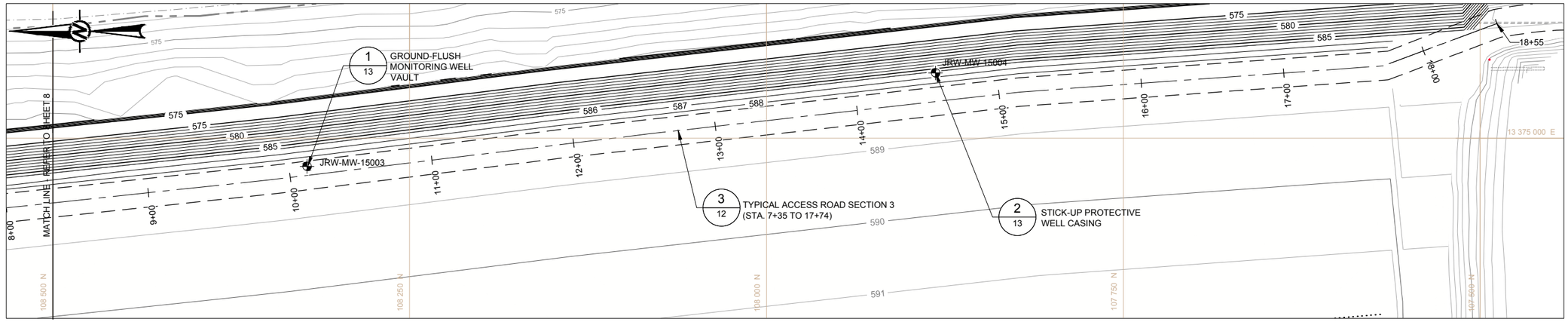
REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO
	B	2017-08-29	FINAL FOR SUBMITTAL	DJC	SAM	JRP	TDJ	
	A	2017-07-24	DRAFT FOR REVIEW	DJC	SAM	TDJ	JP	

SIGNATURE
NAME
MICHIGAN P.E. No.

Consumers Energy
J.R. WHITING PLANT
ERIE, MI

PROPOSED ACCESS ROAD PLAN AND PROFILE 1 OF 2

SCALE:	1" = 40'	DRAWING NO.	SHEET	REV.
JOB:	PT-01851	1667572H007	8	B



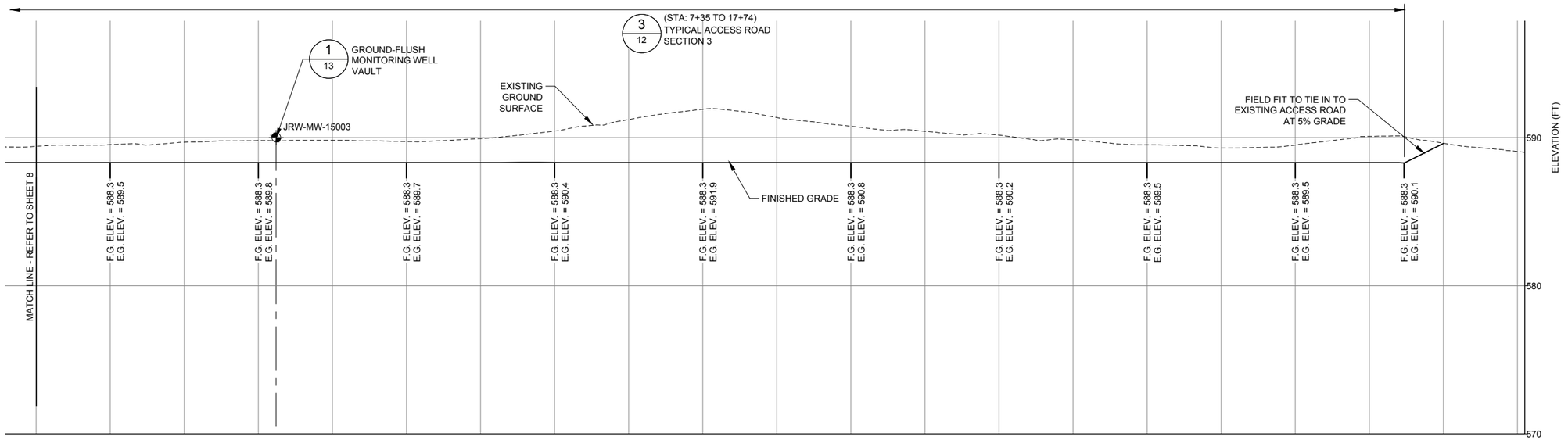
PLAN VIEW
SCALE 1"=40'

LEGEND

- PROPERTY BOUNDARY
- UTILITY PIPE
- STORM PIPE
- 590 EXISTING GROUND MAJOR CONTOUR (5' INTERVAL)
- 591 EXISTING GROUND MINOR CONTOUR (1' INTERVAL)
- 590 PROPOSED COVER MAJOR CONTOUR (5' INTERVAL)
- 589 PROPOSED COVER MINOR CONTOUR (1' INTERVAL)
- MONITORING WELL

NOTE

EXISTING CONDITIONS MAY VARY FROM THOSE SHOWN.



PROFILE VIEW
HORIZONTAL SCALE: 1"=40'
VERTICAL EXAGGERATION: 10x

REFERENCES

1. SITE LOCATION: SECTION 14, T8S, R8E, MONROE COUNTY, MICHIGAN.
2. EXISTING GROUND TOPOGRAPHY WAS PROVIDED BY SHERIDAN SURVEYING CO. ON 02/23/2017.
3. COORDINATE SYSTEM:
   VERTICAL: NVGD29.
   HORIZONTAL: MICHIGAN STATE PLANE SOUTH ZONE NAD83 (2011).
4. MONITORING WELL LOCATIONS AS PRESENTED IN: SUMMARY OF MONITORING WELL DESIGN, INSTALLATION, AND DEVELOPMENT (ARCADIS, 2016).

0 40 80
1" = 40' FEET

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO
	B	2017-08-29	FINAL FOR SUBMITTAL	DJC	SAM	JRP	TDJ	
	A	2017-07-24	DRAFT FOR REVIEW	DJC	SAM	TDJ	JP	

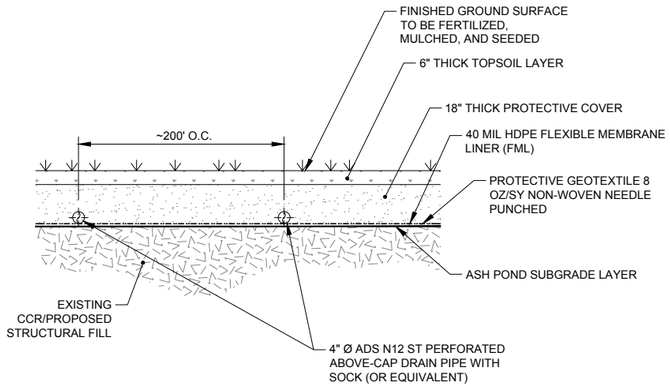
REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO

SIGNATURE
NAME
MICHIGAN P.E. No.

Consumers Energy
J.R. WHITING PLANT
ERIE, MI

PROPOSED ACCESS ROAD PLAN AND PROFILE 2 OF 2

SCALE:	1" = 40'	DRAWING NO.	SHEET	REV.
JOB:	PT-01851	1667572H008	9	B



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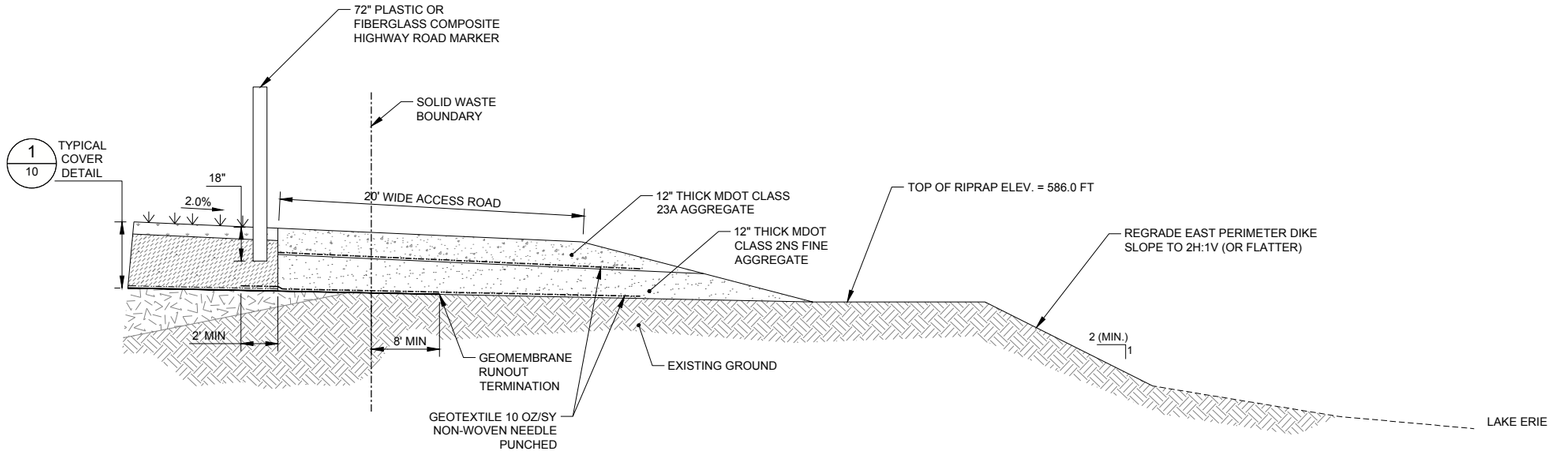

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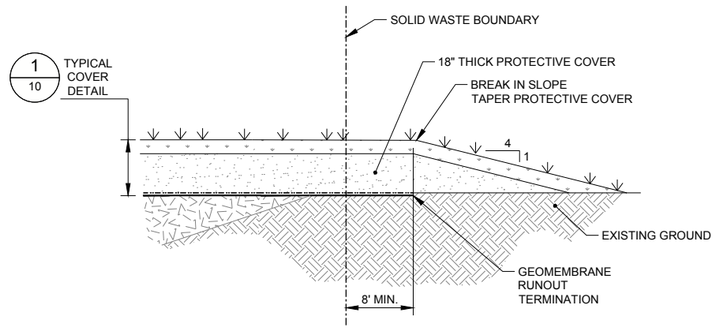

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REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO
B	2017-08-29	FINAL FOR SUBMITTAL	DJC	SAM	JRP	TDJ	
A	2017-07-24	DRAFT FOR REVIEW	DJC	SAM	TDJ	JP	

SIGNATURE

NAME

MICHIGAN P.E. No.

Consumers Energy

J.R. WHITING PLANT
ERIE, MI

FINAL COVER AND BERM DETAILS 1 OF 2

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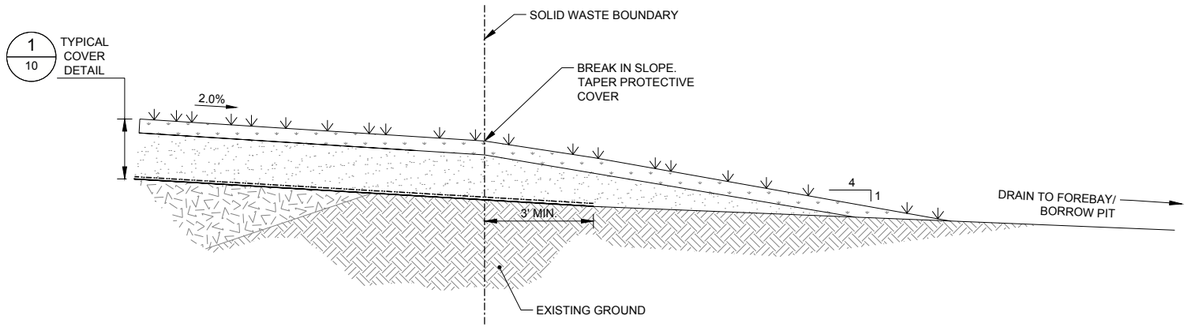

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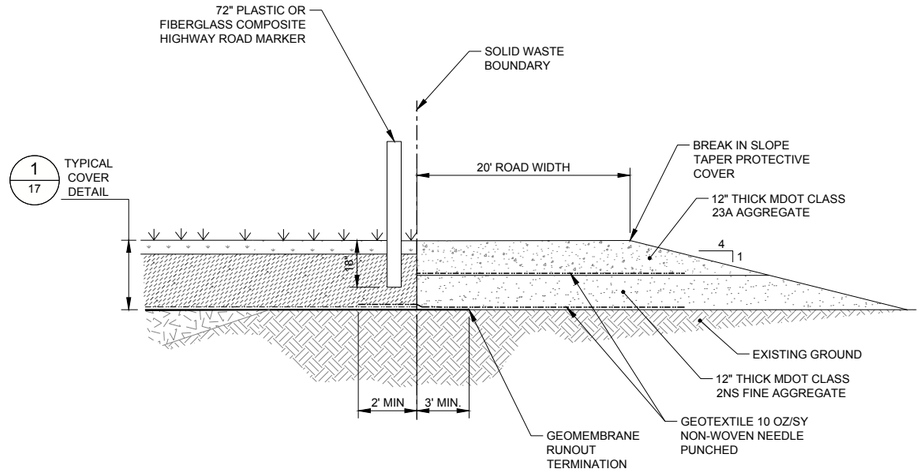

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A	2017-07-24	DRAFT FOR REVIEW	DJC	SAM	TDJ	JP	

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J.R. WHITING PLANT
ERIE, MI

FINAL COVER AND BERM DETAILS 2 OF 2

SCALE:	NONE	DRAWING NO.	SHEET	REV.
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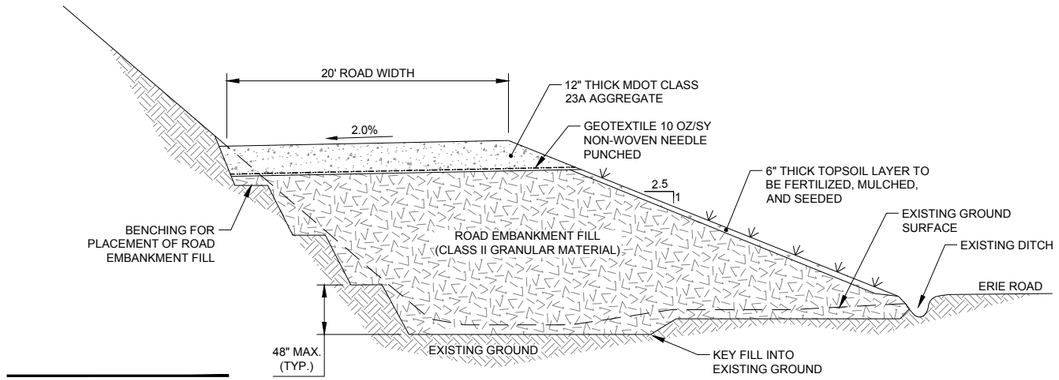
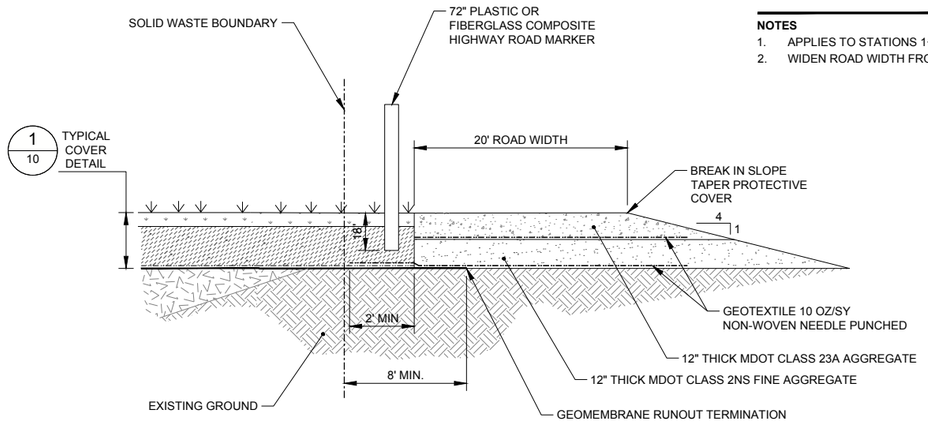


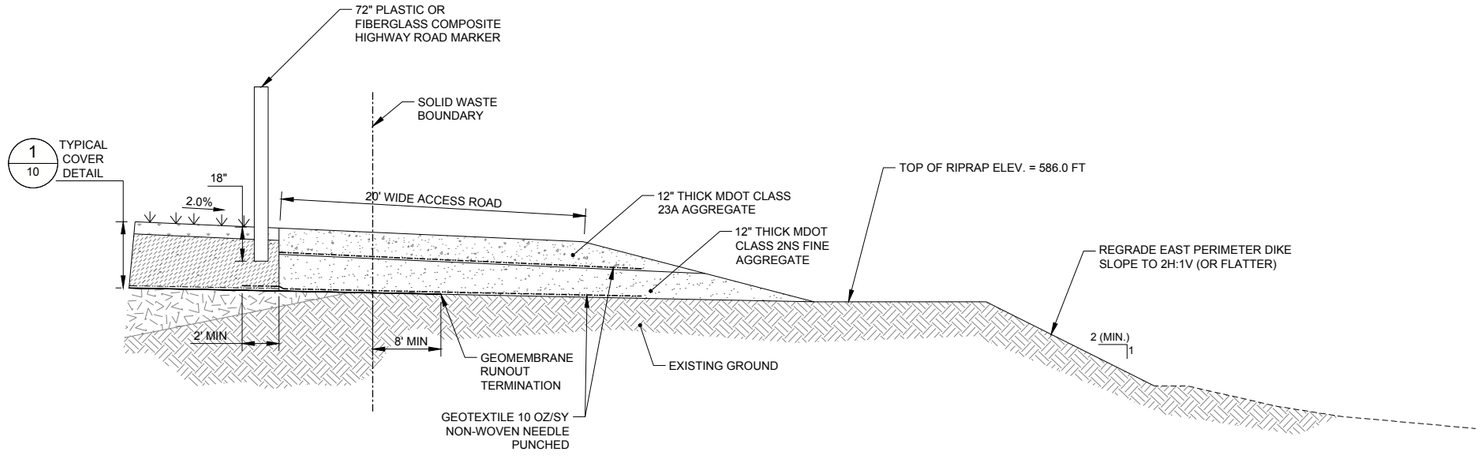
NOTE
APPLIES TO STATIONS 0+68 TO 1+69

NOT TO SCALE 1/12 TYPICAL ACCESS ROAD SECTION 1



NOTES
1. APPLIES TO STATIONS 1+69 TO 7+35.
2. WIDEN ROAD WIDTH FROM STATION 6+36 TO 7+65.

NOT TO SCALE 2/12 TYPICAL ACCESS ROAD SECTION 2



NOTES
1. APPLIES TO STATIONS 7+35 TO 17+74.
2. WIDEN ROAD WIDTH FROM STATION 6+36 TO 7+65.

NOT TO SCALE 3/12 TYPICAL ACCESS ROAD SECTION 3

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	A	2017-07-24	DRAFT FOR REVIEW	DJC	SAM	TDJ	JP	

SIGNATURE
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MICHIGAN P.E. No.

Consumers Energy
J.R. WHITING PLANT
ERIE, MI

PROPOSED ACCESS ROAD DETAILS

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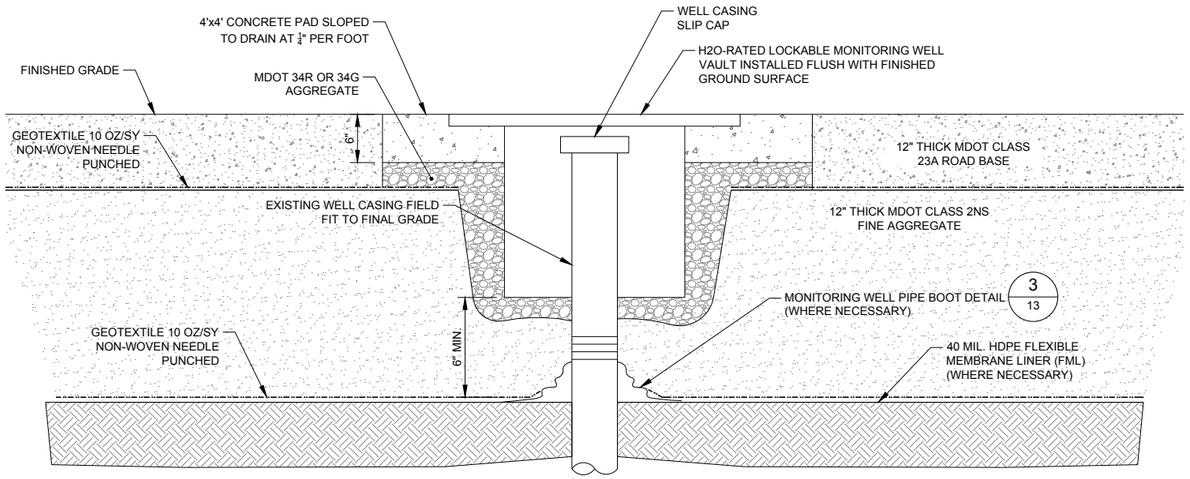
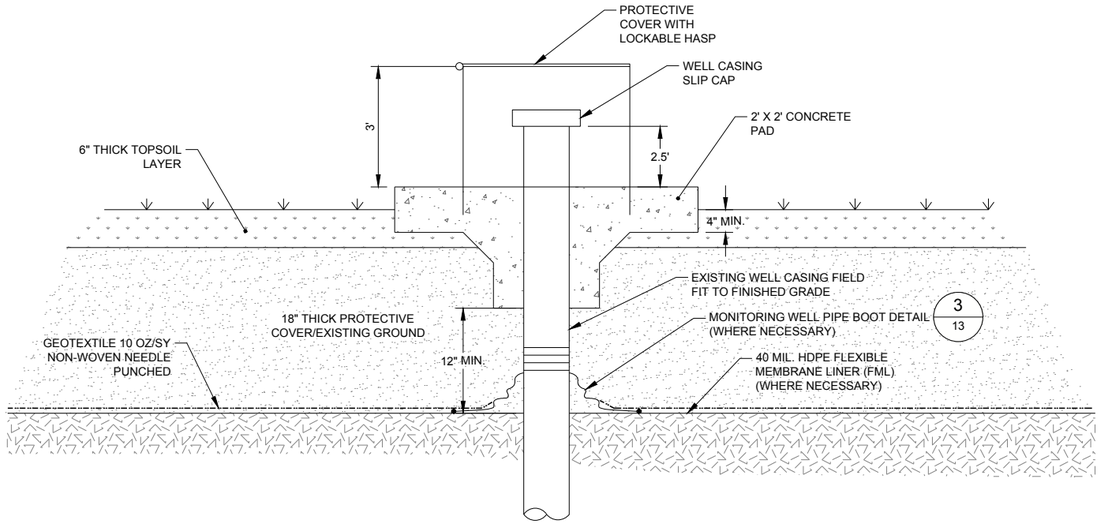
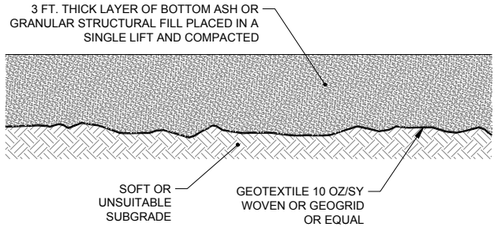


NOT TO SCALE 1 13 GROUND-FLUSH MONITORING WELL VAULT

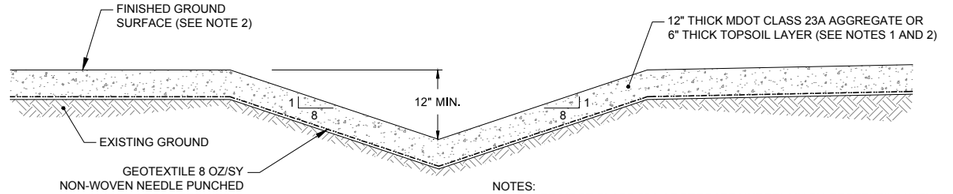


NOT TO SCALE 2 13 STICK-UP PROTECTIVE WELL CASING

NOT TO SCALE 3 13 MONITORING WELL BOOT DETAIL



NOT TO SCALE 4 13 TYPICAL BRIDGING LAYER DETAIL



NOTES:
1. PLACE MDOT CLASS 23A AGGREGATE UNDERLAIN BY GEOTEXTILE WITHIN THE FOOTPRINT OF THE EXISTING ACCESS ROAD.
2. PLACE TOPSOIL AND OMIT THE GEOTEXTILE IN AREAS OUTSIDE THE FOOTPRINT OF THE EXISTING ACCESS ROAD. FERTILIZE, SEED, AND MULCH THE TOPSOIL FINISHED GROUND SURFACE.

NOT TO SCALE 5 13 DRIVABLE OFF-CAP DRAINAGE SWALE DETAIL

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO

REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO
B	2017-08-29	FINAL FOR SUBMITTAL	DJC	SAM	JRP	TDJ	
A	2017-07-24	DRAFT FOR REVIEW	DJC	SAM	TDJ	JP	

SIGNATURE

NAME

MICHIGAN P.E. No.

Consumers Energy

J.R. WHITING PLANT
ERIE, MI

MISCELLANEOUS DETAILS

SCALE:	NONE	DRAWING NO.	SHEET	REV.
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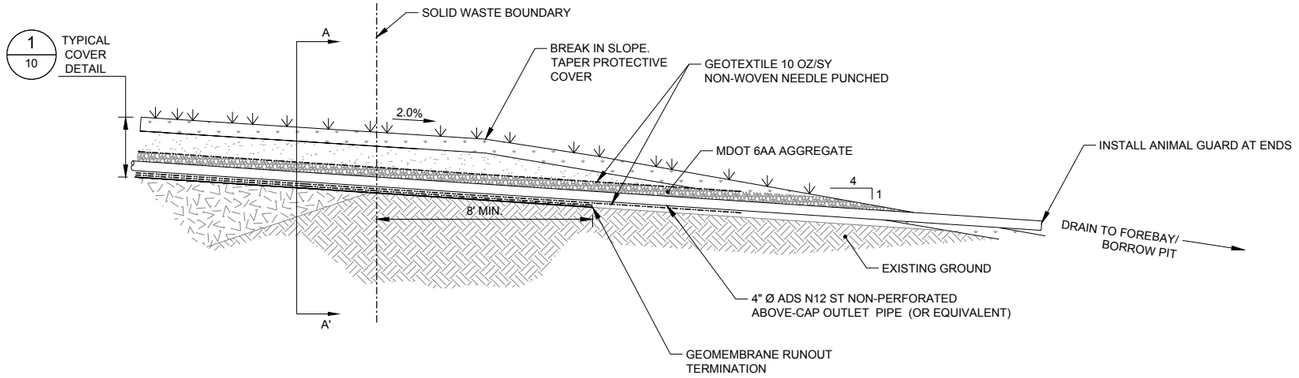

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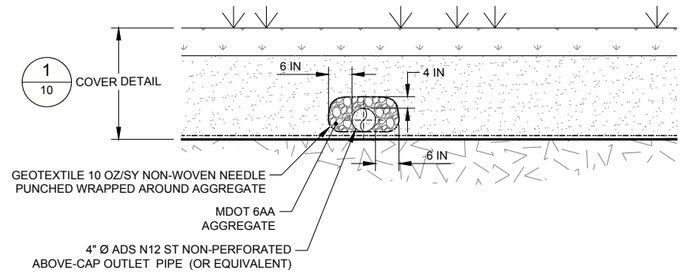

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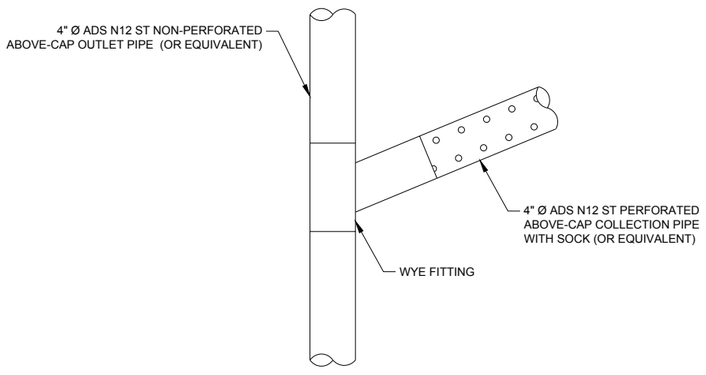

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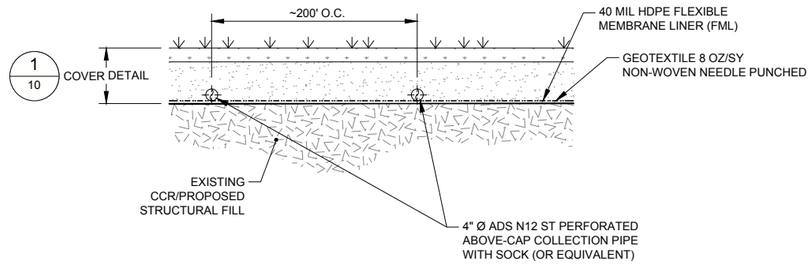

NOT TO SCALE 3 14 ABOVE-CAP COLLECTION PIPING DETAIL

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REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO
B	2017-08-29	FINAL FOR SUBMITTAL	DJC	SAM	JRP	TDJ	
A	2017-07-24	DRAFT FOR REVIEW	DJC	SAM	TDJ	JP	

SIGNATURE

NAME

MICHIGAN P.E. No.

Consumers Energy

J.R. WHITING PLANT
ERIE, MI

ABOVE-CAP DRAINAGE COLLECTION PIPING DETAILS

SCALE:	NONE	DRAWING NO.	SHEET	REV.
JOB:	PT-01851	1667572H013	14	B

APPENDIX B
CONSTRUCTION QUALITY ASSURANCE PLAN

CONSTRUCTION QUALITY ASSURANCE PLAN

J.R. WHITING GENERATING FACILITY

PONDS 1 AND 2 CLOSURE CONSTRUCTION QUALITY ASSURANCE (CQA) PLAN

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

August 31, 2017 **1667572**

Golder Associates

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1.0 INTRODUCTION

1.1 Summary

The Construction Quality Assurance (CQA) program for closure of the Consumers Energy Company (CEC) J.R. Whiting Generating Facility (J.R. Whiting) Ponds 1 and 2, located in Erie, Michigan is presented in the following paragraphs. This plan presents the methods to be followed during fill placement and construction of the final cover necessary to confirm that the construction of the cover is in accordance with the final cover design and regulatory requirements.

1.2 Purpose and Scope

The purpose of the CQA program is to provide minimum requirements for construction observation, testing, and documentation activities to be performed during closure and to verify that the constructed final cover achieves a high quality installation and achieves the requirements of the Michigan Natural Resources and Environmental Protection Act, Public Act 451, Part 115, of 1994, Solid Waste Management, as amended (Part 115). This CQA Plan establishes a program which will verify that the constructed final cover system is in compliance with all design criteria and specifications in the Final Closure Plan. This CQA Plan has been developed to supplement the specifications contained in the Final Closure Plan and will be implemented under direction of a CQA Officer who is a registered professional engineer licensed in the State of Michigan. The plan details sampling and testing programs to be carried out during the final cover construction. The primary goal of the CQA Plan is to provide a means of evaluating the quality of the constructed final cover so that the intent of the design is achieved.

1.3 Design Summary

In general, the closure of Ponds 1 and 2 includes the following major components:

- Dewatering
- Soil stabilization (if necessary)
- Placement of fill material to establish proposed closure grading
- Preparation of the subgrade for placement of geomembrane
- Installation of a geosynthetic capping system (geomembrane and geotextile cushion layer)
- Installation of an above-cap drainage collection piping system
- Placement of protective cover soils
- Placement of topsoil
- Final grading, seeding, mulching, and fertilizing to establish vegetation to protect the completed final cover system
- Placement of on-cover access road

2.0 RESPONSIBILITY AND AUTHORITY

2.1 Facility Owner/Operator

CEC is responsible for the design, construction, and operation of the facility in compliance with the regulatory requirements.

2.2 Regulatory Agency

The regulatory and licensing agency for this project is the Michigan Department of Environmental Quality, Office of Waste Management and Radiological Protection (MDEQ, Regulator).

2.3 Design Engineer

The Design Engineer (Engineer) has the responsibility of designing the final cover system to meet the permitted design and operational requirements of CEC. The Engineer will be onsite once Ponds 1 and 2 are dewatered to accept the initial proof roll of the Ponds 1 and 2 subgrade before fill is placed. If areas do not pass the proof roll, the Engineer will direct the Contractor to install additional drainage to further dry the subgrade and/or direct subgrade replacement with stronger materials, such as a bridging layer or riprap, until the subgrade passes compaction testing.

2.4 Construction Contractors

2.4.1 Earthworks Contractor

The Earthworks Contractor (Contractor) is responsible for construction of the final cover which includes fill placement to meet closure grades as indicated on the design drawings (Appendix A) and in the CQA Plan. The Contractor is also responsible for construction of the access road. The Contractor may implement their own quality control program for purposes of monitoring their related construction. The CQA program presented in this document provides the minimum standards for the acceptance of the work and the regulatory agencies.

2.4.2 Liner Installer

The Liner Installer is responsible for the installation of the geomembrane liner and cushion geotextile in accordance with the design drawings (Appendix A), specifications, and CQA Plan. The Liner Installer is also responsible for providing on-site quality control (QC) personnel and a geomembrane panel layout sufficient to document the as-built condition, as required in the Specifications. The CQA program presented in this document provides the minimum standards for the acceptance of the work and the regulatory agencies.

2.5 Construction Quality Assurance Officer

The Construction Quality Assurance Officer (CQA Officer) is a designated third party representative of CEC who is responsible for certificates of construction. The CQA Officer will be a professional engineer licensed

in the state of Michigan with experience in solid waste unit construction and closure. The CQA Officer is responsible for supervising the inspection and testing quality assurance (QA) requirements of this section. The CQA Officer is also responsible for the preparation of a construction certification report following construction to document the completed observations, measurements, and testing. The report will include a certification statement signed by the CQA Officer that construction meets or exceeds design requirements and specifications contained in the approved Final Closure Plan and achieves regulatory and local requirements.

The specific responsibilities for administering the CQA program are the responsibility of the CQA Officer and will include, at a minimum, the following:

- Reviewing plans and specifications for clarity, completeness, and compliance with the approved closure plan and applicable regulations
- Reviewing contractor and vendor submittals for compliance with the plans and specifications
- Educating and training QA personnel on requirements and procedures outlined in the CQA program
- Scheduling and coordinating QA activities
- Supervising field personnel
- Confirming that QA data are accurately recorded and maintained
- Verifying that raw QA data are properly recorded, reduced, summarized, and interpreted
- Providing associated organizations with reports on CQA activities and results
- Identifying non-conforming construction and verifying corrective measures

2.6 Construction Quality Assurance Technician(s)

The Construction Quality Assurance Technician(s) [CQAT(s)], under the direct supervision of the CQA Officer, will be present to perform observations and testing during the following construction activities:

- Dewatering of Ponds 1 and 2
- Survey of the Ponds 1 and 2 subgrade
- Compaction testing
- Observation of subgrade drainage or subgrade replacement (if required)
- Acceptance of the subgrade
- Installation, seaming, and patching of the geomembrane
- Installation of the geotextile cushion layer
- Installation of the above-cap drainage collection piping system
- Placement of protective cover layer
- Placement of topsoil, seed, fertilizer, and mulch
- Installation of stormwater management features

- Site restoration
- Documentation of tests, work activities, and material deliveries

The CQAT(s) will document construction and CQA activities as described in Section 4.0 of this document.

2.7 Licensed Land Surveyor

The Licensed Land Surveyor shall provide equipment and personnel needed to perform surveying activities as required by the construction project. The Licensed Land Surveyor shall be licensed in the State of Michigan.

2.8 Testing Laboratory

The Testing Laboratory is responsible for providing soil and/or geosynthetic testing as required in the project's plans and specifications.

3.0 MEETINGS

The meeting requirements for the CQA program include a preconstruction meeting, construction progress meetings, and special meetings. The meetings are to be documented by the CQA Officer, and minutes will be transmitted to all parties identified at the preconstruction meeting.

3.1 Preconstruction Meeting

A preconstruction meeting will be held prior to the start of construction and will be attended by all principle parties (CEC, Contractor, CQA Officer) involved in the project. The Michigan Department of Environmental Quality (MDEQ) will be notified as soon as possible in advance of the preconstruction meeting in the event a representative wishes to attend. The purpose of the meeting is to:

- Exchange the following information: business addresses, phone numbers, and e-mail addresses of the Owner (CEC), Engineer, CQA Officer, and pertinent personnel for the Contractor
- Resolve any uncertainties following the award of the construction contract
- Review work scope
- Conduct a site walkthrough and inspection
- Discuss the Contractor's overall construction schedule and anticipated work hours
- Discuss project administration
- Review status of submittals required to be transmitted
- Discuss any appropriate design modifications or clarifications
- Discuss the Contractor's surface water and dust management plan
- Discuss the schedule and procedures of the geomembrane installation
- Discuss CEC's emergency notification and operating practices for emergency situations
- Review project methods, site security, and health and safety

3.2 Progress Meetings

Progress meetings will be held prior to the beginning of each major phase or on an "as needed" basis. The day of week and time of day will be determined and agreed upon by all parties prior to the meetings. The meetings will be conducted by CEC. The purpose of the meetings will be to:

- Review coordination of work
- Review schedule
- Review the previous work activities and accomplishments
- Review the status of the Contractor's submittals
- Identify the Contractor's personnel and equipment assignments for the upcoming work
- Discuss any existing or potential construction problems and their respective corrective actions
- Review non-conformance list

3.3 Special Meetings

Special meetings will be called at the discretion of CEC, Engineer, CQA Officer, or Contractor to resolve problems or other work-related issues.

4.0 CONSTRUCTION OBSERVATIONS

4.1 Daily Reports

The CQAT(s) collects samples and performs or observes the CQA testing required by the CQA Plan. A daily inspection report is prepared by each CQAT(s) for each day they are onsite observing the construction and kept in a record book which is to be made available to CEC on a daily basis. The report will contain (at a minimum) the following information:

- Date
- Type of observations
- Summary of weather conditions such as minimum and maximum temperatures, wind speed, and precipitation
- Summary of any meetings held and attendees
- Equipment and personnel on the project
- Name and titles of Contractor supervisors and Quality Control personnel
- Summary of construction activities and locations
- Description of offsite materials received
- Calibration and recalibration of test equipment
- Description of procedures used
- Test locations, procedures, results, and test data sheets
- Summary of samples collected
- Record of repairs to the liner system
- Personnel involved in daily observations and sampling activities
- Signature of the technician
- Description of delays in construction activities
- Detailed description of any problems or non-conforming construction and resolution/alternatives for each situation
- Approximate quantities completed each day (approximate volume of fill placed, areas of subgrade prepared and/or accepted, areas proof rolled, square footage of geosynthetics placed, etc.)
- Summary of failed testing and corrective actions completed
- Ensuring that all proper lifts or equipment are used to ensure the minimum contact pressure required at the liner
- Record of and field modifications made to the design or if hot or cold weather placement procedures for liner installation are in effect

4.2 Photographs

The CQAT(s) will coordinate with CEC personnel to ensure sufficient photographs are taken to document construction problems, non-conforming work, and related repairs taken before and after the problem or

non-conforming work is corrected. The CQAT(s) will take required photographs and record each photograph in a Photo Log showing photo number, date taken, and description.

Photographs approved by CEC security will be provided to the CQA Officer for inclusion in the Certification Report. At the end of the project, photographs will be retained by CEC.

4.3 Test Data Sheets

At a minimum, the CQAT(s) will record all field test data results on separate forms listed below:

- Daily field report
- Certificate of acceptance of prepared subgrade
- Geosynthetics roll inventory and condition
- Documentation of review of manufacturer's quality control (QC) certificates
- Panel placement summary
- Trial weld summary
- Panel seaming summary
- Repair summary
- Non-destructive test summary
- Destructive test summary - field
- Destructive test summary – laboratory
- Field compaction summary
- Geotechnical Laboratory summary

Independent consultants or laboratories engaged by the CQA Officer will submit their test results on forms acceptable to and approved by the CQA Officer.

4.4 Documentation and Record Storage

The daily records maintained during construction activities include but are not limited to the following:

- Daily observation reports
- Test data sheets
- Test data from independent consultants or laboratories (if any)
- Field book maintained by each CQAT(s)

Daily records will be copied and forwarded to the CQA Officer on a daily basis.

5.0 EARTHWORK OBSERVATIONS AND TESTING

The following section summarizes the CQA plan proposed for testing and monitoring the final cover construction. The Contractor will provide Owner's acceptance criteria that documents imported fill, protective cover soil and topsoil provided for this project is from clean, uncontaminated sources.

The Contractor will document the physical address, including latitude and longitude of each borrow source, to depict the location and provide a brief narrative about the soil and intended use (e.g. structural fill, protective cover, topsoil etc.). Physical properties of the structural fill soil will be established by determining the relationship between moisture and density as established with laboratory test data as part of an initial design report on the borrow source by using either the modified Proctor test, ASTM D1557, or the standard Proctor test, ASTM D698. The Contractor will reevaluate the soil if the nature of the source changes.

5.1 Ponds 1 and 2 Existing Surface Grading

The CQAT(s) will perform testing of the existing surface grading in accordance with the contract documents and this CQA Plan. The Ponds 1 and 2 existing grades will consist of coal combustible residuals (CCR). CCR material from Ponds 1 and 2 used for earthworks grading and will require dewatering prior to placement of additional material required to achieve a surface that is acceptable to place structural fill. Once the Ponds 1 and 2 CCR's grading is acceptable to proceed with fill placement, the surface will be documented by survey for pay quantities documentation. The CQAT(s) is responsible for observing and documenting the CCR dewatering and CCR grading until a suitable surface capable of supporting structural fill is achieved.

5.2 Structural Fill Testing

Structural fill will have a maximum particle size of three inches and should be relatively free of organics, debris, frozen soil, or other deleterious material. Material testing of the structural fill material will include determining the maximum dry density to be performed using the Modified Proctor test (ASTM D 1557) or using the Standard Proctor test (ASTM D 698) and determining the grain size distribution of the soil (ASTM D 422). At least three structural fill samples will be laboratory tested per borrow source.

The Earthwork Contractor shall perform all of the following during construction of structural fill:

1. Place and compact each lift with a general thickness of 9-inches after compaction.
2. Compact each soil lift thoroughly and uniformly to the density, and at the moisture content determined necessary per the project specifications.
3. Protect the structural fill from detrimental climatic effects during construction by doing all of the following:
    - remove all ice, snow, and frozen soil during winter construction prior to placing a lift and not using any frozen soil in any part of the compacted soil liner system;

- recompact any soil lift of which its integrity is so adversely affected by weather that it no longer meets the requirements of the CQA Plan, at the discretion of the Owner and CQA Officer;
- cover to prevent frost penetration during and following placement during winter construction;
- remove observed debris, or rocks larger than three inches in diameter.

The CQA Officer shall determine the in-place moisture content and dry density of the structural fill by nuclear methods following ASTM D 6938, latest edition. In place tests shall be performed at a minimum frequency of one test per acre per lift to verify compliance with the project requirements.

The CQA Officer shall verify that structural fill is compacted to at least 90-percent (%) of the maximum dry density determined by the Modified Proctor (ASTM D 1557) or at least 95% of the maximum dry density determined by the Standard Proctor (ASTM D 698) and at +/- 3% optimum moisture content. The moisture content may vary by more than +/- 3% if approved by the CQA Officer prior to lift placement.

5.3 Subgrade Testing

Once subgrade elevations are achieved, the subgrade will have rocks >0.75-inches removed at the surface and will be smooth drum rolled. The subgrade is the surface that is ready for placement of geosynthetics. The signature of a Subgrade Acceptance Certification by the Owner or the Owner's Representative, the CQA Officer or his/her representative and the Geosynthetics Installer shall verify that the subgrade is suitable for the installation of the overlying geosynthetic components.

Earthworks Contractor: The Earthworks Contractor shall perform all of the following during the preparation of subgrade for geosynthetics installation:

- Prepare the soil to a smooth surface, using a smooth drum roller or other suitable equipment, with grades which meet the construction drawings and grade tolerances.
- Remove debris, organic materials, roots, and angular or sharp rocks or other material which may damage the geosynthetic components.
- Make any other repairs as deemed necessary by the CQA Officer or his/her representative.

CQA Officer or his/her representative: During the preparation of subgrade for geosynthetics installation, the CQA Officer or his/her representative shall verify that:

- The subgrade is properly prepared for the installation of geosynthetic materials and is in compliance with the project specifications and the CQA Plan.
- The underlying soil has been rolled, adequately compacted or hand-worked so as to be free of irregularities, protrusions, standing water, organic matter and abrupt changes in grade that may damage or adversely affect the performance of the geosynthetics.

- Elevations of the subgrade are verified before geosynthetics installation and are within the tolerance specified.
- Areas that do not meet the requirements of the project specifications and CQA Plan are properly repaired and documented.

Geosynthetics Contractor: The Geosynthetics Contractor shall perform all of the following during the preparation of the subgrade for geosynthetics installation:

- Inspect the subgrade surface.
- Accept, with the Geosynthetics Contractor's signature on a Subgrade Acceptance Certification, that the soil surface is acceptable for geosynthetics installation prior to deployment of the geosynthetic material.
- Once the subgrade is accepted, the Geosynthetics Contractor shall maintain and repair any defects resulting from the deployment and installation process.

The top of Ponds 1 and 2 subgrade will be documented by survey and compared to the design elevations. The maximum allowable difference from documented grades to design grades is +0.0/- 0.2 foot and the slope minimums indicated on the design drawings (Appendix A) must be maintained. If the documented subgrade differs from the design grades by more than +0.0/- 0.2 foot, the subgrade will be regraded and resurveyed until the tolerances are met.

5.4 Protective Cover Soil Layer

Protective cover soils will be placed over geosynthetics. Protective cover soils must be classified as SM, ML, SC, or CL according to the Unified Soil Classification System (USCS). Since these soils are placed above the geosynthetics, there will be no stones larger than 0.75 inches, and they will be free of frozen, organic, or other materials that could harm the geosynthetics. Protective soils shall be a minimum of 18-inches thick.

The soil source will be approved by CEC and free of contaminants prior to hauling onsite. Material will be spread to the thickness shown by the plans using low ground pressure equipment (not exceeding pressures of five pounds per square inch (psi) at the geomembrane) and pushed up-slope to prevent tensioning of the geosynthetics. Limited placement of protective cover soils down slope will be allowed only after submittal and approval by the Owner of a slope stability evaluation by the Contractor. Temporary haul roads for normal ground pressure vehicles will be a minimum of 48 inches thick.

The Contractor will perform the following:

1. Install the soil layers above the geosynthetic components of the final cover system with at least 12 inches of soil maintained between the underlying geosynthetic materials and the construction equipment tires or tracks of low ground-pressure equipment.

2. Low ground-pressure equipment shall be utilized for work on the soil cover whenever the thickness of the soil is less than 24 inches. Roadway fill for transporting material over the final cover shall be at least four feet thick at all times. Excessive rutting shall be prevented. No portion of the earthmoving equipment shall be allowed to contact the underlying geosynthetic component of the final cover system.

3. Soil placement shall be accomplished to minimize stresses on the underlying geosynthetic components of the final cover system.

During cover soil placement, the CQAT(s) will observe the following:

- Placement procedures and equipment sizes
- Weather conditions to prevent placement of frozen material
- Removal of stones or other debris
- Confirmation that underlying 40 mil high-density polyethylene (HDPE) geomembrane and geotextile remain in place and are not excessively wrinkled
- Control of protective cover layer thickness over the geosynthetics in areas of hauling

The CQAT(s) will perform the following testing prior to and during protective cover placement:

- Collect one sample per source for contaminant testing at the request of CEC from potential borrow sites;

- Collect a minimum one sample per 3,000 cubic yards of placed material and/or when the material source changes for grain size determination in accordance with ASTM D422, Unified Soil Classification in accordance with ASTM D2487. The protective cover soil samples shall be collected and tested by the CQAT (s). The CQAT (s) will verify that the test results meet the requirements of the project specifications, design drawings (Appendix A), and CQA Plan;
- Document testing and observations in the daily report and with construction photographs in accordance with Section 4.2; and
- The Licensed Land Surveyor shall survey the top of final cover on a 100-foot grid system to verify the protective layer thickness. Alternately, direct depth checks may be used to determine the protective layer thickness. Locations where the protective layer thickness is less than that required on the engineering plans shall be increased to meet the project specifications. The CQA Officer will document the placement of additional soil material to meet the requirements of the CQA Plan. Elevations shall be referenced to the National Geodetic Vertical Datum of 1929 (NGVD29). Grade tolerance is+0.2 to 0.0 at high design points (top of protective cover), from the engineering plans and maintaining slope minimums and protective soil thickness minimums indicated in the design drawings (Appendix A) and specifications.

5.5 Topsoil (Top of Final Cover)

The topsoil for the landfill will be the final six inches of the final cover system. This material may be the same as the protective layer, but it must have at least 2.5 percent organic matter to support the establishment of vegetation and retain moisture. Testing of the topsoil for organic content will be in accordance with ASTM D2974.

The CQAT(s) will observe the following during topsoil placement:

- Placement procedures and equipment sizes
- Weather conditions to prevent placement of frozen material
- Removal of stones or other debris
- Control of protective layer thickness over the geosynthetic layer in areas of hauling

The CQAT(s) will perform the following testing prior to and during topsoil placement:

- Collect sample for contaminant testing at the request of CEC from potential borrow sites
- Collect and test a minimum of one sample per source for organic content
- Document all testing and observations in the daily report and with construction photographs in accordance with Section 4.2

The maximum allowable difference from documented grades to design grades is +0.5/- 0.0 foot. If the documented top of topsoil differs from the design grades by more than +0.5/- 0.0 foot or if the minimum slopes and topsoil thicknesses presented in the engineering plans and specifications are not achieved, the topsoil and/or protective cover layer will be regraded and resurveyed.

6.0 GEOMEMBRANE LINER OBSERVATIONS AND TESTING

The geomembrane is the geosynthetic barrier layer of the final cover system. The geomembrane will be 40-mil thick HDPE.

6.1 Geomembrane Rolls and Panels

Geomembrane materials will be approved by the CQA Officer before being used in construction. Approval will be based on the review of material data provided by the manufacturer prior to shipment and the inspection for defects of material as it is delivered to the site.

The geomembrane manufacturer shall perform the following:

- Provide a certification that the geomembrane manufactured for this project meets the Project specifications and the latest revisions to Geosynthetic Research Institute Test Method GRI-GM13 "Test Methods, Test Properties and Testing Frequency for HDPE Geomembranes" most recent revision.
- Provide a copy of the manufacturer's geomembrane properties and quality control requirements, and instructions for geomembrane delivery, storage and handling.
- Provide quality control (QC) Certificates which represent each roll of geomembrane to be delivered to the job site. Each QC Certificate shall include:
  - Roll number, geomembrane type, thickness, manufacturer, date of production, and roll dimensions. Each finished roll shall be identified by a number corresponding to the particular batch of resin used.
  - The manufacturer's test results on samples from rolls from the same production lot, which verify that the rolls meet the requirements of the project specifications. These samples shall be tested to confirm that the requirements of the project specifications are met, except that testing for environmental stress crack resistance and low temperature impact need not be performed. The test data shall be identified by roll number.
  - Certification that the roll meets the requirements of the project specifications.

The geomembrane manufacturer is responsible for the production of extrusion beads and/or welding rod from polyethylene resin which shall meet the requirements of the project specifications.

The CQA Officer or his/her representative shall review the submittals provided by the geomembrane manufacturer to verify compliance with the requirements of the project specifications.

The CQA Officer will review Contractor submittals and monitor handling and deployment of the materials. These activities include:

- Monitoring and documenting the unloading of trucks delivering geomembrane rolls to the site:
  - Name of the manufacturer and fabricator
  - Name and type of liner

- Thickness of liner
- Batch code
- Date of fabrication
- Physical dimensions of rolls or fabricated panels
- Panel number
- Location and method of storage at the site

- Monitoring the handling and onsite storage of geomembrane rolls
- Recording the manufacturing roll and batch number of geomembrane rolls delivered to the site
- Reviewing the manufacturer's quality control testing for conformance with GRI GM 13 and the required testing in Table 6.1
- Fixing a code number to samples and recording the manufacturing numbers of the rolls from which samples are taken
- Labeling, packaging, and shipping samples to an offsite laboratory for conformance testing (if required)
- Interpreting laboratory test results in accordance with the specifications and accepting or rejecting delivered rolls based on results of offsite testing
- Observing and marking geomembrane as it is unrolled and deployed at the job site for uniformity, damage, and imperfections including holes, cracks, thin spots, tears, punctures, blisters, and foreign matter
- Reviewing documentation of the origin and identification of the raw materials used in the liner
- Reviewing copies of quality control certificates that are issued by the producer of the raw materials

Table 6.1: HDPE Polyethylene Geomembrane Properties and Testing Frequencies

Properties	Test Method	Test Value 40 mils	Testing Frequency (minimum)
Thickness mils (min. ave.) ■ Lowest individual for any of the 10 values	D 5199	-10%	Per roll
Density (min. ave.)	D 1505/ D 792	0.940	200,000 pounds
Tensile Properties (min. ave.)[1] ■ Break strength –lb/in. ■ Break elongation - % ■ Yield strength –lb/in. ■ Yield elongation - %	D 6693 Type IV	152 700% 84 12%	20,000 pounds
Tear Resistance - lb (min. ave.)	D 1004	28	45,000 pounds
Puncture Resistance - lb (min. ave.)	D 4833	72	45,000 pounds
Stress Crack Resistance[2]	D 5397 (App.)	500 hr	Per GRI GM10
Carbon Black Content - % (range)	D 4218[4]	2.0-3.0 %	20,000 pounds
Carbon Black Dispersion	D 5596	Note[4]	45,000 pounds
Oxidative Induction Time (OIT) (min. ave.)[5] (a) Standard OIT — or — High Pressure OIT	D 3895 D 5885	100 min. 400 min.	200,000 pounds
Oven Aging at 85°C[5,6] (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	55% 80%	Per each formulation
UV Resistance[8] (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs[10]	D 7238 D 3895 D 5885	N.R.[8] 50%	Per each formulation

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
Yield elongation is calculated using a gage length of 1.3 inches
Break elongation is calculated using a gage length of 2.0 in.
(2) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

(3) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.
(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views:

9 in Categories 1 or 2 and 1 in Category 3
(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
(7) The condition of the test should be 20 hr. UV cycle at 75□C followed by 4 hr. condensation at 60□C.
(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

6.2 Panel Placement

Liner Installation and QA monitoring for panel placement includes:

- Obtaining written acceptance of the subgrade by the geomembrane installer
- Evaluating and documenting weather conditions (e.g., temperature, wind) for geomembrane placement and informing the CQAT(s) if requirements for weather conditions are not met so the CQAT(s) can decide whether or not to stop geomembrane placement. No seaming shall be performed during precipitation events
- Monitoring and documenting geomembrane placement as well as conditions of panels as placed
- Noting panel defects, tears, or other deformities
- Observing panel placement for proper overlap
- Measuring panel lengths and thicknesses
- Recording the locations of installed panels and checking that the panels have been installed in accordance with the design plan
- Assigning each panel a unique panel number and identifying that panel with the manufacturer's roll number
- Recording panel numbers and locations on a panel layout diagram
- Recording ambient air temperature (daily)
- No gasoline cans are allowed on the liner
- No smoking on or near the liner
- All generators shall have a dual containment pan placed directly under the gas tank while on the liner
- No wheeled or tracked equipment shall traverse directly on the geosynthetics.

6.3 Geomembrane Field Seam Construction

Seam construction information includes:

- Seam Layout:
  - When possible, orient seams parallel to line of maximum slope, (i.e., oriented along, not across, slope)

- When possible, no horizontal seam will be less than 10 feet from toe of slope
- In general, maximize lengths of field panels and minimize number of field seams
- Align geomembrane panels to have nominal overlap of three inches for extrusion welding and four to six inches for fusion welding. Final overlap will be sufficient to allow strength tests to be performed on seam
- Seams will be wiped free of moisture and debris prior to seaming
- Where applicable, the panels will be shingled in a down slope fashion

- Temporary Bonding:
  - Hot air device (Leister) will be used to temporarily bond geomembrane panels to be extrusion welded
  - Do not damage geomembrane when temporarily bonding adjacent panels. Apply minimal amount of heat to lightly tack geomembrane panels together. Control temperature of hot air at nozzle of any temporary welding apparatus to prevent damage to geomembrane
  - Do not use solvent or adhesive
- Seaming Methods:
  - Approved processes for field seaming are extrusion welding and double-wedge fusion welding methods. Proposed alternate processes will be documented and submitted to Owner for approval. Alternate procedures will be used only after being approved in writing by Owner
  - Use double-wedge fusion welding as primary method of seaming adjacent field panels:
    - For cross seam tees associated with fusion welding, patch is required. Extrusion welding of cross seam tees will only be permitted with approval of CQAT(s)
    - When subgrade conditions dictate, use movable protective layer (e.g., extra piece of geomembrane) directly below each overlap of geomembrane that is to be seamed to prevent buildup of moisture between sheets and prevent debris from collecting around pressure rollers. If protective layer is used, it will be removed after completion of seam
  - Use extrusion welding as secondary method of seaming between adjacent panels and as primary method of welding for detail and repair work
- Seaming procedures:
  - General seaming procedures ambient temperature between 32°F and 104°F (seaming outside of this temperature range may be allowed provided trial welds provide passing results and are approved by Owner):
    - Do not seam if dust is blowing because of excessive winds or if raining
    - Align seams with fewest possible number of wrinkles and fishmouths
    - Prior to seaming, ensure that seam area is clean and free of moisture, dust, dirt, debris, or foreign material
    - At beginning and end of each seam, Contractor will write start time of weld, date, welder initials, identification number of seaming unit, seaming unit temperature, and speed
  - Cold weather seaming procedures (ambient temperature below 40°F [5°C]):
    - Sheet grinding may be performed before preheating, if applicable

- Trial seaming will be conducted under same ambient temperature and preheating conditions as actual seams. New trial seams will be conducted if ambient temperature drops by more than 10°F from initial trial seam test conditions. New trial seams will be conducted upon completion of seams in progress during temperature drop
- CQAT(s) or Owner will inspect the geomembrane surfaces for the presence of frost or residual moisture prior and during the welding procedure. If either is present, Installer will make provisions for removal and sufficient drying
- The CQAT(s) will describe the nature and time of the execution of cold weather welding procedures in the certification report as a means of notification to MDEQ

- Warm weather procedures (ambient temperature above 104°F):
  - No seaming of geomembrane is permitted unless demonstrated to CQAT(s) that geomembrane seam quality will not be compromised
  - At option of CQAT(s), additional destructive seam tests may be required for any suspect areas
- Repair procedures:
  - Repair portions of geomembrane exhibiting flaw or failing destructive or nondestructive test
  - Final decision as to repair procedure will be agreed upon between Owner, Contractor, and CQAT(s)
  - Acceptable repair procedures may include following:
    i. Patching: Piece of same geomembrane material welded into place. Use to repair large holes, tears, non-dispersed raw materials, and contamination by foreign matter
    ii. Capping: Strip of same geomembrane material extrusion welded into place over inadequate seam. Use to repair large lengths of failed seams
    iii. Removal and replacement: Remove bad seam and replace with strip of same geomembrane material welded into place. Use to repair large lengths of failed seams

QA monitoring and testing to be conducted for seam construction includes:

- Monitoring trial test seams: Test seams will be made by each operator and seaming unit combination each day prior to commencing field seaming. These seams will be made on fragment pieces of geomembrane liner to observe that seaming conditions are adequate. Such test seams will be made at the beginning of each seaming period; at changes of equipment, equipment settings, or power supply interruption; at the discretion of the CQAT(s); at least once every five hours or as directed by the CQAT(s) in accordance with temperature and weather conditions during continuous operation of each welding machine, and at the end of seaming (end of day). Also, each operator and seaming unit combination will make at least one test seam each day prior to commencing seaming operations. Requirements for test seams are as follows:
  - The test seam sample will be at least three-feet long by one-foot wide, or as agreed with the seam centered lengthwise. Six adjoining specimens, one-inch wide each, will be die cut from the test seam sample. These specimens will be tested in the field with a tensiometer for both shear (three specimens) and peel (three specimens) for single-track fusion welds or extrusion welds. For dual-track fusion welds, the Contractor will test each track as if it were a single-track weld. Test seams will be tested by the

Contractor under observation of the CQAT(s) or designated representative of CEC. The specimens will not fail in the weld. No strain measurements need to be obtained in the field. A passing fusion or extrusion welded test seam will be achieved when the criteria is met described in MDEQ Operational Memorandum 115-19, and GRI GM 19, Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane, latest revision. If a test seam fails, the entire operation will be repeated. If the additional test seam fails, the seaming apparatus or seamer will not be accepted and will not be used for seaming until the deficiencies are corrected and two consecutive successful full test seams are achieved. Test seam failure is defined as failure of any one of the specimens tested in shear or peel. For double-weld seams, both weld tracks will meet the test seam criteria

- The CQAT(s) will collect the calibration certificates for all tensiometers used on site and will log the date, hour, ambient temperature, number of seaming unit, name of seamer, and pass or fail description

- Non-destructive testing:
  - Production seams will be tested by the Contractor continuously using non-destructive techniques. The Contractor will perform all pressure and vacuum testing under the observation of the CQAT(s) or CQA Officer. Requirements for non-destructive testing are as follows:
    - Extrusion weld seams:
      i. The Contractor will maintain and use equipment and personnel at the site to perform continuous vacuum box testing on all single weld production seams. The system will be capable of applying a vacuum of at least five psi. The vacuum will be held for a minimum of 10 seconds for each section of seam. If bubbles are present indicating leakage, the area will be marked clearly for repair. If the vacuum test indicates leakage, the area will be patched; or the entire seam will be capped
    - Double-wedge fusion weld seams:
      i. The Contractor will maintain and use equipment and personnel to perform air pressure testing of all double weld seams. The system will be capable of applying a pressure of at least 30 psi for not less than five minutes. Seam will be cut at opposite end from the air pressure gauge to assure full continuity of the test. Pressure loss tests will be conducted in accordance with the procedures outlined in "Pressurized Air Channel Test for Dual Seamed Geomembranes," GRI Test Method GM 6. As outlined by the test method, the seam or portion thereof being tested will be pressurized to 30 psi and; following a two-minute pressurized stabilization period, pressure losses over a measurement period of five minutes will not exceed four psi for a 40-mil sheet. The Contractor will demonstrate the required pressure over the entire length of the seam. If pressure drops below the allowance, the test will be considered a failure, and the following procedures will be implemented: Check to determine if there is excessive seepage around the inflation needle; check both ends of the seam to ensure the flow channel is completely sealed off; walk the length of the seam; and look and listen for air leaks. If either of these procedures fails to identify the leak, trim the seam overlap and vacuum test the seam to locate the leak. Once the leak is identified, make the necessary repairs and retest the seam

- Destructive Testing:
  - Destructive testing will be performed on at least one field-seamed sample per day per seaming crew and machine combination. The sampling and testing frequency will be

at least one test every 500 linear feet of production seam for fusion and extrusion welded seams. Repairs with less than 10 feet diagonal dimension are not included in the extrusion weld seam total and are considered minor. If the weather conditions are such that the ambient air temperature is less than 40°F, then the minimum frequency may be increased by CEC, CQAT(s), or CQA Officer. GRI Test Method GM 9, "Cold Weather Seaming of Geomembrane" will be utilized for seaming under 40°F. The locations will be selected by the CQAT(s) or CQA Officer. Sufficient samples will be obtained by the Contractor to provide one sample to the archive, one sample to the CQAT(s) or CQA Officer for laboratory testing (if required), and one sample to be retained by the Contractor for field testing. The CQAT(s) will mark each sample with the name of the person welding, date, time, ambient air temperature, temperature of heating element, speed of seaming, and identification number of seaming unit. The test seam sample will be a minimum of 42-inches long-by-one-foot wide with the seam centered lengthwise. Testing requirements are as indicated in GRI standard GM 19, "Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembrane." Final determination of sample sizes will be agreed upon at the preconstruction meeting

- The Contractor will test samples in the field under the observation of the CQAT(s) or CQA Officer. Tests will be performed using a calibrated, motor-driven, strain-controlled tensiometer approved by the CQA Officer
  - Peel will be measured for one sample (five specimens). Peel tests will be evaluated for the criteria described in GRI GM 19. For double track welders, peel tests (five specimens) will be evaluated for each track
  - Shear will be measured for one sample (five specimens). Tests will be evaluated for the criteria described in GRI GM 19
- The CQAT(s) or CQA Officer will observe all production seam field test procedures and will provide samples to a third party laboratory certified by "Geosynthetic Accreditation Institute – Laboratory Accreditation Program" for laboratory testing for both peel and shear and evaluate test results in accordance with GRI GM 19
- The CQAT(s) or CQA Officer will be responsible for the archive specimen and will assign a number to the archive sample and mark the sample with the number and will also log the date, seam number, approximate location in the seam, and field test pass-or-fail description, if applicable

6.4 Seam Repair

Damaged and sample areas of geomembrane will be repaired by the Contractor by construction of a cap strip, patching, or removal and replacement. No repairs will be made to seams by application of an extrusion bead to a seam edge previously welded by fusion or extrusion methods. Repaired areas will be tested for seam integrity. Damaged materials are the property of the Contractor and will be removed from the site. The following QA monitoring and testing will be implemented to monitor defect repairs:

- Destructive test failure procedures: When a sample fails destructive testing, Contractor has the following options:
  - Repair seam between any two passing destructive test locations
  - Trace welding path to intermediate point (10 feet minimum from point of failed test in the previous and next direction) and take a small sample with a one-inch-wide coupon for an additional field test at each location. If these additional samples pass test, then take a full size destructive sample for peel and shear testing in accordance with Section

6.3. If these samples pass tests, repair seam between these locations. If either sample fails, repeat process to establish a zone in which seam should be repaired

- Acceptable repaired seams will be bound by locations from which samples passing destructive tests have been taken. In cases exceeding 150 feet of repaired seam, the CQA Officer may have Contractor destructively test the repair seam
- When sample fails, CQA Officer or CQAT(s) may require additional testing of seams that were welded by same welder and/or welding apparatus during same time shift

- Repair Verification:
  - The CQAT(s) will observe, number, and log each repair
  - The CQAT(s) will observe and document non-destructive testing of each repair
  - The CQAT(s) will document passing non-destructive test results as adequate repairs
  - Repairs more than 150-feet-long may require destructive test sampling

Failed destructive or non-destructive tests indicate that repair will be redone and retested until passing test results.

6.5 Documentation and Reporting

Documentation and reporting methods will be implemented to systematically record results of onsite monitoring and testing. Reporting forms will be used for roll and panel placement, trial weld construction, panel seaming, non-destructive seam testing, and destructive seam testing. Unique identifying numbers will be assigned to each panel and seam and used to reference the panel and seam location and test results. Copies of example CQA forms are included in Appendix A.

Panel location and seam location diagrams will be kept showing the location of all panel and seams, repairs, and destructive sample test locations. These location diagrams will be updated on a daily basis and will be available for review.

A photo log will be created containing photos of all phases of the geomembrane liner installation, including deployment, seaming, testing, and anchor trench construction.

Copies of test results for any offsite laboratory testing will be forwarded to the CQA Officer and CQAT(s). The laboratory test result documents will be maintained in a job file and submitted with the final certification report.

7.0 CUSHION GEOTEXTILE

The following section defines the CQA program for installation of the geotextile cushion layer in the final cover system. Geotextile (8 oz/sy) for cushion will be installed over the 40-mil HDPE geomembrane.

7.1 Geotextile Rolls

Prior to the installation of any geotextile, the geotextile manufacturer shall provide the CQA Officer or his/her representative with quality control documentation in accordance with specified geotextile characteristics as defined in project specifications and this CQA Plan. The CQA Officer or his/her representative shall review the information and reject any non-conformance material. The CQA Officer or his/her representative shall verify that:

- Property values certified by the geotextile manufacturer meet its guaranteed specifications.
- Measurements of properties by the geotextile manufacturer are properly documented and that the test methods used are acceptable.
- Quality control certificates have been provided at the specified frequency for rolls, and that each certificate identifies the rolls related to it.
- Roll Packages are appropriately labeled.
- Certified minimum average roll values (MARV) meet the project specifications.
- Project specifications and the CQA Plan were submitted by the Owner or the Owner's representative to the Geosynthetics Contractor.

Geotextile manufacturers' certifications shall be included in the Construction Documentation Report.

Monitoring for geotextile cushion rolls includes the following:

- Monitoring the condition of the rolls following delivery and unloading
- Recording the roll number of rolls delivered to the site
- Reviewing manufacturer's quality control testing for conformance with the CQA Plan shown in Table 7.1
- Obtaining samples and recording the manufacturer roll numbers from which samples are taken
- Labeling, packaging, and shipping samples to an offsite laboratory for conformance testing (if required)
- Observing geotextile as it is installed for uniformity, damage, and imperfections including holes, tears, thin spots, punctures, and foreign matter

Table 7.1: Cushion Geotextile Properties

Property	Test Method	Frequency	Minimum Value
Mass per unit area, oz/yd^2	ASTM D 5261	90,000 ft^2	8
Puncture resistance, lb.	ASTM D 6241	90,000 ft^2	500
Grab tensile strength, lb. (elong. percent)	ASTM D 4632	90,000 ft^2	50%
Trapezoidal tear strength, lb.	ASTM D 4533	90,000 ft^2	80
UV resistance, percent	ASTM D 7238	90,000 ft^2	70%

Note: Alternative test methods must be approved by Engineer

7.2 Installation

The Geosynthetics Contractor shall ensure that geotextiles are not damaged during handling. The geotextile shall be deployed as described below:

- In the presence of wind, geotextiles shall be weighted with sandbags or the equivalent. Sandbags shall be installed during deployment and shall remain until replaced with cover material.
- Geotextiles shall be cut using a geotextile cutter (hook blade) only. If in place, special care shall be taken to protect other materials from damage that could be caused by the cutting of the geotextiles.
- The Geosynthetics Contractor shall take any necessary precautions to prevent damage to underlying layers during placement of the geotextile.
- During placement of geotextiles, care shall be taken not to entrap, in or beneath the geotextile, stones, bones, debris, excessive dust, or moisture that could damage the geomembrane, cause clogging of drains or filters, or hamper subsequent seaming.
- A visual examination of the geotextile shall be carried out over the entire surface, after installation, to ensure that no potentially harmful foreign objects, such as needles, are present.
- No wheeled vehicles shall traverse directly on the geosynthetics.

7.3 Geotextile Seams and Overlaps

The geotextile will be continuously sewn with a double stitch seam. Overlaps will be at least four inches or as required to perform the proper seaming.

7.4 Geotextile Repairs

The geotextile will overlap the repair area by six inches to provide proper excess material to perform the sewing. On repairs smaller than six square feet, the geotextile may be repaired by overlapping the damaged area with new geotextile and heat bonding it into place.

7.5 Documentation and Reporting

Daily estimates of the amount of geotextile placed and seamed will be kept. This information will be included in the CQAT(s) field book and on the daily reports. A record of geotextile roll numbers delivered to the project site will be kept with a copy of the required manufacturer certifications.

8.0 ABOVE-CAP DRAINAGE COLLECTION PIPING SYSTEM PLACEMENT AND DOCUMENTATION

An Above-Cap Drainage Collection Piping System will be placed in the final cover as shown in the design drawings (Appendix A). The CQAT(s) will record the type, size, and quantity of drain tile placed. The piping system will be field verified by survey at junctions and every 100 feet along the length following installation.

Piping used in the project shall meet the requirements of the construction drawings, project specifications, and the CQA Plan.

8.1 Pipe Materials

The pipe manufacturer shall provide the CQA Officer or his/her representative with the following information:

- Documentation that the pipe provided to this construction project meets the project specifications, CQA Plan and requirements of the construction drawings.

The CQA Officer or his/her representative shall review the manufacturer's information to verify that the project specifications, CQA Plan and construction drawings requirements are met.

8.2 Delivery and Storage

The CQA Officer or his/her representative shall obtain the following information when the pipe is delivered to the job-site:

- Name of manufacturer;
- Product type and identification number;
- Pipe diameter; and
- Pipe Wall Thickness Schedule or Standard Dimension Ratio.

The pipe shall be protected, by the manufacturer, during shipment from excessive heat or cold, puncture, or other damage. The pipe shall be stored on-site in a manner to protect it from damage.

The CQA Officer or his/her representative shall inspect the pipe delivery paperwork to ensure that the information is correct. The CQA Officer or his/her representative shall also document the pipe material delivery in the daily summary report.

8.3 Pipe Installation

The pipe shall be joined by methods as defined by the pipe manufacturer.

The Earthworks Contractor shall perform the following:

- Pipe placement shall not be performed in the presence of excessive moisture.
- Prepare the pipe subgrade condition and slope according to the project specifications.

- Join the pipe sections according to the pipe manufacturer's specifications.
- Backfill the pipe according to the project specifications.

The CQA Officer or his/her representative shall perform the following:

- Inspect the pipe material for compliance with the project specifications.
- Observe and document the placement and backfill of the pipe for compliance with the project specifications.
- Observe and document the placement and joining of the pipe for compliance with the project specifications.
- Observe and document the placement of any filter materials, if used, around the pipe for compliance with project specifications.

9.0 PLACEMENT OF ON-COVER ACCESS ROAD

An access road will be constructed adjacent to and over the flexible membrane liner as shown in the design drawings (Appendix A). The Contractor will provide Owner's acceptance criteria that documents imported road base aggregate is from clean, uncontaminated sources.

The Contractor will document the physical address, including latitude and longitude of each borrow source, to depict the location and provide a brief narrative about the soil and intended use (e.g. road surface aggregate, fine aggregate sub-base, etc.).

9.1 Class 2NS Fine Aggregate

Class 2NS fine aggregate will be placed over geosynthetics and must meet the gradation requirements presented in the specifications. Since these soils are placed adjacent to the geosynthetics, there will be no stones larger than 0.75 inches, and they will be free of frozen, organic, or other materials that could harm the geosynthetics. The class 2NS fine aggregate road sub-base layer shall be a minimum of 12-inches thick.

The soil source will be approved by CEC and free of contaminants prior to hauling onsite. Material will be spread to the thickness shown by the plans using low ground pressure equipment (not exceeding pressures of five pounds per square inch (psi) at the geomembrane) and pushed up-slope to prevent tensioning of the geosynthetics. Limited placement of protective cover soils down slope will be allowed only after submittal and approval by the Owner of a slope stability evaluation by the Contractor. Temporary haul roads for normal ground pressure vehicles will be a minimum of 48 inches thick.

The Contractor will perform the following:

1. Install the class 2NS fine aggregate above the geosynthetic components of the final cover system in a single lift with at least 12 inches of soil maintained between the underlying geosynthetic materials and the construction equipment tires or tracks.

2. Low ground-pressure equipment shall be utilized for work on the class 2NS fine aggregate whenever the thickness of the soil is less than 24 inches. Roadway fill for transporting material over the final cover shall be at least four feet thick at all times. Excessive rutting shall be prevented. No portion of the earthmoving equipment shall be allowed to contact the underlying geosynthetic component of the final cover system.

3. Soil placement shall be accomplished to minimize stresses on the underlying geosynthetic components of the final cover system.

During placement of the class 2NS fine aggregate, the CQAT(s) will observe the following:

- Placement procedures and equipment sizes
- Weather conditions to prevent placement of frozen material

- Removal of stones or other debris
- Confirmation that underlying 40 mil high-density polyethylene (HDPE) geomembrane and geotextile remain in place and are not excessively wrinkled
- Control of protective cover layer thickness over the geosynthetics in areas of hauling

The CQAT(s) will perform the following testing prior to and during placement of the class 2NS fine aggregate:

- Collect one sample per source for contaminant testing at the request of CEC from potential borrow sites;
- Collect a minimum one sample per 3,000 cubic yards of placed material and/or when the material source changes for grain size determination in accordance with ASTM D422. The class 2NS fine aggregate samples shall be collected and tested by the CQAT (s). The CQAT (s) will verify that the test results meet the requirements of the project specifications, design drawings (Appendix A), and CQA Plan;
- Document testing and observations in the daily report and with construction photographs in accordance with Section 4.2; and
- The Licensed Land Surveyor shall survey the top of the class 2NS fine aggregate every 100 linear feet to verify the class 2NS fine aggregate layer thickness. Alternately, direct depth checks may be used to determine the class 2NS fine aggregate layer thickness. Locations where the class 2NS fine aggregate layer thickness is less than that required on the engineering plans shall be increased to meet the project specifications. The CQA Officer will document the placement of additional soil material to meet the requirements of the CQA Plan. Elevations shall be referenced to the National Geodetic Vertical Datum of 1929 (NGVD29). Grade tolerance is+0.2 to 0.0 at high design points (top of class 2NS fine aggregate), from the engineering plans and maintaining slope minimums and protective soil thickness minimums indicated in the design drawings (Appendix A), and specifications.

9.2 Roadway Geotextile

Within the footprint of the on-cover access road, geotextile (10 oz/sy) will be installed for cushion over the 40-mil HDPE geomembrane and as a separation layer between the access road fill materials. Section 7.0 defines the CQA program for installation of the roadway geotextile. Monitoring for roadway geotextile includes reviewing the manufacturer's quality control testing for conformance with the requirements shown in Table 9.1

Table 9.1: Roadway Geotextile Properties

Property	Test Method	Frequency	Minimum Value
Mass per unit area, oz/yd^2	ASTM D 5261	90,000 ft^2	10
Puncture resistance, lb.	ASTM D 6241	90,000 ft^2	700
Grab tensile strength, lb. (elong. percent)	ASTM D 4632	90,000 ft^2	50%
Trapezoidal tear strength, lb.	ASTM D 4533	90,000 ft^2	95
UV resistance, percent	ASTM D 7238	90,000 ft^2	70%

Note: Alternative test methods must be approved by Engineer

9.3 Class 23A Aggregate

Class 23A Aggregate will be placed over a separation geotextile and class 2NS fine aggregate, as shown on the design drawings (Appendix A), and must meet the gradation requirements presented in the specifications. These soils will be free of frozen, organic, or other materials that could harm geosynthetics. The class 23A aggregate layer shall be a minimum of 12-inches thick.

The soil source will be approved by CEC and free of contaminants prior to hauling onsite. Material will be spread to the thickness shown by the plans using low ground pressure equipment (not exceeding pressures of five pounds per square inch (psi) at the geomembrane) and pushed up-slope to prevent tensioning of the geosynthetics. Limited placement of protective cover soils down slope will be allowed only after submittal and approval by the Owner of a slope stability evaluation by the Contractor. Temporary haul roads for normal ground pressure vehicles will be a minimum of 48 inches thick.

The Contractor will perform the following:

1. Install the class 23A aggregate above the class 2NS fine aggregate and separation geotextile, as shown in the design drawings (Appendix A), in a single lift with at least 12 inches of soil maintained between the underlying geosynthetic materials and the construction equipment tires or tracks.

2. Low ground-pressure equipment shall be utilized for work on the class 23A aggregate whenever the thickness of the soil is less than 24 inches. Roadway fill for transporting material over the final cover shall be at least four feet thick at all times. Excessive rutting shall be prevented. No portion of the earthmoving equipment shall be allowed to contact the underlying geosynthetic component of the final cover system.

3. Soil placement shall be accomplished to minimize stresses on the underlying geosynthetic components of the final cover system.

During placement of the class 23A aggregate, the CQAT(s) will observe the following:

- Placement procedures and equipment sizes
- Weather conditions to prevent placement of frozen material
- Removal of debris
- Control of protective cover layer thickness over the geosynthetics in areas of hauling

The CQAT(s) will perform the following testing prior to and during placement of the class 23A aggregate:

- Collect one sample per source for contaminant testing at the request of CEC from potential borrow sites;
- Collect a minimum one sample per 3,000 cubic yards of placed material and/or when the material source changes for grain size determination in accordance with ASTM D422. The class 23A aggregate samples shall be collected and tested by the CQAT (s). The CQAT (s) will verify that the test results meet the requirements of the project specifications, design drawings (Appendix A), and CQA Plan;
- Document testing and observations in the daily report and with construction photographs in accordance with Section 4.2; and
- The Licensed Land Surveyor shall survey the top of the class 23A aggregate every 100 linear feet to verify the class 23A aggregate layer thickness. Alternately, direct depth checks may be used to determine the class 23A aggregate layer thickness. Locations where the class 23A aggregate layer thickness is less than that required on the engineering plans shall be increased to meet the project specifications. The CQA Officer will document the placement of additional soil material to meet the requirements of the CQA Plan. Elevations shall be referenced to the National Geodetic Vertical Datum of 1929 (NGVD29). Grade tolerance is +0.2 to -0.0 at high design points (top of class 23A aggregate), from the engineering plans and maintaining slope minimums indicated in the design drawings (Appendix A) and sSpecifications.

The maximum allowable difference from documented grades to design grades is +0.2/- 0.0 foot. If the documented top of the class 23A aggregate differs from the design grades by more than +0.2/- 0.0 foot, if the minimum slopes and thicknesses presented in the engineering plans and specifications are not achieved, or if the finished ground surface does not form a smooth slope to prevent ponding or concentration of runoff, the class 23A aggregate layer and/or topsoil layer will be regraded and resurveyed.

10.0 SITE RESTORATION

The following section describes the CQA requirements for the site restoration such as final cover seeding, fertilizing, and mulching. Miscellaneous activities (i.e., road grading) required for complete site restoration are included in this section.

10.1 Erosion and Sediment Control

The CQAT(s) will monitor the installation of all erosion and sediment control features. This includes the documentation of temporary silt fencing, location of silt check dams, and temporary ditching. The CQAT(s) will document the type and quantity of material installed.

Documentation of the maintenance of the features will be recorded following major storm events and weekly.

10.2 Seeding, Fertilizer, and Mulch

The final cover topsoil will be prepared for seeding and mulching in accordance with typical MDOT standards. Alternative seed mixtures may be proposed by the Contractor and approved by CEC. The CQAT(s) will document material and equipment delivered to the site for the seeding operation. In general, the CQAT(s) will record the following information:

- Seed types and quantities delivered to the site
- Type and quantity of fertilizer delivered
- Type and quantity of lime or other soil amendments
- Area seeded and rate of seed application on a daily basis
- Area fertilized or limed and rate of application on a daily basis
- Copies of soil nutrient test results from Contractor
- Type and quantity of mulch applied

10.3 Documentation

The CQAT(s) or CEC personnel will document the limits of site restoration and dates of seeding as the work progresses. All installation procedures and types of equipment used for the work will be recorded. Photographs of typical procedures will be taken in accordance with Section 4.2. The data will be reported in the final documentation report.

While onsite, the CQAT(s) will document any repairs to the erosion controls or areas that are reseeded. Calculations and/or confirmation will also be provided that demonstrate the seeding equipment does not exceed five psi at the liner.

11.0 CONSTRUCTION CERTIFICATION REPORT

11.1 Summary

A Construction Certification Report will be prepared under the direction of the CQA Officer in accordance with Rule 921 of Part 115. The report will contain, at a minimum, the following information:

- Daily field reports
- Detailed narrative describing the construction activities in chronological order
- Analysis and discussion of the QA and QC testing performed with summaries of all test results
- Data collected and testing performed during construction
- Detailed description and documentation of material, equipment types, and specifications
- Discussion of construction material or equipment which deviated from the engineering plan and reason for deviation
- Photographs documenting aspects of construction
- Correspondence and documentation with MDEQ concerning rule exceptions or CQA changes
- Record drawings containing:
  - Existing site grades prior to construction
  - Liner system subgrade grades
  - Granular drainage layer thickness measurement locations
  - Pipe invert grades
  - Geomembrane panel layout diagram including seam locations and types, repair locations, destructive sample locations, and anchor trench location
  - Location of all field tests
  - Final site grades

Based on the review of the data and the CQA Officer's personal observations during construction, the CQA Officer will certify that the construction has been prepared and constructed in conformance with the engineering plans and specifications, the CQA Plan, and the requirements of applicable MDEQ rules.

12.0 REFERENCES

Geosynthetics Research Institute (GRI) GM 6 – Pressurized Air Channel Test for Dual Seamed Geomembranes.

GRI GM 9 - Cold Weather Seaming of Geomembranes.

GRI GM 13 - Test Methods, Test Properties, and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes.

GRI GM 19 - Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes.

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Golder Associates

Engineering Earth's Development, Preserving Earth's Integrity

APPENDIX A

SAMPLE CQA FORMS

- **Field Monitoring Report**
- **Geosynthetic Installation Monitoring Report**
- **Trial Weld Summary**
- **Certificate of Soil Surface Acceptance**
- **Initial Roll Inventory Summary**
- **Geosynthetic Deployment Summary**
- **Panel Seaming Summary**
- **Construction and Repair Summary**
- **Air Channel Pressure Test Summary**
- **Destructive Testing Summary**
- **Vacuum Testing Logs**

FIELD MONITORING REPORT

FIELD MONITORING REPORT

PAGE _____ OF _____

PROJECT NUMBER: _____ **PROJECT TITLE:** _____
OWNER: _____ **CONTRACTOR:** _____
LOCATION: _____

DATE | | **S M T W T F S**

THE FOLLOWING WAS NOTED: _____

SUBMITTED BY:

_____

GOLDER FORM R1-0699

(May 2001)

GOLDER ASSOCIATES INC.

FIELD MONITORING SUMMARY

PROJECT NUMBER: _____ **PROJECT TITLE:** _____

OWNER: _____ **CONTRACTOR:** _____

LOCATION: _____

DATE: _____ **S M T W T F S**

WEATHER: **TEMPERATURE:** **LOW:** _____ @ _____ **HIGH** _____ @ _____

CLOUD COVER _____ **PRECIPITATION** _____ **WIND** _____

GOLDER PERSONNEL ON SITE: _____

SUMMARY OF CONSTRUCTION PROGRESS: _____

GOLDER ACTIVITIES AND TEST RESULTS: _____

SUBMITTED BY:

_____

GOLDER FORM: R4-0699

(JUNE 1999)

GEOSYNTHETIC INSTALLATION MONITORING REPORT

GEOSYNTHETIC INSTALLATION MONITORING REPORT

PAGE ___ OF ___

PROJECT NUMBER: _____ **PROJECT TITLE:** _____

OWNER: _____ **CONTRACTOR:** _____

LOCATION: _____

DATE: _____ S M T W R F S

GEOSYNTHETIC DEPLOYMENT: _____

TRIAL SEAMING: _____

SEAMING: _____

NON-DESTRUCTIVE TESTING: _____

DESTRUCTIVE TESTING: _____

GENERAL REMARKS: _____

SUBMITTED BY:

_____

GOLDER FORM: R2-0899

GOLDER ASSOCIATES INC.

TRIAL WELD SUMMARY

GEOMEMBRANE TRIAL SEAM LOG

PROJECT NUMBER: ______________________ **PROJECT TITLE:** ______________________
OWNER: ______________________ **CONTRACTOR:** ______________________
LOCATION: ______________________

[ ] **TF - # = FUSION** **DATE** ______________________
[ ] **TX - # = EXTRUSION** **SHEET NUMBER** ______________________

SAMPLE NUMBER	APPROX. TIME	WELDING MACHINE NUMBER	WELD TECH.	TEMPERATURES				TEST RESULTS			PASS OR FAIL	MON.	REMARKS **
				AMBIENT AIR TEMP.	PREHEAT OR MACHINE SPEED	EXTRUDER	NOZZLE OR WEDGE	INSIDE PEEL STRENGTH	OUTSIDE PEEL STRENGTH	SHEAR STRENGTH			
								/ /	/ /	/			
								/ /	/ /	/			
								/ /	/ /	/			
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								/ /	/ /	/			
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								/ /	/ /	/			
								/ /	/ /	/			

NOTE: ADHESION FAILURE OF TRIAL SEAM SAMPLES SHALL BE NOTED IN THE REMARKS COLUMN
FOR JOBS IN MICHIGAN, PUT DESTRUCTIVE SAMPLE NUMBER CORRESPONDING TO EACH MACHINE

GOLDER FORM: G12-TSS **REVIEWED BY:** ____________ **DATE:** ____________

(August 2000)

GOLDER ASSOCIATES INC.

CERTIFICATE OF SOIL SURFACE ACCEPTANCE

CERTIFICATE OF ACCEPTANCE OF SOIL SURFACE
BASED UPON VISUAL OBSERVATION ONLY

COMPANY: _____ **PROJECT TITLE:** _____

PROJECT NUMBER: _____ **LOCATION:** _____

OWNER: _____

I, the Undersigned, the duly authorized representative of _____
do hereby accept the area of soil surface bounded by (Panels)

_____

_____

and shall be responsible for maintaining its integrity and suitability in accordance with the project specifications from this date to the completion of the installation.

_____

NAME **SIGNATURE** **TITLE** **DATE**

I, the Undersigned, the duly authorized representative of _____
do hereby accept the area of soil surface bounded by (Panels)

_____

_____

_____

_____

NAME **SIGNATURE** **TITLE** **DATE**

I, the Undersigned, the duly authorized representative of the CQA Engineer, do hereby accept the area of soil surface bounded by (Panels)

_____

_____

_____

_____

NAME **SIGNATURE** **TITLE** **DATE**

Reviewed/Approved by: _____ **Date:** _____

INITIAL ROLL INVENTORY SUMMARY

GEOSYNTHETIC INVENTORY CONTROL LOG

PROJECT NUMBER: _____ **PROJECT TITLE:** _____
OWNER: _____ **CONTRACTOR:** _____
LOCATION: _____

MATERIAL TYPE : GEOMEMBRANE GEONET GEOTEXTILE OTHER _____
DATE OF ARRIVAL: _____ **DATE OF INVENTORY:** _____
MATERIAL MANUFACTURER: _____ **INVENTORY MONITOR:** _____
PRODUCT IDENTIFICATION: _____ **CONDITION IN TRUCK:** _____
TRUCK TYPE: _____ **UNLOADING METHOD:** _____

	ROLL NUMBER	BATCH OR LOT NO.	MATERIAL DIMENSIONS			QC CERT Y / N	CONF. SAMP. Y / N	OTHER	REMARKS
			LENGTH	WIDTH	THICKNESS OR WEIGHT				
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									

Golder Form: G2
(July 2000)

REVIEWED BY: _____ **DATE:** _____

GOLDER ASSOCIATES INC.

GEOSYNTHETIC DEPLOYMENT SUMMARY

GEOSYNTHETIC PANEL DEPLOYMENT LOG

PROJECT NUMBER: _____ **PROJECT TITLE:** _____
OWNER: _____ **CONTRACTOR:** _____
LOCATION: _____

GEOMEMBRANE: Secondary Primary Closure Other: _____
SUBGRADE CONDITION: (Surface Compaction Protrusions Dessiccation Excessive Moisture)
REMARKS: _____

TRANSPORT EQUIPMENT: _____

PANEL #	ROLL NUMBER	DEPLY'D LENGTH	AMBIENT AIR TEMP	OBS'D OVERLAP	MONITOR	THICKNESS MEASUREMENTS		REMARKS
						LEAD	SIDE	
						/ / / /	/ / / /	

Golder Form: G2-TSS
(August 2000)

REVIEWED BY: _____ **DATE:** _____

GOLDER ASSOCIATES INC.

PANEL SEAMING SUMMARY

GEOMEMBRANE SEAM LOG

PROJECT NUMBER: _____ **PROJECT TITLE:** _____
OWNER: _____ **CONTRACTOR:** _____
LOCATION: _____

PASSING TRIAL SEAMS

	NO.	TIME	TECH ID
☐ FUSION			
☐ EXTRUSION			

DESTRUCTIVE LENGTH CARRY-OVER FROM PREVIOUS LOG _____

DATE _____

MACHINE # _____

SHEET NUMBER _____

	SEAM NUMBER	SEAM SECTION* START POINT	SEAM SECTION* FINISH POINT	APPROX. START TIME	AMB. AIR TEMP.	WELD TECH.	PREHEAT OR MACH. SPEED	MACHINE TEMPERATURES DIGITAL SET WEDGE OR BARREL	MACHINE TEMPERATURES INDICATOR WEDGE OR NOZZLE	APPROX. LENGTH WELDED	LENGTH FROM PREVIOUS DESTR.	DESTR. NUMBER	MON.	REMARKS	** NON-DESTRUCTIVE TEST DATE	** NON-DESTRUCTIVE MON.
1	/	-						-	-							
2	/	-						-	-							
3	/	-						-	-							
4	/	-						-	-							
5	/	-						-	-							
6	/	-						-	-							
7	/	-						-	-							
8	/	-						-	-							
9	/	-						-	-							
10	/	-						-	-							
11	/	-						-	-							
12	/	-						-	-							
13	/	-						-	-							
14	/	-						-	-							
15	/	-						-	-							
16	/	-						-	-							
17	/	-						-	-							
							DAILY TOTAL									
							DESTRUCTIVE LENGTH CARRY-OVER									

* REFERENCE SEAM ENDPOINTS FROM AN END OF SEAM (EOS), A REPAIR NUMBER, OR A POINT LOCATION ON THE SEAM.

** COLUMNS TO BE USED BY THE DATA REVIEWER ONLY

GOLDER FORM: G13-0699
(JUNE 1999)

REVIEWED BY: _____ **DATE:** _____

GOLDER ASSOCIATES INC.

CONSTRUCTION AND REPAIR SUMMARY

GEOMEMBRANE REPAIR LOG

PROJECT NUMBER _____ **PROJECT TITLE:** _____
OWNER: _____ **CONTRACTOR:** _____
LOCATION: _____

PASSING TRIAL SEAMS

NO.	TIME	TECH	NO.	TIME	TECH

MACHINE NUMBER: _____

DATE: _____

SHEET NO: _____

	DEFECT CODE	REPAIR DATE	APPRX. TIME	REPAIR TYPE	APPRX. DIM.	WELD TECH.	MON.	REMARKS
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								

	DEFECT CODE	REPAIR DATE	APPRX. TIME	REPAIR TYPE	APPRX. DIM.	WELD TECH.	MON.	REMARKS
26								
27								
28								
29								
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								
40								
41								
42								
43								
44								
45								
46								
47								
48								
49								
50								

REPAIR TYPE: P - PATCH, C - CAP, RS - RECONSTRUCTED SEAM, G&W - GRIND WELD

REVIEWED BY: _____ **DATE** _____

GOLDER FORM: G19-tss

(August 2000)

GOLDER ASSOCIATES INC.

AIR CHANNEL PRESSURE TEST SUMMARY

GEOMEMBRANE SEAM NON-DESTRUCTIVE TEST LOG

PROJECT NUMBER: _____ **PROJECT TITLE:** _____

OWNER: _____ **CONTRACTOR:** _____

LOCATION: _____

DATE: _____

SHEET NUMBER: _____

	SEAM NUMBER	SEAM SECTION * FROM	TO	VACUUM OR PRESSURE	TECH ID	TIME START	FINISH	PRESSURE INITIAL	FINAL	OBS. TEST	RESULTS PASS/ FAIL	SEAM COMPLETE NO	YES	MON.	REMARKS
1	/	-				:		:							
2	/	-				:		:							
3	/	-				:		:							
4	/	-				:		:							
5	/	-				:		:							
6	/	-				:		:							
7	/	-				:		:							
8	/	-				:		:							
9	/	-				:		:							
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11	/	-				:		:							
12	/	-				:		:							
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16	/	-				:		:							
17	/	-				:		:							
18	/	-				:		:							
19	/	-				:		:							
20	/	-				:		:							

*** REFERENCE SEAM ENDPOINTS FROM AND END OF SEAM (EOS), A REPAIR NUMBER, OR A POINT LOCATION ON THE SEAM (i e, REFERENCE POINT, DISTANCE, DIRECTION FROM REF. PT.)**

GOLDER FORM: G16-tss

(August 2000)

REVIEWED BY: _____ **DATE:** _____

GOLDER ASSOCIATES INC.

APPENDIX C
J.R WHITING FUGITIVE DUST CONTROL PLAN

J.R Whiting Plant
Erie, MI
SRN: B2846

Fugitive Dust Control Plan
For
Coal Combustion Residuals (CCR)

Date: 9/15/2017
Rev: 02

Table of Contents

1.0 INTRODUCTION

The purpose of this Fugitive Dust Control Plan (FDCP) is to describe the measures adopted at the JR Whiting facility for minimizing fugitive dust emissions from coal combustion residual (CCR) handling operations (also known as ash handling operations). The CCR units covered by this FDCP are located to the east of the former JR Whiting facility which was located at 4525 Erie Road in Erie, Michigan which ceased operation on April 12, 2016. This plan has been developed in accordance with the coal combustion residual regulations stipulated in 40 CFR Part 257, subpart D. The scope of this plan includes the active CCR units and their corresponding roads and associated activities therein. A site Fugitive Dust Plan Coordinator (FDPC) has been appointed and is responsible for ensuring adequate resources are provided for controlling fugitive dust, as well as implementing the monitoring and recordkeeping requirements of this plan. This FDCP has been certified by a qualified professional engineer and is placed in the facility's CCR operating record and on the Consumers Energy Website. The initial FDCP was posted and made available to the public by October 19, 2015, with a notification sent to the Michigan Department of Environmental Quality (MDEQ-Waste Division) within 30 days of that posting. All Subsequent revisions are posted to the operating record and the public-facing web site with a notice sent to the MDEQ of that posting.

The CCR facility currently consists of Ash Ponds 1 and, 2 and the respective access roads as Pond 6 has received final cover and reached 70% vegetation germination. There are no further fugitive dust requirements for Pond 6 with regard to Michigan Part 115 Rules, as the landfill is no longer operating. Please see the regulatory reference below:

> *R299.4315 (5) - (5) Measures shall be provided to control fugitive dust, odors, and other emissions at a type III landfill. These measures shall be sufficient to ensure that the operation of the landfill will not produce any emission that results in a violation of Part 55 of the act.*

The appropriate control activities selected for the Ash Pond 1 and 2 and the corresponding roads are based on good engineering practices, in part, that were developed for the Engineering Control Plan (1991) that was submitted and approved by the Michigan Department of Environmental Quality, as well as in accordance with Michigan's Fugitive Dust Regulations under Act 451 of 1994, Rule 324.5524. The following sections outline the FDCP.

2.0 CCR OPERATIONS

2.1 STORAGE

The Ash Storage ponds are no longer actively accepting CCR material, however excavating activities may be a part of the Pond 1 and 2 closure and are visually monitored for dusting during the construction season. Activities are suspended if there is excessive dusting (ie. dust leaving the site boundaries) or when there are sustained wind speeds of over 20 mph. Ash Ponds 1 and 2 are mostly covered with vegetation and/or are sufficiently wet (contain standing water) which controls formation of fugitive dust.

2.2 ROADS

Fugitive dust emissions may be generated from trucks and other heavy equipment traveling on the site haul roads and entering/exiting the site. To control fugitive dust, road wetting and brine application are implemented as necessary to minimize fugitive dust emissions from travel on the site roadways. Water trucks are available and used on site during the construction season. There is a site wide speed limit of 15 mph on non-paved roads to minimize fugitive dust generation from roadways.

3.0 MONITORING/RECORDKEEPING

3.1 MONITORING

Daily visible emission inspections are conducted on 1 and 2 Ash Ponds during construction days, and weekly during the off season when no construction activities are taking place. These inspections are documented on the Fugitive Dust Inspections Checklist.

A fugitive dust record is maintained that includes events such as visible emissions observed reaching the site boundary, as well as of suspended activities (as reported by Ash Pond Contractor Supervisor). The date, cause and corrective action taken shall be logged relative to suspended activities. Fugitive dust control techniques and/or activities which are used for any of the various site activities to control fugitive are also documented.

3.2 RECORDKEEPING

- The following records will be retained for a period of at least five (5) years: All actions taken to control CCR fugitive dust
- Record of all citizen complaints
- Summary of any corrective measures taken

4.0 CITIZEN COMPLAINTS

All complaints, concerns and/or inquiries that result in an action shall be documented in the External Communications Log in SharePoint. Environmental Services and Legal shall be notified of any citizen complaint regarding CCR Fugitive Dust. In accordance with the CCR regulation, external complaints and resultant actions will be summarized in the annual report.

5.0 PLAN ASSESSMENTS/AMENDMENTS

The FDCP will be audited utilizing Consumers Energy Compliance Assurance guidance once per year, coordinated by the site Fugitive Dust Plan Coordinator in order to periodically assess the effectiveness of the control plan. Results of the audit shall be reported to site management and Corporate Environmental Services.

This FDCP may be amended at any time provided that revisions are logged and the revised plan is placed in the facility's operating record. The FDPC is responsible for amending the written plan whenever there is a change in site conditions that would substantially affect the written plan in effect. All amendments

to the fugitive dust control plan must be certified by a qualified professional engineer. A notice shall be send to the MDEQ (Waste Division) within 30 days of when the plan is revised.

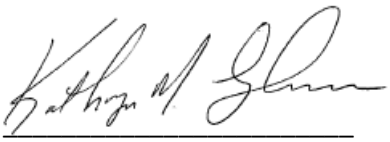
6.0 ANNUAL REPORTING

The FDPC will prepare an annual CCR fugitive dust control report that includes a description of the actions taken by plant personnel or contractors to control CCR fugitive dust, a record of all citizen complaints, and a summary of any corrective actions taken. The report shall be reviewed by Environmental Services and Legal prior to posting to the operating record. Annual reports shall be completed and posted in the operating record one year after the date of posting the previous report. A notice will be sent to MDEQ (Waste Division) within 30 days of posting the annual report.

7.0 CERTIFICATIONS

CCR Fugitive Dust Plan, Professional Engineer Certification:
By means of this certification, I attest that I am familiar with the requirements of provisions of 40 CFR Part 257, that I or my designated agent have visited and examined the facility, that this CCR FDP has been prepared in accordance with good engineering practices, including consideration of applicable industry standards, and with the requirements of this Part, that procedures for required fugitive dust minimization activities, monitoring, and reporting have been established and that the Plan is adequate for the facility.

Kathryn M. Cunningham — 44447
Professional Engineer — Registration Number (MI)



Professional Engineer (Signature) — 9/15/17 Date of Plan Certification:

CCR Fugitive Dust Plan Management Approval:
This Plan is certified as being prepared in accordance with good engineering practices. Thus, this Plan has the full approval of Consumers Energy Company Management. I am at a level of sufficient authority to commit the necessary resources to implement this Plan as described. I have appointed the following representative as the Fugitive Dust Plan Coordinator: Frank Rand

Corrie Meeks / Thomas Shields — 9/15/2017
EPM Project Managers — Date

8.0 REVISION HISTORY

Revision Number	Date of Revision	Reason(s) for Revision
0	9/16/15	Original Edition
1	10/17/16	Update for Site Decommissioning
2	9/15/17	Update for Pond 6 Closure and reduced monitoring (daily to weekly during non-construction days)

APPENDIX D
GEOTECHNICAL CALCULATIONS

FINAL COVER VENEER STABILITY CALCULATIONS

CALCULATIONS

Date:	July-2017	**Made by:**	BAB
Project No.:	1667572	**Checked by:**	SAM
Subject:	STABILITY - SHORT TERM WITH EQUIPMENT FORCES	**Reviewed by:**	TDJ

Project Short Title: JR Whiting Pond 1 & 2 Closure

1.0 OBJECTIVE

To analyze and determine the short-term static stability of the final cover system considering peak low normal load shear strengths with regards to wedge/block failure and sliding due to equipment forces.

30"

2.0 ASSUMPTIONS

1.) The proposed Final Cover system consists of (from top to bottom):

Erosion Protection Layer 0.5 feet (ft) thick (Topsoil)
Protective Cover Soil, 1.5 ft thick
8-ounce per square yard (oz/sy) Nonwoven Needle-Punched Geotextile
Geomembrane Liner, 40-mil Smooth High Density Polyethylene (HDPE)
Smooth drum rolled liner subgrade soils

2.) Material Properties:
See attached Table 1: Definitions and Assumptions
See Appendix F for material properties and references.

3.) The final cover will be constructed with a 2-percent (2%) slope.

4.) Maximum slope length along the 2.0% slope is 850 ft.

5.) Bulk Density of cover soil borrow material ~120 pounds per cubic foot (pcf) (reference 3).

6.) This calculation is valid for equipment moving up the slope only.

3.0 METHODS

1.) **Use method outlined in R.M. Koerner and T. Soong's method, Reference 8. Please see Figure 1 for Equations and Parameter definitions for the calculations performed below.**

2.) Allow a minimum interim factor of safety of 1.3, when saturated conditions are considered, and peak interface friction angles are used. Peak interface friction is appropriate for HDPE geomembranes that will not experience significant settlement.

3.) Interface friction angles were taken as averages of representative lab data for similar materials. (These friction angels are conservative and for design purposes, the owner may choose to purchase materials with interface friction angles greater than those used in the design.)

Golder Associates

CALCULATIONS

Date:	July-2017	**Made by:**	BAB
Project No.:	1667572	**Checked by:**	SAM
Subject:	STABILITY - SHORT TERM WITH EQUIPMENT FORCES	**Reviewed by:**	TDJ

Project Short Title: JR Whiting Pond 1 & 2 Closure

4.0 CALCULATIONS

Calculate Factor of Safety using Koerner's Method for short term stability with equipment loads;
(See attached "Analysis and design of veneer cover soils" (reference 8) for method)

Uniform Cover Soil Thickness with the Incorporation of Equipment Loads

Total thickness of cover soils =	h =	2	ft	
Cover slope=	β =	1.15	degrees	Slope = 2.0%
Length of slope measured along the geotextile =	L =	850	ft	
Unit wt. of soil (reference 3) =	γ_t =	120	pcf	
Friction angle of soil =	φ =	28	degrees	(see reference 3)
Cohesion of soil =	c =	0	psf	C = 0 lb
Interface friction between geotextile and 40-mil HDPE liner=	δ =	11	***degrees peak low normal load (see reference 3)***	
Adhesion between geotextile and 40-mil HDPE liner=	c_a =	0	psf	Ca = 0.00 lb

Notes:
c_a is conservatively assumed to be zero.
psf = pounds per square foot
lb = pounds

From CAT Handbook (reference 4)

D6T LGP Track- type tractor	45,400	lb
Track	128	inches long
	36	inches wide

Total thickness of cover soils =	h =	2	ft	b/h= 1.5
Equipment ground pressure (=wt. of equip./(2*w*b)) =	q =	709.38	psf	We = q*w*I = 7491.0 lb/ft
Length of equipment track =	w =	10.67	ft	Ne = We*cosb = 7489.5 lb/ft
Width of equipment track =	b =	3.00	ft	Fe=We*a/g*I= 506.7 lb
Influence factor at geotextile interface =	I =	0.99		*Conservatively overestimated (reference 1)
Acceleration of bulldozer =	a =	0.07	g	*Assume Cat D6T dozer accelerating to 3 miles per hour in approx. 2 sec. (acceleration. = 0.07 g)

Note: g = acceleration due to gravity at Earth's surface (32.2 feet per second squared)

W_A	180,083.6	lb	(calculated per Figure 1)
N_A	180,047.4	lb	(calculated per Figure 1)
W_p	11,960.6	lb	(calculated per Figure 1)

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

a	4,270.44	(calculated per equation (22) on Figure 1)
b	-42,851.27	(calculated per equation (22) on Figure 1)
c	389.01	(calculated per equation (22) on Figure 1)

Factor of Safety (FS):	**10.0**

5.0 CONCLUSIONS

Using low peak normal load shear strengths, the evaluation of this short-term condition of a 2% sloped surface considering equipment forces is found to be acceptable with a Factor of Safety greater than 1.3.

Date:	July-2017	**Made by:**	BAB
Project No.:	1667572	**Checked by:**	SAM
Subject:	STABILITY - SHORT TERM WITH EQUIPMENT FORCES	**Reviewed by:**	TDJ

Project Short Title: JR Whiting Pond 1 & 2 Closure

6.0 REFERENCES

1.) Koerner, R.M., *Designing with Geosynthetics* , Prentice Hall, New Jersey, 1998.

2.) Koerner, R.M. and Soong, T., "Cover Soil Slope Stability Involving Geosynthetic Interfaces", GRI Report #18, December 1996.

3.) Golder Associates Inc., 2017. J.R. Whiting Ash Ponds 1 and 2 Closure Plan, Appendix F, Table 1: Global Material Properties Used for Calculations.

4.) Caterpillar, Specification Summary, D6N LGP Track-type Tractor.

5.) NAVFAC, "Section IV. Specific-Gravity-of-Solids Determination (ASTM D 854-92)", March 2017

6.) Coduto, Donald P., "Geotechnical Engineering: Principles and Practices", Prentice Hall, New Jersey, 1999.

7.) Qian, Xuede, Koerner, R.M, Gray, D.H, Geotechnical Aspects of Landfill Design and Construction, Prentice Hall, New Jersey, 2002.

8.) Koerner, R.M. and Soong, T., "Analysis and Design of Veneer Cover Soils", Geosynthetics International, 2005, 12, No. 1.

Date:	July-2017	**Made by:**	BAB
Project No.:	1667572	**Checked by:**	SAM
	FINAL COVER STABILITY - Long Term	**Reviewed by:**	TDJ
Subject:	Seepage Forces		
Project Short Title:	JR Whiting Pond 1 & 2 Closure		

1.0 OBJECTIVE

To analyze a "worst case" scenario and determine the long-term stability of the final cover system considering peak low normal load shear strengths with regards to wedge/block failure and sliding due to water seepage forces within the lateral drainage layer.

30"

2.0 ASSUMPTIONS

1.) The proposed cover system consists of (from top to bottom):

Erosion Protection Layer 0.5 feet (ft) thick (Topsoil)
Protective Cover Soil, 1.5 ft thick
8-ounce per square yard (oz/sy) Nonwoven Needle-Punched Geotextile
Geomembrane Liner, 40-mil Smooth High Density Polyethylene (HDPE)
Smooth drum rolled liner subgrade soils

2.) Material Properties:
See attached Table 1: Definitions and Assumptions
See Appendix F for material properties and references.

3.) The final cover will be constructed with a 2-percent (2%) slope.

4.) Maximum slope length along the 2.0% slope is 850 ft.

5.) Bulk Density of cover soil borrow material ~120 pounds per cubic foot (pcf) (reference 3).

3.0 METHODS

1.) **Use the methods outlined in Xuede Qian, R.M. Koerner, and D.H. Gray's *Geotechnical Aspects of Landfill Design and Construction*, see Reference 7 for Equations and Parameter definitions.**

2.) Allow a minimum interim factor of safety of 1.3, when saturated conditions are considered and peak interface friction angles are used. Peak interface friction is appropriate for HDPE geomembranes that will not experience significant settlement.

3.) Interface friction angles were taken as averages of representative lab data for similar materials. (These friction angles are conservative and for design purposes. The owner may choose to purchase materials with interface friction angles greater than those used in the design.)

Date:	July-2017	**Made by:**	BAB
Project No.:	1667572	**Checked by:**	SAM
	FINAL COVER STABILITY - Long Term	**Reviewed by:**	TDJ
Subject:	Seepage Forces		
Project Short Title:	JR Whiting Pond 1 & 2 Closure		

4.0 CALCULATIONS

Calculate Factor of Safety for long term stability with
wet conditions (i.e. water on the liner); (See Reference 7)

Uniform Cover Soil Thickness
Seepage Forces Horizontal-to-Slope Buildup

1) Conservatively assume 4 inches of head over the HDPE liner (depth equal to the diameter of the on-cap drain pipes).
2) Assume cover soil will have a uniform average unit weight (see reference 3)

Total thickness of cover soils =	h =	2	ft	
Cover slope=	β =	1.15	degrees	Slope= 2.0%
Length of slope measured along the geotextile =	L =	850	ft	
Vertical height of slope measured from toe =	*H* =	*17*	ft	
Depth of water over 40-mil HDPE liner =	h_w =	0.3333	ft	
Parallel submergence ratio =	*PSR* =	*0.167*		PSR = depth of water on FML
Composite moist unit wt. of cover soil (reference 3) =	γ_{moist} =	120	pcf	thickness of cover soil
Composite saturated unit wt. of cover soil =	γ_{sat} =	125	pcf	(see reference 6)
Unit wt. of water =	γ_w =	62.4	pcf	
Friction angle of cover soil =	φ =	28	degrees	(see reference 3)
Interface friction. between Geotextile and 40-mil HDPE liner=	δ =	11	***degrees peak low normal load (see reference 3)***	

W_A	191,707.1	pounds (lb)
Un	17,503.7	lb
Uh	3.5	lb
N_A	174,164.9	lb
W_p	12,459.0	lb
Uv	172.7	lb

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

a	3,846.8
b	-40,421.1
c	361.3

Factor of Safety (FS):	**10.5**

Date:	July-2017	**Made by:**	BAB
Project No.:	1667572	**Checked by:**	SAM
	FINAL COVER STABILITY - Long Term	**Reviewed by:**	TDJ
Subject:	Seepage Forces		
Project Short Title:	JR Whiting Pond 1 & 2 Closure		

4.0 CALCULATIONS (Continued)

Uniform Cover Soil Thickness

Seepage Forces Parallel-to-Slope Buildup

(See attached Figure 1 depicting seepage forces with parallel-to-slope buildup)

1) Conservatively assume 4 inches of head over the HDPE liner (depth equal to the diameter of the on-cap drain pipes).
2) Assume cover soil will have a uniform average unit weight (see reference 3)

Total thickness of cover soils =	h =	2	ft	
Cover slope=	β =	1.15	degrees	Slope= 2.0%
Length of slope measured along the geotextile =	L =	850	ft	
Vertical height of slope measured from toe =	*H* =	*17*	ft	
Depth of water over 40-mil HDPE liner =	h_w =	0.3333	ft	
Parallel submergence ratio =	*PSR* =	*0.167*		PSR = depth of water on FML / thickness of cover soil
Composite moist unit wt. of cover soil (reference 3) =	γ_{moist} =	120	pcf	
Composite saturated unit wt. of cover soil =	γ_{sat} =	125	pcf	(see reference 6)
Unit wt. of water =	γ_w =	62.4	pcf	
Friction angle of cover soil =	φ =	28	degrees	(see reference 3)
Interface friction. between Geotextile and 40-mil HDPE liner=	δ =	11	***degrees peak low normal load (see reference 3)***	

W_A	193,442.2	lb
Uh	3.5	lb
W_p	11,974.4	lb
U_{AN}	17,503.8	lb
U_{PN}	172.7	lb

a	3,881.6
b	-40,501.1
c	364.9

Factor of Safety (FS):	**10.4**

5.0 CONCLUSIONS

Considering low peak normal load shear strengths and saturated conditions, the long-term "worst case" stability evaluations for the lateral drainage layer option are considered acceptable with factors of safety greater than 1.3.

6.0 REFERENCES

1.) Koerner, R.M., *Designing with Geosynthetics* , Prentice Hall, New Jersey, 1998.

2.) Koerner, R.M. and Soong, T., "Cover Soil Slope Stability Involving Geosynthetic Interfaces", GRI Report #18, December 1996.

3.) Golder Associates Inc., 2017. J.R. Whiting Ash Ponds 1 and 2 Closure Plan, Appendix F, Table 1: Global Material Properties Used for Calculations.

4.) Caterpillar, Specification Summary, D6N LGP Track-type Tractor.

5.) NAVFAC, "Section IV. Specific-Gravity-of-Solids Determination (ASTM D 854-92)", March 2017

6.) Coduto, Donald P., "Geotechnical Engineering: Principles and Practices", Prentice Hall, New Jersey, 1999.

7.) Qian, Xuede, Koerner, R.M, Gray, D.H, Geotechnical Aspects of Landfill Design and Construction, Prentice Hall, New Jersey, 2002.

8.) Koerner, R.M. and Soong, T., "Analysis and Design of Veneer Cover Soils", Geosynthetics International, 2005, 12, No. 1.

Date:	July-2017	**Made by:**	BAB
Project No.:	1667572	**Checked by:**	SAM
		Reviewed by:	TDJ
Subject:	FINAL COVER STABILITY - Long Term Seismic		
Project Short Title:	JR Whiting Pond 1 & 2 Closure		

1.0 OBJECTIVE

To analyze a "worst case" scenario and determine the long-term stability of the final cover system considering peak low normal load shear strengths with regards to seismic forces.

30"

2.0 ASSUMPTIONS

1.) The proposed cover system consists of (from top to bottom):

Erosion Protection Layer 0.5 feet (ft) thick (Topsoil)
Protective Cover Soil, 1.5 ft thick
8-ounce per square yard (oz/sy) Nonwoven Needle-Punched Geotextile
Geomembrane Liner, 40-mil Smooth High Density Polyethylene (HDPE)
Smooth drum rolled liner subgrade soils

2.) Material Properties:
See attached Table 1: Definitions and Assumptions
See Appendix F for material properties and references.

3.) The final cover will be constructed with a 2-percent (2%) slope.

4.) Maximum slope length along the 2.0% slope is 850 ft.

5.) Bulk Density of cover soil borrow material ~120 pounds per cubic foot (pcf) (reference 3).

3.0 METHODS

1.) **Use method outlined in R.M. Koerner and T. Soong's method, Reference 2. Please see Figure 1 for Equations and Parameter definitions for the calculations performed below.**

2.) Allow a minimum interim factor of safety of 1.0, when seismic conditions, and peak interface friction angles are considered (per the US Environmental Protection Agency (EPA) Coal Combustion Residual (CCR) regulations (40 CFR257.73). Peak interface friction is appropriate for HDPE geomembranes that will not experience significant settlement.

3.) Interface friction angles were taken as averages of representative lab data for similar materials, residual strengths. (These friction angels are conservative and for design purposes, the owner may choose to purchase materials with interface friction angles greater than those used in the design.)

Date:	July-2017	**Made by:**	BAB
Project No.:	1667572	**Checked by:**	SAM
		Reviewed by:	TDJ
Subject:	FINAL COVER STABILITY - Long Term Seismic		
Project Short Title:	JR Whiting Pond 1 & 2 Closure		

4.0 CALCULATIONS

Calculate Factor of Safety using Koerner's Method for long term stability (See attached GRI Report #18).

Uniform Cover Soil Thickness with Seismic Forces

1) Assume cover soil will have a uniform average unit weight (see reference 3)

Total thickness of cover soils =	h =	2	ft		
Cover slope=	β =	1.15	degrees	Slope= 2.0%	
Length of slope measured along the geotextile =	L =	850	ft		
Vertical height of slope measured from toe =	*H* =	*17*	ft		
Composite moist unit wt. of cover soil (reference 3) =	γ_{moist} =	120	pcf		
Unit wt. of water =	γ_w =	62.4	pcf		
Friction angle of cover soil =	φ =	28	degrees	(see reference 3)	
Interface friction. between Geotextile and 40-mil HDPE liner=	δ =	11	***degrees peak low normal load (see reference 3)***		
Seismic coefficient =	Cs =	0.05	g		
Cohesion of soil =	c =	0	psf	C =	0
Adhesion between geotextile and 40-mil HDPE liner=	ca =	0	psf	Ca =	0.00

Notes:

c_a is conservatively assumed to be zero.

psf = pounds per square foot

g = acceleration due to gravity at Earth's surface (32.2 feet per second squared)

tan β =	0.02
tan φ =	0.53
tan δ =	0.19
sin β =	0.02
cos β =	1.00

W_A	180,083.6	pounds (lb)	
N_A	180,047.4	lb	With Seismic
W_p	11,960.6	lb	Cs * W_A (lb) = 9,004.18
			Cs * W_P (lb) = 598.03

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

a	13,213.1
b	-41,476.5
c	373.4

Factor of Safety (FS):	**3.1**

5.0 CONCLUSIONS

Considering the use of seismic loading and low peak normal load shear strengths, the long-term "worst case" stability evaluation is considered acceptable with a factor of safety greater than 1.0.

6.0 REFERENCES

1.) Koerner, R.M., *Designing with Geosynthetics* , Prentice Hall, New Jersey, 1998.

2.) Koerner, R.M. and Soong, T., "Cover Soil Slope Stability Involving Geosynthetic Interfaces", GRI Report #18, December 1996.

3.) Golder Associates Inc., 2017. J.R. Whiting Ash Ponds 1 and 2 Closure Plan, Appendix F, Table 1: Global Material Properties Used for Calculations.

4.) Caterpillar, Specification Summary, D6N LGP Track-type Tractor.

5.) NAVFAC, "Section IV. Specific-Gravity-of-Solids Determination (ASTM D 854-92)", March 2017

6.) Coduto, Donald P., "Geotechnical Engineering: Principles and Practices", Prentice Hall, New Jersey, 1999.

7.) Qian, Xuede, Koerner, R.M, Gray, D.H, Geotechnical Aspects of Landfill Design and Construction, Prentice Hall, New Jersey, 2002.

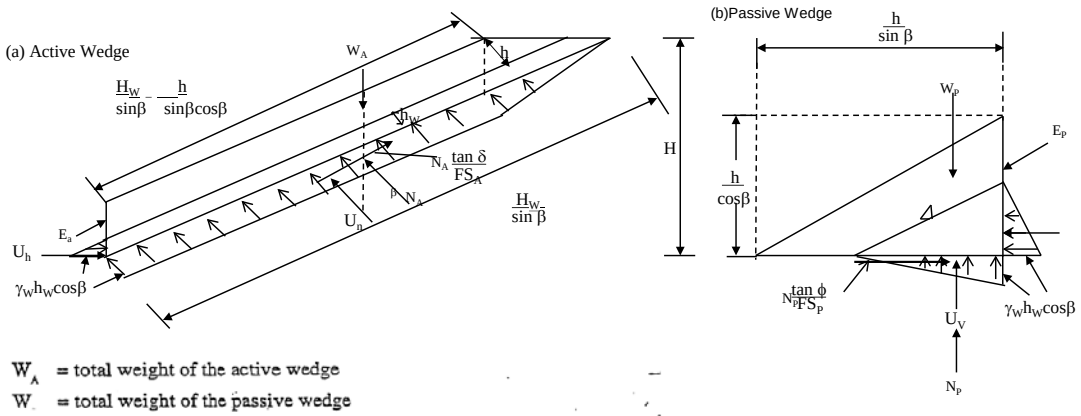
8.) Koerner, R.M. and Soong, T., "Analysis and Design of Veneer Cover Soils", Geosynthetics International, 2005, 12, No. 1.

TABLE 1 - Definitions and Assumptions

Symbol	Definitions and assumptions
h =	*Thickness of the soil layer* - The protective cover will be 1.5 feet thick and the erosion protection layer will be 0.5 feet thick, for a total of 2.0 feet of cover soil.
β =	*Soil slope angle beneath the geomembrane -The* slope exhibits an angle beneath the geomembrane of 2.0%.
L =	*Length of slope measured along the geomembrane* - The maximum slope length anticipated is 850 feet.
γ_t =	*Unit weight of final cover soil* - The cover is assumed to be composed of 0.5 foot sandy clay erosion protection layer, and 1.5 feet of silty clay loam protective cover.
ϕ =	*Minimum friction angle of final cover soil*
c =	*Cohesion of the cover soil* - Cohesion is assumed to be zero because the cover soils are granular.
δ =	*Critical Interface friction angle within the final cover system* - The critical interface occur between the 40-mil Smooth HDPE Geomembrane Liner and the NW-NP Geotextile.
ca =	*Adhesion between cover soil of the active wedge and the geomembrane* - Adhesion is assumed to be zero because the cover soils are granular.
γ_{sat} =	*Saturated unit weight of final cover soils* - The unit weights of the saturated protective cover soil and erosion protection soil.
Cs =	*Average seismic coefficient* - The average horizontal component seismic coefficient for the the State of Michigan.
I =	*Influence factor at the geotextile interface* - The influence factor at the geomembrane interface and width of the dozer track divided by the thickness of the soil layer of interest. (Reference 2)

FIGURE 1

Uniform Cover Soil Thickness
Seepage Forces with Parallel-to-Slope Buildup



W_A = total weight of the active wedge
W_P = total weight of the passive wedge
N_A = effective force normal to the failure plane of the active wedge
N_P = effective force normal to the failure plane of the passive wedge
γ = unit weight of the cover soil
h = thickness of the cover soil
L = length of slope measured along the geomembrane
β = soil slope angle beneath the geomembrane
ϕ = friction angle of the cover soil
δ = interface friction angle between cover soil and geomembrane
C_a = adhesive force between cover soil of the active wedge and the geomembrane
c_a = adhesion between cover soil of the active wedge and the geomembrane

C = cohesive force along the failure plane of the passive wedge
c = cohesion of the cover soil
E_A = interwedge force acting on the active wedge from the passive wedge
E_P = interwedge force acting on the passive wedge from the active wedge
FS = factor-of-safety against cover soil sliding on the geomembrane

$$W_A = \gamma h^2\left(\frac{L}{h} - \frac{1}{2\sin 2\beta} - \frac{1}{2\tan\beta}\right)$$

$$N_A = W_A \cos\beta$$

$$W_P = \frac{\gamma h^2}{\sin 2\beta}$$

$$N_P = W_P + E_P \sin\beta$$

$$C = \frac{(c)(h)}{\sin\beta}$$

AND:

$$E_P \cos\beta = \frac{C + N_P \tan\phi}{FS}$$

$$a(FS)^2 + b(FS) + c = 0$$

$$a = (W_A - N_A\cos\beta)\cos\beta$$

$$b = -[(W_A - N_A\cos\beta)\sin\beta\tan\phi + (N_A\tan\delta + C_a)\sin\beta\cos\beta + \sin\beta(C + W_P\tan\phi)]$$

$$c = (N_A\tan\delta + C_a)\sin^2\beta\tan\phi$$

$$a = [(W_A + W_e)\sin\beta + F_e]\cos\beta$$
$$b = -\{[(N_e + N_A)\tan\delta + C_a]\cos\beta + [(W_A + W_e)\sin\beta + F_e]\sin\beta\tan\phi + (C + W_P\tan\phi)\}$$
$$c = [(N_e + N_A)\tan\delta + C_a]\sin\beta\tan\phi \quad (22)$$

$$\left.\begin{aligned} a &= W_A\sin\beta\cos\beta - U_h\cos^2\beta + U_h \\ b &= -W_A\sin^2\beta\tan\phi + U_h\sin\beta\cos\beta\tan\phi - N_A\cos\beta\tan\delta - (W_P - U_V)\tan\phi \\ c &= N_A\sin\beta\tan\delta\tan\phi \end{aligned}\right\} \quad (31)$$

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a}$$

GLOBAL STABILITY CALCULATIONS

CALCULATIONS

Date:	August, 2017	**Made by:**	AK
Project No.:	1667572	**Checked by:**	SAM
Subject:	Global Stability Analyses - Closure Plan J.R. Whiting Ponds 1 and 2	**Reviewed by:**	TDJ
Project Short Title:	**JR WHITING PONDS 1 AND 2 CLOSURE**		

1.0 OBJECTIVE

To analyze the stability of the proposed closure design for Consumers Energy Corporation (Consumers) J.R. Whiting Ponds 1 and 2, located in Erie, Michigan.

2.0 ANALYSIS METHODS

The static and pseudo-static stability of the proposed closure design for J.R. Whiting Ponds 1 and 2 were evaluated using the computer program SLIDE Version 7.017 (Rocscience, 2016). Generalized limit equilibrium method of stability analysis, developed by Morgenstern and Price (Abramson et al., 2002), was utilized for the analysis. Block and circular search surfaces were analyzed to find failure surfaces that resulted in the minimum calculated factor of safety (FOS) for each critical cross section analyzed.

Per the US Environmental Protection Agency (EPA) Coal Combustion Residual (CCR) regulations (40 CFR 257.73) (see Reference 3), the minimum FOS results for this analysis are 1.5 for permanent loading conditions (long-term, drained) and 1.0 for seismic conditions (undrained). A seismic coefficient of 0.05 times the acceleration due to gravity at Earth's surface was used for pseudo-static analysis, as discussed in Appendix F. Global failure surfaces or those impacting the crest of the cover slopes were considered "Critical" surfaces that may compromise the stability of the closed ponds. Shallow or surficial slip surfaces along the slope surface (i.e., not global or impacting the cover system) with factors of safety lower than the "Critical" surfaces were often generated during the analyses. The shallow slip surfaces were considered "Non-Critical" erosion related issues that could likely be addressed by maintenance (e.g. local regrading, riprap armoring, etc.). Veneer stability of the proposed closure cover system is presented in a separate calculation.

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Golder Associates: Operations in Africa, Asia, Australasia, Europe, North America and South America

3.0 ANALYSIS SECTIONS:

Two critical sections were selected to evaluate the stability of the designed closure of Ponds 1 and 2. Sections A and B were considered the most critical and were utilized for this analysis because they are located in areas with the steepest slopes, or highest amount of fill. Figure 1 provides an overview of the section locations.

4.0 ANALYSIS CASES:

The following stability cases were analyzed for the current analysis:

Proposed Fill Conditions - Long-term Strength Parameters (Drained Conditions)
Proposed Fill Conditions - Short-term Strength Parameters (Undrained Conditions with Seismic)

5.0 MATERIAL PROPERTIES:

The material properties used for this analysis are provided in Appendix F. For pseudo-static analyses, a strength reduction factor of 0.8 has been applied to undrained shear strength parameters per Hynes-Griffin and Franklin (1984) method (Reference 4).

Table 1: Summary of Stability Analyses Results

Cross-Section A-A'

Analysis	Method	Calculated Value	Required FoS	Evaluation	Figure
Static, Long-Term	Block	2.2	1.5	OK	1A
	Circular	2.2	1.5	OK	1B
Pseudo-Static, Short-Term	Block	1.5	1.0	OK	1C
	Circular	1.5	1.0	OK	1D

Cross-Section B-B'

Analysis	Method	Calculated Value	Required FoS	Evaluation	Figure
Static, Long-Term	Block	1.5	1.5	OK	1E
	Circular	1.5	1.5	OK	1F
Pseudo-Static, Short-Term	Block	4.2	1.0	OK	1G
	Circular	4.2	1.0	OK	1H

6.0 REFERENCES:

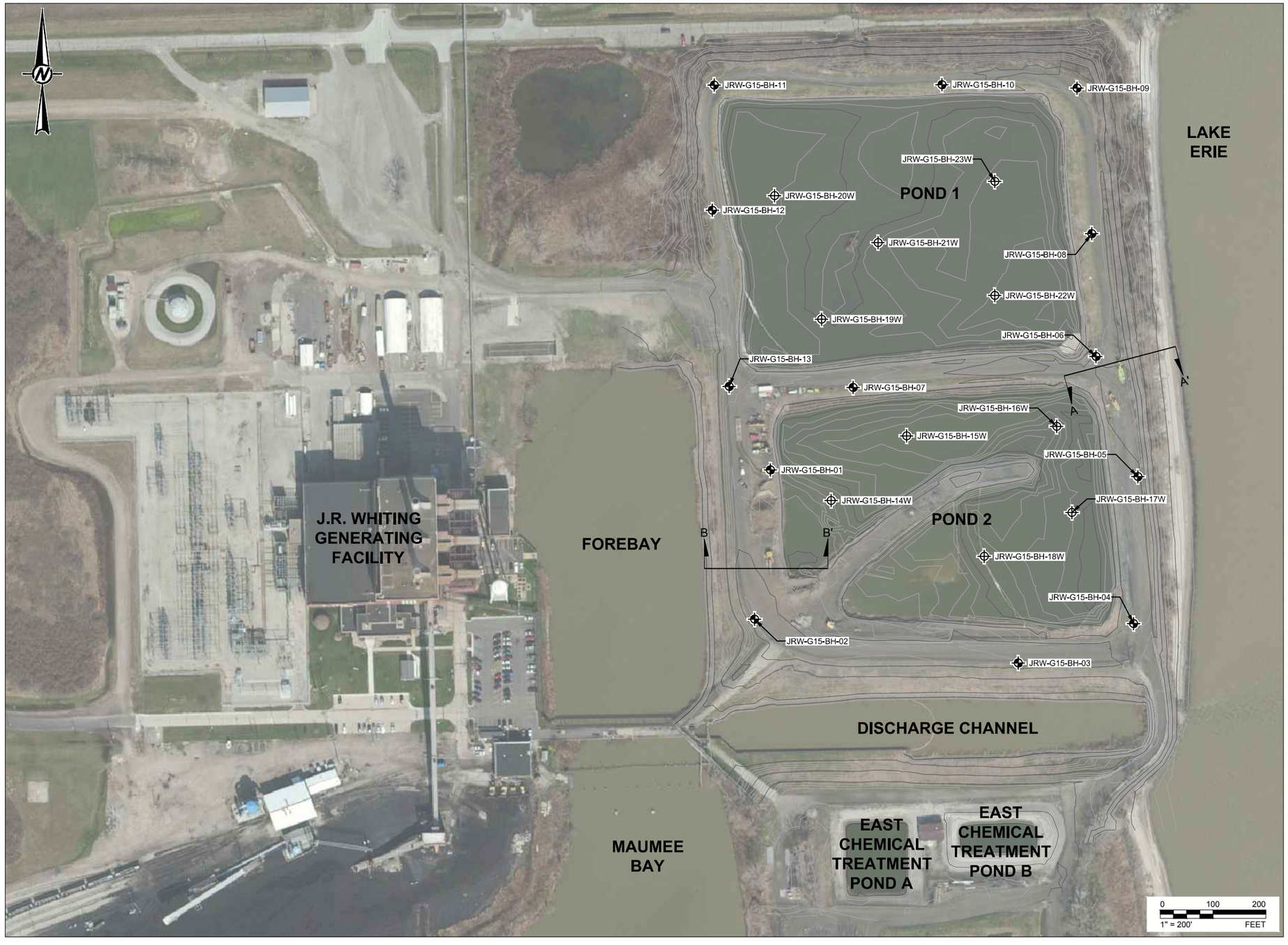
1. Rocscience (2016), SLIDE Version 7.017

2. 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.

3. US Environmental Protection Agency (EPA) Resource Conservation and Recovery Act (RCRA) "Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule" (Rule, 40 Code of Federal (CFR) Part 257), April 2015.

4. Hynes-Griffin, M.E., Franklin, A.G., 1984. Rationalizing the seismic coefficient method. U.S. Army Corps of Engineers Waterways Experiment Station, Miscellaneous Paper GL-84-13, 37 pp

5. Golder Associates Inc., 2017. J.R. Whiting Ash Ponds 1 and 2 Closure Plan, Appendix F, Table1: Global Material Properties Used for Calculations.



LEGEND

- JRW-G15-BH-## — 2015 LAND BOREHOLE LOCATION (GOLDER, 2016)
- JRW-G15-BH-##W — 2015 OVER-WATER BOREHOLE LOCATION (GOLDER, 2016)
- EXISTING GROUND MAJOR CONTOUR (5' INTERVAL)
- EXISTING GROUND MINOR CONTOUR (1' INTERVAL)

NOTES

1. ALL BOREHOLE LOCATIONS SHOWN ARE APPROXIMATE.
2. SCALE OF AERIAL IMAGERY IS APPROXIMATE.
3. AERIAL IMAGE IS SHOWN FOR GENERAL REFERENCE ONLY AND CURRENT SITE CONDITIONS MAY VARY FROM THE IMAGE SHOWN ON THIS FIGURE.
4. NO DIMENSIONS OR QUANTITIES ARE TO BE SCALED OR DEVELOPED FROM THIS FIGURE.
5. THIS FIGURE IS SIZED FOR 11"X17" ANSI-B PAPER AND ALL SCALES ASSOCIATED MUST BE VERIFIED.
6. 2015 OVER-WATER BOREHOLE LOCATIONS WERE LOCATED HORIZONTALLY BY GOLDER USING A HAND HELD GPS (TRIMBLE).
7. 2015 LAND BOREHOLE LOCATIONS WERE STAKED OUT AND DOCUMENTED ON 2015-10-19 HORIZONTALLY AND VERTICALLY BY MUXLOW SURVEY COMPANY.
8. 2016 MANNIK AND SMITH GROUP (MSG) BOREHOLE LOCATIONS ARE APPROXIMATE, BASED ON BOREHOLE LOCATION SKETCH PROVIDED BY IBRAHEEM SHUNNAR (MSG) TO GEORGE L. MCKENZIE II (CEC) VIA EMAIL ON JANUARY 27, 2017. NO SURVEY OR GPS LOCATIONS HAVE BEEN PROVIDED.
9. BOREHOLES DRILLED BY SME IN 1976 AND 1977 (SME, 1977) AND LOCATIONS HAVE BEEN ESTIMATED FROM TEST BORING LOCATION PLAN - POND #1, 2, AND 6; NTH, 2011.

REFERENCES

1. AERIAL IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, I-CUBED, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY.
2. HORIZONTAL DATUM: NAD 1983 STATE PLANE COORDINATES, MICHIGAN SOUTH ZONE, INTERNATIONAL FEET.
3. VERTICAL DATUM: NGVD 29.
4. GROUND SURFACE SURVEY DATED NOVEMBER 2015 PROVIDED BY CEC TO GOLDER VIA DWG FILE. PER ELEVATION BASIS NOTE ON DRAWING NO SF-19884, SHEET 34 PROVIDED BY SHERIDAN SURVEYING CO. ELEVATIONS WERE LOWERED 0.90' TO OBTAIN NAVD 88 ELEVATIONS.
5. PONDS SURVEY COMPLETED IN MARCH 2015, ADDITIONAL SURVEY PERFORMED IN OCTOBER AND NOVEMBER 2015 PER SHERIDAN SURVEYING CO. DRAWING.

CLIENT
CONSUMERS ENERGY COMPANY
4525 E. ERIE ROAD
ERIE, MICHIGAN

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-07-05
DESIGNED	AK
PREPARED	DJC
REVIEWED	SAM
APPROVED	

PROJECT
J.R. WHITING GENERATING FACILITY
ASH PONDS 1 & 2 AND EAST CHEMICAL TREATMENT PONDS CLOSURE

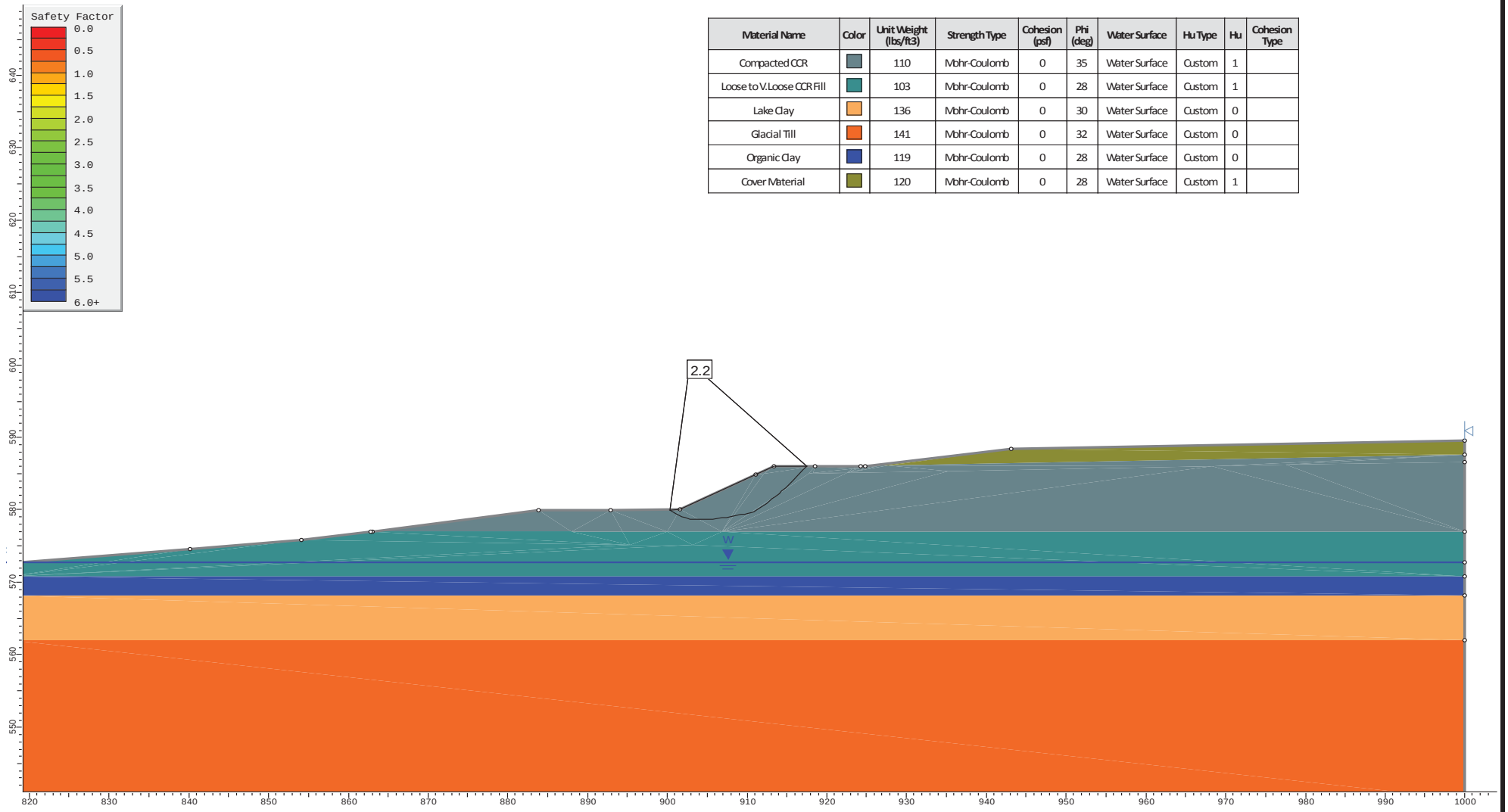
TITLE
SLOPE STABILITY CROSS-SECTION LOCATION PLAN

PROJECT NO.	CONTROL	REV.	FIGURE
1667572	1667572E001.dwg	0	1

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

1 in
0

Path: \\detroitcad\Projects\16x-Projects\1667572-CCR Pond Closures\PRODUCTION\E-SLOPE STABILITY\ | File Name: 1667572E001.dwg



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Cohesion Type
Compacted CCR		110	Mohr-Coulomb	0	35	Water Surface	Custom	1	
Loose to V.Loose CCR Fill		103	Mohr-Coulomb	0	28	Water Surface	Custom	1	
Lake Clay		136	Mohr-Coulomb	0	30	Water Surface	Custom	0	
Glacial Till		141	Mohr-Coulomb	0	32	Water Surface	Custom	0	
Organic Clay		119	Mohr-Coulomb	0	28	Water Surface	Custom	0	
Cover Material		120	Mohr-Coulomb	0	28	Water Surface	Custom	1	

Golder Associates

SCALE	AS SHOWN
DATE	Aug 2017
MADE BY	AK
CAD	DJC
CHECK	SAM
REVIEW	TDJ

PROJECT: **J.R. Whiting Ash Ponds 1 & 2 Closure**

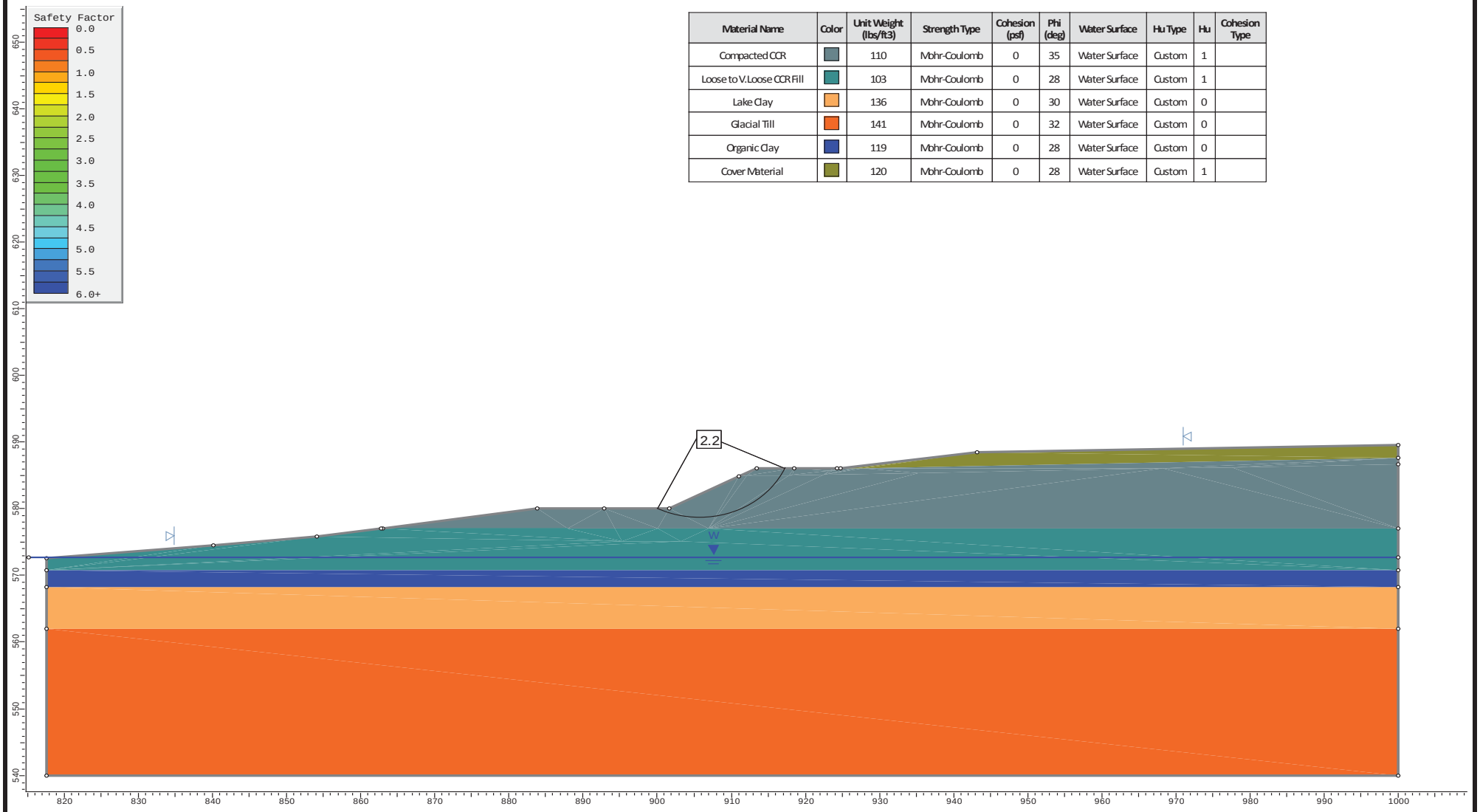
TITLE: **Cross-Section A-A'**
Static, Long-Term Condition-Block Failure

FILE: STABILITY

PROJECT No. 1667572 REV. 0

CLIENT: **Consumers Energy Company**

FIGURE: **1A**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Cohesion Type
Compacted CCR		110	Mohr-Coulomb	0	35	Water Surface	Custom	1	
Loose to V. Loose CCR Fill		103	Mohr-Coulomb	0	28	Water Surface	Custom	1	
Lake Clay		136	Mohr-Coulomb	0	30	Water Surface	Custom	0	
Glacial Till		141	Mohr-Coulomb	0	32	Water Surface	Custom	0	
Organic Clay		119	Mohr-Coulomb	0	28	Water Surface	Custom	0	
Cover Material		120	Mohr-Coulomb	0	28	Water Surface	Custom	1	

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REVIEW	TDJ

PROJECT: **J.R. Whiting Ash Ponds 1 & 2 Closure**

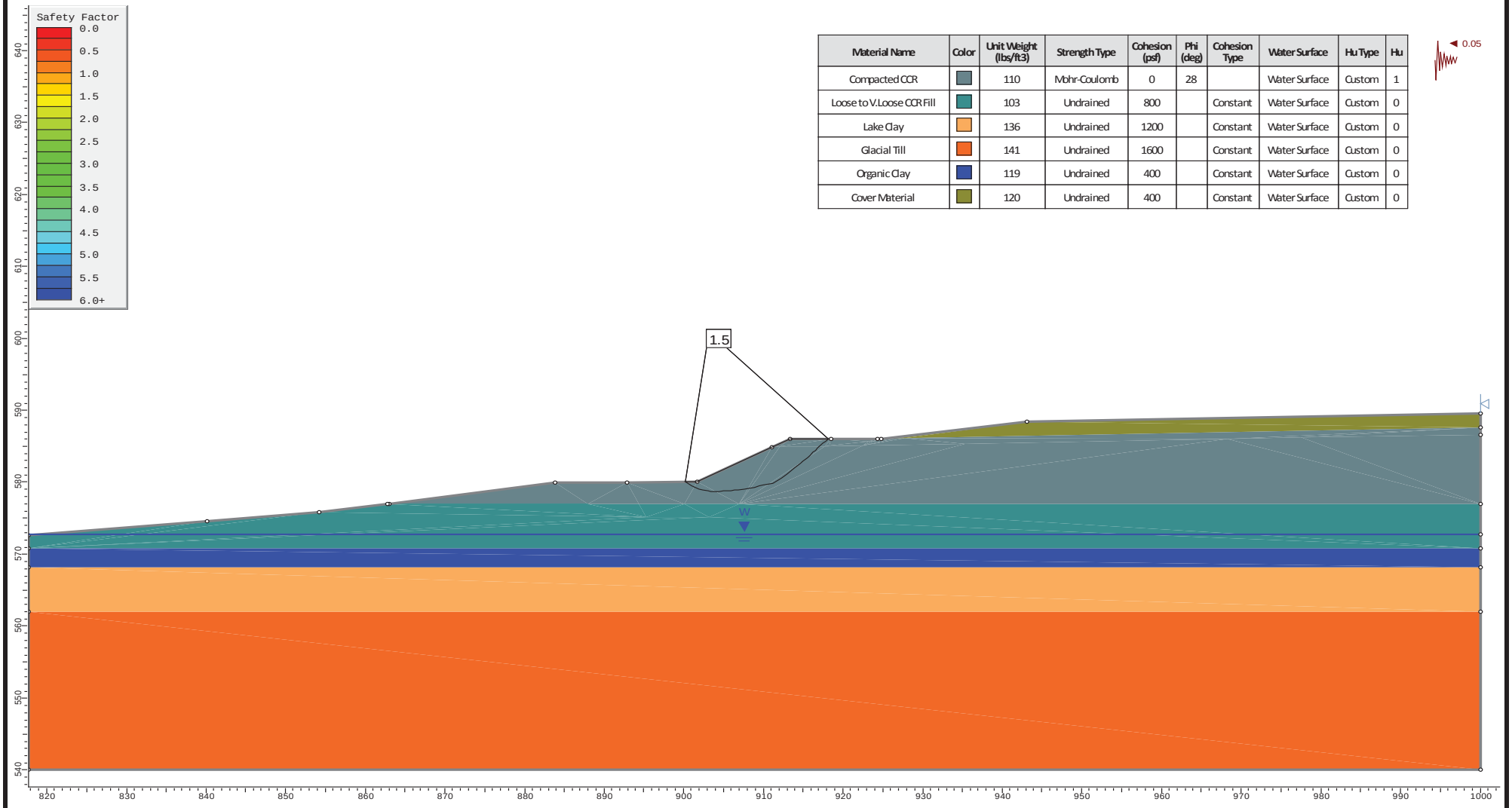
TITLE: **Cross-Section A-A'**
Static, Long-Term Condition-Circular Failure

FILE: STABILITY

PROJECT No. 1667572 REV. 0

CLIENT: **Consumers Energy Company**

FIGURE: **1B**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Water Surface	Hu Type	Hu
Compacted CCR		110	Mohr-Coulomb	0	28		Water Surface	Custom	1
Loose to V.Loose CCR Fill		103	Undrained	800		Constant	Water Surface	Custom	0
Lake Clay		136	Undrained	1200		Constant	Water Surface	Custom	0
Glacial Till		141	Undrained	1600		Constant	Water Surface	Custom	0
Organic Clay		119	Undrained	400		Constant	Water Surface	Custom	0
Cover Material		120	Undrained	400		Constant	Water Surface	Custom	0

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SCALE	AS SHOWN
DATE	Aug 2017
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CAD	DJC
CHECK	SAM
REVIEW	TDJ

PROJECT: **J.R. Whiting Ash Ponds 1 & 2 Closure**

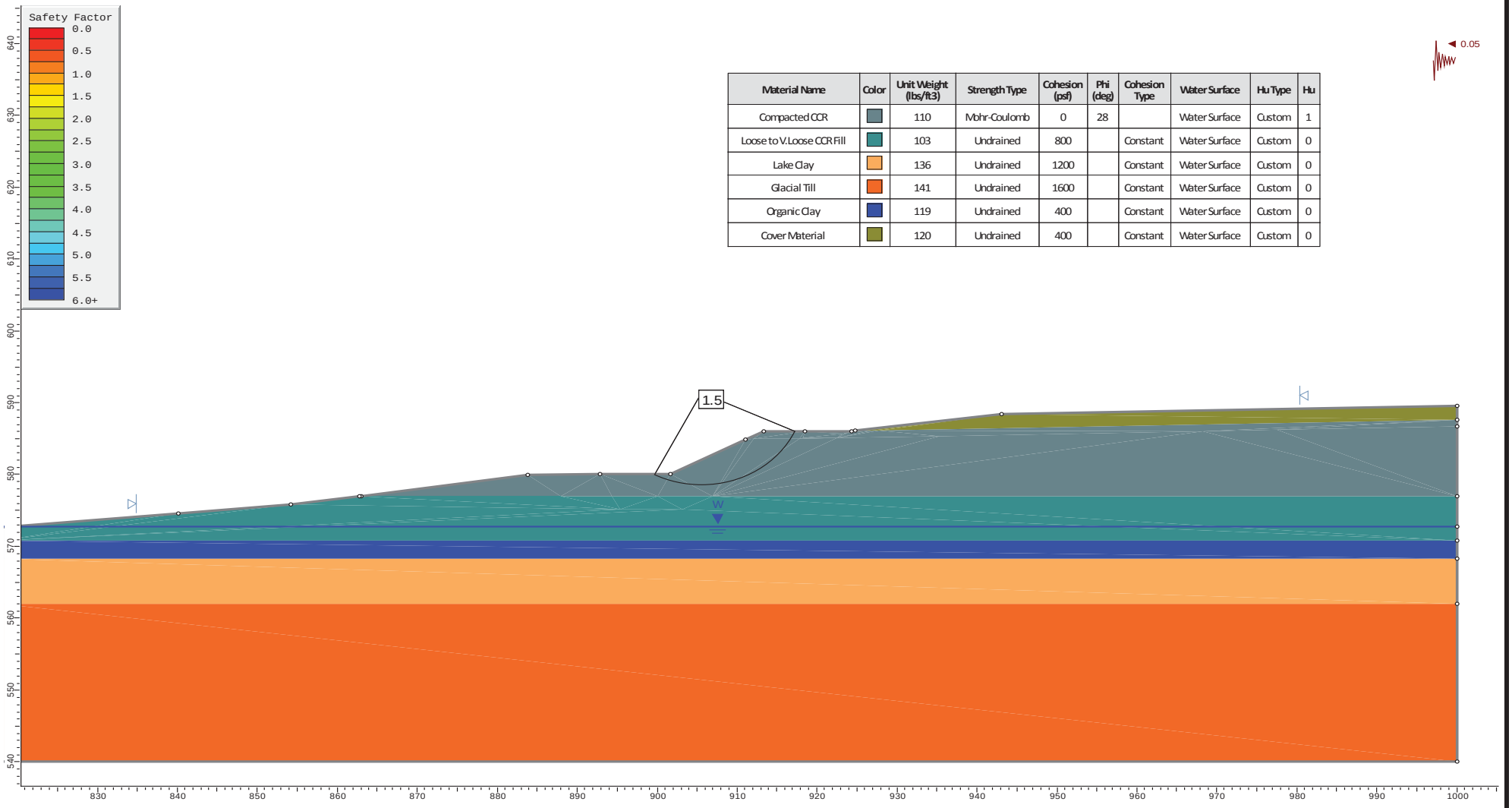
TITLE: **Cross-Section A-A'**
Pseudo-Static, Short-Term Condition-Block Failure

FILE: STABILITY

PROJECT No. 1667572 REV. 0

CLIENT: **Consumers Energy Company**

FIGURE: **1C**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Water Surface	Hu Type	Hu
Compacted CCR		110	Mohr-Coulomb	0	28		Water Surface	Custom	1
Loose to V.Loose CCR Fill		103	Undrained	800		Constant	Water Surface	Custom	0
Lake Clay		136	Undrained	1200		Constant	Water Surface	Custom	0
Glacial Till		141	Undrained	1600		Constant	Water Surface	Custom	0
Organic Clay		119	Undrained	400		Constant	Water Surface	Custom	0
Cover Material		120	Undrained	400		Constant	Water Surface	Custom	0

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SCALE	AS SHOWN
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MADE BY	AK
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REVIEW	TDJ

PROJECT: **J.R. Whiting Ash Ponds 1 & 2 Closure**

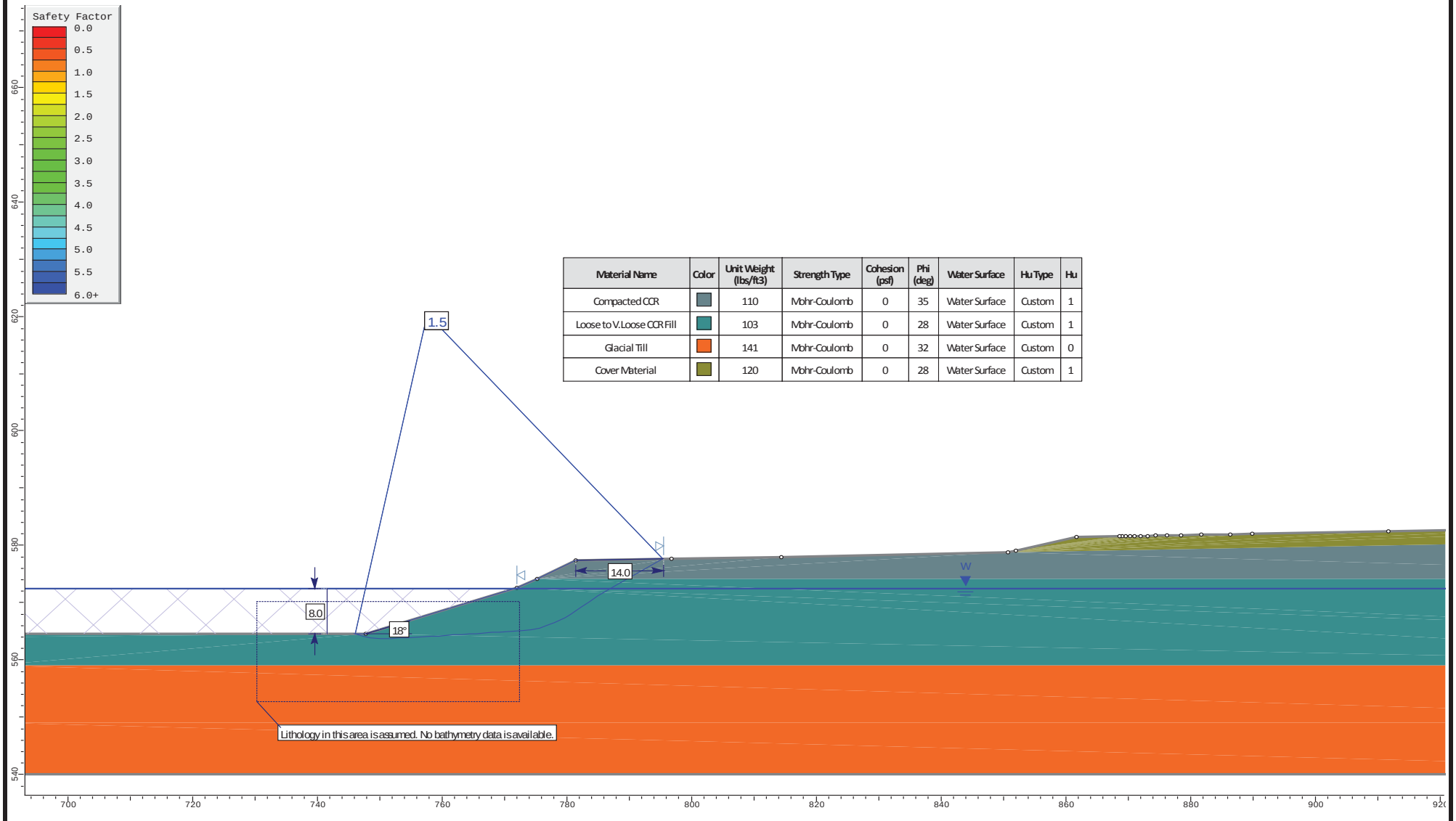
TITLE: **Cross-Section A-A'**
Pseudo-Static, Short-Term Condition-Circular Failure

FILE: STABILITY

PROJECT No. 1667572 REV. 0

CLIENT: **Consumers Energy Company**

FIGURE: **1D**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Compacted CCR		110	Mohr-Coulomb	0	35	Water Surface	Custom	1
Loose to V.Loose CCR Fill		103	Mohr-Coulomb	0	28	Water Surface	Custom	1
Glacial Till		141	Mohr-Coulomb	0	32	Water Surface	Custom	0
Cover Material		120	Mohr-Coulomb	0	28	Water Surface	Custom	1

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DATE	Aug 2017
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REVIEW	TDJ

PROJECT: **J.R. Whiting Ash Ponds 1 & 2 Closure**

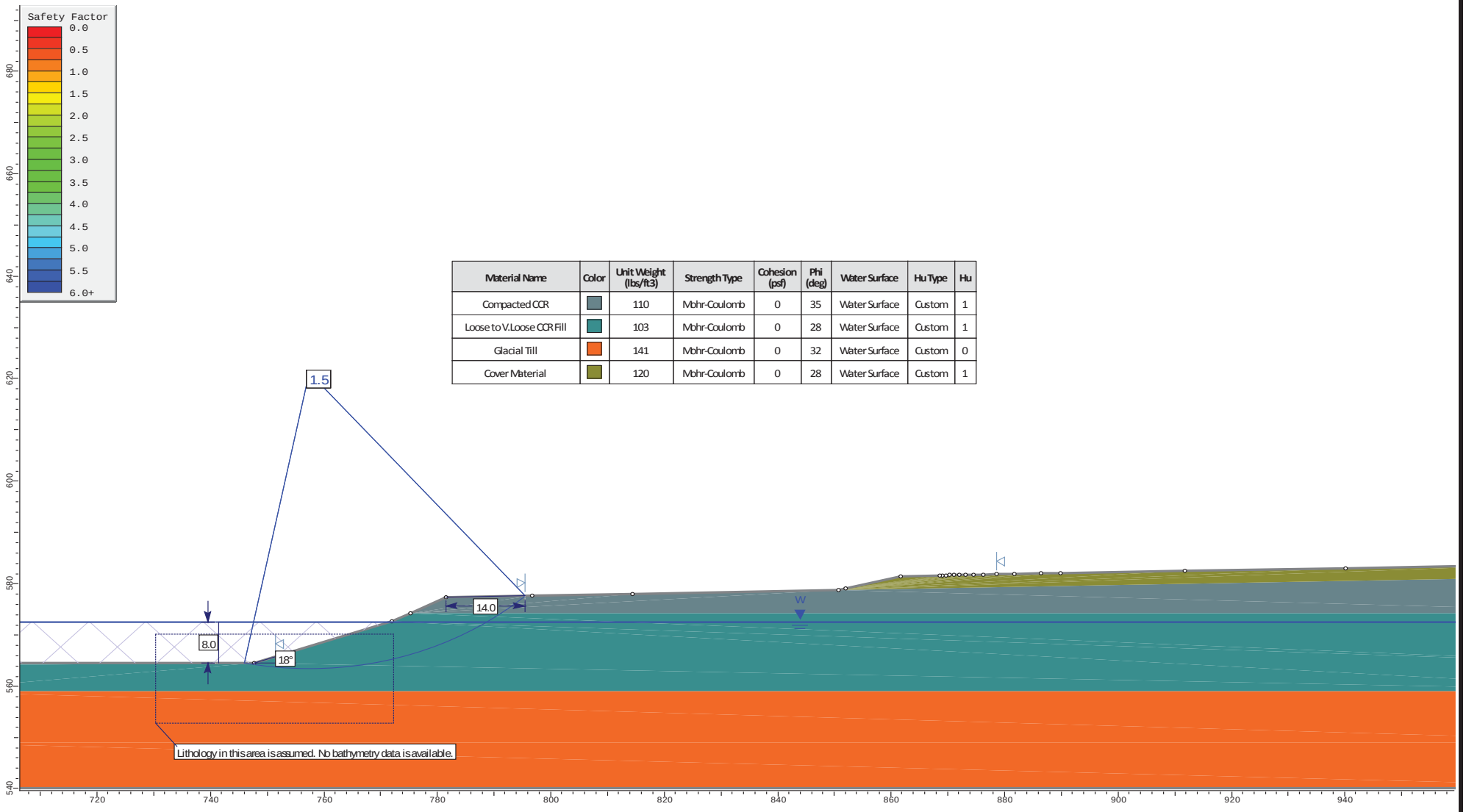
TITLE: **Cross-Section B-B'**
Static, Long-Term Condition-Block Failure

FILE: STABILITY

PROJECT No. 1667572 REV. 0

CLIENT: **Consumers Energy Company**

FIGURE: **1E**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Compacted CCR		110	Mohr-Coulomb	0	35	Water Surface	Custom	1
Loose to V.Loose CCR Fill		103	Mohr-Coulomb	0	28	Water Surface	Custom	1
Glacial Till		141	Mohr-Coulomb	0	32	Water Surface	Custom	0
Cover Material		120	Mohr-Coulomb	0	28	Water Surface	Custom	1

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SCALE	AS SHOWN
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CHECK	SAM
REVIEW	TDJ

PROJECT: **J.R. Whiting Ash Ponds 1 & 2 Closure**

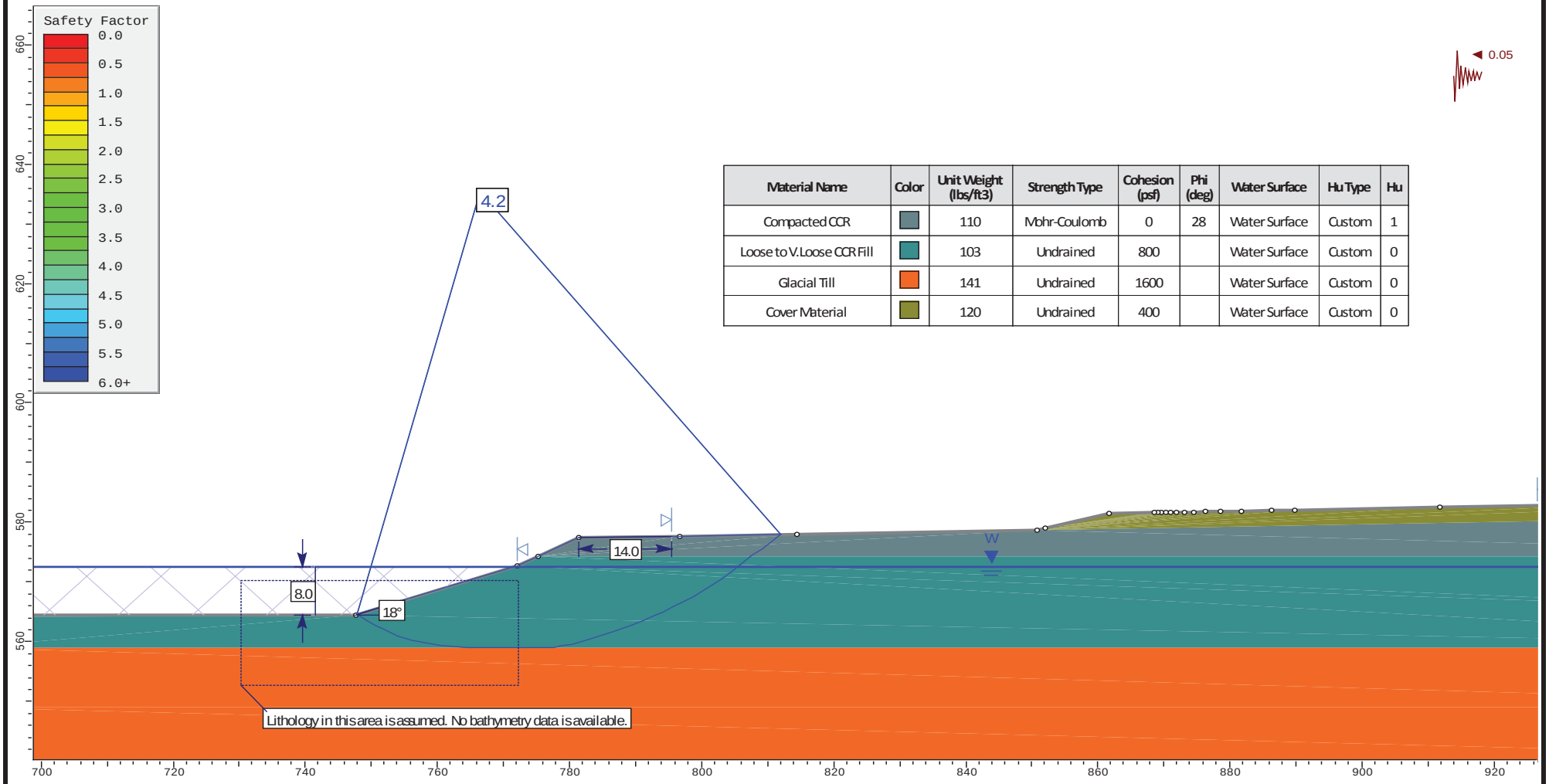
TITLE: **Cross-Section B-B'**
Static, Long-Term Condition-Circular Failure

FILE: STABILITY

PROJECT No. 1667572 REV. 0

CLIENT: **Consumers Energy Company**

FIGURE: **1F**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
Compacted CCR		110	Mohr-Coulomb	0	28	Water Surface	Custom	1
Loose to V.Loose CCR Fill		103	Undrained	800		Water Surface	Custom	0
Glacial Till		141	Undrained	1600		Water Surface	Custom	0
Cover Material		120	Undrained	400		Water Surface	Custom	0

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SCALE	AS SHOWN
DATE	Aug 2017
MADE BY	AK
CAD	DJC
CHECK	SAM
REVIEW	TDJ

PROJECT: **J.R. Whiting Ash Ponds 1 & 2 Closure**

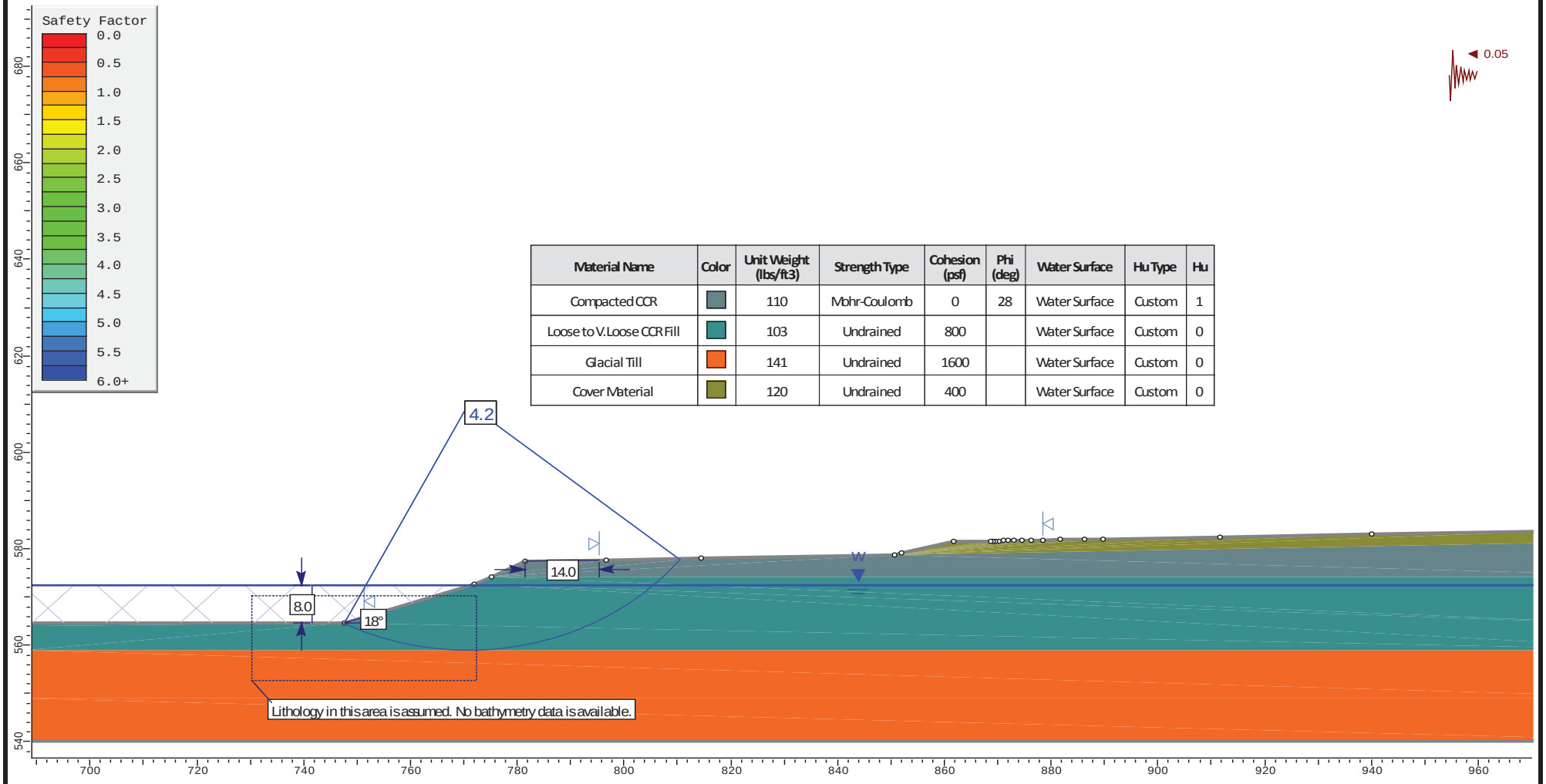
TITLE: **Cross-Section B-B'**
Pseudo-Static, Short-Term Condition-Block Failure

FILE: STABILITY

PROJECT No. 1667572 REV. 0

CLIENT: **Consumers Energy company**

FIGURE: **1G**



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu
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Loose to V. Loose CCR Fill		103	Undrained	800		Water Surface	Custom	0
Glacial Till		141	Undrained	1600		Water Surface	Custom	0
Cover Material		120	Undrained	400		Water Surface	Custom	0

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SCALE	AS SHOWN	PROJECT	J.R. Whiting Ash Ponds 1 & 2 Closure
DATE	Aug 2017	TITLE	Cross-Section B-B' Pseudo-Static, Short-Term Condition-Circular Failure
MADE BY	AK		
CAD	DJC		
FILE	STABILITY	CHECK	SAM
PROJECT No.	1667572	REV. 0	REVIEW TDJ
CLIENT	Consumers Energy Company	FIGURE	1H

SETTLEMENT CALCULATIONS

CALCULATIONS

Date:	July 2017	**Made by:**	AK
Project No.	1667572	**Checked by**	SAM
Short Name:	J.R. Whiting Ponds 1 and 2 Closure	**Reviewed by:**	TDJ
Subject:	**SETTLEMENT ANALYSIS OF PONDS 1 AND 2**		

1.0 OBJECTIVE

Settlement analyses were completed to estimate total and differential settlements of Ponds 1 and 2 (closure area) at the Consumers Energy Company (CEC) J.R. Whiting Ash Ponds 1 and 2 site and determine whether anticipated settlements will cause ponding of water on the cover system. Part 115 of the MDEQ Solid Waste Management, of the Natural Resources and Environmental Protection Act (Part 115 Rules) requires that no slope reversal or localized depressions will develop due to settlement. Post settlement slopes were estimated using the calculated settlements.

2.0 METHODOLOGY

The software program Settle3D (version 4.0) was used to estimate total and differential settlement. The settlement analysis was performed for two critical cross sections. The cross section locations are shown in Figure 1. The post-settlement slopes at each section were estimated to verify that no slope reversal will occur. The subsurface conditions were developed using historical boring logs. Thin, discontinuous lenses of organic clay observed during historical drilling events were not included in the lithology. The subgrade elevation is assumed to be 580 feet above mean sea level (ft-amsl) as measured from the National Geodetic Vertical Survey of 1929 (NGVD29), based on the estimated ground surface elevation after regrade of existing coal combustion residuals (CCR). Bedrock elevation is assumed to be 528 ft-amsl NGVD29 based on the historical well records. Groundwater level is assumed to be 572.5 ft-amsl NGVD29, based on the long-term water surface level of Lake Erie. During construction of the Ponds 1 and 2 closure, fill will be placed and compacted in unsaturated conditions. Primary consolidation and densification (i.e. settlement) will occur before final grades are achieved and the post-closure settlement of the fill will be negligible.

2.1 Material Properties

Historical boring logs and laboratory testing with Cone Penetration test (CPT) data obtained by Conetec in 2017 (Reference 1) were used to estimate the material properties. Material properties estimated for each soil layer include: unit weight; elastic modulus (E_s) for cohesionless soils; compression index (C_c), recompression index (C_r), initial void ratio (e_o) and overconsolidation ratio (OCR) for cohesive soils. Material properties are summarized in the following table:

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Golder Associates: Operations in Africa, Asia, Australasia, Europe, North America and South America

Project No.:	1667572	Made by:	AK
Site Name:	JR Whiting	Checked by:	SAM
Date:	July, 2017	Reviewed by:	TDJ

Material Properties						
Material	**Unit Weight (pcf)**	**E_s (tsf)**	**C_c**	**C_r**	**e_o**	**OCR**
Compacted Backfill	125	-	-	-	-	-
Sluiced Ash	90	120	-	-		-
Lake Clay	136	-	0.378	0.0378	0.88	1
Glacial Till	141	-	0.108	0.0108	0.35	5

Notes:
pcf = pounds per cubic foot
tsf = tons per square foot

Unit weights for the sluiced ash and native soils were obtained from historical laboratory testing results. Unit weight for the compacted backfill is assumed from typical values for sandy fill materials (Reference 2).

The elastic modulus for the sluiced ash was estimated based on the correlations with the angle of internal friction. The consolidated undrained triaxial compression test results (SME, 1977) (Reference 1) indicated the angle of internal friction (φ) of 30.3 degrees. The angle of internal friction was used to estimate the SPT-N value (N) of the sluiced ash (Dunham, 1954) (Reference 3). The SPT-N value was calculated to be 8.8. The SPT-N value was used to estimate the elastic modulus of the sluiced ash (Tan et al., 1991) (Reference 3). The elastic modulus was calculated to be 120 tons per square foot (tsf).

$$\varphi = (12 * N)^{0.5} + 20 \qquad (D \quad ha \quad ,1954)$$

$$E_s = 500 * (N + 15) \qquad (T \quad e \quad a.,1991)$$

Where:

φ= the angle of internal friction (degree)
N=SPT N-value
E_s= the elastic modulus (tsf)

Project No.:	1667572	Made by:	AK
Site Name:	JR Whiting	Checked by:	SAM
Date:	July, 2017	Reviewed by:	TDJ

Consolidation properties for the lake clay and the glacial till were estimated based on Atterberg limits and natural water content (w) from index testing performed by NTH Consultants (2011) (Reference 1) using the following correlations:

$$C_c = 0.009 * (L \quad - 10)$$

$$C_r = 0.1C_c$$

$$e_o = G_s * w \quad \text{(Assumes 100\% saturation)}$$

Where, LL is the liquid limit and G_s is the specific gravity (assumed to be 2.7 for clay). For the lake clay with LL = 52-percent (%) and w = 31.8%, C_c is 0. 378, C_r is 0.0378, and e_o is 0.86. For the glacial till with LL = 22% and w = 13.9%, C_c is 0. 108, C_r is 0.0108, and e_o is 0.37. The CPT data indicated average OCR of 5 for the glacial till.

2.2 Hand Calculation

A settlement calculation was performed for Point 3 using hand calculations to verify the results from the computer models. The subsurface conditions at Point 3 consist of a 10-feet thick sluiced ash layer underlain by 39-feet glacial till layer. The total settlement was calculated with adding the elastic settlement of the sluiced ash and the consolidation settlement of the glacial till.

The elastic settlement of the sluiced ash was calculated using the following equations (Ref. 3):

$$S_e = \left(\frac{\Delta\sigma}{M_s}\right) * H_0$$

$$M_s = \frac{E_s(1-\nu_s)}{(1+\nu_s)(1-2*\nu_s)}$$

Where;

S_e= Elastic settlement of soil layer (ft)
H_0=initial thickness of soil layer (ft)
Δσ=increment of vertical effective stress (tsf)
M_s=constrained modulus of soil (tsf)
ν_s=Poisson's ratio of soil

Project No.:	1667572	Made by:	AK
Site Name:	JR Whiting	Checked by:	SAM
Date:	July, 2017	Reviewed by:	TDJ

Assuming $\nu_s = 0.21$ and $E_s = 120\ t$ $\rightarrow$ $M_s = 135\ t$

Assuming the subgrade elevation at Point 3 at 580 ft-amsl the increment of vertical effective stress will be:

$$\Delta\sigma = \Upsilon * H = 125 * 11.9 = 0.74\ t$$

$$S_e = \left(\frac{0.74}{135}\right) * 10 = 0.66\ in\ \ h$$

The primary consolidation of the highly overconsolidated glacial till (OCR=5) can be calculated using the following equation (Ref. 1):

$$S_c = \frac{C_r}{1 + e_0}\log\left(\frac{\sigma' + \Delta\sigma}{\sigma'}\right)$$

Where

σ'=initial vertical effective stress (psf)

In the middle of the glacial till layer:

$$\sigma' = 10 * 90 + \left(\frac{39}{2}\right) * 141 - 21.5 * 62.4 = 2307\ p$$

$$S_c = \frac{0.0108}{1 + 0.35} * 39 * \log\left(\frac{2307 + 1480}{2307}\right) = 0.80\ in\ \ h$$

Total settlement will be:

$$S = S_e + S_c = 0.80 + 0.66 = 1.5\ in\ \ h$$

3.0 RESULTS

The settlement analysis was primarily performed using Settle3D. Hand calculations were also performed to verify the computer model results. The settle 3D model results are presented in Figures 2 and 3 and summarized in the table below:

Location	Length (ft)	Point	Ground Surface Elevation (ft-amsl NGVD29)	Total Settlement (inches)	Design Slope	Post Settlement Slope
Section A	465	1	591.8	10.4	2.0%	1.8%
		2	582.5	0		
Section B	500	3	591.9	1.8	2.0%	2.0%
		4	581.9	0		

Hand calculations performed for Point 3 estimated a total settlement of 1.5 inches. Therefore, the total settlement of 1.8 inches (as calculated by Settle3D) is a reasonable expectation.

Project No.:	1667572	Made by:	AK
Site Name:	JR Whiting	Checked by:	SAM
Date:	July, 2017	Reviewed by:	TDJ

4.0 RESULTS AND CONCLUSIONS

Approximately 10.4 inches of total settlement can be anticipated due to loading from the backfill material. Differential settlement ranging between 0 to 10.4 inches is anticipated. The minimum post settlement slope was calculated as 1.8% which indicates that no slope reversal or localized depressions will develop, as required by Part 115 of the MDEQ Solid Waste Management, of the Natural Resources and Environmental Protection Act (Rule 304.5).

5.0 ATTACHMENTS

Figure 1- Settlement Cross Section Locations

Figure 2 - Settle 3D Output-Section A-Point 1

Figure 3 - Settle 3D Output-Section B-Point 3

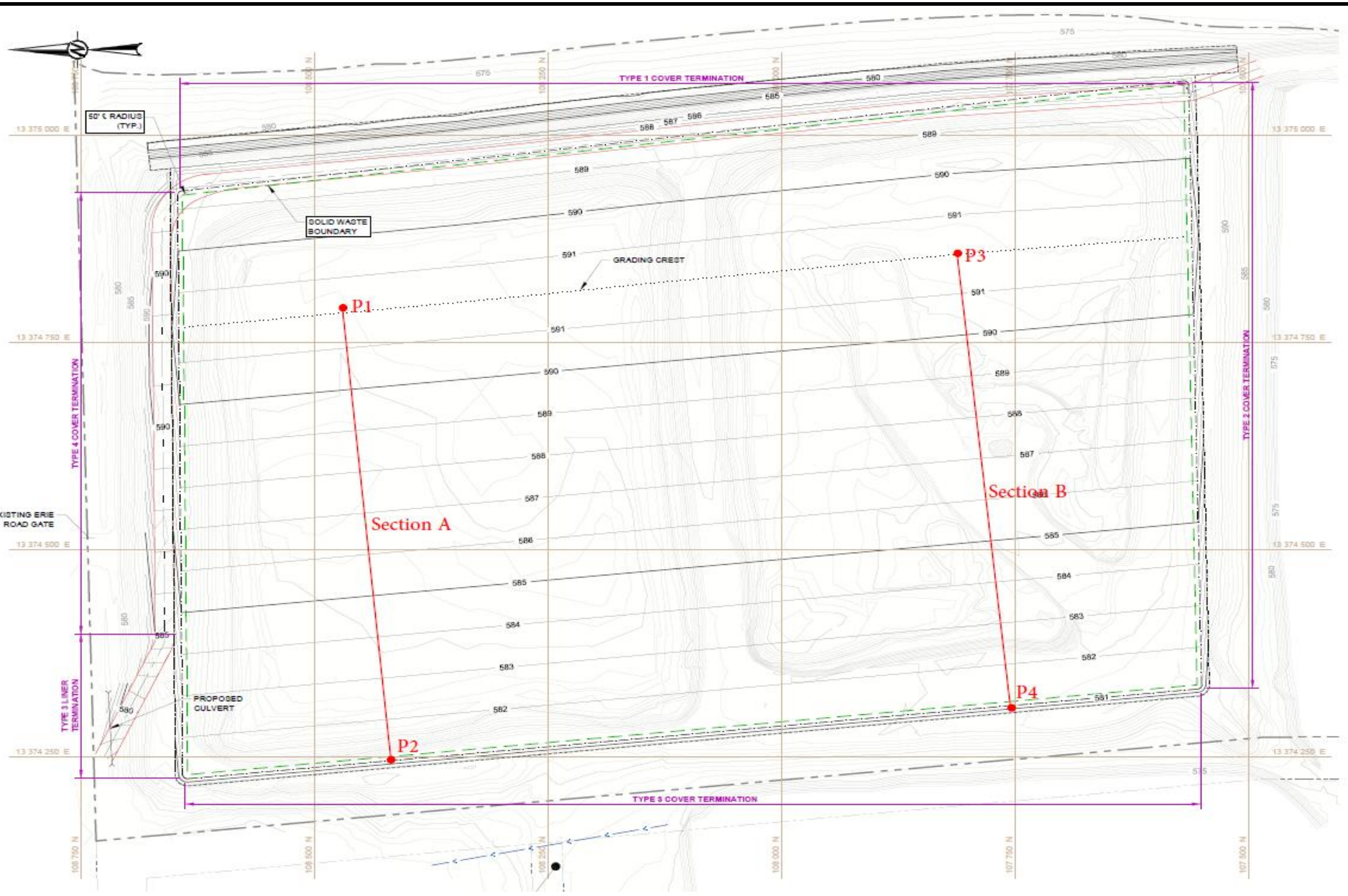
6.0 REFERENCES

1. Golder Associates Inc., 2017. J.R. Whiting Ash Ponds 1 and 2 Closure Plan, Appendix G, Historical Geotechnical Information.

2. Golder Associates Inc., 2017. J.R. Whiting Ash Ponds 1 and 2 Closure Plan, Appendix F, Table1: Global Material Properties Used f or Calculations.

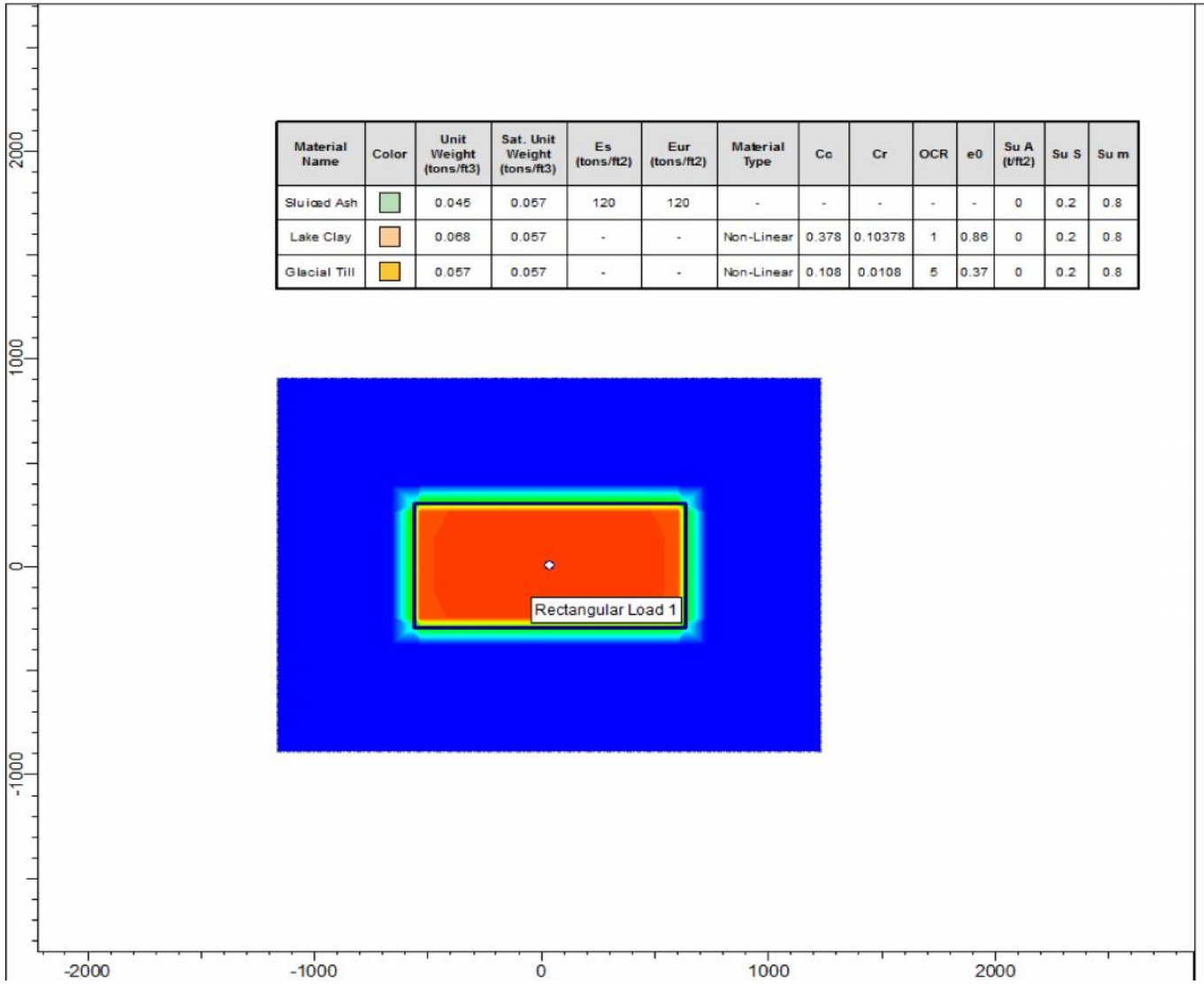
3. Naval Facilities Engineering Command (NAVFAC), Design Manual 7.01, 1986.

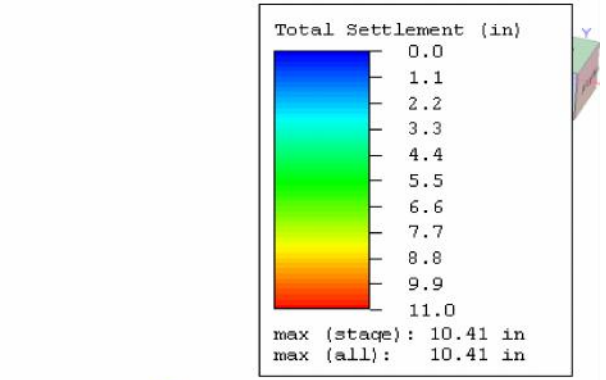
4. Qian, X., Koerner, R. M., and Gray, D. H., (2002). Geotechnical Aspects of Landfill Design and Construction. Prentice-Hall, Inc., New Jersey.

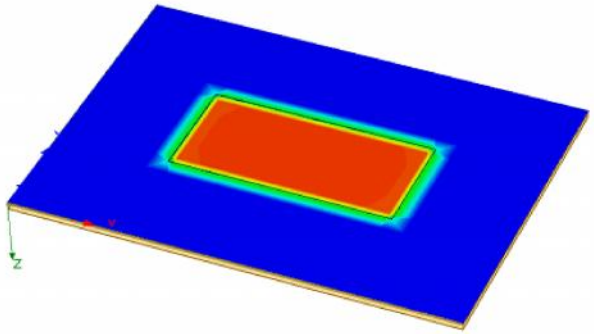


Golder Associates	SCALE AS SHOWN	PROJECT **J.R. Whiting Ash Ponds 1 & 2 Closure**	
	DATE Jul 2017	TITLE **Settlement Cross Section Locations**	
	MADE BY AK		
	CAD DC		
FILE STABILITY	CHECK SAM	CLIENT **Consumers Energy Company**	FIGURE 1
PROJECT No. 1667572 REV. 0	REVIEW TDJ		

Material Name	Color	Unit Weight (tons/ft3)	Sat. Unit Weight (tons/ft3)	Es (tons/ft2)	Eur (tons/ft2)	Material Type	Cc	Cr	OCR	e0	Su A (t/ft2)	Su S	Su m
Sluiced Ash		0.045	0.057	120	120	-	-	-	-	-	0	0.2	0.8
Lake Clay		0.068	0.057	-	-	Non-Linear	0.378	0.10378	1	0.86	0	0.2	0.8
Glacial Till		0.057	0.057	-	-	Non-Linear	0.108	0.0108	5	0.37	0	0.2	0.8

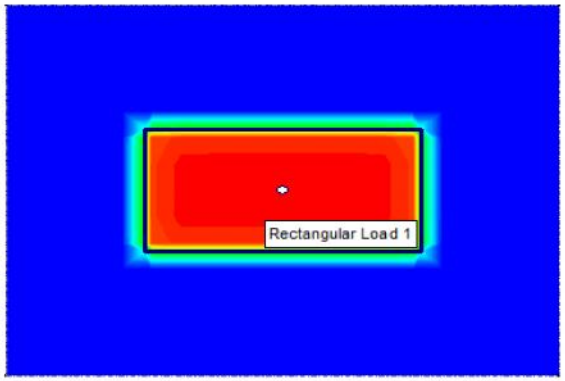


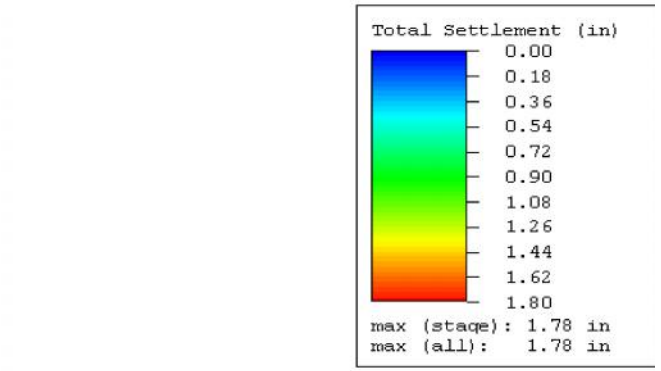


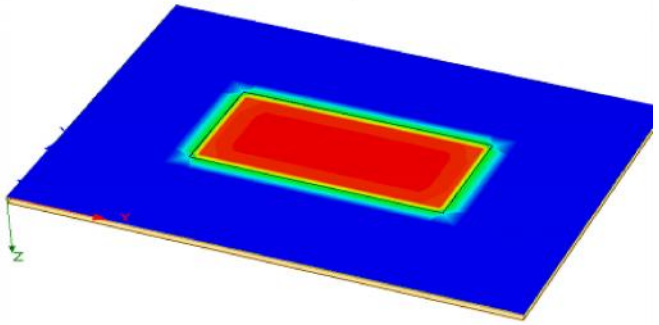


Golder Associates	SCALE: AS SHOWN	PROJECT: **J.R. Whiting Ash Ponds 1 & 2 Closure**	
	DATE: Jul 2017	TITLE: **Settlement Analysis- Section A-Point 1**	
	MADE BY: AK		
	CAD: DC		
FILE: STABILITY	CHECK: SAM	CLIENT: **Consumers Energy Company**	FIGURE: **2**
PROJECT No.: 1667572 REV.: 0	REVIEW: TDJ		

Material Name	Color	Unit Weight (tons/ft3)	Sat. Unit Weight (tons/ft3)	Es (tons/ft2)	Eur (tons/ft2)	Material Type	Cc	Cr	OCR
Sluiced Ash		0.045	0.057	120	120	-	-	-	-
Glacial Till		0.057	0.057	-	-	Non-Linear	0.108	0.0108	5







Golder Associates	SCALE: AS SHOWN	PROJECT: **J.R. Whiting Ash Ponds 1 & 2 Closure**	
	DATE: Jul 2017	TITLE: **Settlement Analysis- Section B-Point 3**	
	MADE BY: AK		
	CAD: DC		
FILE: STABILITY	CHECK: SAM	CLIENT: **Consumers Energy Company**	FIGURE: **3**
PROJECT No.: 1667572 REV.: 0	REVIEW: TDJ		

GEOTEXTILE CUSHION CALCULATIONS

CALCULATIONS

Date:	July 2017	**Made by:**	BAB
Project No.:	1667572.0005	**Checked by:**	SAM
Subject:	Geomembrane Puncture with Geocomposite Cushion (Cover Soils on Liner)	**Reviewed by:**	TDJ
Project Short Title:	J.R. Whiting Ponds 1 and 2 Closure Project		

1.0 OBJECTIVE

To evaluate the puncture resistance of 40-mil thick high density polyethylene (HDPE) geomembrane, when overlain by an 8-ounce per square yard (oz/sy) nonwoven (NW) needle-punched (NP) geotextile using soil, snow, and equipment loading.

2.0 GIVENS/ASSUMPTIONS

1) The proposed Final Cover system consists of (from top to bottom):

   Erosion Protection Layer 0.5 feet (ft) thick (Topsoil)
   Protective Cover Soil, 1.5 ft thick
   8-oz/sy Nonwoven Needle-Punched Geotextile
   Geomembrane Liner, 40-mil HDPE
   Smooth drum rolled and rock-picked liner subgrade soils

2) In place unit weight of the protective layer and topsoil is assumed to be 120 pounds per cubic foot (pcf) (reference 2).
3) The largest diameter particle size allowed in the protective cover will be a 3/4-inch diameter subrounded particle.
4) The normal pressure exerted by typical low ground pressure installation equipment is assumed to be 5 pounds per square inch (psi) or 720 pounds per square foot (psf) at the liner (reference 4).
5) Typical snow loading is 20 psf. (reference 7)
6) Assume the minimum acceptable factor of safety against geomembrane puncture is 2.0 ($FS \geq 2.0$).

3.0 METHODS

The normal pressure exerted by the cover soils is 120 pcf x 2 ft thickness = 240 psf.

Total normal loading pressures are soils + equipment + snow = 240 psf + 720 psf + 20 psf = 980 psf.

The method presented herein (Koerner, 2005, reference 1) focuses on the protection of 40-mil (1.0 mm) thick HDPE geomembrane. The method uses the design by function approach.

$$FS = P_{allow} / P_{actual}$$

where:

FS = factor of safety against geomembrane puncture.

P_{actual} = actual pressure due to the cover soils and equipment loads.

P_{allow} = allowable pressure using different types of geotextiles and site specific conditions.

Date: July 2017 **Made by:** BAB
Project No.: 1667572.0005 **Checked by:** SAM
Subject: Geomembrane Puncture with Geocomposite Cushion (Cover Soils on Liner) **Reviewed by:** TDJ

Project Short Title: J.R. Whiting Ponds 1 and 2 Closure Project

3.0 METHODS (Continued)

The allowable pressure, P_{allow} is determined by the following equation:

$$P_{allow} = [50 + 0.00045* (M/H^2)] * [1/(MFs* MF_{PD} * MF_A)] * [1/(RF_{CR} * RF_{CBD})]$$

where:

P_{allow} = allowable pressure (kiloPascals; kPa)
M = geotextile mass per unit area (grams per square meter; g/m^2)
H = protrusion height (meters; m)
MFs = modification factor for protrusion shape
MF_{PD} = modification factor for packing density
MF_A = modification factor for arching in solids
RF_{CR} = reduction factor for long-term creep
RF_{CBD} = reduction factor for long-term chemical/biological degradation

4.0 CALCULATIONS

Evaluate the factor of safety against geomembrane puncture when an 8 ounce per square yard (oz/sy) nonwoven needle punched geotextile overlies the geomembrane.

Table 1 - Modification Factors and Reduction Factors for Geomembrane Protection Design (reference 1).

MFs		MF_{PD}		MF_A	
Angular:	1	Isolated	1	Hydrostatic	1
Subrounded:	0.5	Dense, 38 mm	0.83	Geostatic, shallow	0.75
Rounded:	0.25	Dense, 25 mm	0.67	Geostatic, mod.	0.5
		Dense, 12mm	0.5	Geostatic, deep	0.25

RF_{CBD}		RF_{CR}			
		Mass per unit area (g/m^2)	Protrusion (mm)		
			38	25	12
Mild leachate	1.1	Geomembrane alone	N/R	N/R	N/R
Moderate leachate	1.3	270	N/R	N/R	>1.5
Harsh leachate	1.5	550	N/R	1.5	1.3
		1100	1.3	1.2	1.1
		>1100	1.2	1.1	1

- Geotextile mass per unit area, M = 271 g/m^2 (8 oz/sy).
- Depth of material on top of geomembrane, d = 0.61 m (2.0 feet of material)
- Unit weight of material on top of geomembrane, γ = 18.9 kN/m^3 (120 pcf)
- Pressure from equipment loading = 34.6 kPa
- Pressure from snow loading = 0.96 kPa

Date:	July 2017	**Made by:**	BAB
Project No.:	1667572.0005	**Checked by:**	SAM
Subject:	Geomembrane Puncture with Geocomposite Cushion (Cover Soils on Liner)	**Reviewed by:**	TDJ

Project Short Title: J.R. Whiting Ponds 1 and 2 Closure Project

4.0 CALCULATIONS (Continued)

For a 3/4-inch particle size:

- Protrusion height, H = 0.0191 m (less than or equal to 0.75 inches)
- Modification and Reduction Factors:

MF_S = 0.5 assume subrounded particles
MF_{PD} = 0.83
MF_A = 1
RF_{CR} = 1.5
RF_{CBD} = 1.1 storm water

$$P_{allow} = [50 + 0.00045 * (M/H^2)] * [1/(MFs * MF_{PD} * MF_A)] * [1/(RF_{CR} * RF_{CBD})]$$

P_{allow} = 564 kPa

$P_{actual} = d * \gamma + Pequip + Psnow$ = 47.0 kPa

$$FS = \frac{564}{47} = 12.0$$ **<= Acceptable for 3/4-inch particle**

5.0 CONCLUSION

The resulting factor of safety against geomembrane puncture is 12.0, when the geomembrane is overlain by 8 oz/sy nonwoven, needle punched geotextile. This meets the design requirement of a minimum factor of safety against geomembrane puncture of 2.0.

6.0 REFERENCES

1 - Koerner, R.M. (2005), *Designing with Geosynthetics* , Prentice Hall Publishing Co., Englewood Cliffs, NJ, 5th edition.

2 - Golder Associates Inc. (2017). J.R. Whiting Ash Ponds 1 and 2 Closure Plan, Appendix F, Table 1: Global

3 - Coduto, Donald P., 2001. Foundation Design Principles and Practices, Second Edition. Prentice-Hall, Inc. New Jersey

4 - Caterpillar, Specification Summary, D6N LGP Track-type Tractor, CAT Performace Handbook, Edition 26, 1995.

5 - ADS, Inc. Drainage Handbook, 2.0 Structures, May 2015.

6 - The Michelin X MULTIWAY 3D XZE, Tire Specs, www.michelintruck.com, 2017.

7 - GroundSnowByZip Web Page, Ground Snow Loading Results for Monroe MI, 2017.

7.0 ATTACHMENTS

#1 - Stress Influence Factor Calculation
#2 - The Michelin X MULTIWAY 3D XZE Tire Specs

CALCULATIONS

Date:	July 2017	**Made by:**	BAB
Project No.:	1667572.0005	**Checked by:**	SAM
Subject:	Geomembrane Puncture with Geotextile Cushion (Access Road over Cap)	**Reviewed by:**	TDJ
Project Short Title:	J.R. Whiting Ponds 1 and 2 Closure Project		

1.0 OBJECTIVE

To evaluate the puncture resistance of 40-mil thick high density polyethylene (HDPE) geomembrane, when overlain by an 8-ounce per square yard (oz/sy) nonwoven (NW) needle-punched (NP) geotextile using soil, snow, and equipment loading.

2.0 GIVENS/ASSUMPTIONS

1) The proposed On-Cover Access Road section will consist of (from top to bottom):

   Road Base Aggregate, 12-inches thick
   10-oz/sy Nonwoven Needle Punched Geotextile (separation layer)
   Protective Cover Soil, 12-inches thick
   10-oz/sy Nonwoven Needle Punched Geotextile (geomembrane protection layer)
   Geomembrane Liner, 40-mil HDPE
   Smooth drum rolled and rock-picked liner subgrade soils

2) In place unit weight of the soil protective layer and gravel base is assumed to be 120 pounds per cubic foot (pcf) (reference 2).
3) The largest diameter particle size allowed in the protective cover will be a 3/4-inch diameter subrounded particle.
4) Typical snow loading is 20 pounds per square foot (psf). (reference 7)
5) Assume the minimum acceptable factor of safety against geomembrane puncture is 2.0 (FS ≥ 2.0).

3.0 METHODS

Total normal loading pressures = soils + equipment + snow

The normal pressure exerted by the cover soils is 120 pcf x 2.0 feet thickness = 240.0 pounds per square foot (psf).

The normal pressure exerted by the "worst case scenario" maintenance assosiated traffic (semi tractor-trailer) equipment will be 120 pounds per square inch (psi) or 17,280 psf at the surface (see Attachment 2, Ref 6).

Using the thickness of soil over the geomembrane (2.0 feet) and the assumed tire width of the maintenance equipment (11.7 inches; see Attachment 2, reference 6) a stress reduction factor of 0.3 was calculated (see Attachment 1, reference 3).

Using a stress influence reduction factor of 0.3, the normal pressure exerted by the mowing and maintenance equipment is estimated to be 36 psi or 5,184 psf at the liner (references 3 and 6).

An additional force from the rolling motion of the vehicle will be exerted on the particle (reference 5). To account for this "impact factor" the American Association for Safety, Highway, and Transportation Officers (AASHTO) provides the following equation: IM = 33(1.0 - 0.125H)/100. Where: IM= impact factor, % ; H = burial depth, feet.
Therefore, IM = 33(1.0 - 0.125 * (2.0))/100 = 24.75%

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Project No.:	1667572.0005	**Checked by:**	SAM
Subject:	Geomembrane Puncture with Geotextile Cushion (Access Road over Cap)	**Reviewed by:**	TDJ
Project Short Title:	J.R. Whiting Ponds 1 and 2 Closure Project		

3.0 METHODS (Continued)

The method presented herein (Koerner, 2005; reference 1) focuses on the protection of a 40-mil (1.0 mm) thick HDPE geomembrane. The method uses the design by function approach.

$$FS = P_{allow} / P_{actual}$$

where:

FS = factor of safety against geomembrane puncture.

P_{actual} = actual pressure due to the cover soils and equipment loads.

P_{allow} = allowable pressure using different types of geotextiles and site specific conditions.

The allowable pressure, P_{allow} is determined by the following equation:

$$P_{allow} = [50 + 0.00045* (M/H^2)] * [1/(MFs* MF_{PD} * MF_A)] * [1/(RF_{CR} * RF_{CBD})]$$

where:

P_{allow} = allowable pressure (kiloPascals; kPa)

M = geotextile mass per unit area (grams per square meter; g/m^2)

H = protrusion height (meters; m)

MFs = modification factor for protrusion shape

MF_{PD} = modification factor for packing density

MF_A = modification factor for arching in solids

RF_{CR} = reduction factor for long-term creep

RF_{CBD} = reduction factor for long-term chemical/biological degradation

4.0 CALCULATIONS

Evaluate the factor of safety against geomembrane puncture when a 10 ounce per square yard (oz/sy) nonwoven needle punched geotextile overlies the geomembrane.

Table 1 - Modification Factors and Reduction Factors for Geomembrane Protection Design (ref 1).

MFs		**MF_{PD}**		**MF_A**	
Angular:	1	Isolated	1	Hydrostatic	1
Subrounded:	0.5	Dense, 38 mm	0.83	Geostatic, shallow	0.75
Rounded:	0.25	Dense, 25 mm	0.67	Geostatic, mod.	0.5
		Dense, 12mm	0.5	Geostatic, deep	0.25

RF_{CBD}		**RF_{CR}**			
		Mass per unit area (g/m^2)	Protrusion (mm)		
			38	25	12
Mild leachate	1.1	Geomembrane alone	N/R	N/R	N/R
Moderate leachate	1.3	270	N/R	N/R	>1.5
Harsh leachate	1.5	550	N/R	1.5	1.3
		1100	1.3	1.2	1.1
		>1100	1.2	1.1	1

Date: July 2017 **Made by:** BAB
Project No.: 1667572.0005 **Checked by:** SAM
Subject: Geomembrane Puncture with Geotextile Cushion (Access Road over Cap) **Reviewed by:** TDJ
Project Short Title: J.R. Whiting Ponds 1 and 2 Closure Project

Geotextile mass per unit area, M =	339	g/m^2	(10 oz/sy).
Depth of material on top of geomembrane, d =	0.61	m	(2.0 feet of material)
Unit weight of material on top of geomembrane, γ =	18.9	kN/m^3	(120 pcf)
Pressure from equipment loading (at the liner) =	248	kPa	
Pressure from snow loading =	0.96	kPa	
Pressure from equipment loading "impact factor", IM =	61.4	kPa	

4.0 CALCULATIONS (Continued)

For a 3/4-inch particle size:

Protrusion height, H = 0.0191 m (less than or equal to 0.75 inches)
Modification and Reduction Factors:

MF_S =	0.5	assume subrounded particles
MF_{PD} =	0.83	
MF_A =	1	
RF_{CR} =	1.5	
RF_{CBD} =	1.1	storm water

$$P_{allow} = [50 + 0.00045* (M/H^2)] * [1/(MFs* MF_{PD} * MF_A)] * [1/(RF_{CR} * RF_{CBD})]$$

P_{allow} = 687 kPa

$P_{actual} = d * \gamma + Pequip + Psnow + P_{IM}$ = 322.1 kPa

$$FS = \frac{687}{322} = 2.1$$ **<= Acceptable for 3/4-inch particle**

5.0 CONCLUSION

The resulting factor of safety against geomembrane puncture is 2.1, when the geomembrane is overlain by 10 oz/sy nonwoven, needle punched geotextile. This meets the design requirement of a minimum factor of safety against geomembrane puncture of 2.0.

Date:	July 2017	**Made by:**	BAB
Project No.:	1667572.0005	**Checked by:**	SAM
Subject:	Geomembrane Puncture with Geotextile Cushion (Access Road over Cap)	**Reviewed by:**	TDJ
Project Short Title:	J.R. Whiting Ponds 1 and 2 Closure Project		

6.0 REFERENCES

1 - Koerner, R.M. (2005), *Designing with Geosynthetics* , Prentice Hall Publishing Co., Englewood Cliffs, NJ, 5th edition.

2 - Golder Associates Inc. (2017). J.R. Whiting Ash Ponds 1 and 2 Closure Plan, Appendix F, Table 1: Global Material Properties Used for Calculations.

3 - Coduto, Donald P., 2001. Foundation Design Principles and Practices, Second Edition. Prentice-Hall, Inc. New Jersey

4 - Caterpillar, Specification Summary, D6N LGP Track-type Tractor, CAT Performace Handbook, Edition 26, 1995.

5 - ADS, Inc. Drainage Handbook, 2.0 Structures, May 2015.

6 - The Michelin X MULTIWAY 3D XZE, Tire Specs, www.michelintruck.com, 2017.

7 - GroundSnowByZip Web Page, Ground Snow Loading Results for Monroe MI, 2017.

7.0 ATTACHMENTS

#1 - Stress Influence Factor Calculation
#2 - The Michelin X MULTIWAY 3D XZE Tire Specs

Attachment 1

7.3 INDUCED STRESSES BENEATH SHALLOW FOUNDATIONS

The bearing pressure from shallow foundations induces a vertical compressive stress in the underlying soils. We call this stress $\Delta\sigma_z$, because it is the change in stress that is superimposed on the initial vertical stress:

$$\Delta\sigma_z = I_\sigma(q - \sigma'_{zD}) \tag{7.3}$$

Where:

$\Delta\sigma_z$ = induced vertical stress due to load from foundation
I_σ = stress influence factor
q = bearing pressure along bottom of foundation
σ_{zD}' = vertical effective stress at a depth D below the ground surface

The q term reflects the increase in vertical stress caused by the applied structural load and the weight of the foundation, while the σ_{zD}' term reflects the reduction in vertical stress caused by excavation of soil to build the foundation. Thus, $\Delta\sigma_z$ reflects the net result of these two effects.

Immediately beneath the foundation, the applied load is distributed across the base area of the foundation, so $I_\sigma = 1$. However, as the load propagates through the ground, it is spread over an increasingly larger area, so $\Delta\sigma_z$ and I_σ decrease with depth, as shown in Figure 7.2.

Boussinesq's Method

Boussinesq (1885) developed the classic solution for induced stresses in an elastic material due to an applied point load. Newmark (1935) then integrated the Boussinesq equation to produce a solution for I_σ at a depth z_f beneath the corner of a rectangular foundation of width B and length L, as shown in Figure 7.3. This solution produces the following two equations:

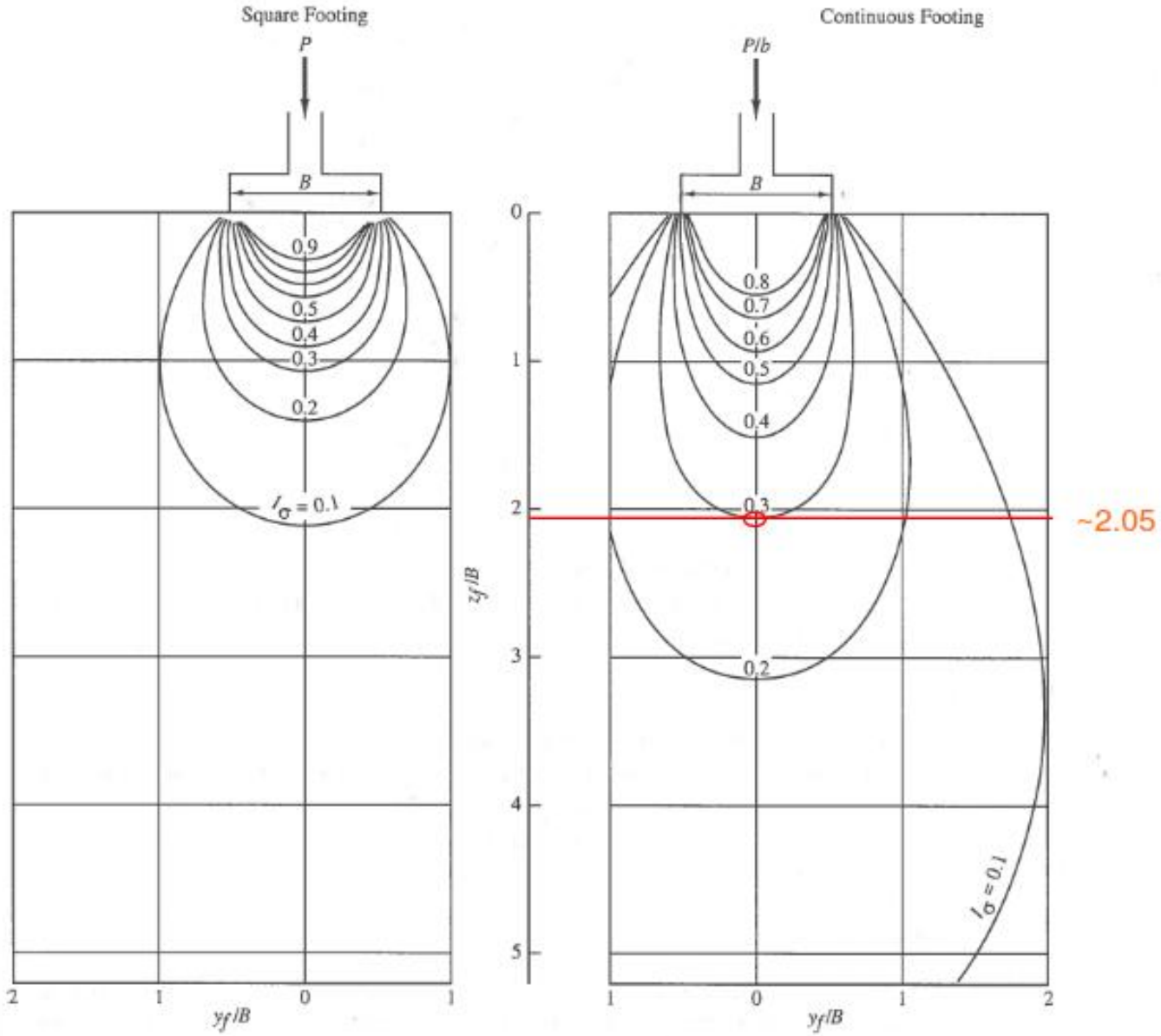
If $B^2 + L^2 + z_f^2 < B^2L^2/z_f^2$:

$$I_\sigma = \frac{1}{4\pi}\left[\left(\frac{2BLz_f\sqrt{B^2+L^2+z_f^2}}{z_f^2(B^2+L^2+z_f^2)+B^2L^2}\right)\left(\frac{B^2+L^2+2z_f^2}{B^2+L^2+z_f^2}\right) + \pi - \sin^{-1}\frac{2BLz_f\sqrt{B^2+L^2+z_f^2}}{z_f^2(B^2+L^2+z_f^2)+B^2L^2}\right] \tag{7.4}$$

Otherwise:

$$I_\sigma = \frac{1}{4\pi}\left[\left(\frac{2BLz_f\sqrt{B^2+L^2+z_f^2}}{z_f^2(B^2+L^2+z_f^2)+B^2L^2}\right)\left(\frac{B^2+L^2+2z_f^2}{B^2+L^2+z_f^2}\right) + \sin^{-1}\frac{2BLz_f\sqrt{B^2+L^2+z_f^2}}{z_f^2(B^2+L^2+z_f^2)+B^2L^2}\right] \tag{7.5}$$

Attachment 1



y_f = horizontal distance from centerline of footing
z_f = depth below bottom of footing
B = footing width
I_σ = stress inflence factor

Figure 7.2 Stress bulbs based on Newmark's solution of Boussinesq's equation for square and continuous footings.

Zf/B = 24 inches / 11.7 inches = ~2.05
Zf/B (2.05) => Stress influence factor = 0.30

Attachment 2

THE MICHELIN® X® MULTIWAY 3D XZE®

REGIONAL & COACH APPLICATIONS

Improved fuel economy and mileage in an all-position tire for regional and coach applications.(1)

Outstanding Driving Safety

Improved Braking and Traction

– Braking distances reduced by 25%(2)

– Grip, traction and handling improved in all weather conditions over the entire lifespan of the tire(3)

- **3D Sipes**
  Full depth sipes for optimal grip in wintry conditions on smooth, icy, and slippery road surfaces. Align with the preferred suggested rotation of the tire.

Excellent Mileage

Tread life improvement of 15% on front tires and 30% on rear tires(5)

- **Optimized Tread Design and materials**
- **Directional Tread**
  Optimizes wear pattern

Excellent Fuel Economy

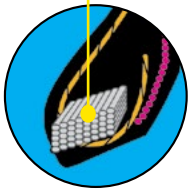
0.2 gallons per 100 miles in fuel savings(4) vs. MICHELIN® XZE®2+ tires

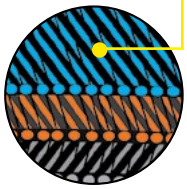
- **Optimized Tread Design and Materials**

Extended Casing Life

Long life and retreadability

- **Full Width Elastic Protector Ply**
  Protects against penetrations, impacts breaks and shocks for maximum casing durability.
- **Rectangular Bead Bundle**
  Reduced heat and fatigue. Michelin exclusive





Explanation of the meaning of the arrows for MICHELIN® X® MULTIWAY™ 3D XZE® tire

The arrow with the larger head indicates the Michelin preferred direction of rotation for the tire, optimizing tread wear performance. We strongly recommend that, especially when new, Michelin® tires marked with a bi-directional arrow should be run in the direction of rotation indicated by the larger arrow head.

However, if a tire marked with the bi-directional arrow shows an irregular wear profile, (for example, a sloped wear pattern) then it may be turned on the rim and run in the direction of the smaller arrow head with no detriment to any other performance criteria. In cases such as this, Michelin recommends that all tires on the same axle should be turned on the rim such that all arrows face in the same direction.

When turning these tires on the rim or moving from side to side on a vehicle, they should be treated in the same way as any other. Please remember that tires on the same axle must always be compatible with each other.

Line Haul	Regional	Urban	On/Off Road
Recommended		Acceptable	

Size	Load Range	Catalog Number	Tread Depth	Max. Speed (*)	Loaded Radius		Overall Diameter		Overall Width (‡)		Approved Wheels (Measuring wheel listed first.)	Min. Dual Spacing (‡)		Revs Per Mile	Max. Load and Pressure Single				Max. Load and Pressure Dual			
			32nds	mph	in.	mm	in.	mm	in.	mm		in	mm		lbs.	psi	kg.	kPa	lbs.	psi	kg.	kPa
295/80R22.5 (1)	H	07719	19	75	19.2	488	41.5	1054	11.7	297	8.25, 9.00	12.8	326	501	7830	120	3550	830	6940	120	3150	830

Note: Wheel listed first is the measuring wheel.

(1) **"No bus shall be operated with regrooved, recapped or retreaded tires on the front wheels." US Code of Federal Regulations: Title 49, Transportation; Part 393.75.**

(2) Internal Michelin study. Vehicle fitted with MICHELIN® X® MULTIWAY™ 3D XZE® tires two-thirds worn compared with similarly worn MICHELIN® XZE®2+ tires for emergency braking (18 mph to 0 mph) on a wet, smooth, concrete surface.

(3) Compared to MICHELIN XZE®2+ tires.

(4) Internal Michelin simulation, MICHELIN® X® MULTIWAY™ 3D XZE® tires compared to MICHELIN XZE®2+ tires.

(5) Internal Michelin study. MICHELIN® X® MULTIWAY™ 3D XZE® tire compared with MICHELIN XZE®2+ tire.

(*) Exceeding the lawful speed limit is neither recommended nor endorsed.

(‡) Overall widths will change 0.1 inch (2.5 mm) for each 1/4 inch change in wheel width. Minimum dual spacing should be adjusted accordingly.

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APPENDIX E
HYDROLOGIC AND HYDRAULIC CALCULATIONS

HYDROLOGIC PARAMETERS

Client CEC **Subject** Hydrologic Parameters
Project J.R. Whiting Ash Ponds 1 & 2
Prepared By JSH **Date** 07/19/17
Reviewed By JDP **Date** 07/20/17
Approved By SAM **Date** 07/22/17

HYDROLOGIC PARAMETERS

Objective

Determine hydrologic parameters (curve number, rainfall depth and rainfall distribution) and design criteria to design and evaluate the proposed surface water management system.

Design Criteria and Assumptions

1. Curve numbers were calculated using the Soil Conservation Service ("SCS") methodology.

2. Times of concentration were computed by HydroCAD, a hydrologic and hydraulic modeling software program using methodology developed by the SCS.

3. Rainfall depths are provided in Attachment 1. Depths for rainfall distributions are based on the NOAA Atlas 14, Volume 8, Version 2 Point Precipitation Frequency Estimates.

4. HydroCAD was used to calculate the peak flow and velocity into channels and the culvert, and compute peak surface water discharge from Ash Ponds 1 & 2. Storage-Indication-Translation Method routing techniques were used to route surface water through the surface water management system. The antecedent moisture condition specifies the moisture level in the ground immediately prior to the storm. A value of "2" for normal conditions is used in the analyses.

5. The stormwater management system is designed to meet the following criteria:

   - The run-off channels will collect and control run-off from the SCS Type II, 100-year, 24-hour storm event without overflow, which exceeds MI DEQ R 299.4435(b) requirement for a 25-year storm.
   - Culvert design will be completed by the Monroe County Drain Commissioner

6. All proposed culverts were modeled with a manning's n value of 0.012 for concrete pipe. Alternative culverts types may be used with equal hydraulic performance.

Calculations

Curve Numbers

A Curve Number ("CN") was applied to the final cover drainage areas. A summary of the curve number used throughout the calculations is provided in Table 1 shown below. The TR-55 Tables 2-2a was used to develop the curve number summary and is provided in Attachment 2.

TABLE 1- CURVE NUMBER SUMMARY

Study Area Cover Description	TR-55 Cover Type and Hydrologic Condition	Hydrologic Soil Group	Curve Number
Final Cover	Grassland in good condition	D	80

Final cover material will be Lenawee silty clay loam which is classified by the NRCS as a type D soil.

Client CEC **Subject** Hydrologic Parameters
Project J.R. Whiting Ash Ponds 1 & 2
Prepared By JSH **Date** 07/19/17
Reviewed By JDP **Date** 07/20/17
Approved By SAM **Date** 07/22/17

Rainfall Depth

Rainfall depths for storm events used in the analyses are provided in Attachment 1. The rainfall depths used in the analyses are summarized in Table 2, below.

Table 2- Summary of Rainfall Depths

Rainfall Event	Duration (hours)	Depth (inches)
SCS Type II 25-yr	24	3.99
SCS Type II 100-yr	24	5.20

Conclusions

CNs for the final cover conditions were determined using standard SCS methods. Rainfall depths for storm events are summarized in Table 2. These hydrologic parameters will be used to design the surface water management system for Ash Ponds 1 & 2.

ATTACHMENT 1

NOAA Atlas 14, Volume 8, Version 2
Location name: Erie Twp, Michigan, USA*
Latitude: 41.7928°, Longitude: -83.4453°
Elevation: 589.3 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

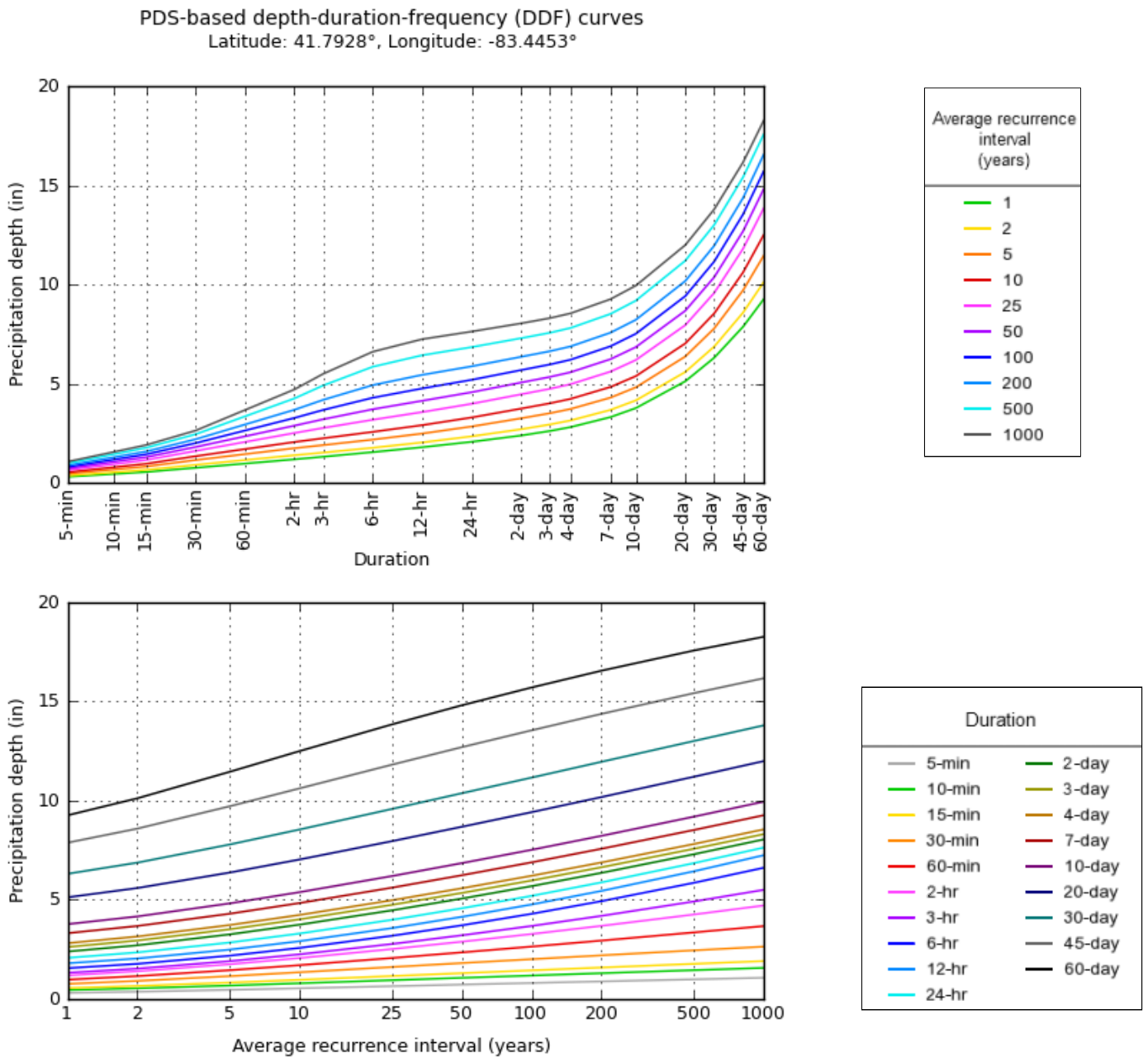
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.311** (0.244-0.395)	**0.370** (0.290-0.469)	**0.465** (0.364-0.591)	**0.543** (0.423-0.692)	**0.649** (0.492-0.839)	**0.730** (0.545-0.950)	**0.810** (0.590-1.07)	**0.890** (0.629-1.19)	**0.994** (0.683-1.35)	**1.07** (0.724-1.47)
10-min	**0.456** (0.358-0.578)	**0.542** (0.425-0.687)	**0.681** (0.533-0.865)	**0.796** (0.620-1.01)	**0.951** (0.721-1.23)	**1.07** (0.798-1.39)	**1.19** (0.864-1.56)	**1.30** (0.921-1.74)	**1.46** (1.00-1.98)	**1.57** (1.06-2.15)
15-min	**0.556** (0.436-0.704)	**0.661** (0.518-0.838)	**0.831** (0.650-1.05)	**0.970** (0.756-1.24)	**1.16** (0.879-1.50)	**1.30** (0.973-1.70)	**1.45** (1.05-1.91)	**1.59** (1.12-2.13)	**1.77** (1.22-2.41)	**1.91** (1.29-2.63)
30-min	**0.766** (0.601-0.971)	**0.915** (0.717-1.16)	**1.16** (0.903-1.47)	**1.35** (1.05-1.72)	**1.61** (1.22-2.08)	**1.81** (1.35-2.36)	**2.01** (1.46-2.65)	**2.20** (1.56-2.94)	**2.45** (1.69-3.33)	**2.64** (1.78-3.63)
60-min	**0.979** (0.768-1.24)	**1.16** (0.907-1.47)	**1.45** (1.14-1.85)	**1.71** (1.33-2.17)	**2.07** (1.57-2.69)	**2.35** (1.76-3.08)	**2.64** (1.93-3.50)	**2.95** (2.09-3.96)	**3.36** (2.31-4.58)	**3.68** (2.48-5.05)
2-hr	**1.19** (0.948-1.49)	**1.40** (1.11-1.75)	**1.75** (1.39-2.20)	**2.06** (1.63-2.60)	**2.52** (1.95-3.25)	**2.89** (2.19-3.75)	**3.28** (2.42-4.31)	**3.69** (2.65-4.92)	**4.26** (2.97-5.77)	**4.71** (3.21-6.41)
3-hr	**1.32** (1.06-1.65)	**1.53** (1.23-1.91)	**1.91** (1.52-2.38)	**2.25** (1.79-2.81)	**2.77** (2.17-3.58)	**3.21** (2.46-4.16)	**3.68** (2.75-4.83)	**4.19** (3.03-5.58)	**4.92** (3.45-6.64)	**5.50** (3.76-7.44)
6-hr	**1.56** (1.26-1.91)	**1.77** (1.44-2.18)	**2.19** (1.76-2.69)	**2.58** (2.07-3.18)	**3.19** (2.54-4.09)	**3.71** (2.89-4.78)	**4.29** (3.25-5.59)	**4.93** (3.61-6.52)	**5.86** (4.15-7.85)	**6.61** (4.56-8.86)
12-hr	**1.80** (1.48-2.19)	**2.04** (1.68-2.48)	**2.49** (2.04-3.03)	**2.91** (2.37-3.55)	**3.57** (2.88-4.52)	**4.14** (3.25-5.26)	**4.76** (3.64-6.13)	**5.45** (4.03-7.12)	**6.44** (4.60-8.53)	**7.25** (5.04-9.61)
24-hr	**2.08** (1.73-2.48)	**2.35** (1.95-2.82)	**2.85** (2.36-3.42)	**3.30** (2.72-3.97)	**3.99** (3.24-4.96)	**4.57** (3.63-5.71)	**5.20** (4.01-6.59)	**5.88** (4.38-7.57)	**6.85** (4.93-8.96)	**7.63** (5.36-10.0)
2-day	**2.39** (2.02-2.83)	**2.71** (2.28-3.20)	**3.26** (2.73-3.86)	**3.75** (3.13-4.45)	**4.47** (3.65-5.46)	**5.06** (4.05-6.23)	**5.69** (4.42-7.11)	**6.36** (4.77-8.08)	**7.29** (5.30-9.43)	**8.04** (5.69-10.4)
3-day	**2.62** (2.23-3.07)	**2.95** (2.50-3.46)	**3.52** (2.97-4.13)	**4.02** (3.38-4.73)	**4.75** (3.91-5.75)	**5.34** (4.30-6.52)	**5.97** (4.67-7.40)	**6.64** (5.01-8.37)	**7.57** (5.52-9.71)	**8.31** (5.91-10.7)
4-day	**2.81** (2.40-3.28)	**3.15** (2.69-3.68)	**3.73** (3.17-4.36)	**4.24** (3.58-4.97)	**4.98** (4.11-5.99)	**5.58** (4.51-6.77)	**6.21** (4.88-7.66)	**6.88** (5.21-8.63)	**7.81** (5.72-9.97)	**8.55** (6.10-11.0)
7-day	**3.32** (2.86-3.83)	**3.68** (3.17-4.25)	**4.30** (3.69-4.97)	**4.84** (4.14-5.61)	**5.61** (4.68-6.67)	**6.24** (5.09-7.48)	**6.89** (5.46-8.40)	**7.57** (5.78-9.40)	**8.52** (6.28-10.8)	**9.26** (6.66-11.8)
10-day	**3.77** (3.28-4.32)	**4.16** (3.61-4.77)	**4.82** (4.17-5.53)	**5.38** (4.64-6.20)	**6.20** (5.20-7.31)	**6.85** (5.62-8.15)	**7.52** (5.99-9.10)	**8.22** (6.31-10.1)	**9.19** (6.81-11.5)	**9.94** (7.18-12.6)
20-day	**5.12** (4.51-5.79)	**5.59** (4.92-6.33)	**6.37** (5.59-7.22)	**7.03** (6.14-7.99)	**7.95** (6.75-9.24)	**8.68** (7.21-10.2)	**9.42** (7.58-11.2)	**10.2** (7.88-12.4)	**11.2** (8.37-13.9)	**12.0** (8.74-15.0)
30-day	**6.31** (5.60-7.08)	**6.87** (6.10-7.71)	**7.79** (6.89-8.75)	**8.54** (7.51-9.63)	**9.58** (8.17-11.0)	**10.4** (8.66-12.0)	**11.2** (9.03-13.2)	**12.0** (9.30-14.4)	**13.0** (9.76-16.0)	**13.8** (10.1-17.2)
45-day	**7.88** (7.05-8.76)	**8.59** (7.68-9.56)	**9.71** (8.66-10.8)	**10.6** (9.41-11.9)	**11.8** (10.1-13.4)	**12.7** (10.7-14.6)	**13.5** (11.0-15.8)	**14.4** (11.2-17.2)	**15.4** (11.6-18.8)	**16.2** (11.9-20.0)
60-day	**9.26** (8.34-10.2)	**10.1** (9.10-11.2)	**11.4** (10.3-12.7)	**12.5** (11.1-13.9)	**13.8** (11.9-15.6)	**14.8** (12.5-16.9)	**15.7** (12.8-18.2)	**16.5** (13.0-19.6)	**17.6** (13.3-21.3)	**18.3** (13.5-22.5)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

PF graphical

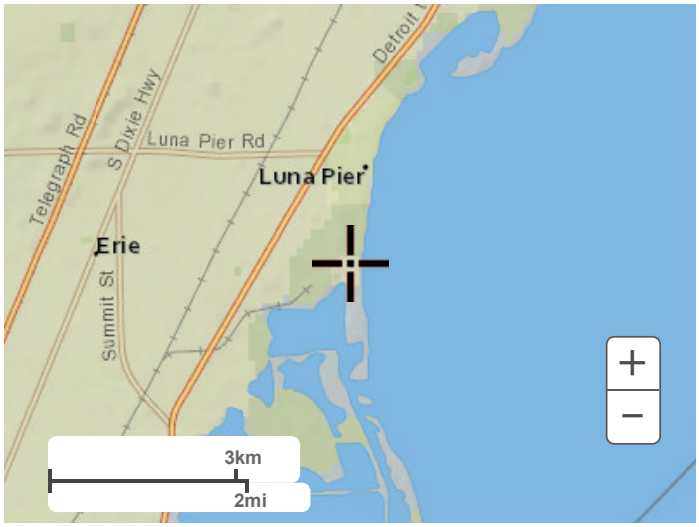


NOAA Atlas 14, Volume 8, Version 2

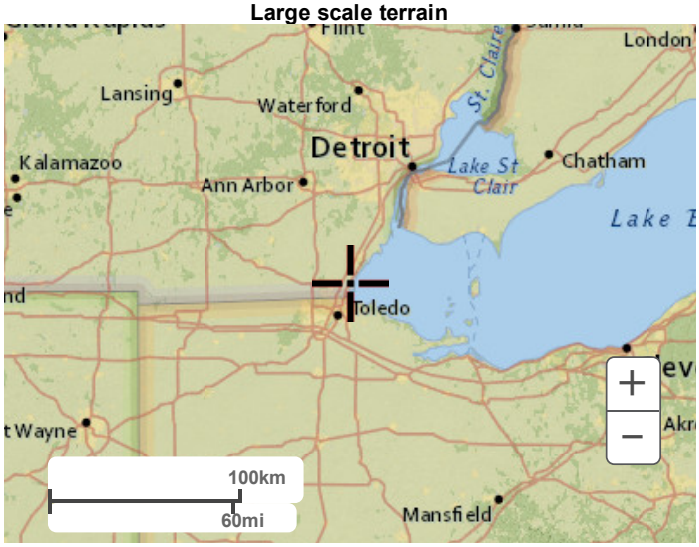
Created (GMT): Fri Feb 10 15:04:21 2017

Maps & aerials

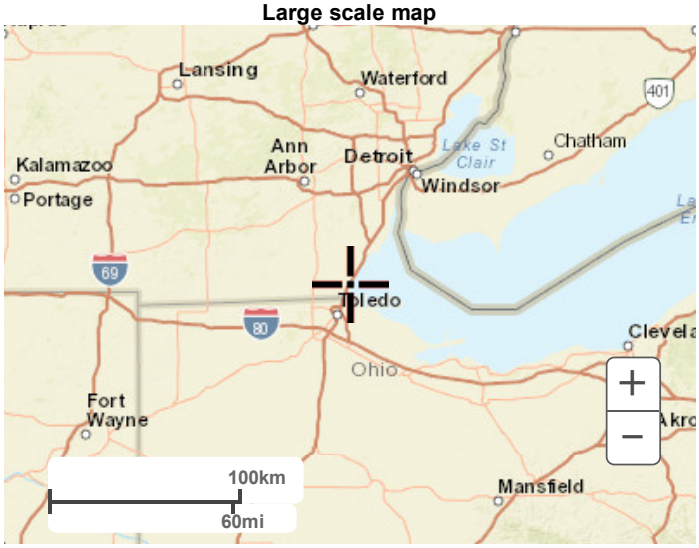
Small scale terrain



Large scale terrain



Large scale map



Large scale aerial

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

ATTACHMENT 2

Table 2-2a Runoff curve numbers for urban areas [1/]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2/]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3/]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4/]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5/]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1] Average runoff condition, and $I_a = 0.2S$.

[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

[4] Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

[5] Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

HYDRAULIC CALCULATIONS

Client CEC **Subject** Design Calculations

Project J.R. Whiting Ash Ponds 1 & 2

Prepared By JSH **Date** 08/30/17

Reviewed By JDP **Date** 08/30/17

Approved By SAM **Date** 08/30/17

Objective

Design the stormwater management system for J.R. Whiting Ash Ponds 1 & 2. Ash Ponds 1 & 2 are shown on Figure 01 in Attachment 1.

Design Criteria and Assumptions

1. HydroCAD was used to design and evaluate the stormwater management system for Ash Ponds 1 & 2.
2. The drivable drainage swale will collect and control run-off from the SCS Type II, 100-year, 24-hour storm event without overflow, which exceeds MI DEQ R 299.4435(b) requirement for a 25-year storm.
3. Culvert design was completed by the Monroe County Drain Commissioner.
4. Maximum channel side slopes of the drivable drainage swale were modeled as 8 horizontal: 3 vertical (H:V).
5. Design channels with flow velocities under 5 fps for the 25-year event. Velocities exceeding 5 fps have the capability to erode grass lined channels.

Calculations

Subbasin Delineations

Subbasins were delineated based on the grading of Ash Ponds 1 & 2 which is provided on Figure 01.

Curve Numbers

Curve Numbers are summarized in Appendix E Hydrologic Parameters.

Times of Concentration

Calculations for the times of concentrations of each subbasin are shown in the HydroCAD outputs as provided in Attachment 1. Maximum sheet flow lengths of 100 feet were used in the calculations.

Rainfall Depths

Rainfall depths used in this analysis are provided in Appendix E Hydrologic Parameters.

Flow Rate Calculations

HydroCAD was used to design and evaluate the stormwater management structures for Ash Ponds 1 & 2. HydroCAD outputs are provided in Attachment 1.

Client CEC **Subject** Design
Project J.R. Whiting Calculations **Prepared By** JSH **Date** 08/30/17
Ash Ponds 1 & 2 **Reviewed By** JDP **Date** 08/30/17
Approved By SAM **Date** 08/30/17

A summary of the stormwater channel and the culvert are provided in Tables 1 and 2 below.

Stormwater management system structure labels are shown on Figure 01. The HydroCAD output files, which include all input parameters and a summary of drainage structures, are provided in Attachment 1.

Table 1 – Proposed Channel Reach Summary

Channel I.D.	Channel Type	Length (feet)	25-year In-Flow (cfs)	Slope (%)	Depth (feet)		25-year Velocity (fps)	100-year Flow Depth
					25-year Flow Depth	Design (min)		
OFF-CAP SWALE	V-ditch	257	10.47	0.97	0.77	1.0	2.19	0.89

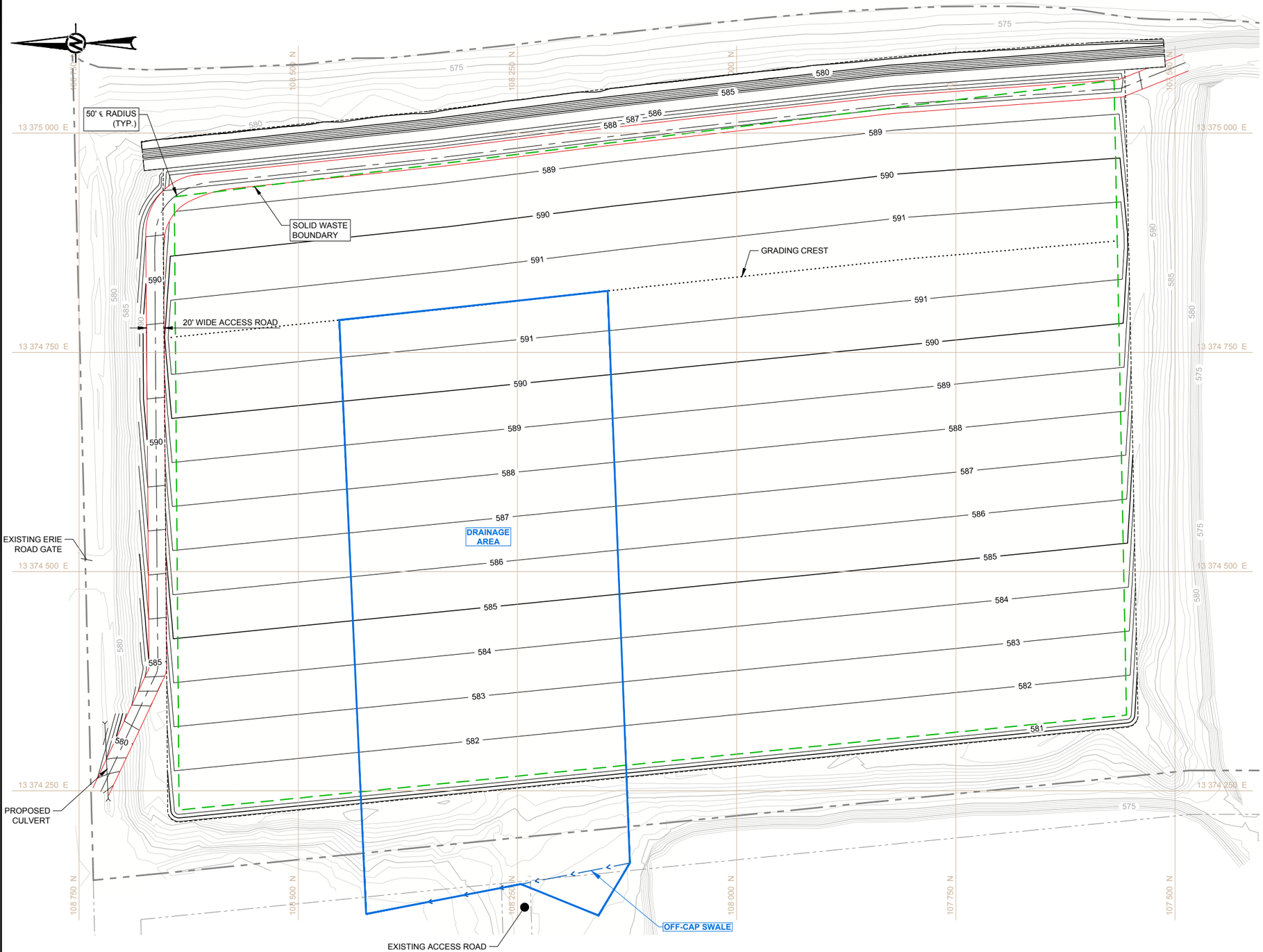
A summary of the proposed culvert, as designed and specified by the Monroe County Road Commission, is presented in Table 2. The culvert requirements (characteristics and conditions of construction) are specified in Permit No. 2017-00303, which is included as Attachment 2.

Table 2 – Outfall Summary

Culvert ID	Number of Culverts	Culvert Material	Culvert Diameter (in)	Culvert Length (ft-MSL)	Culvert Slope (%)	Design Inlet Invert Elevation (ft-MSL)	Design Outlet Invert Elevation (ft-MSL)
AR-CULVERT	1	RCP	12	60 (approx.)	Field Fit	Field Fit	Field Fit

Notes: ft-MSL = feet above mean sea level

FIGURE 1



LEGEND

- PROPERTY BOUNDARY
- OVERHEAD UTILITY
- PROPOSED COVER MAJOR CONTOUR (5' INTERVAL)
- PROPOSED COVER MINOR CONTOUR (1' INTERVAL)
- PROPOSED DRAINAGE SWALE
- EXISTING GROUND MAJOR CONTOUR (5' INTERVAL)
- EXISTING GROUND MINOR CONTOUR (1' INTERVAL)
- PROPOSED GRADING LIMITS
- SOLID WASTE BOUNDARY
- CONTROL POINT

NOTE

EXISTING CONDITIONS MAY VARY FROM THOSE SHOWN.

REFERENCES

1. SITE LOCATION: SECTION 14, T8S, R8E, MONROE COUNTY, MICHIGAN.
2. EXISTING GROUND TOPOGRAPHY WAS PROVIDED BY SHERIDAN SURVEYING CO. ON 02/23/2017.
3. COORDINATE SYSTEM:
   VERTICAL: NGVD29.
   HORIZONTAL: MICHIGAN STATE PLANE SOUTH ZONE NAD83 (2011).
4. MONITORING WELL LOCATIONS AS PRESENTED IN: SUMMARY OF MONITORING WELL DESIGN, INSTALLATION, AND DEVELOPMENT (ARCADIS, 2016).

WORK IN PROGRESS

DRAFT

0 60 120
1" = 60' FEET

CLIENT
CONSUMERS ENERGY COMPANY
4525 E. ERIE ROAD
ERIE, MICHIGAN

PROJECT
J.R. WHITING GENERATING FACILITY
ASH PONDS 1 & 2

TITLE
ASH PONDS 1 & 2 STORMWATER DESIGN

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-07-20
DESIGNED	JH
PREPARED	DJC
REVIEWED	
APPROVED	

PROJECT NO.	CONTROL	REV.	SHEET
1667572	1667572D002.dwg	0	1

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

0 1in

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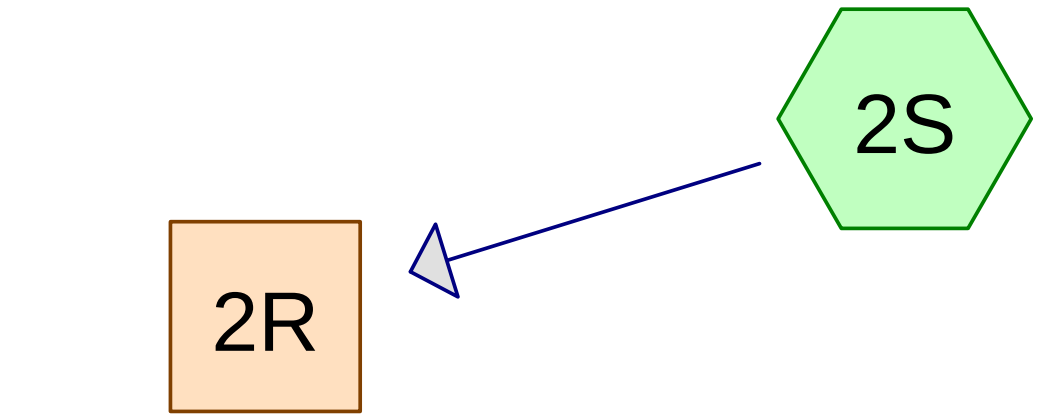
ATTACHMENT 1



OFF-CAP SWALE

Subcat Reach Pond Link

Drainage Diagram for J.R.Whiting Ash Ponds 1-2
Prepared by Golder Associates, Inc.

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
4.128	80	>75% Grass cover, Good, HSG D (2S)

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
0.000	HSG C	
4.128	HSG D	2S
0.000	Other	

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 2S: Runoff Area=4.128 ac 0.00% Impervious Runoff Depth>1.87"
Flow Length=367' Slope=0.0200 '/' Tc=15.9 min CN=80 Runoff=10.47 cfs 0.642 af

Reach 2R: OFF-CAP SWALE Avg. Depth=0.77' Max Vel=2.19 fps Inflow=10.47 cfs 0.642 af
n=0.035 L=257.0' S=0.0097 '/' Capacity=20.99 cfs Outflow=10.09 cfs 0.640 af

Summary for Subcatchment 2S:

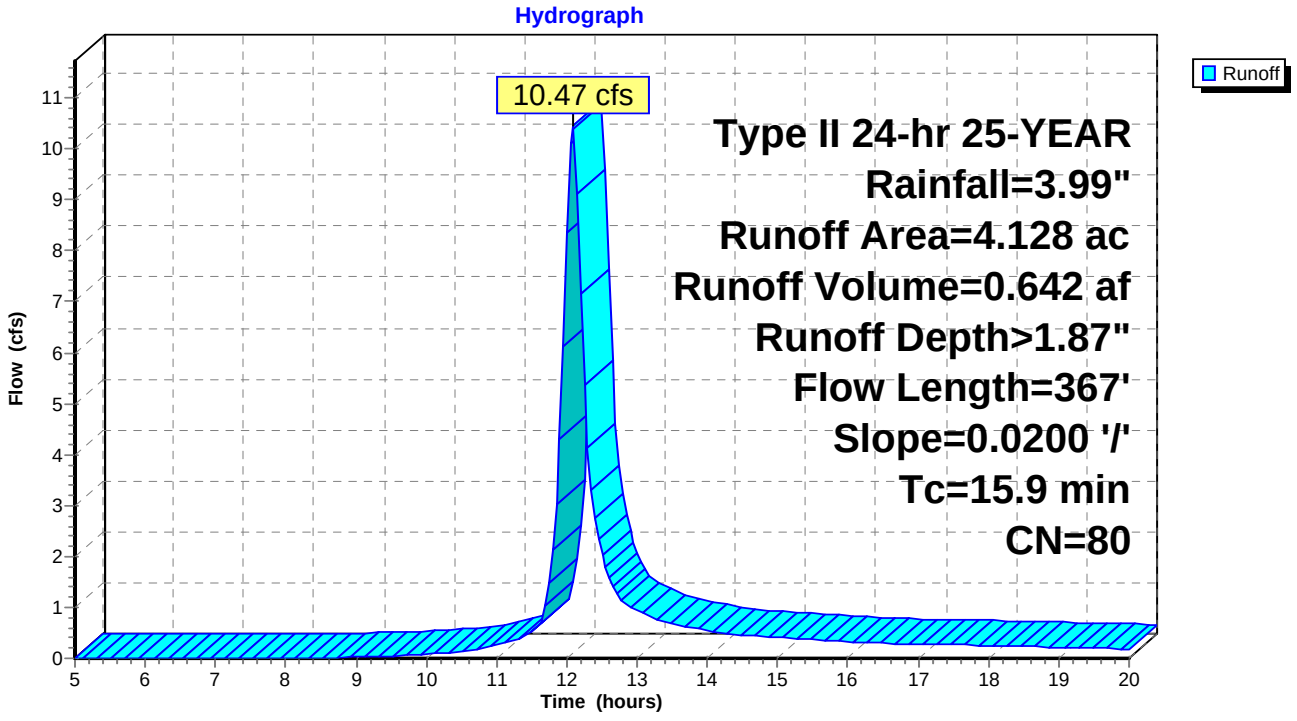
Runoff = 10.47 cfs @ 12.08 hrs, Volume= 0.642 af, Depth> 1.87"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-YEAR Rainfall=3.99"

Area (ac)	CN	Description
4.128	80	>75% Grass cover, Good, HSG D
4.128		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.4	100	0.0200	0.15		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.35"
4.5	267	0.0200	0.99		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
15.9	367	Total			

Subcatchment 2S:



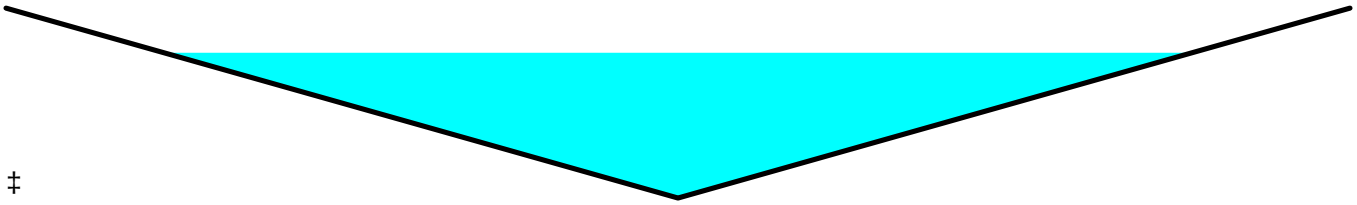
Summary for Reach 2R: OFF-CAP SWALE

Inflow Area = 4.128 ac, 0.00% Impervious, Inflow Depth > 1.87" for 25-YEAR event
Inflow = 10.47 cfs @ 12.08 hrs, Volume= 0.642 af
Outflow = 10.09 cfs @ 12.14 hrs, Volume= 0.640 af, Atten= 4%, Lag= 3.6 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.19 fps, Min. Travel Time= 2.0 min
Avg. Velocity = 0.93 fps, Avg. Travel Time= 4.6 min

Peak Storage= 1,204 cf @ 12.11 hrs, Average Depth at Peak Storage= 0.77'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 20.99 cfs

0.00' x 1.00' deep channel, n= 0.035
Side Slope Z-value= 8.0 '/' Top Width= 16.00'
Length= 257.0' Slope= 0.0097 '/'
Inlet Invert= 576.00', Outlet Invert= 573.50'



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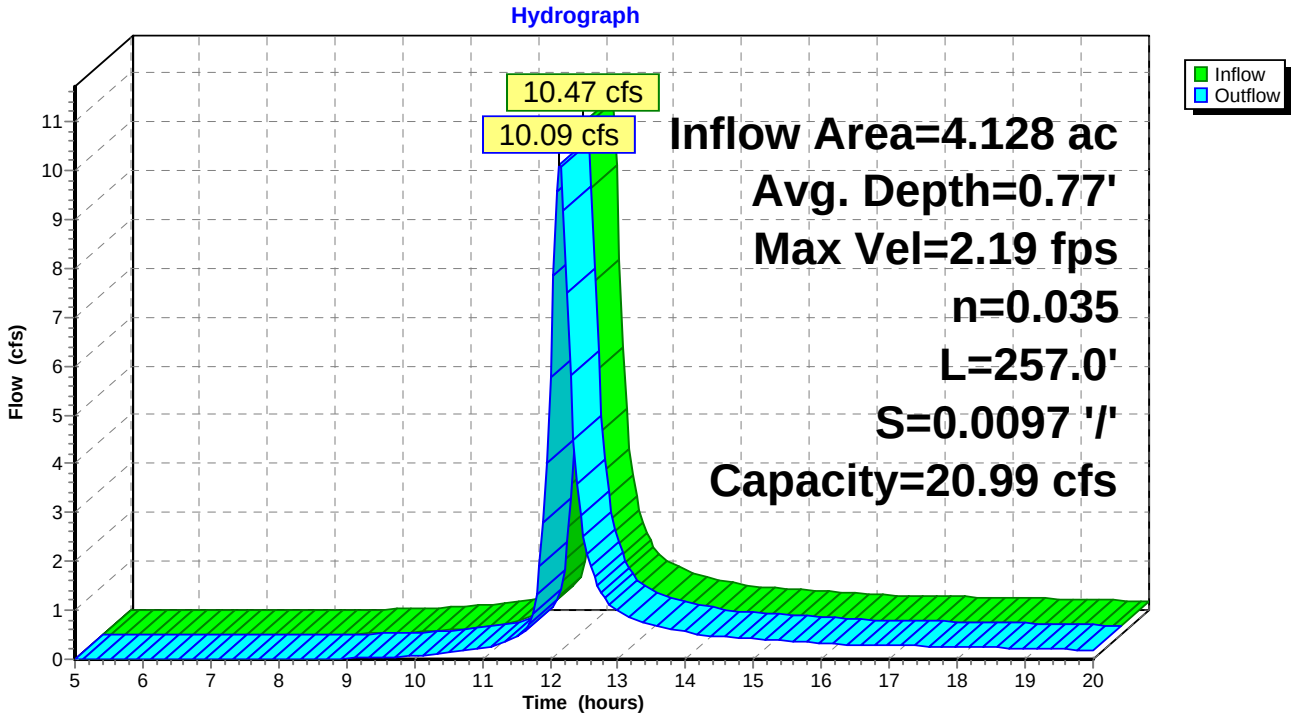
Reach 2R: OFF-CAP SWALE



Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 2S: Runoff Area=4.128 ac 0.00% Impervious Runoff Depth>2.84"
Flow Length=367' Slope=0.0200 '/' Tc=15.9 min CN=80 Runoff=15.76 cfs 0.976 af

Reach 2R: OFF-CAP SWALE Avg. Depth=0.89' Max Vel=2.43 fps Inflow=15.76 cfs 0.976 af
n=0.035 L=257.0' S=0.0097 '/' Capacity=20.99 cfs Outflow=15.23 cfs 0.973 af

Summary for Subcatchment 2S:

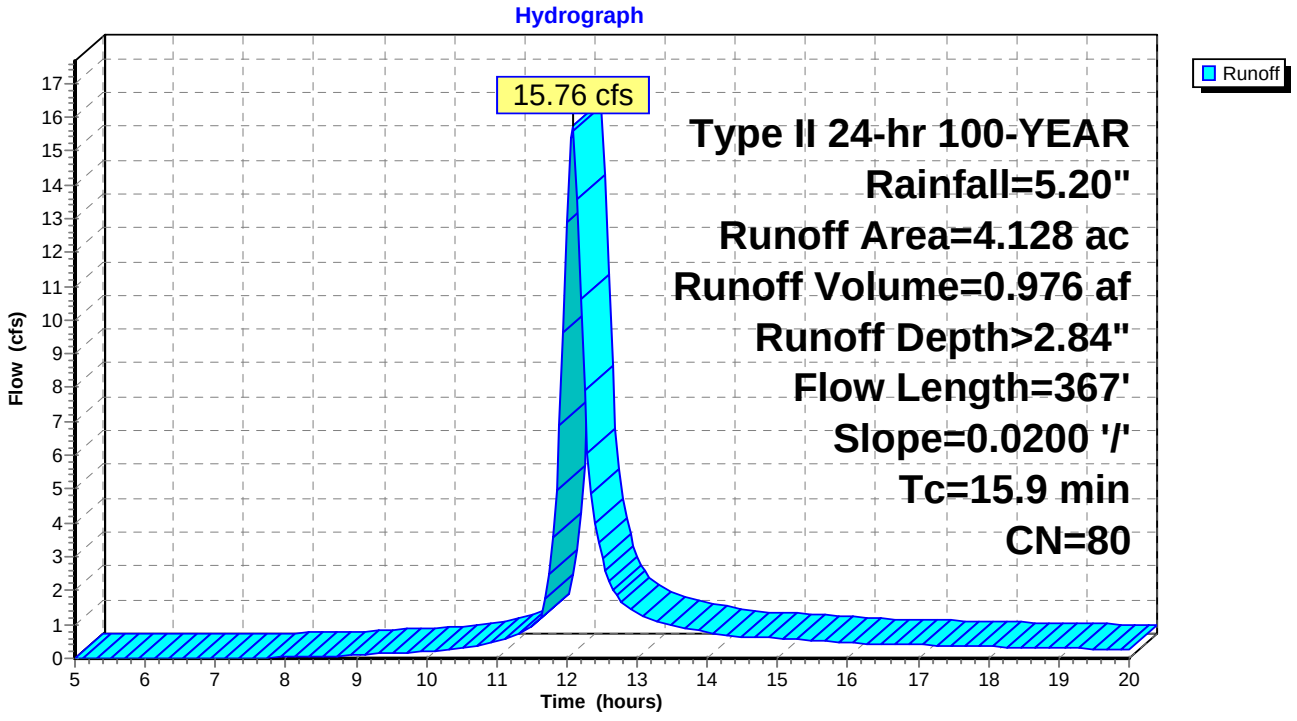
Runoff = 15.76 cfs @ 12.08 hrs, Volume= 0.976 af, Depth> 2.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-YEAR Rainfall=5.20"

Area (ac)	CN	Description
4.128	80	>75% Grass cover, Good, HSG D
4.128		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.4	100	0.0200	0.15		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.35"
4.5	267	0.0200	0.99		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
15.9	367	Total			

Subcatchment 2S:



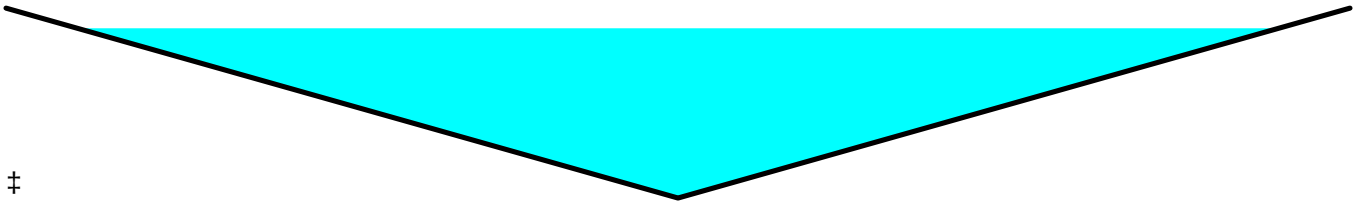
Summary for Reach 2R: OFF-CAP SWALE

Inflow Area = 4.128 ac, 0.00% Impervious, Inflow Depth > 2.84" for 100-YEAR event
Inflow = 15.76 cfs @ 12.08 hrs, Volume= 0.976 af
Outflow = 15.23 cfs @ 12.13 hrs, Volume= 0.973 af, Atten= 3%, Lag= 3.2 min

Routing by Stor-Ind+Trans method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.43 fps, Min. Travel Time= 1.8 min
Avg. Velocity = 0.98 fps, Avg. Travel Time= 4.3 min

Peak Storage= 1,642 cf @ 12.10 hrs, Average Depth at Peak Storage= 0.89'
Bank-Full Depth= 1.00', Capacity at Bank-Full= 20.99 cfs

0.00' x 1.00' deep channel, n= 0.035
Side Slope Z-value= 8.0 '/' Top Width= 16.00'
Length= 257.0' Slope= 0.0097 '/'
Inlet Invert= 576.00', Outlet Invert= 573.50'



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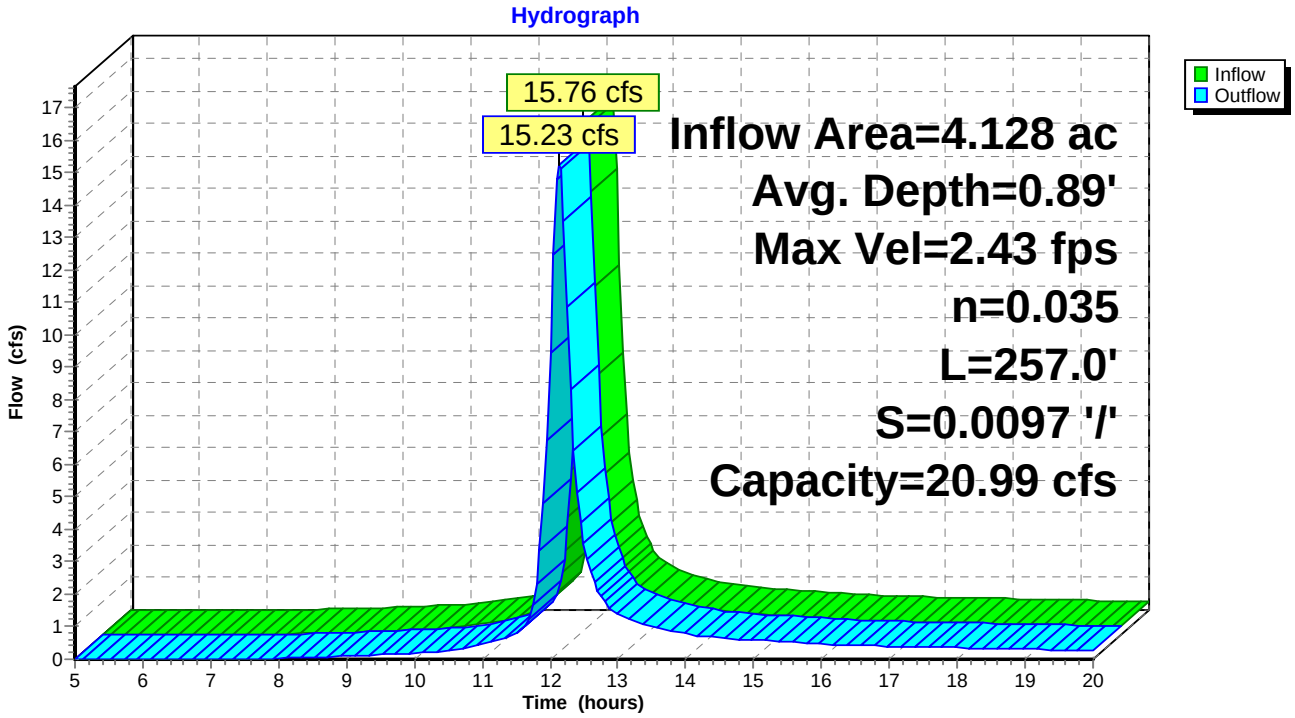
Reach 2R: OFF-CAP SWALE



ATTACHMENT 2

CRA 100 (03/2005)

MONROE COUNTY ROAD COMMISSION
840 S. TELEGRAPH RD.
MONROE, MI 48161-0000
Phone: 734-240-5102
Fax: 734-240-5101

Application No. 13744
Permit No. 2017-000303
Issue Date 08/24/2017

APPLICATION AND PERMIT TO CONSTRUCT, OPERATE, USE AND/OR MAINTAIN WITHIN THE RIGHT-OF-WAY OF; OR TO CLOSE, A COUNTY ROAD APPLICATION

An applicant is defined as an owner of property adjacent to the right-of-way, the property owner's authorized representative; or an authorized representative of a private or public utility who applies for a permit to construct, operate, use, and/or maintain a facility within the right-of-way for the purpose outlined within the application. A contractor who makes application on behalf of a property owner or utility must provide documentation of authority to apply for a permit.

APPLICANT	CONTRACTOR
Consumers Energy Co. JR Whiting Facility 4525 E. Erie Rd Erie, MI 48133-0000	Golder Associates Jeff Piaskowski 15851 South US27, Suite 50 Lansing, MI 48906-0000 Phone(s): 920-370-4959___-___-____

Applicant/Contractor request a permit for the following work within the right of way of a county road:
Commercial - Modified Comm. Approach

LOCATION: County Road ERIE Between GRODI And DEAD END

Township Erie Township Section _____ Side of Road South Property ID _____

DATE: Work to begin on 08/24/2017 Work to be completed by 07/02/2018

I certify and acknowledge that (1) the information contained in this application is true and correct, (2) the commencement of the work described in this application shall constitute acceptance of the permit as issued, including all terms and conditions thereof and, (3) if this permit is for commercial or residential driveway work, I am the legal owner of the property that this driveway will serve, or I am the authorized representative.

Applicant's Signature: _____ Contractor's Signature: _____

Title: _____ Date: _____ Title: _____ Date: _____

PERMIT

The term "Permit Holder" in the terms and conditions set forth on the reverse side hereof, refers to the applicant and the contractor, where applicable. By performing work under this permit, the Permit Holder acknowledges and agrees that this permit is subject to all the rules, regulations, terms and conditions set forth herein, including on the reverse side hereof. Failure to comply with any of said rules, regulations, terms and conditions shall render this permit NULL AND VOID.

REQUIREMENTS

FEE TYPE	AMOUNT	RECEIPT NO	DATE
Permit	150.00	59248	

Letter of Credit _____	☐ Y	☒ N
Surety Bond _____	☐ Y	☒ N
Retainer Letter	☐ Y	☒ N
Approved Plans on File	☐ Y	☒ N
Certificate of Insurance	☐ Y	☒ N
Attachments/Supplemental Specifications	☐ Y	☒ N

OTHER REQUIREMENTS:

This modified commercial drive permit is being issued for an entrance to close Ash Pond 1 & 2 and east chemical treament ponds at the J.R. Whiting gererating facility. This permit shall be considered null and void if intent of the property changes. MCRC driveway requirements are as follows:

1. Set 60' of 12" Concrete Pipe only to grade according to MDOT Specifications. Call for inspection prior to backfilling.
2. Pavement width shall be = 24' (Driveway shall slope away from the roadway to the ditch or storm sewer)
3. Minimum radius 25'
4. Minimum 2' wide, 3" thick MDOT 23A shoulder behind radii

STANDARD PERMIT SPECIFICATIONS

1. SPECIFICATIONS - All work performed under this permit must be done in accordance with the plans, specifications, maps and statements filed with and approved by the Monroe County Road Commission ("MCRC") and must comply with the MCRC's current requirements and specifications on file at its office and with current Michigan Department of Transportation ("MDOT") specifications.

2. FEES AND COSTS - Permit Holder shall be responsible for all expenses incurred by the MCRC, including staff time, in connection with this permit and shall promptly pay all charges and/or deposits, per the current MCRC Fee Schedule, to cover such costs and expenses as determined by the MCRC at the time the permit is issued.

3. PERFORMANCE/MAINTENANCE GUARANTEE AND SECURITY - If required by MCRC, the Permit Holder shall provide, as requested, a cash deposit, letter of credit, and/or performance/maintenance guarantee in a form and amount acceptable to the MCRC at the time permit is issued. For performance guarantee purposes, the applicant shall supply the guarantee. For maintenance guarantee purposes, the contractor shall supply the guarantee.

4. INSURANCE AND INDEMNIFICATION - Required insurance coverage shall be documented per current MCRC requirements. Permit Holder shall furnish proof of liability and property damage insurance in the amounts set forth on the MCRC website at www.mcrc-mi.org and shall provide and state "Additional Insured: The Board of County Road Commissioners for Monroe County, the MCRC and its officers, agents and employees". The Contractor/Permit Holder shall hold harmless, indemnify, and defend the BOARD OF COUNTY ROAD COMMISSIONERS OF THE COUNTY OF MONROE (BOARD) and its officers, agents and employees against any and all claims for bodily injury or property damage, or any other claim arising out of or related to the work covered by the permit or for any other work done within county road right-of-way whether or not specifically authorized or in conformance with the description of the work for which the permit was issued. Such indemnity agreement shall not be applicable to any liability caused by the sole negligence or willful misconduct of the MCRC, its officers, agents of employees. The Contractor/Permit Holder agrees and shall require that the obligations set forth herein are binding upon its/their sub-contractors, successors, assigns, sureties, and guarantors.

5. MISS DIG - The Permit Holder must comply with the requirements of Act 53 Public Acts of 1974, as amended. CALL MISS DIG (800) 482-7171 or 811 AT LEAST THREE (3) FULL WORKING DAYS, NOT MORE THAN TWENTY-ONE (21) CALENDAR DAYS, BEFORE YOU START WORK. This does not relieve the Permit Holder of the responsibility of notifying utility owners who may not be part of the Miss Dig system. Permit Holder assumes all responsibility for damage to or interruption of underground and overhead utilities.

6. PERMIT, NOTIFICATION OF START, INSPECTION AND COMPLETION OF WORK - The individual in charge, on behalf of the Permit Holder, shall have the permit and the approved plans or sketches in his possession on the job at all times. Permit Holder must notify the MCRC two (2) full working days before starting work and must notify the MCRC when work is completed. Current business hours can be found on the MCRC website at www.mcrc-mi.org.

7. SAFETY - Permit Holder agrees to perform all work under this permit in a safe manner and to keep the area affected by this permit in a safe condition until the work is complete. All work site conditions shall comply with Michigan Manual of Uniform Traffic Control Devices ("MMUTCD").

8. RESTORATION AND REPAIR OF ROAD - Permit Holder agrees to restore the road and right-of-way to a condition equal to or better than its condition before the work began, and to repair any damage to the road right-of-way which is the result of the facility whenever it occurs or appears. Aggregate shoulder, if contaminated, shall be removed, replaced and properly compacted.

9. LIMITATIONS OF PERMIT - This permit shall not relieve Permit Holder from compliance with any other applicable laws and regulations of any other governmental agencies. Permit Holder is responsible for obtaining additional permits or releases which may be required in connection with this work from other governmental agencies, public utilities, corporations and individuals, including property owners. Permission may be required from adjoining property owners. Full compliance is required with any regulation of the Public Service Commission and Municipal or State Regulations.

10. REVOCATION OF PERMIT - This permit may be suspended or revoked at will, and the Permit Holder shall surrender this permit and alter, relocate or remove its facilities at its expense at the request of the MCRC.

11. VIOLATION OF PERMIT - This permit shall become immediately null and void if Permit Holder violates the terms of this permit, and the MCRC may require immediate removal of Permit Holder's permitted facilities, or the MCRC may remove same without notice at Permit Holder's expense.

12. TRAFFIC CONTROL & PERMANENT SIGNS - The Contractor shall furnish and maintain all traffic control devices including signs, barricades, lights, etc., in accordance with the MMUTCD or as otherwise deemed necessary by the MCRC. No traffic lanes shall be closed without the prior approval of the MCRC. When such closure is permitted and results in two-way, one-lane traffic, a flag person shall be stationed at each end of such section of road to direct traffic. All signs, signals and other traffic control as directed by the MCRC Planning/Engineering Department shall be erected and maintained by the contractor at its expense. Permanent traffic control signs which require relocation as part of permitted activity within the road right-of-way shall not be removed without prior approval of the MCRC Planning/Engineering Department. Removal and relocation of signs shall be performed by MCRC Sign Shop and the cost will be billed to the Permit Holder.

13. PERMIT HOLDER RISK –Permit Holder assumes any and all risk of removal or modification of any permitted improvements within the right of way, at the discretion of the MCRC. Such modifications may include, but not be limited to, an overlay of Permit Holder approach, a change of Permit Holder approach material or introduction of a ditch across Permit Holder frontage.

14. EQUIPMENT/VEHICLES/TRAILERS - The individual performing the work on behalf of the Permit Holder shall abide by all posted road, bridge, and seasonal weight restrictions and shall obtain any necessary transportation permits from the MCRC. Equipment, vehicles, and trailers necessary for the permitted work shall not be located on the road shoulder or pavement without proper traffic control devices and advance warning signs per the MMUTCD.

15. EXCAVATION AND DISPOSAL OF EXCAVATED MATERIAL - The Permit Holder, Contractor, and/or Utility Company shall provide and place any necessary sheeting, shoring and/or bracing required to prevent caving, loss or settlement of foundation material supporting the pavement or any other highway installation such as sewer, culvert, etc. The Contractor and/or Utility Company shall assume full responsibility for this protection. Excavated material shall be stockpiled in such locations as to avoid obstructing vision on the traveled portion of the highway and in such manner as to not interfere with the flow of traffic. The Permit Holder shall dispose of all surplus and unsuitable material outside of the limits of the right-of-way unless the permit provides for locations within the right-of-way. In the latter case the material shall be leveled and trimmed in an approved manner. BERMS WILL NOT BE ALLOWED UNLESS SHOWN AND APPROVED ON THE PERMIT. See Paragraph eight (8) regarding aggregate shoulder replacement.

16. BACKFILLING AND COMPACTING TRENCHES, HOLES, PITS, ETC. - The "area of influence" is defined as the area under the existing or future road bed and a one-on-one slope line drawn outward and down from a point one (1) foot outside and horizontal to the existing or proposed shoulder or curb and gutter. All trenches, holes and pits within the area of influence shall be filled with approved materials placed in successive layers no more than ten (10) inches in depth, loose measure and compacted to not less than 95% of the maximum dry density. Aggregate bases within the area of influence shall be compacted to no less than 98% of the maximum dry density. Trenches, holes or pits outside the area of influence shall be compacted to no less than 90% of the maximum dry density. Excavation falling within the existing or proposed area of influence and under hard-surface roads shall be backfilled with an approved Controlled Density Backfill (CDB) material.

17. GRAVEL ROADS - All trenches across the roadbed shall be backfilled as described in Paragraph sixteen (16) to within ten (10) inches of the finished road surface. The top ten (10) inches shall be constructed with 21A, 21AA or 22A aggregate compacted to not less than 98% of the maximum density. Paving of an approach within the right of way of a gravel road will not be allowed.

18. CROSSING ROADBED BY TUNNELING OR BORING AND JACKING - When pipe is installed by this method without cutting the existing pavement, all remaining voids around the installation shall be filled by a method approved by the MCRC Inspector. Pressure grouting shall be required when deemed necessary. The length of the pipe or casing shall extend beyond the area of influence as defined in Paragraph sixteen (16). Special consideration will be given when field conditions preclude these requirements. The bore pit shall be backfilled and compacted in accordance to the requirements of Paragraph sixteen (16).

19. PAVEMENT REPLACEMENT - In general, all hard-surface pavement crossings shall be bored. However, if open cutting is permitted, the pavement shall be sawed or milled so that the pavement area to be removed is a minimum of one (1) foot wider on each side than the maximum width of the trench. Asphalt shall be cut in neat straight lines perpendicular to the road centerline and shall extend to the next lane seam. Pavement shall be cut full depth. Wearing coarse milling may be utilized in lieu of full depth cut. The pavement shall be replaced in kind and thickness with proper inspection and density testing. Density will be measured with a nuclear density gage using Gmm from the specified mix formula for the density control target. The required density of the HMA mixture specified shall be 93% to 96% of the density control target. For asphalt pavement sections, a typical minimum of six (6) inches of Hot Mix Asphalt (HMA) on eight (8) inches of compacted 21A, 21AA or 22A stone base is required. All seams shall be sealed with a bituminous crack fill sealer. For concrete pavement sections, a typical minimum of eight (8) inches, non-reinforced concrete is required. Concrete patches shall be tied to the existing slab by drilling hook bolts on nine (9) inch centers on all exposed faces on the existing pavement. The hook bolts shall be located at one-half (½) the pavement depth. Backfill shall be placed as provided in Paragraph sixteen (16).

20. DRIVEWAY REPLACEMENT - Driveways shall be replaced in kind and thickness, except that no stone driveway shall be replaced with less than eight (8) inches of compacted 23A stone. Backfill under driveways shall be compacted to 95% of maximum dry density as defined in Paragraph sixteen (16).

21. TREES - No trees shall be removed without prior written approval of the MCRC and, if necessary, the adjoining property owner. Trees damaged by the Contractor shall be neatly trimmed and repaired/replaced in an approved manner.

22. DEPTH OF COVER - Underground utilities shall be installed with not less than four (4) feet of cover below the surface of roadways, nor less than three (3) feet of cover over any adjacent ditch bottoms and culverts in all other areas.

23. PROTECTION OF ESTABLISHED SURVEY POINTS and DATUM - The Permit Holder shall protect, preserve, and/or restore, at its own expense, any established survey points and datum within the limits of the work covered by this permit.

24. THE FOLLOWING MUST BE ATTACHED TO APPLICATION WHEN APPLICABLE: (1) Deposit and/or bond, except for local units of government; (2) Plans, specifications and location of facility; (3) Copy of Resolution for local units of government; (4)Traffic plans; and (5) In cases of banner application, legend must be shown.

25. OTHER OPERATIONS - Any operation in the right-of-way not covered by these specifications shall be done in accordance with the instructions of the MCRC County Highway Engineer or his/her designated representative to the project.

ACCESS PERMIT UPON COMPLETION

1. TIME FOR COMPLETION OF WORK - The initial time period applied for and granted in this application and permit pertains to activity within a right-of-way. Failure of the applicant to complete the permitted work within said time period shall result in this permit becoming null and void. Renewal may be obtained for an additional time period upon payment of any additional permit fees which may be required. Failure to complete the work as required will result in forfeiture of any security posted in conjunction with the permit.

2. RIGHT OF ACCESS AFTER COMPLETION AND APPROVAL - Where the initially permitted activity results in construction of a new or modified point of access ("driveway") to the public road, upon completion of the work, MCRC will conduct a final inspection. Provided the work meets all requirements of the permit, including any attached plans and specifications and MCRC's standards for construction, MCRC will issue a Final Approval Certification. The Final Approval Certification shall then be considered an access permit pursuant to MCL 247.321, et. seq. subject to all of the terms contained in that statute and in the MCRC regulations enacted pursuant thereto. The obligation to operate, use and/or maintain the facility in accordance with MCRC requirements shall remain in force as long as the facility exists and is within an area under the jurisdiction of the MCRC.

MONROE COUNTY ROAD COMMISSION
840 S. TELEGRAPH RD.
MONROE, MI 48161-0000
Phone: 734-240-5102
Fax: 734-240-5101

Application No. 13744
Permit No. 2017-000303
Issue Date 08/24/2017

5. Pavement thickness-4" asphalt (1 1/2" 36A on 2 1/2" 13A) on 8" 21AA stone.
6. Edge of pavement to be sawcut to assure clean edge to meet pavement.

Call 734-240-5132 for inspection prior to placement of stone base. All traffic control shall be in accordance with MMUTCD.

**All equipment, vehicles, trailers or materials that are necessary for the permitted work shall not be located on the County Road shoulder or pavement without the standard MMUTCD advanced warning sign sequence for shoulder work. No full or partial lane closures shall be allowed without the standard MMUTCD advanced warning sign sequence for closing one traffic lane and a properly equipped traffic regulator controlling traffic at all times.

Recommended for Issuance By:

Title: _____ Date: _____

Approved By: Donna Kucharek

Title: CA Date: 8/30/17

STANDARD PERMIT SPECIFICATIONS

1. SPECIFICATIONS - All work performed under this permit must be done in accordance with the plans, specifications, maps and statements filed with and approved by the Monroe County Road Commission ("MCRC") and must comply with the MCRC's current requirements and specifications on file at its office and with current Michigan Department of Transportation ("MDOT") specifications.

2. FEES AND COSTS - Permit Holder shall be responsible for all expenses incurred by the MCRC, including staff time, in connection with this permit and shall promptly pay all charges and/or deposits, per the current MCRC Fee Schedule, to cover such costs and expenses as determined by the MCRC at the time the permit is issued.

3. PERFORMANCE/MAINTENANCE GUARANTEE AND SECURITY - If required by MCRC, the Permit Holder shall provide, as requested, a cash deposit, letter of credit, and/or performance/maintenance guarantee in a form and amount acceptable to the MCRC at the time permit is issued. For performance guarantee purposes, the applicant shall supply the guarantee. For maintenance guarantee purposes, the contractor shall supply the guarantee.

4. INSURANCE AND INDEMNIFICATION - Required insurance coverage shall be documented per current MCRC requirements. Permit Holder shall furnish proof of liability and property damage insurance in the amounts set forth on the MCRC website at www.mcrc-mi.org and shall provide and state "Additional Insured: The Board of County Road Commissioners for Monroe County, the MCRC and its officers, agents and employees". The Contractor/Permit Holder shall hold harmless, indemnify, and defend the BOARD OF COUNTY ROAD COMMISSIONERS OF THE COUNTY OF MONROE (BOARD) and its officers, agents and employees against any and all claims for bodily injury or property damage, or any other claim arising out of or related to the work covered by the permit or for any other work done within county road right-of-way whether or not specifically authorized or in conformance with the description of the work for which the permit was issued. Such indemnity agreement shall not be applicable to any liability caused by the sole negligence or willful misconduct of the MCRC, its officers, agents of employees. The Contractor/Permit Holder agrees and shall require that the obligations set forth herein are binding upon its/their sub-contractors, successors, assigns, sureties, and guarantors.

5. MISS DIG - The Permit Holder must comply with the requirements of Act 53 Public Acts of 1974, as amended. CALL MISS DIG (800) 482-7171 or 811 AT LEAST THREE (3) FULL WORKING DAYS, NOT MORE THAN TWENTY-ONE (21) CALENDAR DAYS, BEFORE YOU START WORK. This does not relieve the Permit Holder of the responsibility of notifying utility owners who may not be part of the Miss Dig system. Permit Holder assumes all responsibility for damage to or interruption of underground and overhead utilities.

6. PERMIT, NOTIFICATION OF START, INSPECTION AND COMPLETION OF WORK - The individual in charge, on behalf of the Permit Holder, shall have the permit and the approved plans or sketches in his possession on the job at all times. Permit Holder must notify the MCRC two (2) full working days before starting work and must notify the MCRC when work is completed. Current business hours can be found on the MCRC-website at www.mcrc-mi.org.

7. SAFETY - Permit Holder agrees to perform all work under this permit in a safe manner and to keep the area affected by this permit in a safe condition until the work is complete. All work site conditions shall comply with Michigan Manual of Uniform Traffic Control Devices ("MMUTCD").

8. RESTORATION AND REPAIR OF ROAD - Permit Holder agrees to restore the road and right-of-way to a condition equal to or better than its condition before the work began, and to repair any damage to the road right-of-way which is the result of the facility whenever it occurs or appears. Aggregate shoulder, if contaminated, shall be removed, replaced and properly compacted.

9. LIMITATIONS OF PERMIT - This permit shall not relieve Permit Holder from compliance with any other applicable laws and regulations of any other governmental agencies. Permit Holder is responsible for obtaining additional permits or releases which may be required in connection with this work from other governmental agencies, public utilities, corporations and individuals, including property owners. Permission may be required from adjoining property owners. Full compliance is required with any regulation of the Public Service Commission and Municipal or State Regulations.

10. REVOCATION OF PERMIT - This permit may be suspended or revoked at will, and the Permit Holder shall surrender this permit and alter, relocate or remove its facilities at its expense at the request of the MCRC.

11. VIOLATION OF PERMIT - This permit shall become immediately null and void if Permit Holder violates the terms of this permit, and the MCRC may require immediate removal of Permit Holder's permitted facilities, or the MCRC may remove same without notice at Permit Holder's expense.

12. TRAFFIC CONTROL & PERMANENT SIGNS - The Contractor shall furnish and maintain all traffic control devices including signs, barricades, lights, etc., in accordance with the MMUTCD or as otherwise deemed necessary by the MCRC. No traffic lanes shall be closed without the prior approval of the MCRC. When such closure is permitted and results in two-way, one-lane traffic, a flag person shall be stationed at each end of such section of road to direct traffic. All signs, signals and other traffic control as directed by the MCRC Planning/Engineering Department shall be erected and maintained by the contractor at its expense. Permanent traffic control signs which require relocation as part of permitted activity within the road right-of-way shall not be removed without prior approval of the MCRC Planning/Engineering Department. Removal and relocation of signs shall be performed by MCRC Sign Shop and the cost will be billed to the Permit Holder.

13. PERMIT HOLDER RISK - Permit Holder assumes any and all risk of removal or modification of any permitted improvements within the right of way, at the discretion of the MCRC. Such modifications may include, but not be limited to, an overlay of Permit Holder approach, a change of Permit Holder approach material or introduction of a ditch across Permit Holder frontage.

14. EQUIPMENT/VEHICLES/TRAILERS - The individual performing the work on behalf of the Permit Holder shall abide by all posted road, bridge, and seasonal weight restrictions and shall obtain any necessary transportation permits from the MCRC. Equipment, vehicles, and trailers necessary for the permitted work shall not be located on the road shoulder or pavement without proper traffic control devices and advance warning signs per the MMUTCD.

15. EXCAVATION AND DISPOSAL OF EXCAVATED MATERIAL - The Permit Holder, Contractor, and/or Utility Company shall provide and place any necessary sheeting, shoring and/or bracing required to prevent caving, loss or settlement of foundation material supporting the pavement or any other highway installation such as sewer, culvert, etc. The Contractor and/or Utility Company shall assume full responsibility for this protection. Excavated material shall be stockpiled in such locations as to avoid obstructing vision on the traveled portion of the highway and in such manner as to not interfere with the flow of traffic. The Permit Holder shall dispose of all surplus and unsuitable material outside of the limits of the right-of-way unless the permit provides for locations within the right-of-way. In the latter case the material shall be leveled and trimmed in an approved manner. BERMS WILL NOT BE ALLOWED UNLESS SHOWN AND APPROVED ON THE PERMIT. See Paragraph eight (8) regarding aggregate shoulder replacement.

16. BACKFILLING AND COMPACTING TRENCHES, HOLES, PITS, ETC. - The "area of influence" is defined as the area under the existing or future road bed and a one-on-one slope line drawn outward and down from a point one (1) foot outside and horizontal to the existing or proposed shoulder or curb and gutter. All trenches, holes and pits within the area of influence shall be filled with approved materials placed in successive layers no more than ten (10) inches in depth, loose measure and compacted to not less than 95% of the maximum dry density. Aggregate bases within the area of influence shall be compacted to no less than 98% of the maximum dry density. Trenches, holes or pits outside the area of influence shall be compacted to no less than 90% of the maximum dry density. Excavation falling within the existing or proposed area of influence and under hard-surface roads shall be backfilled with an approved Controlled Density Backfill (CDB) material.

17. GRAVEL ROADS - All trenches across the roadbed shall be backfilled as described in Paragraph sixteen (16) to within ten (10) inches of the finished road surface. The top ten (10) inches shall be constructed with 21A, 21AA or 22A aggregate compacted to not less than 98% of the maximum density. Paving of an approach within the right of way of a gravel road will not be allowed.

18. CROSSING ROADBED BY TUNNELING OR BORING AND JACKING - When pipe is installed by this method without cutting the existing pavement, all remaining voids around the installation shall be filled by a method approved by the MCRC inspector. Pressure grouting shall be required when deemed necessary. The length of the pipe or casing shall extend beyond the area of influence as defined in Paragraph sixteen (16). Special consideration will be given when field conditions preclude these requirements. The bore pit shall be backfilled and compacted in accordance to the requirements of Paragraph sixteen (16).

19. PAVEMENT REPLACEMENT - In general, all hard-surface pavement crossings shall be bored. However, if open cutting is permitted, the pavement shall be sawed or milled so that the pavement area to be removed is a minimum of one (1) foot wider on each side than the maximum width of the trench. Asphalt shall be cut in neat straight lines perpendicular to the road centerline and shall extend to the next lane seam. Pavement shall be cut full depth. Wearing coarse milling may be utilized in lieu of full depth cut. The pavement shall be replaced in kind and thickness with proper inspection and density testing. Density will be measured with a nuclear density gage using Gmm from the specified mix formula for the density control target. The required density of the HMA mixture specified shall be 93% to 96% of the density control target. For asphalt pavement sections, a typical minimum of six (6) inches of Hot Mix Asphalt (HMA) on eight (8) inches of compacted 21A, 21AA or 22A stone base is required. All seams shall be sealed with a bituminous crack fill sealer. For concrete pavement sections, a typical minimum of eight (8) inches, non-reinforced concrete is required. Concrete patches shall be tied to the existing slab by drilling hook bolts on nine (9) inch centers on all exposed faces on the existing pavement. The hook bolts shall be located at one-half (½) the pavement depth. Backfill shall be placed as provided in Paragraph sixteen (16).

20. DRIVEWAY REPLACEMENT - Driveways shall be replaced in kind and thickness, except that no stone driveway shall be replaced with less than eight (8) inches of compacted 23A stone. Backfill under driveways shall be compacted to 95% of maximum dry density as defined in Paragraph sixteen (16).

21. TREES - No trees shall be removed without prior written approval of the MCRC and, if necessary, the adjoining property owner. Trees damaged by the Contractor shall be neatly trimmed and repaired/replaced in an approved manner.

22. DEPTH OF COVER - Underground utilities shall be installed with not less than four (4) feet of cover below the surface of roadways, nor less than three (3) feet of cover over any adjacent ditch bottoms and culverts in all other areas.

23. PROTECTION OF ESTABLISHED SURVEY POINTS and DATUM - The Permit Holder shall protect, preserve, and/or restore, at its own expense, any established survey points and datum within the limits of the work covered by this permit.

24. THE FOLLOWING MUST BE ATTACHED TO APPLICATION WHEN APPLICABLE: (1) Deposit and/or bond, except for local units of government; (2) Plans, specifications and location of facility; (3) Copy of Resolution for local units of government; (4)Traffic plans; and (5) In cases of banner application, legend must be shown.

25. OTHER OPERATIONS - Any operation in the right-of-way not covered by these specifications shall be done in accordance with the instructions of the MCRC County Highway Engineer or his/her designated representative to the project.

ACCESS PERMIT UPON COMPLETION

1. TIME FOR COMPLETION OF WORK - The initial time period applied for and granted in this application and permit pertains to activity within a right-of-way. Failure of the applicant to complete the permitted work within said time period shall result in this permit becoming null and void. Renewal may be obtained for an additional time period upon payment of any additional permit fees which may be required. Failure to complete the work as required will result in forfeiture of any security posted in conjunction with the permit.

2. RIGHT OF ACCESS AFTER COMPLETION AND APPROVAL - Where the initially permitted activity results in construction of a new or modified point of access ("driveway") to the public road, upon completion of the work, MCRC will conduct a final inspection. Provided the work meets all requirements of the permit, including any attached plans and specifications and MCRC's standards for construction, MCRC will issue a Final Approval Certification. The Final Approval Certification shall then be considered an access permit pursuant to MCL 247.321, et. seq. subject to all of the terms contained in that statute and in the MCRC regulations enacted pursuant thereto. The obligation to operate, use and/or maintain the facility in accordance with MCRC requirements shall remain in force as long as the facility exists and is within an area under the jurisdiction of the MCRC.

EROSION CALCULATIONS

CALCULATIONS

Date:	Jul-2017	**Made by:**	BAB
Project No.:	1667572	**Checked by:**	SAM
Subject:	UNIVERSAL SOIL LOSS/BERM SPACING	**Reviewed by:**	JDP
Project Short Title:	JR Whiting Pond Closure		

1.0 OBJECTIVE

To analyze the soil loss for the proposed surface water control berm configuration and spacing. The configuration shall be found acceptable if the annual soil loss is not more than 2 tons/acre/year, in accordance with Michigan Department of Environmental Quality (MDEQ) Rule 425. (8)(b).

2.0 METHOD

1.) This erosion check shall be performed by using the Universal Soil Loss Equation (USLE). Guidelines presented in the MDEQ, Waste Management Division, "FINAL COVER EROSION CONTROL DESIGN GUIDANCE" (FCECDG) have been used for the selection of all parameters.

2.) A = (R) (C) (K) (LS) (P)

Where:

A	Computed Soil Loss in tons/acre/year
R	Rainfall Energy Factor (as per attached map from reference 1)
C	Cropping Management Factor (as suggested in reference 1, based on critical area planting guide)
K	Soil Erodibility Factor (based on soil types determined from reference 2 and table from reference 1)
LS	Slope Length / Topographic factor (calculated from design berm spacing and configuration in accordance with reference 1)
P	Erosion Control Practice Factor (as suggested in reference 1)

3.0 ASSUMPTIONS AND PARAMETERS

R = 105 The rainfall energy factor has been selected from the FCECDG Attachment 1 Michigan County Map, for Monroe County.

C = 0.007 The suggested C value is 0.007 (dimensionless) for 95% to 100% soil surface coverage, and topsoil with an organic matter content greater than or equal to 2.5% (as recommended in reference 1). This assumes seeding, mulching, and fertilization practices follow recommendations in the Natural Resources Conservation Service (NRCS) Critical Area Planting Guide (reference 2).

K = 0.27 The cover soil is assumed to be mostly SILTY CLAY LOAM with an average organic matter content of 3.8%. Soil type was provided by the NRCS Web Soil Survey (reference 4). Organic matter content was calculated from the average organic matter content of the dredge borrow area soil laboratory results (reference 3). K was interpolated from values presented in Attachment 3 of reference 1.

LS = 4.56 The Topographic factor depends on the average slope length of final cover. For this

CALCULATIONS

Date:	Jul-2017	**Made by:**	BAB
Project No.:	1667572	**Checked by:**	SAM
Subject:	UNIVERSAL SOIL LOSS/BERM SPACING	**Reviewed by:**	JDP
Project Short Title:	JR Whiting Pond Closure		

calculation, slope has been conservatively assumed to be 3% to account for potential overbuild. The topographic factor was calculated from Equation 5 of reference 1.

P = 1.0 Per reference 1, this factor has been set equal to one.

These calculations are performed with an assumed topsoil organic content of greater than 2.5%.

CALCULATIONS:

1.) Calculate Soil Loss in tons/acre/year.

A = (R) (C) (K) (LS) (P)

A = 0.89 tons/acre/year

CONCLUSIONS:

The proposed cover design includes no surface water control berms. The soils loss in tons/acre/year is not great enough to merit control berms.
The configuration without surface water control berms yields a soil loss of 0.89 tons/acre/year, which satisfies the erosion requirement of less than 2 tons/acre/year identified in Rule 425.(8)(b).

Provide Closure Plan for topsoil to contain >2.5% organic material. Also, mowing should be conducted a minimum of two times per year.

REFERENCES:

1) Michigan Waste Management Division, *Final Cover Erosion Control Design Guidance.*

2) Natural Resources Conservation Service - Critical Planting Guide.

3) The Mannik & Smith Group, Inc, *JR Whiting Ash Ponds 6 CQA Summary of Laboratory Results*

4) Natural Resources Conservation Service, Web Soil Survey, Monroe County Michigan, 2017.

ATTACHMENTS:

Attachment 1: Rainfall Energy Factor Michigan County Map, for Monroe County (from reference 1).

ATTACHMENT 1

Attachment 1

DEQ

Waste Management Division
Final Cover Erosion Control Design Guidance
Attachment 1

ABOVE-CAP DRAINAGE CALCULATIONS

Golder Associates

CALCULATIONS

Date:	Jul-2017	**Made by:**	TDJ
Project No.:	1667572.0005	**Checked by:**	SAM
Subject:	Above Cap Drainage	**Reviewed by:**	JDP
Project Short Title:	J.R. Whiting Ponds 1 and 2 Closure Project		

1.0 OBJECTIVE

To evaluate the amount of storm water infiltration expected through the proposed final cap system at the J.R. Whiting Ponds 1 and 2 Closure Project over a 30 year post closure period. The site is located in Erie, Michigan.

2.0 ASSUMPTIONS

1. The cap design follows the requirements of CCR Rule 257.102 and includes the following layers from top to bottom:
   - 6-inch thick top soil layer (permeability = 0.52x10-3 centimeters per second (cm/sec)
   - 18-inch thick protective soil layer (permeability = $1x10^{-5}$ centimeters per second (cm/sec)
   - 4-inch diameter ADS N-12 (or equal) socked perforated corrugated plastic pipes
   - 8 ounce per square yard (oz/sy) nonwoven needle-punched geotextile cushion
   - 40-mil high density polyethylene (HDPE) geomembrane liner
   - Smoothed subgrade (thickness varies)

2. The depth and rate of storm water infiltration will be derived from the average annual totals calculated by the U.S. Environmental Protection Agency (USEPA), Hydrologic Performance of Landfill Performance (HELP) Model, version 3.07 (November 1997), as shown in the attached calculation (Attachment 1). The infiltration is calculated as the Total Precipitation minus Runoff minus Evapotranspiration. The maximum slope drainage length is assumed to be 850 feet.

3. The proposed cap system will be sloped at a minimum of 2-percent (%) .

4. During the lifetime of the final cap system, the protective soil overlying the geomembrane could potentially saturate under severe or multiple precipitation events. Therefore, the methods of water balance analysis conservatively assume the hydraulic gradient is equal to one (unit gradient) which results in the rate of infiltration being equal to the protective soil hydraulic conductivity.

5. For the HELP Model analysis, the following was assumed:
a. Evapotranspiration, solar radiation precipitation, and temperature for Toledo, Ohio (closest station to Erie, Michigan) were simulated by the model for a 30 year post-closure period.

b. The soil and geosynthetic layers comprising the proposed liner system configuration were modeled as follows:

Layer No.	Material	Thickness (inches)	Description
1	Vertical Percolation Layer	6	Topsoil Layer
2	Vertical Percolation Layer	18	Protective Layer, permeability $1x10^{-5}$ cm/sec
3	Assume Lateral Drainage Layer	0.11	8 oz/sy Geotextile Layer
4	Flexible Membrane Liner	0.04	40-mil HDPE geomembrane
5	Vertical Percolation Layer	180	Subgrade and Ash

Date:	Jul-2017	**Made by:**	TDJ
Project No.:	1667572.0005	**Checked by:**	SAM
Subject:	Above Cap Drainage	**Reviewed by:**	JDP
Project Short Title:	J.R. Whiting Ponds 1 and 2 Closure Project		

3.0 CALCULATIONS

1. The HELP Model results are attached to this calculation, and were prepared using the assumptions noted in Section 2.0.

Per the HELP Model, the average annual totals are:

Precipitation	=	31.3	inches per acre per year
Runoff	=	6.0	inches per acre per year
Evapotranspiration	=	23.8	inches per acre per year
Infiltration Collected on Layer 3	=	1.3	inches per acre per year
Infiltration Collected on Layer 3	=	0.004	inches per acre per day
Average Head on Layer 4	=	5.3	inches per acre per year
Average Head on Layer 4	=	0.01	inches per acre per day
Area Drained By Piping System	=	13.7	acres
Average Drainage Collected from Layer 3	=	4731.6	cubic feet per acre per year
Average Drainage Collected from Layer 3	=	13.0	cubic feet per acre per day
Average Drainage Collected from Layer 3	**=**	**0.0021**	**cubic feet per second (cfs)**

2. The drainage collected on layer 4 will be managed using above-cap drainage pipes. The above-cap pipes will serve as a conduit to transfer water that drains through the cap soils to the perimeter of the closure area. The above cap collection pipes are designed as 4-inch diameter ADS N-12 (or equal) smooth interior perforated and socked corrugated plastic pipes (CPPs), spaced at 200 feet on center and sloped at 1%. The above cap conveyance pipes are designed as 4-inch diameter ADS N-12 (or equal) smooth interior non-perforated corrugated plastic pipes and sloped at 2%. Since the pipes will be free-flowing to unrestricted outlets, Manning's equation is used to verify the pipe diameter size.

4-inch dia. perforated pipe : $Q = (1.486)(A)(R^{2/3})(S^{1/2})/n$ flowing 1/2 full

Where:
- Q = pipe capacity, (cfs)
- n = Manning's "n" coefficient
- A = cross-sectional flow area of the pipe (square feet; sf)
- R = hydraulic radius (feet)
- *R = A/P*
- P = Wetted perimeter (ft); Pipe inside circumference, or (1/2)(π)(diameter) for 1/2 full flowing pipe conditions
- S = pipe slope (feet/foot)

$A = (\pi)r^2 =$	0.04			
S = 1.0% =	0.01	$S^{1/2} =$	0.10	
P = (π)(4/12) =	0.52			
R = A/P	0.08	$R^{2/3} =$	0.19	
n = 0.012	(from ADS, Inc. Drainage Handbook)			

Q = 0.10 cfs per perforated pipe

4-inch dia. non-perforated pipe : $Q = (1.486)(A)(R^{2/3})(S^{1/2})/n$ flowing 1/2 full

$A = (\pi)r^2 =$	0.04			
S = 2.0% =	0.02	$S^{1/2} =$	0.14	
P = (π)(4/12) =	0.52			
R = A/P	0.08	$R^{2/3} =$	0.19	
n = 0.012	(from ADS, Inc. Drainage Handbook)			

Q = 0.15 cfs per non-perforated pipe

5.0 CONCLUSIONS

The drainage collection system is sufficently sized to convey the expected drainage through the cap soils to the diascharge points outside the capped area.

6.0 REFERENCES

1. USEPA, “The Hydrologic Evaluation of Landfill Performance (HELP) Model – Users Guide for Version 3.07,” 1997.
2. ADS, Inc. Drainage Handbook. February 2017.

ATTACHMENT 1

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*******************************************************************************
**                                                                           **
**                                                                           **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                 **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                    USAE WATERWAYS EXPERIMENT STATION                      **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY               **
**                                                                           **
**                                                                           **
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PRECIPITATION DATA FILE:    C:\jrw\pc.D4
TEMPERATURE DATA FILE:      C:\jrw\pc.D7
SOLAR RADIATION DATA FILE:  C:\jrw\pc.D13
EVAPOTRANSPIRATION DATA:    C:\jrw\pc.D11
SOIL AND DESIGN DATA FILE:  C:\jrw\pc.D10
OUTPUT DATA FILE:           C:\jrw\pc.OUT


TIME:  10:50     DATE:   6/29/2017


*******************************************************************************

     TITLE:  CEC JR Whiting Ponds 1 and 2 Capping - Post Closure

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   7
          THICKNESS                     =      6.00   INCHES
          POROSITY                      =      0.4730 VOL/VOL
          FIELD CAPACITY                =      0.2220 VOL/VOL
          WILTING POINT                 =      0.1040 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.4530 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.520000001000E-03 CM/SEC
       NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.90
                FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                LAYER  2
                                --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   0
          THICKNESS                     =     18.00   INCHES
          POROSITY                      =      0.4300 VOL/VOL
          FIELD CAPACITY                =      0.3210 VOL/VOL
          WILTING POINT                 =      0.2210 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.4281 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.999999975000E-05 CM/SEC


                                LAYER  3
                                --------

                    TYPE 2 - LATERAL DRAINAGE LAYER
                        MATERIAL TEXTURE NUMBER   0
          THICKNESS                     =      0.11   INCHES
          POROSITY                      =      0.8500 VOL/VOL
          FIELD CAPACITY                =      0.0100 VOL/VOL
          WILTING POINT                 =      0.0050 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.8500 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.300000012000     CM/SEC
          SLOPE                         =      2.00   PERCENT
          DRAINAGE LENGTH               =    850.0    FEET


                                LAYER  4
                                --------

                    TYPE 4 - FLEXIBLE MEMBRANE LINER
                        MATERIAL TEXTURE NUMBER   0
          THICKNESS                     =      0.04   INCHES
          POROSITY                      =      0.0000 VOL/VOL
          FIELD CAPACITY                =      0.0000 VOL/VOL
          WILTING POINT                 =      0.0000 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.0000 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.199999996000E-12 CM/SEC
          FML PINHOLE DENSITY           =      1.00   HOLES/ACRE
          FML INSTALLATION DEFECTS      =      1.00   HOLES/ACRE
          FML PLACEMENT QUALITY         =  3 - GOOD


                                LAYER  5
                                --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER  30
          THICKNESS                     =    180.00   INCHES
          POROSITY                      =      0.5410 VOL/VOL
          FIELD CAPACITY                =      0.1870 VOL/VOL
          WILTING POINT                 =      0.0470 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.1871 VOL/VOL
          EFFECTIVE SAT. HYD. COND.     =  0.499999987000E-04 CM/SEC


                    GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                    ---------------------------------------

       NOTE:  SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

     SCS RUNOFF CURVE NUMBER             =     80.00
     FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
```

AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	20.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	8.761	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	8.858	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	3.718	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	44.199	INCHES
TOTAL INITIAL WATER	=	44.199	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
TOLEDO OHIO

STATION LATITUDE	=	41.36 DEGREES
MAXIMUM LEAF AREA INDEX	=	4.00
START OF GROWING SEASON (JULIAN DATE)	=	119
END OF GROWING SEASON (JULIAN DATE)	=	286
EVAPORATIVE ZONE DEPTH	=	20.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	9.40 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	72.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	74.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	76.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR TOLEDO OHIO

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.99	1.80	2.64	3.04	2.90	3.49
3.26	3.19	2.53	1.94	2.41	2.59

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR TOLEDO OHIO

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
23.10	25.80	35.40	47.80	58.60	68.00
71.80	70.10	63.20	51.70	39.30	28.10

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR TOLEDO OHIO
AND STATION LATITUDE = 41.36 DEGREES

****

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	33.35	121060.523	100.00
RUNOFF	6.829	24789.678	20.48
EVAPOTRANSPIRATION	24.832	90140.789	74.46
DRAINAGE COLLECTED FROM LAYER 3	1.4817	5378.482	4.44
PERC./LEAKAGE THROUGH LAYER 4	0.175180	635.903	0.53
AVG. HEAD ON TOP OF LAYER 4	6.0126		
PERC./LEAKAGE THROUGH LAYER 5	0.173884	631.200	0.52
CHANGE IN WATER STORAGE	0.033	120.375	0.10
SOIL WATER AT START OF YEAR	46.443	168586.969	
SOIL WATER AT END OF YEAR	46.476	168707.344	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.006	0.00

****

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	33.69	122294.711	100.00
RUNOFF	8.873	32208.834	26.34
EVAPOTRANSPIRATION	22.620	82109.883	67.14
DRAINAGE COLLECTED FROM LAYER 3	1.5461	5612.506	4.59
PERC./LEAKAGE THROUGH LAYER 4	0.157172	570.535	0.47
AVG. HEAD ON TOP OF LAYER 4	5.3742		
PERC./LEAKAGE THROUGH LAYER 5	0.135483	491.804	0.40
CHANGE IN WATER STORAGE	0.516	1871.667	1.53
SOIL WATER AT START OF YEAR	46.476	168707.344	
SOIL WATER AT END OF YEAR	43.893	159330.141	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	3.099	11248.871	9.20
ANNUAL WATER BUDGET BALANCE	0.0000	0.014	0.00

****

ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	36.19	131369.687	100.00
RUNOFF	9.330	33867.824	25.78
EVAPOTRANSPIRATION	28.138	102141.195	77.75
DRAINAGE COLLECTED FROM LAYER 3	0.9346	3392.445	2.58
PERC./LEAKAGE THROUGH LAYER 4	0.126766	460.161	0.35
AVG. HEAD ON TOP OF LAYER 4	4.3601		
PERC./LEAKAGE THROUGH LAYER 5	0.157672	572.350	0.44
CHANGE IN WATER STORAGE	-2.370	-8604.140	-6.55
SOIL WATER AT START OF YEAR	43.893	159330.141	
SOIL WATER AT END OF YEAR	44.227	160542.500	
SNOW WATER AT START OF YEAR	3.099	11248.871	8.56
SNOW WATER AT END OF YEAR	0.395	1432.368	1.09
ANNUAL WATER BUDGET BALANCE	0.0000	0.005	0.00

ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	28.71	104217.305	100.00
RUNOFF	5.731	20801.963	19.96
EVAPOTRANSPIRATION	20.614	74827.352	71.80
DRAINAGE COLLECTED FROM LAYER 3	0.7292	2647.036	2.54
PERC./LEAKAGE THROUGH LAYER 4	0.061666	223.846	0.21
AVG. HEAD ON TOP OF LAYER 4	2.0850		
PERC./LEAKAGE THROUGH LAYER 5	0.076101	276.247	0.27
CHANGE IN WATER STORAGE	1.561	5664.731	5.44
SOIL WATER AT START OF YEAR	44.227	160542.500	
SOIL WATER AT END OF YEAR	44.225	160535.937	
SNOW WATER AT START OF YEAR	0.395	1432.368	1.37
SNOW WATER AT END OF YEAR	1.957	7103.664	6.82
ANNUAL WATER BUDGET BALANCE	0.0000	-0.028	0.00

ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	30.68	111368.383	100.00
RUNOFF	7.422	26941.594	24.19
EVAPOTRANSPIRATION	23.051	83673.406	75.13
DRAINAGE COLLECTED FROM LAYER 3	0.8666	3145.743	2.82
PERC./LEAKAGE THROUGH LAYER 4	0.086487	313.947	0.28
AVG. HEAD ON TOP OF LAYER 4	2.9365		
PERC./LEAKAGE THROUGH LAYER 5	0.086094	312.522	0.28
CHANGE IN WATER STORAGE	-0.745	-2704.866	-2.43
SOIL WATER AT START OF YEAR	44.225	160535.937	
SOIL WATER AT END OF YEAR	44.444	161332.641	
SNOW WATER AT START OF YEAR	1.957	7103.664	6.38
SNOW WATER AT END OF YEAR	0.992	3602.104	3.23
ANNUAL WATER BUDGET BALANCE	0.0000	-0.020	0.00

ANNUAL TOTALS FOR YEAR 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	32.37	117503.125	100.00
RUNOFF	5.595	20308.068	17.28
EVAPOTRANSPIRATION	25.128	91213.680	77.63
DRAINAGE COLLECTED FROM LAYER 3	1.4218	5161.295	4.39
PERC./LEAKAGE THROUGH LAYER 4	0.147706	536.173	0.46
AVG. HEAD ON TOP OF LAYER 4	5.0455		
PERC./LEAKAGE THROUGH LAYER 5	0.147336	534.828	0.46

CHANGE IN WATER STORAGE	0.079	285.237	0.24
SOIL WATER AT START OF YEAR	44.444	161332.641	
SOIL WATER AT END OF YEAR	44.868	162871.359	
SNOW WATER AT START OF YEAR	0.992	3602.104	3.07
SNOW WATER AT END OF YEAR	0.647	2348.610	2.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.016	0.00

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ANNUAL TOTALS FOR YEAR 7

	INCHES	CU. FEET	PERCENT
PRECIPITATION	34.82	126396.641	100.00
RUNOFF	4.371	15865.758	12.55
EVAPOTRANSPIRATION	27.716	100609.875	79.60
DRAINAGE COLLECTED FROM LAYER 3	1.7253	6262.965	4.96
PERC./LEAKAGE THROUGH LAYER 4	0.297575	1080.196	0.85
AVG. HEAD ON TOP OF LAYER 4	10.2697		
PERC./LEAKAGE THROUGH LAYER 5	0.113720	412.805	0.33
CHANGE IN WATER STORAGE	0.894	3245.225	2.57
SOIL WATER AT START OF YEAR	44.868	162871.359	
SOIL WATER AT END OF YEAR	46.383	168369.437	
SNOW WATER AT START OF YEAR	0.647	2348.610	1.86
SNOW WATER AT END OF YEAR	0.026	95.758	0.08
ANNUAL WATER BUDGET BALANCE	0.0000	0.012	0.00

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ANNUAL TOTALS FOR YEAR 8

	INCHES	CU. FEET	PERCENT
PRECIPITATION	40.50	147014.984	100.00
RUNOFF	7.597	27577.959	18.76
EVAPOTRANSPIRATION	27.740	100696.664	68.49
DRAINAGE COLLECTED FROM LAYER 3	1.5530	5637.528	3.83
PERC./LEAKAGE THROUGH LAYER 4	0.206114	748.195	0.51
AVG. HEAD ON TOP OF LAYER 4	7.0969		
PERC./LEAKAGE THROUGH LAYER 5	0.229145	831.796	0.57
CHANGE IN WATER STORAGE	3.380	12271.063	8.35
SOIL WATER AT START OF YEAR	46.383	168369.437	
SOIL WATER AT END OF YEAR	46.590	169120.953	
SNOW WATER AT START OF YEAR	0.026	95.758	0.07
SNOW WATER AT END OF YEAR	3.200	11615.313	7.90
ANNUAL WATER BUDGET BALANCE	0.0000	-0.024	0.00

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ANNUAL TOTALS FOR YEAR 9

	INCHES	CU. FEET	PERCENT
PRECIPITATION	29.07	105524.141	100.00
RUNOFF	7.450	27043.441	25.63
EVAPOTRANSPIRATION	21.833	79255.180	75.11
DRAINAGE COLLECTED FROM LAYER 3	1.3943	5061.253	4.80
PERC./LEAKAGE THROUGH LAYER 4	0.145623	528.613	0.50
AVG. HEAD ON TOP OF LAYER 4	4.9852		
PERC./LEAKAGE THROUGH LAYER 5	0.297439	1079.702	1.02
CHANGE IN WATER STORAGE	-1.905	-6915.530	-6.55
SOIL WATER AT START OF YEAR	46.590	169120.953	
SOIL WATER AT END OF YEAR	45.437	164934.719	
SNOW WATER AT START OF YEAR	3.200	11615.313	11.01
SNOW WATER AT END OF YEAR	2.448	8886.018	8.42
ANNUAL WATER BUDGET BALANCE	0.0000	0.090	0.00

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ANNUAL TOTALS FOR YEAR 10

	INCHES	CU. FEET	PERCENT

PRECIPITATION	28.26	102583.828	100.00
RUNOFF	4.861	17645.459	17.20
EVAPOTRANSPIRATION	25.682	93226.406	90.88
DRAINAGE COLLECTED FROM LAYER 3	1.5684	5693.306	5.55
PERC./LEAKAGE THROUGH LAYER 4	0.157736	572.583	0.56
AVG. HEAD ON TOP OF LAYER 4	5.3787		
PERC./LEAKAGE THROUGH LAYER 5	0.134937	489.822	0.48
CHANGE IN WATER STORAGE	-3.987	-14471.218	-14.11
SOIL WATER AT START OF YEAR	45.437	164934.719	
SOIL WATER AT END OF YEAR	43.477	157820.047	
SNOW WATER AT START OF YEAR	2.448	8886.018	8.66
SNOW WATER AT END OF YEAR	0.421	1529.472	1.49
ANNUAL WATER BUDGET BALANCE	0.0000	0.054	0.00

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ANNUAL TOTALS FOR YEAR 11

	INCHES	CU. FEET	PERCENT
PRECIPITATION	25.37	92093.086	100.00
RUNOFF	2.629	9542.029	10.36
EVAPOTRANSPIRATION	19.823	71955.898	78.13
DRAINAGE COLLECTED FROM LAYER 3	1.0310	3742.424	4.06
PERC./LEAKAGE THROUGH LAYER 4	0.084737	307.594	0.33
AVG. HEAD ON TOP OF LAYER 4	2.8914		
PERC./LEAKAGE THROUGH LAYER 5	0.117604	426.902	0.46
CHANGE IN WATER STORAGE	1.770	6425.892	6.98
SOIL WATER AT START OF YEAR	43.477	157820.047	
SOIL WATER AT END OF YEAR	43.031	156202.656	
SNOW WATER AT START OF YEAR	0.421	1529.472	1.66
SNOW WATER AT END OF YEAR	2.637	9572.747	10.39
ANNUAL WATER BUDGET BALANCE	0.0000	-0.055	0.00

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ANNUAL TOTALS FOR YEAR 12

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.52	99897.617	100.00
RUNOFF	7.045	25574.934	25.60
EVAPOTRANSPIRATION	19.558	70994.773	71.07
DRAINAGE COLLECTED FROM LAYER 3	0.9600	3484.946	3.49
PERC./LEAKAGE THROUGH LAYER 4	0.122049	443.038	0.44
AVG. HEAD ON TOP OF LAYER 4	4.1899		
PERC./LEAKAGE THROUGH LAYER 5	0.114523	415.718	0.42
CHANGE IN WATER STORAGE	-0.158	-572.778	-0.57
SOIL WATER AT START OF YEAR	43.031	156202.656	
SOIL WATER AT END OF YEAR	44.844	162782.187	
SNOW WATER AT START OF YEAR	2.637	9572.747	9.58
SNOW WATER AT END OF YEAR	0.667	2420.442	2.42
ANNUAL WATER BUDGET BALANCE	0.0000	0.021	0.00

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ANNUAL TOTALS FOR YEAR 13

	INCHES	CU. FEET	PERCENT
PRECIPITATION	33.39	121205.695	100.00
RUNOFF	4.033	14640.863	12.08
EVAPOTRANSPIRATION	26.931	97760.070	80.66
DRAINAGE COLLECTED FROM LAYER 3	1.5815	5740.874	4.74
PERC./LEAKAGE THROUGH LAYER 4	0.218145	791.866	0.65
AVG. HEAD ON TOP OF LAYER 4	7.5122		
PERC./LEAKAGE THROUGH LAYER 5	0.134601	488.603	0.40
CHANGE IN WATER STORAGE	0.709	2575.282	2.12
SOIL WATER AT START OF YEAR	44.844	162782.187	
SOIL WATER AT END OF YEAR	46.099	167340.859	
SNOW WATER AT START OF YEAR	0.667	2420.442	2.00
SNOW WATER AT END OF YEAR	0.120	437.051	0.36

ANNUAL WATER BUDGET BALANCE	0.0000	0.008	0.00

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ANNUAL TOTALS FOR YEAR 14

	INCHES	CU. FEET	PERCENT
PRECIPITATION	28.90	104907.016	100.00
RUNOFF	4.285	15553.744	14.83
EVAPOTRANSPIRATION	23.778	86315.758	82.28
DRAINAGE COLLECTED FROM LAYER 3	1.5792	5732.390	5.46
PERC./LEAKAGE THROUGH LAYER 4	0.208448	756.667	0.72
AVG. HEAD ON TOP OF LAYER 4	7.1862		
PERC./LEAKAGE THROUGH LAYER 5	0.208627	757.315	0.72
CHANGE IN WATER STORAGE	-0.951	-3452.187	-3.29
SOIL WATER AT START OF YEAR	46.099	167340.859	
SOIL WATER AT END OF YEAR	44.901	162990.719	
SNOW WATER AT START OF YEAR	0.120	437.051	0.42
SNOW WATER AT END OF YEAR	0.368	1335.009	1.27
ANNUAL WATER BUDGET BALANCE	0.0000	-0.003	0.00

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ANNUAL TOTALS FOR YEAR 15

	INCHES	CU. FEET	PERCENT
PRECIPITATION	22.21	80622.328	100.00
RUNOFF	1.935	7022.416	8.71
EVAPOTRANSPIRATION	19.187	69647.680	86.39
DRAINAGE COLLECTED FROM LAYER 3	1.2346	4481.419	5.56
PERC./LEAKAGE THROUGH LAYER 4	0.105760	383.907	0.48
AVG. HEAD ON TOP OF LAYER 4	3.5975		
PERC./LEAKAGE THROUGH LAYER 5	0.195834	710.879	0.88
CHANGE IN WATER STORAGE	-0.342	-1240.123	-1.54
SOIL WATER AT START OF YEAR	44.901	162990.719	
SOIL WATER AT END OF YEAR	44.493	161510.516	
SNOW WATER AT START OF YEAR	0.368	1335.009	1.66
SNOW WATER AT END OF YEAR	0.434	1575.085	1.95
ANNUAL WATER BUDGET BALANCE	0.0000	0.057	0.00

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ANNUAL TOTALS FOR YEAR 16

	INCHES	CU. FEET	PERCENT
PRECIPITATION	31.34	113764.242	100.00
RUNOFF	3.325	12070.305	10.61
EVAPOTRANSPIRATION	25.042	90903.180	79.90
DRAINAGE COLLECTED FROM LAYER 3	1.3474	4891.056	4.30
PERC./LEAKAGE THROUGH LAYER 4	0.134138	486.921	0.43
AVG. HEAD ON TOP OF LAYER 4	4.5893		
PERC./LEAKAGE THROUGH LAYER 5	0.134342	487.661	0.43
CHANGE IN WATER STORAGE	1.491	5412.048	4.76
SOIL WATER AT START OF YEAR	44.493	161510.516	
SOIL WATER AT END OF YEAR	44.488	161490.906	
SNOW WATER AT START OF YEAR	0.434	1575.085	1.38
SNOW WATER AT END OF YEAR	1.930	7006.741	6.16
ANNUAL WATER BUDGET BALANCE	0.0000	-0.007	0.00

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ANNUAL TOTALS FOR YEAR 17

	INCHES	CU. FEET	PERCENT
PRECIPITATION	30.44	110497.242	100.00
RUNOFF	6.891	25015.674	22.64
EVAPOTRANSPIRATION	24.502	88941.359	80.49
DRAINAGE COLLECTED FROM LAYER 3	1.3669	4961.818	4.49
PERC./LEAKAGE THROUGH LAYER 4	0.151838	551.170	0.50

AVG. HEAD ON TOP OF LAYER 4	5.2209		
PERC./LEAKAGE THROUGH LAYER 5	0.151860	551.253	0.50
CHANGE IN WATER STORAGE	-2.472	-8972.905	-8.12
SOIL WATER AT START OF YEAR	44.488	161490.906	
SOIL WATER AT END OF YEAR	43.895	159339.312	
SNOW WATER AT START OF YEAR	1.930	7006.741	6.34
SNOW WATER AT END OF YEAR	0.051	185.437	0.17
ANNUAL WATER BUDGET BALANCE	0.0000	0.048	0.00

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ANNUAL TOTALS FOR YEAR 18

	INCHES	CU. FEET	PERCENT
PRECIPITATION	44.83	162732.859	100.00
RUNOFF	6.755	24519.262	15.07
EVAPOTRANSPIRATION	33.127	120249.500	73.89
DRAINAGE COLLECTED FROM LAYER 3	1.3319	4834.860	2.97
PERC./LEAKAGE THROUGH LAYER 4	0.327601	1189.193	0.73
AVG. HEAD ON TOP OF LAYER 4	11.3808		
PERC./LEAKAGE THROUGH LAYER 5	0.109788	398.531	0.24
CHANGE IN WATER STORAGE	3.507	12730.765	7.82
SOIL WATER AT START OF YEAR	43.895	159339.312	
SOIL WATER AT END OF YEAR	46.721	169598.016	
SNOW WATER AT START OF YEAR	0.051	185.437	0.11
SNOW WATER AT END OF YEAR	0.732	2657.502	1.63
ANNUAL WATER BUDGET BALANCE	0.0000	-0.049	0.00

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ANNUAL TOTALS FOR YEAR 19

	INCHES	CU. FEET	PERCENT
PRECIPITATION	28.22	102438.656	100.00
RUNOFF	7.845	28477.309	27.80
EVAPOTRANSPIRATION	22.050	80042.461	78.14
DRAINAGE COLLECTED FROM LAYER 3	1.3038	4732.779	4.62
PERC./LEAKAGE THROUGH LAYER 4	0.128494	466.434	0.46
AVG. HEAD ON TOP OF LAYER 4	4.4010		
PERC./LEAKAGE THROUGH LAYER 5	0.157887	573.131	0.56
CHANGE IN WATER STORAGE	-3.137	-11387.077	-11.12
SOIL WATER AT START OF YEAR	46.721	169598.016	
SOIL WATER AT END OF YEAR	43.704	158646.703	
SNOW WATER AT START OF YEAR	0.732	2657.502	2.59
SNOW WATER AT END OF YEAR	0.612	2221.727	2.17
ANNUAL WATER BUDGET BALANCE	0.0000	0.052	0.00

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ANNUAL TOTALS FOR YEAR 20

	INCHES	CU. FEET	PERCENT
PRECIPITATION	29.50	107085.031	100.00
RUNOFF	8.097	29391.885	27.45
EVAPOTRANSPIRATION	18.543	67309.742	62.86
DRAINAGE COLLECTED FROM LAYER 3	0.7953	2886.858	2.70
PERC./LEAKAGE THROUGH LAYER 4	0.087422	317.343	0.30
AVG. HEAD ON TOP OF LAYER 4	2.9707		
PERC./LEAKAGE THROUGH LAYER 5	0.250323	908.672	0.85
CHANGE IN WATER STORAGE	1.815	6587.861	6.15
SOIL WATER AT START OF YEAR	43.704	158646.703	
SOIL WATER AT END OF YEAR	46.131	167456.297	
SNOW WATER AT START OF YEAR	0.612	2221.727	2.07
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.007	0.00

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ANNUAL TOTALS FOR YEAR 21

	INCHES	CU. FEET	PERCENT
PRECIPITATION	35.08	127340.383	100.00
RUNOFF	7.443	27018.072	21.22
EVAPOTRANSPIRATION	25.285	91786.062	72.08
DRAINAGE COLLECTED FROM LAYER 3	1.6253	5899.910	4.63
PERC./LEAKAGE THROUGH LAYER 4	0.245273	890.342	0.70
AVG. HEAD ON TOP OF LAYER 4	8.4616		
PERC./LEAKAGE THROUGH LAYER 5	0.186221	675.981	0.53
CHANGE IN WATER STORAGE	0.540	1960.365	1.54
SOIL WATER AT START OF YEAR	46.131	167456.297	
SOIL WATER AT END OF YEAR	46.267	167948.422	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.404	1468.230	1.15
ANNUAL WATER BUDGET BALANCE	0.0000	-0.015	0.00

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ANNUAL TOTALS FOR YEAR 22

	INCHES	CU. FEET	PERCENT
PRECIPITATION	29.88	108464.406	100.00
RUNOFF	5.743	20847.119	19.22
EVAPOTRANSPIRATION	23.478	85223.984	78.57
DRAINAGE COLLECTED FROM LAYER 3	1.3431	4875.441	4.49
PERC./LEAKAGE THROUGH LAYER 4	0.129261	469.218	0.43
AVG. HEAD ON TOP OF LAYER 4	4.4226		
PERC./LEAKAGE THROUGH LAYER 5	0.214427	778.371	0.72
CHANGE IN WATER STORAGE	-0.898	-3260.535	-3.01
SOIL WATER AT START OF YEAR	46.267	167948.422	
SOIL WATER AT END OF YEAR	44.391	161139.453	
SNOW WATER AT START OF YEAR	0.404	1468.230	1.35
SNOW WATER AT END OF YEAR	1.382	5016.673	4.63
ANNUAL WATER BUDGET BALANCE	0.0000	0.021	0.00

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ANNUAL TOTALS FOR YEAR 23

	INCHES	CU. FEET	PERCENT
PRECIPITATION	31.72	115143.633	100.00
RUNOFF	7.796	28297.988	24.58
EVAPOTRANSPIRATION	22.316	81008.180	70.35
DRAINAGE COLLECTED FROM LAYER 3	1.2746	4626.859	4.02
PERC./LEAKAGE THROUGH LAYER 4	0.143601	521.272	0.45
AVG. HEAD ON TOP OF LAYER 4	4.9353		
PERC./LEAKAGE THROUGH LAYER 5	0.121250	440.136	0.38
CHANGE IN WATER STORAGE	0.212	770.444	0.67
SOIL WATER AT START OF YEAR	44.391	161139.453	
SOIL WATER AT END OF YEAR	44.539	161675.687	
SNOW WATER AT START OF YEAR	1.382	5016.673	4.36
SNOW WATER AT END OF YEAR	1.447	5250.878	4.56
ANNUAL WATER BUDGET BALANCE	0.0000	0.024	0.00

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ANNUAL TOTALS FOR YEAR 24

	INCHES	CU. FEET	PERCENT
PRECIPITATION	27.58	100115.406	100.00
RUNOFF	6.189	22464.748	22.44
EVAPOTRANSPIRATION	19.518	70848.961	70.77
DRAINAGE COLLECTED FROM LAYER 3	1.4328	5201.245	5.20
PERC./LEAKAGE THROUGH LAYER 4	0.140170	508.818	0.51
AVG. HEAD ON TOP OF LAYER 4	4.7641		
PERC./LEAKAGE THROUGH LAYER 5	0.136327	494.867	0.49
CHANGE IN WATER STORAGE	0.305	1105.596	1.10
SOIL WATER AT START OF YEAR	44.539	161675.687	

SOIL WATER AT END OF YEAR	46.290	168032.156	
SNOW WATER AT START OF YEAR	1.447	5250.878	5.24
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.010	0.00

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ANNUAL TOTALS FOR YEAR 25

	INCHES	CU. FEET	PERCENT
PRECIPITATION	34.99	127013.695	100.00
RUNOFF	6.281	22800.045	17.95
EVAPOTRANSPIRATION	30.122	109341.602	86.09
DRAINAGE COLLECTED FROM LAYER 3	1.3423	4872.667	3.84
PERC./LEAKAGE THROUGH LAYER 4	0.163193	592.390	0.47
AVG. HEAD ON TOP OF LAYER 4	5.6185		
PERC./LEAKAGE THROUGH LAYER 5	0.114971	417.346	0.33
CHANGE IN WATER STORAGE	-2.870	-10417.951	-8.20
SOIL WATER AT START OF YEAR	46.290	168032.156	
SOIL WATER AT END OF YEAR	42.828	155464.125	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.592	2150.084	1.69
ANNUAL WATER BUDGET BALANCE	0.0000	-0.013	0.00

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ANNUAL TOTALS FOR YEAR 26

	INCHES	CU. FEET	PERCENT
PRECIPITATION	28.35	102910.531	100.00
RUNOFF	4.646	16865.154	16.39
EVAPOTRANSPIRATION	20.916	75926.555	73.78
DRAINAGE COLLECTED FROM LAYER 3	0.8375	3039.955	2.95
PERC./LEAKAGE THROUGH LAYER 4	0.061377	222.797	0.22
AVG. HEAD ON TOP OF LAYER 4	2.0556		
PERC./LEAKAGE THROUGH LAYER 5	0.135142	490.566	0.48
CHANGE IN WATER STORAGE	1.815	6588.259	6.40
SOIL WATER AT START OF YEAR	42.828	155464.125	
SOIL WATER AT END OF YEAR	45.235	164202.469	
SNOW WATER AT START OF YEAR	0.592	2150.084	2.09
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.038	0.00

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ANNUAL TOTALS FOR YEAR 27

	INCHES	CU. FEET	PERCENT
PRECIPITATION	30.21	109662.305	100.00
RUNOFF	4.569	16584.998	15.12
EVAPOTRANSPIRATION	23.912	86802.094	79.15
DRAINAGE COLLECTED FROM LAYER 3	1.4221	5162.139	4.71
PERC./LEAKAGE THROUGH LAYER 4	0.157259	570.851	0.52
AVG. HEAD ON TOP OF LAYER 4	5.3821		
PERC./LEAKAGE THROUGH LAYER 5	0.130741	474.589	0.43
CHANGE IN WATER STORAGE	0.176	638.450	0.58
SOIL WATER AT START OF YEAR	45.235	164202.469	
SOIL WATER AT END OF YEAR	45.321	164513.703	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.090	327.217	0.30
ANNUAL WATER BUDGET BALANCE	0.0000	0.034	0.00

****

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ANNUAL TOTALS FOR YEAR 28

	INCHES	CU. FEET	PERCENT
PRECIPITATION	32.17	116777.109	100.00
RUNOFF	6.165	22377.725	19.16

EVAPOTRANSPIRATION	21.779	79057.758	67.70
DRAINAGE COLLECTED FROM LAYER 3	1.4557	5284.356	4.53
PERC./LEAKAGE THROUGH LAYER 4	0.158629	575.822	0.49
AVG. HEAD ON TOP OF LAYER 4	5.4030		
PERC./LEAKAGE THROUGH LAYER 5	0.169893	616.712	0.53
CHANGE IN WATER STORAGE	2.601	9440.564	8.08
SOIL WATER AT START OF YEAR	45.321	164513.703	
SOIL WATER AT END OF YEAR	45.738	166028.594	
SNOW WATER AT START OF YEAR	0.090	327.217	0.28
SNOW WATER AT END OF YEAR	2.274	8252.896	7.07
ANNUAL WATER BUDGET BALANCE	0.0000	-0.011	0.00

****

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ANNUAL TOTALS FOR YEAR 29

	INCHES	CU. FEET	PERCENT
PRECIPITATION	26.20	95106.000	100.00
RUNOFF	6.055	21980.205	23.11
EVAPOTRANSPIRATION	21.634	78532.328	82.57
DRAINAGE COLLECTED FROM LAYER 3	1.3025	4728.050	4.97
PERC./LEAKAGE THROUGH LAYER 4	0.145780	529.181	0.56
AVG. HEAD ON TOP OF LAYER 4	5.0042		
PERC./LEAKAGE THROUGH LAYER 5	0.145468	528.049	0.56
CHANGE IN WATER STORAGE	-2.937	-10662.658	-11.21
SOIL WATER AT START OF YEAR	45.738	166028.594	
SOIL WATER AT END OF YEAR	44.188	160404.172	
SNOW WATER AT START OF YEAR	2.274	8252.896	8.68
SNOW WATER AT END OF YEAR	0.886	3214.657	3.38
ANNUAL WATER BUDGET BALANCE	0.0000	0.027	0.00

****

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ANNUAL TOTALS FOR YEAR 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	31.84	115579.211	100.00
RUNOFF	4.684	17001.307	14.71
EVAPOTRANSPIRATION	25.657	93135.734	80.58
DRAINAGE COLLECTED FROM LAYER 3	1.3158	4776.427	4.13
PERC./LEAKAGE THROUGH LAYER 4	0.133166	483.393	0.42
AVG. HEAD ON TOP OF LAYER 4	4.5447		
PERC./LEAKAGE THROUGH LAYER 5	0.145164	526.944	0.46
CHANGE IN WATER STORAGE	0.038	138.813	0.12
SOIL WATER AT START OF YEAR	44.188	160404.172	
SOIL WATER AT END OF YEAR	44.704	162274.047	
SNOW WATER AT START OF YEAR	0.886	3214.657	2.78
SNOW WATER AT END OF YEAR	0.409	1483.594	1.28
ANNUAL WATER BUDGET BALANCE	0.0000	-0.009	0.00

****

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.96	1.68	2.68	3.04	2.68	3.71
	2.98	3.36	2.35	1.57	2.51	2.70
STD. DEVIATIONS	0.74	0.77	0.88	1.33	0.91	2.00
	1.64	1.50	1.03	0.99	1.30	1.12
RUNOFF						
TOTALS	0.721	1.081	2.931	0.692	0.031	0.062
	0.018	0.023	0.004	0.013	0.099	0.342
STD. DEVIATIONS	0.772	0.823	1.400	0.920	0.089	0.168
	0.060	0.071	0.020	0.051	0.317	0.534
EVAPOTRANSPIRATION						
TOTALS	0.499	0.433	0.547	2.687	3.561	5.193
	3.618	2.898	2.202	0.998	0.708	0.473
STD. DEVIATIONS	0.099	0.089	0.254	0.709	0.973	1.147
	1.306	1.207	0.787	0.284	0.139	0.102

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	0.1032	0.0879	0.0862	0.1256	0.1444	0.1336
	0.1366	0.1368	0.1161	0.0786	0.0609	0.0937
STD. DEVIATIONS	0.0574	0.0538	0.0569	0.0441	0.0094	0.0038
	0.0004	0.0024	0.0139	0.0329	0.0525	0.0608

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0064	0.0029	0.0034	0.0342	0.0394	0.0217
	0.0103	0.0062	0.0022	0.0028	0.0089	0.0153
STD. DEVIATIONS	0.0062	0.0023	0.0055	0.0152	0.0073	0.0083
	0.0063	0.0070	0.0037	0.0064	0.0150	0.0150

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0192	0.0087	0.0047	0.0068	0.0131	0.0245
	0.0215	0.0193	0.0080	0.0048	0.0075	0.0162
STD. DEVIATIONS	0.0137	0.0108	0.0113	0.0123	0.0083	0.0079
	0.0142	0.0117	0.0097	0.0077	0.0091	0.0128

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	2.4656	1.1741	1.3465	14.5534	16.2655	9.1307
	4.0356	2.3557	0.8232	1.0935	3.7470	6.2396
STD. DEVIATIONS	2.4918	0.9215	2.2671	6.4805	3.0296	3.5870
	2.6683	2.9166	1.5295	2.6442	6.3965	6.1724

****

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	31.25	(4.444)	113423.0	100.00
RUNOFF	6.016	(1.8017)	21836.54	19.252
EVAPOTRANSPIRATION	23.817	(3.4241)	86455.93	76.224
LATERAL DRAINAGE COLLECTED FROM LAYER 3	1.30348	(0.26744)	4731.634	4.17167
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.15361	(0.06075)	557.612	0.49162
AVERAGE HEAD ON TOP OF LAYER 4	5.269	(2.117)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.15423	(0.04850)	559.843	0.49359
CHANGE IN WATER STORAGE	-0.044	(1.9228)	-160.98	-0.142

****

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	2.72	9873.601
RUNOFF	1.725	6261.6118
DRAINAGE COLLECTED FROM LAYER 3	0.00646	23.45533
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.001895	6.87907
AVERAGE HEAD ON TOP OF LAYER 4	24.110	
MAXIMUM HEAD ON TOP OF LAYER 4	35.809	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	218.5 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.002165	7.85796
SNOW WATER	4.88	17725.5898

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4429

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1859

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

****

FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	1.3793	0.2299
2	7.3235	0.4069
3	0.0935	0.8500
4	0.0000	0.0000
5	33.6633	0.1870
SNOW WATER	0.409	

****

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APPENDIX F
GLOBAL MATERIAL PROPERTIES TABLE

Table 1: Global Material Properties Used for Calculations

Material	Cohesion (psf)	Effective Stress Friction Angle φ'(°)	Total Stress Friction Angle φ(°)	Undrained Shear Strength (psf)	Peak Interface Friction Angle, ϕ (°)	Peak Interface Adhesion, C (psf)	Total (Moist) In-Place Unit Weight, ϒ (pcf)	Thickness (ft) (or as shown)	Reference #
Erosion Protection Layer	0	28	n/a	500	n/a	n/a	120	0.5	2
Protective Cover (Cover Material)	0	28	n/a	500	n/a	n/a	120	1.5	2
Protective Cover vs. Protective Geotextile	n/a	n/a	n/a	n/a	30.0	0	n/a	n/a	5
Protective Geotextile	n/a	n/a	n/a	n/a	n/a	n/a	n/a	330-mil	n/a
Protective Geotextile vs. 40-mil Smooth HDPE Geomembrane	n/a	n/a	n/a	n/a	11.0	0	n/a	n/a	5
Flexible Membrane Liner (40-mil Smooth HDPE Geomembrane)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	40-mil	n/a
40-mil Smooth HDPE Geomembrane vs. Fill Material	n/a	n/a	n/a	n/a	21.0	0	n/a	n/a	5
Structural Fill	0	35	35	n/a	n/a	n/a	125	varies	2
Upper CCR Dike Fill (Compact)	0	35	35	n/a	n/a	n/a	110	varies	1
Lower CCR Dike Fill (Very Loose to Loose)	0	28	n/a	1000	n/a	n/a	103	varies	1
Sluiced CCR	0	22	n/a	$0.22\sigma'^{1}$	n/a	n/a	90	varies	1
Organic Clay	0	28	n/a	500	n/a	n/a	119	varies	1
Lake Clay	0	30	n/a	1500	n/a	n/a	136	varies	1
Glacial Till	0	32	n/a	2000	n/a	n/a	141	varies	1
Road Base Aggregate	0	n/a	n/a	n/a	n/a	n/a	120	1.0	2

Note:
1. BOLD items indicate interfaces.
2. σ'= Vertical effective stress (psf)

SEISMIC COEFFICIENT:
For pseudo-static analyses, Hynes-Griffin and Franklin (1984) recommend using a seismic coefficient equal to 0.5 times the peak horizontal acceleration at bedrock (PHA). The PHA using the United States Geological Survey (USGS) seismic design maps application (Beta) with a 2% probability of exceedance in 50 years (2,475-year return period) is 0.065g, which corresponds to a seismic coefficient of 0.032. However, the Natural Resources Conservation Service (NRCS) recommends a minimum seismic coefficient of 0.05 for Michigan, so a seismic coefficient of 0.05 was used in pseudo-static analyses.

UNITS:
Units commonly used units for this document:

acre	1 acre = 43,560 square feet	**ksf**	kips per square foot
cf, ft^3	cubic feet	**mil**	1 inch = 1000 mils
cf/acre/day	cubic feet per acre per day	**mm**	millimeter
cm	centimeter	**mph**	miles per hour
cm/s	centimeter per second	**pcf**	pounds per cubic foot
cy, yd^3	cubic yards	**psf**	pounds per square foot
°	degrees	**psi**	pounds per square inch
ft	feet	**s, sec**	second
ft^2	square feet	**yr**	year
g	gravity = 9.81 meters/square second	**oz/sy**	ounce per square yard
g/cm^3	grams per cubic centimeter	**gpad**	gallons per acre per day
gal	gallons	**in**	inches
ipad	inches per acre per day	**in^2**	square inches
kPA	kilopascals		

REFERENCES:
1.) Professional judgment, based on Golder's review of available geotechnical data
2.) Naval Facilities Engineering Command (NAVFAC), Design Manual 7.02, 1986.
3.) Hynes-Griffin, M.E., Franklin, A.G., 1984. Rationalizing the seismic coefficient method. U.S. Army Corps of Engineers Waterways Experiment Station, Miscellaneous Paper GL-84-13, 37 pp.
4.) The United States Geological Survey (USGS), https://earthquake.usgs.gov/designmaps/beta/us.
5.) Koerner, R.M., and Narejo, D., 2005. "Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to- Soil Interfaces", GRI Report #30.

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APPENDIX G
J.R. WHITING GENERATING FACILITY PONDS 1 AND 2 POST-CLOSURE PLAN

JR Whiting Ponds 1 and 2 Post-Closure Plan

J.R. WHITING GENERATING FACILITY

PONDS 1 AND 2 POST-CLOSURE PLAN

Erie, Michigan

Pursuant to 40 CFR 257.104

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 2017

1667572.0005

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CERTIFICATION

Professional Engineer Certification Statement [40 CFR 257.104(d)(4)]

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 257.104 (40 CFR Part 257.104), I attest that this Post-Closure Plan 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 257.104.

Golder Associates Inc.

Signature

October 24, 2017

Date of Report Certification

Jeffrey R. Piaskowski, PE

Name

6201061033

Professional Engineer Certification Number

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1.0 INTRODUCTION

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. In accordance with the CCR RCRA Rule, any CCR surface impoundment or CCR landfill that was actively receiving CCRs on the effective date of the CCR RCRA Rule (October 19, 2015) was deemed to be an "Existing CCR Unit" on that date and subject to self-implementing compliance standards and schedules. Consumers Energy Company (CEC) identified Ash Ponds 1 and 2 as an existing CCR surface impoundment at the J.R. Whiting Generating Facility (JR Whiting).

JR Whiting is located in Erie, Michigan as presented on Figure 1 – Site Location Map. The location of Ponds 1 and 2 is presented on Figure 2 – Site Map.

This post-closure plan is specific to Ponds 1 and 2 at JR Whiting. The intent of the post-closure plan is to assure that integrity and effectiveness of the final cover is maintained over the 30-year post-closure care period. Ponds 1 and 2 is anticipated to be certified closed by December 31, 2018, which would result in the 30-year post-closure care period lasting through 2048 if the site is operating under detection monitoring.

2.0 FACILITY CONTACT [40 CFR 257.104(d)(1)(ii)]

The post-closure point of contact for Ponds 1 and 2 at JR Whiting is:

Michelle Marion
1945 W Parnall Road
Jackson, Michigan 49201
(517) 788-5824
michelle.marion@cmsenergy.com

3.0 MONITORING AND MAINTENANCE ACTIVITIES [40 CFR 257.104(d)(1)(i, iii)]

3.1 Site Maintenance [40 CFR 257.104(d)(1)(i)]

The following general site maintenance and monitoring will be conducted to ensure the integrity and effectiveness of the final cover system:

- Fertilizer will be applied in areas of stressed or poor quality cover vegetation as needed.
- Vegetative cover will be mowed as needed to restrict uncontrolled woody plant establishment on the cover for the remainder of the 30-year post-closure period (estimated through 2048).
- Areas of erosion, including erosion from run-off or vehicle use, will be repaired by restoring the thickness of the protective cover and topsoil and seeding as necessary upon discovery.
- Erosion repairs will utilize clean soils. Typically, repair is expected to involve minor regrading, spreading of small amounts of additional soil, and reseeding. Areas of repeated erosion will be evaluated to determine if additional protection, such as erosion blankets or riprap, should be added.
- Groundwater monitoring system will be maintained in accordance with applicable requirements from 40 CFR 257.90 to 40 CFR 257.98.
- Differential settlement will be repaired as follows:
  - Minor differential settlement in which no ponding can occur or in which the subsurface drainage will not be compromised shall be repaired by stripping topsoil, adding sandy soil, and replacing topsoil to attain a smooth surface before seeding.
  - If differential settlement has occurred to the extent that drainage is compromised, surface soils shall be removed in the area to expose the geomembrane. The geomembrane shall be cut back and sand added to attain the line grade. Geomembrane, protective soil, and topsoil shall be replaced and seeded with repair certification maintained in the site files.

Areas requiring repair due to erosion or settlement will be identified during annual site inspections which are detailed below in Section 3.2.

3.2 Periodic Inspection Requirements [40 CFR 257.104(d)(1)(i)]

Periodic site inspections verifying the integrity and effectiveness of the final cover system will be conducted throughout the 30-year post-closure period (estimated through 2048) on no less than an annual basis. When and if items requiring construction and/or maintenance are identified during an inspection, CEC will schedule and conduct repairs promptly while noting the risk associated with the deficiency. During site inspections, the inspector will walk the entire closed Ponds 1 and 2 area and document the problematic items. An example inspection form is provided in Appendix A – General Site Inspection Sheet.

If maintenance is required, only low ground-pressure tire or track equipment should be utilized to correct the deficiencies on closed portions of Ponds 1 and 2. Larger equipment can be used, but the equipment loading cannot exert more than five pounds per square inch (psi) on the liner material. The exterior dike is

not being capped, as it will serve as an access road around the site during construction of the final cover system.

If repairs to the geosynthetics (e.g., geomembrane, geotextile, etc.) are necessary, a certified geosynthetic installer must conduct the repairs under the direction of a quality assurance representative. Repairs will be documented in a report, and a copy will be placed in the site's operating record.

3.3 Site Use Restrictions [40 CFR 257.104(d)(1)(iii)]

Currently, the identified end use for Ponds 1 and 2 at JR Whtiing has been limited to securing the area and maintaining the site as described in Sections 3.1 and 3.2. If the area is to be developed in the future, the integrity of the geomembrane cover liner shall be confirmed with the proposed use; and institutional controls for maintaining the integrity of the geomembrane cover will be provided through an update to the post-closure plan. Once closed, the owner or operator must record a notation on the deed to the property. The notation on the deed must in perpetuity notify any potential purchaser of the property that:

- The land has been used as a CCR unit; and
- Its use is restricted under the post-closure care requirements as provided by Section 257.104(d)(1)(iii).

Use of the site will be restricted by either fencing and gating or procedure to prohibit access other than for performing inspections, maintenance, and monitoring; established easements; and to restrict the use of intrusive vehicles and activities at the site.

3.4 Groundwater Monitoring

Twelve groundwater monitoring wells were installed around Ponds 1 and 2 to establish a groundwater monitoring system under 40 CFR 257.91(e)(1) during the fourth quarter of 2015. The groundwater monitoring well locations are provided on Figure 2 – Site Map. Groundwater monitoring wells will be used to collect data to develop an initial RCRA annual groundwater monitoring and corrective action report that is required to be certified by a qualified professional engineer (QPE) and posted in the operating record by January 31, 2018 per 40 CFR 257.90(e). In conformance with 40 CFR 257.93, a groundwater sampling and analysis procedure plan was developed for the groundwater monitoring program. The plan is included in Appendix B – Groundwater Sampling Analysis and Procedure Plan and includes direction on how to perform or acquire the following:

- Groundwater elevations
- Sample collection and handling procedures
- Equipment decontamination procedures
- Chain of custody control
- Sample preservation and shipment
- Quality assurance/Quality control (QA/QC)

- Investigation derived waste (IDW)
- Field documentation
- Analytical suite and procedures
- Optional additional analyses
- Data evaluation

Once the CCR unit is certified closed, post-closure periodic groundwater samples will be collected at least semi-annually and analyzed for 30 years for the following constituents in Table 3.4.1 – Groundwater Detection Monitoring Constituents.

Table 3.4.1 – Groundwater Detection Monitoring Constituents

Common Name	
Boron	Fluoride
Calcium	Sulfate
Chloride	Total Dissolved Solids (TDS)
pH	-

If a statistically significant increase over background levels for one or more of the constituents listed in Table 3.4.1 is detected during groundwater detection monitoring, then CEC will follow the procedures outlined in 40 CFR 257.93(h) and 257.94(e). If required by 40 CFR 257.94(e), an assessment groundwater monitoring program will be established meeting the requirements of 40 CFR 257.95 for the constituents presented in Table 3.4.2 – Groundwater Assessment Monitoring Constituents. The data will be presented in an annual groundwater monitoring and corrective action report per 40 CFR 257.90(e).

Table 3.4.2 – Groundwater Assessment Monitoring Constituents

Common Name		
Antimony	Chromium	Mercury
Arsenic	Cobalt	Molybdenum
Barium	Fluoride	Selenium
Beryllium	Lead	Thallium
Cadmium	Lithium	Radium 226 and 228 combined

The annual groundwater monitoring and corrective action reports will be maintained in the JR Whiting operating record per 40 CFR 257.105(h)(1) and posted on a publicly accessible internet website per 40 CFR 257.107(h)(1). Additionally, the Michigan Department of Environmental Quality (MDEQ) will be notified per 40 CFR 257.106(h)(1) when the plan is available for their review.

If additional notification is warranted, CEC will notify appropriate parties per 40 CFR 257.106(h).

4.0 REFERENCES

"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.

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FIGURES

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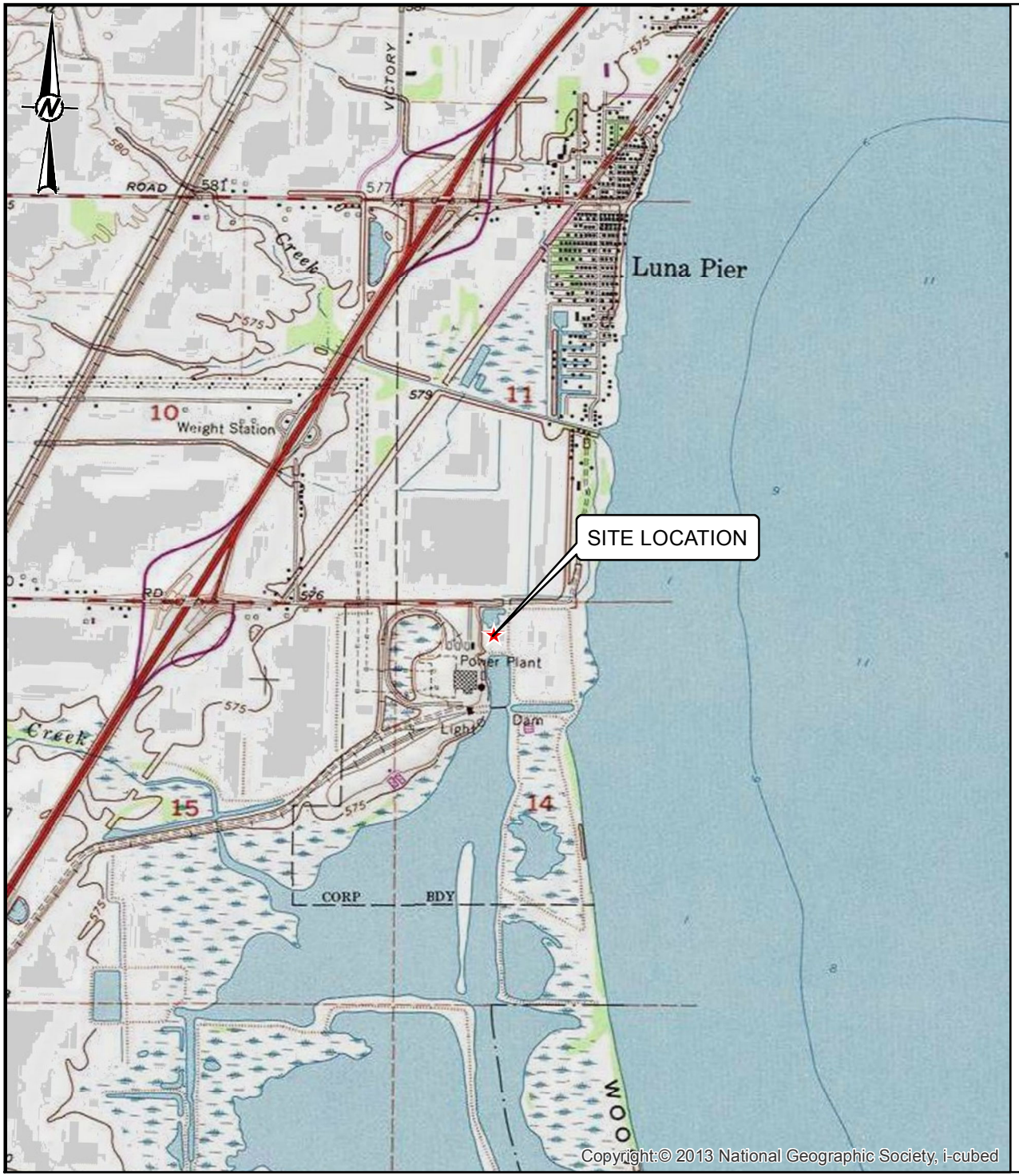

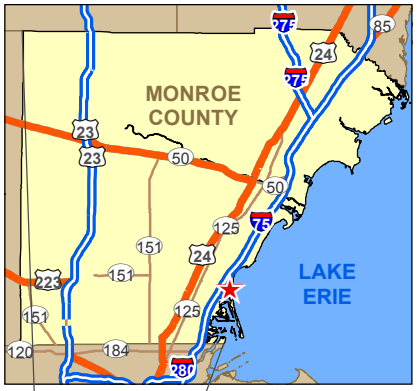

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Feet

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CONSUMERS ENERGY

PROJECT
J.R. WHITING GENERATING FACILITY
ERIE, MICHIGAN

TITLE
SITE LOCATION MAP

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-10-12
PREPARED	DJC
DESIGN	JP
REVIEW	
APPROVED	

PROJECT No.	CONTROL	Rev.	FIGURE
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CONSUMERS ENERGY COMPANY

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CONSULTANT

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YYYY-MM-DD	2017-10-12
DESIGNED	JP
PREPARED	DJC
REVIEWED	
APPROVED	

PROJECT
J.R. WHITING GENERATING FACILITY
ERIE, MICHIGAN

TITLE
RCRA MONITORING WELL LOCATIONS

PROJECT No.	CONTROL	Rev.	FIGURE
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APPENDIX A
GENERAL SITE INSPECTION SHEET

GENERAL SITE INSPECTION
J.R. WHITING PONDS 1 AND 2 CLOSURE AREA

Inspector:	***Inspection Date:***
Post Closure Manager:	**Review Date:**

SITE CONDITIONS	
Weather:	**Temperature:**
Precipitation:	**Wind:**

INSPECTION TASKS
1) Note areas of erosion (gullies exceeding 6 inches deep).
2) Note areas of sedimentation.
3) Note areas of settlement that have compromised surface drainage controls.
4) Note areas of ponding.
5) Note areas of vegetative stress.
6) Note areas of woody plant growth.
7) Note location of animal burrows.
8) Condition of ditches, culverts, riprap shoreline, and channels.

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9) Condition of site access road(s), silt fences surrounding the site.
10) Condition of fencing and gates.
11) Proper site restriction signage.
12) Miscellaneous findings.

ADDITIONAL COMMENTS

CORRECTIVE ACTION PLAN (To Be Completed by Post Closure Manager)

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APPENDIX B
GROUNDWATER SAMPLING ANALYSIS AND PROCEDURE PLAN

ARCADIS Design & Consultancy for natural and built assets

Consumers Energy Company

ELECTRIC GENERATION FACILITIES RCRA CCR DETECTION MONITORING PROGRAM

JR Whiting Monitoring Program
Sample and Analysis Plan
Erie, Michigan

May 18, 2016

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ELECTRIC GENERATION FACILITIES RCRA CCR DETECTION MONITORING PROGRAM

JR Whiting Monitoring Program Sample and Analysis Plan

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1 INTRODUCTION

ARCADIS has prepared this Groundwater Sampling and Analysis Plan (SAP) to evaluate background and downgradient groundwater quality at the JR Whiting electric generation facility (JRW), located in Erie, Michigan (Site). The collection of groundwater data will be completed to achieve compliance under the recently published 40 CFR Part 257, Subpart D – Standards for the Disposal of Coal Combustion Residuals (CCR) in Landfills and Surface Impoundments. The methodologies outlined in this SAP are consistent with the regulations, general federal and state guidance, ARCADIS and Consumers Energy (CE) Standard Operating Procedures (SOPs), and industry standards.

2 PURPOSE AND OBJECTIVES

The groundwater monitoring and corrective action compliance requirements for existing CCR units are set forth in 40 CFR 257.90 through 257.98. The groundwater sampling and analysis requirements are detailed in 40 CFR 257.93, and require the development of a SAP which details the sampling and analysis procedures that will be utilized to provide an accurate representation of groundwater quality at the background and downgradient wells. As per, 40 CFR 257.93(a) this SAP includes a description of the procedures and techniques that will be implemented for:

- Sample collection
- Sample preservation and shipment
- Analytical procedures
- Chain of custody control
- Quality assurance and quality control

3 IMPLEMENTATION AND SAMPLING SCHEDULE

As set forth in 40 CFR 257.93, a minimum of eight (8) background samples must be collected prior to October 17, 2017. Establishment of a groundwater monitoring system is necessary for the JR Whiting Pond 1&2 and Pond 6 (CCR Surface Impoundments).Background and detection monitoring events will be completed concurrently by comparison of data from monitoring wells located both away from (background) and downgradient of any impoundments still receiving ash as of the implementation date of the rule (October 19, 2015).

The sampling events will be distributed to account for seasonal variability and will be spaced at least 30 days apart to be considered statistically independent. The following is a conceptual schedule to be followed assuming sampling is completed in the middle of each calendar quarterly sampling interval beginning November 2015 and ending in August 2017 for a total of eight (8) independent samples. Adjustments to the timing of sampling events can be made as long as the requirements listed above are still met.

- Event 1 – 4th Quarter 2015 (November)

- Event 2 – 1st Quarter 2016 (February)
- Event 3 – 2nd Quarter 2016 (May)
- Event 4 – 3rd Quarter 2016 (August)
- Event 5 – 4th Quarter 2016 (November)
- Event 6 – 1st Quarter 2017 (February)
- Event 7 – 2nd Quarter 2017 (May)
- Event 8 – 3rd Quarter 2017 (August)

Resampling of a well due to an anomalous result, either relative to data collected from other monitoring wells of similar type, or relative to other time-series data at an individual monitoring well may be completed at any time. The timing of the resampling event, and the reason for additional data collection will determine if events are statistically dependent and inform the appropriate method for addressing interpretation or inclusion of data. Additional analytes may also be required pending the results of the quarterly monitoring events (in accordance with Section 257.94(e)). This document does not cover collection and analysis of such additional data.

4 SAMPLE COLLECTION AND HANDLING PROCEDURES

The following sections address the methods and procedures associated with the collection and handling of groundwater samples at the Site. The monitoring well locations are shown in Drawing SG-22374, and relevant construction details and monitoring purpose (e.g. background or downgradient) provided in Table 1. A total of twelve (12) monitoring wells are present at the JRW facility. Six monitoring are designated as downgradient monitoring wells to assess the uppermost aquifer at the site, which consists of limestone bedrock at approximately 50-70 feet below ground surface (bgs). Additionally, six (6) existing monitoring wells will be utilized to monitor background groundwater conditions as follows:

Historical Well Name	RCRA Well Name
82MW-1	JRW MW-15007
82MW-2	JRW MW-15008
79MW-3	JRW MW-15009
93MW-4	JRW MW-15010
93MW-5	JRW MW-15011
93MW-6	JRW MW-15012

4.1 Groundwater Elevations

Groundwater level data will be collected from all monitoring wells during each sampling event, prior to sampling. The monitoring well locations are depicted on Drawing SG-22374. Groundwater level monitoring will be conducted in accordance with Section 9.2 of the Low Stress (Low Flow) Purging and Sampling of Groundwater Monitoring Wells SOP presented in Appendix A.

Upon arrival at the site, all monitoring wells will be opened and allowed to equilibrate with ambient air pressures prior to measuring the depths to water. Groundwater level measurements will then be made to the nearest 0.01 foot with an electronic water level indicator from the entire monitoring well network prior to sampling – monitoring wells that constitute a groundwater monitoring system for a CCR Unit shall be preferentially sampled in order to further minimize water level elevational changes relative to the CCR Unit. The entire monitoring well network shall be gauged on the same day to minimize temporal bias of measured groundwater elevation changes for the monitoring well network. Depth to water will be measured from established top of casing reference points as referenced in the record survey drawing. Groundwater levels, well conditions, and any pertinent observations will be recorded on the depth to water level measurements field log provided in Appendix A.

The measured hydraulic gradient will be used along with previously completed hydraulic conductivity testing to determine the apparent groundwater rate and direction during each sampling event.

4.2 Groundwater Sample Collection

Groundwater samples will be collected from the monitoring wells following Low-Flow (Minimal Drawdown) Groundwater Sampling Procedures (US EPA, 1996), as detailed in the Low Stress (Low Flow) Purging and Sampling of Groundwater Monitoring Wells SOP (Appendix A). Low flow sampling will commence with the installation of either a peristaltic, stainless-steel 12-volt submersible impeller pump or bladder pump to a depth representing the middle of the saturated screen interval. An appropriate length of polyethylene tubing will be connected to the pump discharge prior to pump placement. The discharge line will be connected to a flow-cell and multi-meter to collect water quality indicator parameters (described below) during well purging to determine water quality stabilization.

The pump will be operated at a flow rate that ensures low volatilization and low well disturbance. Water quality indicator parameters and depth to water will be recorded at 3 to 5 minute intervals during the purging process and recorded on the sampling worksheet provided in Appendix B. Purging and sampling will proceed at a low pumping rate, expected to be between approximately 0.1 and 0.5 liters per minute or less, such that the water column in the well is not lowered more than 0.3 feet below the initial static depth to water measurement. The subject well will be considered ready to sample when three consecutive water quality measurements meet the stabilization criteria presented below.

Parameter	Stabilization Criteria
pH	3 readings within +/- 0.1 standard units (SU)
Specific Conductance	3 readings within +/- 3% millisiemens per centimeter (mS/cm)

Temperature	For Information Only
Turbidity	+/- 10% Nephelometric Turbidity Unit (NTU) variance between three consecutive readings and a turbidity less than 10 NTU
Oxygen Reduction Potential (ORP)	3 readings within +/- 10 millivolts (mV)
Dissolved Oxygen (DO)	3 readings within +/- 0.3 milligrams per liter (mg/L)

If the well is dry, no attempt at sampling will be conducted, as the aquifer is not considered to have sufficient quantity at that location. Additionally, if the well is pumped dry during low-flow monitoring activity, the well will be left overnight to accumulate water, then a sample collected assuming the NTU criteria can be met. Prior to use, all equipment will be calibrated in accordance with the manufactures recommendations. Calibration information will be recorded in the field notes.

4.3 Sample Preservation and Shipment

Samples will be collected immediately following stabilization of field parameters as set forth in in the preceding section. Groundwater samples will be collected into the laboratory provided sample containers required for the analyses specified in the following section. The groundwater samples will be collected from the discharge tubing upstream of the water quality meter flow cell. Care will be taken to allow for a non-turbulent filling of laboratory containers. Routine samples will not be filtered in the field to provide a measure of total recoverable metals that will include both the dissolved and particulate fractions of metals as per the CCR RCRA Rule.

If a more detailed understanding of the source of metals concentrations in groundwater is required for select monitoring wells, field filtered samples may be analyzed in addition to routine analysis. Field filtering may also be completed on highly turbid samples (greater than 10 NTU at stabilization). Field filtering will be completed using a 0.45 micron filter. If required, an attempt will be made to redevelop any monitoring wells that produce highly turbid prior to the subsequent sampling event. Where samples are filtered, a corresponding, unfiltered sample will also be collected.

The samples will be labelled, stored and transported to the laboratory according to the Chain-of-Custody, Handling, Packing and Shipping SOP presented in Appendix B. Following collection, samples will be immediately labelled, logged on the chain-of-custody, and placed in a cooler with ice. Sample coolers transported to the laboratory via overnight or next day air freight will be sealed with packing tape and a signed Chain-of-Custody seal. Sample coolers transported to the laboratory directly must be secured to ensure sample integrity is maintained. The samples will be packaged and shipped according to U. S. Department of Transportation and EPA regulations. The documentation of actual sample storage and transport will be by the use of chain-of-custody procedures. A laboratory provided chain-of-custody record will contain the dates and times of collection, receipt, and completion of all the analyses on a particular set of samples. The laboratory will return a copy of the chain-of-custody with the analytical report.

4.4 Quality Assurance/Quality Control (QA/QC)

Quality assurance/quality control (QA/QC) samples will be collected to ensure sample containers are free of analytes of interest, assess the variability of the sampling and laboratory methods, and monitor the effectiveness of decontamination protocols. The following QA/QC samples will be collected during each groundwater sampling event:

- Field duplicates will be collected at a frequency of one duplicate sample per 10 groundwater samples with at least one duplicate collected from each Unit. The field duplicates will be collected at the same time and in the same manner as the original sample. The duplicates will be labeled as a blind sample and noted on the sampling form of the designated well.
- Matrix spike/matrix spike duplicate (MS/MSD) samples will be collected at a frequency of one MS/MSD sample per 20 groundwater samples with at least one MS/MSD from each Unit. Duplicate and MS/MSD samples will be collected from different monitoring wells.
- Field blanks will be collected at a frequency of one field blank per 20 groundwater samples with at least one field blank collected from each Unit.
- Equipment blanks will be collected at a frequency of one equipment blank per 10 groundwater samples with at least one equipment blank collected from each Unit. The equipment blank will be collected by pouring distilled or deionized water over the decontaminated static water level meter or low flow pump and into the laboratory supplied containers.

The groundwater monitoring system at JRW consists of 12 monitoring wells. Therefore, a total of 2 field duplicates, 1 MS/MSD, 1 field blank, and 2 equipment blanks will be collected during each sample event. The QA/QC samples will be submitted to the laboratory for the routine analyses specified in Section 5 and in Appendix III and IV to Part 257. The laboratory should provide adequate documentation of laboratory reporting and QA/QC procedures.

4.5 Equipment Decontamination Procedures

All non-dedicated equipment will be decontaminated prior to use and between samples, following procedures presented in paragraph 9.6 of the SOP in Appendix A. Non-dedicated equipment will include a water level meter and low flow sampling pump (submersible). Each item will be cleaned using distilled or deionized water, and when necessary, and non-phosphate detergent wash followed by a distilled or deionized water rinse. When a peristaltic pump is used for low flow sampling, decontamination is not required, only replacement of the pump head tubing.

All dedicated equipment will be disposed of after each sampling point. Dedicated equipment will include polyethylene tubing and bladders if a bladder pump is used for low-flow sampling.

The flow-cell and water quality multi-meter (sonde) will be decontaminated at the completion of low-flow sampling. All sample collection will occur upstream of this device and therefore will not affect groundwater sample analytical results.

4.6 Investigation Derived Waste (IDW)

All waste created during monitoring well sampling will remain on site. All purge water from wells installed within the CCR Units will be discharged back onto the ground near the well it was purged from. All purge water from wells installed outside of a CCR Unit will be discharged to the ground in a manner that it doesn't directly enter a surface water or drain. All IDW will be handled according to details provided in paragraphs 9.3.8 and 9.4.10 of the SOP provided in Appendix A.

4.7 Field Documentation

All information pertinent to the field activities and sampling efforts will be recorded in a log or notebook, following the documentation procedures presented in section 5.4 of the SOP in Appendix B. Field logs are provided in the Attachments to Appendix A. At a minimum, entries in the sample logs will include the following:

- Property details and location
- Type of sample (for example, groundwater, surface water, waste)
- Number and volume of samples taken
- Sampling methodology
- Date and time of collection
- Sample identification number(s)
- Field observations including weather
- Any field measurements made (for example, pH, temperature, water depth and air monitoring data)
- Personnel present

Records shall contain sufficient information so that the sampling activity can be reconstructed without relying on the collector's memory. The sample logs will be preserved in electronic format.

5 ANALYTICAL SUITE AND PROCEDURES

As required for existing CCR units, all groundwater samples collected at the JRW facility will be submitted to a laboratory for the analyses specified in Appendix III and IV to Part 257. The analytical methods and practical quantitation limits for each constituent are summarized below. If required, and in consultation with the laboratory, a comparable analytical method may be substituted for the analytical method recommended below. Analytical methods may also be modified to incorporate newer versions of the stated methods. All groundwater samples will be submitted to Consumers Energy Trail Street Laboratory. If any analyses are subsequently subcontracted to another accredited laboratory, the samples will be shipped using appropriate methods and COC documentation. All analyses will be performed within required hold times and consistent with the data quality objectives of this SAP.

Appendix III to Part 257—Constituents

Constituent	Analytical method	Preservation	Hold Time (Days)	Reporting Limit (µg/L)
Boron	EPA 6020B	HNO_3, pH <2	180	20
Calcium	EPA 6020B	HNO_3, pH <2	180	1,000
Chloride	EPA 300.0	None, <6ºC	28	1,000
Fluoride#	EPA 300.0	None	28	1,000
pH	Stabilized field measurement	NA	NA	0.1 standard units
Sulfate	EPA 300.0	None, <6ºC	28	2,000
Total Dissolved Solids	SM 2540C	None, <6ºC	7	1,000

HNO_3 – Nitric acid
NA – Not applicable

Appendix IV to Part 257—Constituents

Constituent	Analytical method	Preservation	Hold Time (Days)	Reporting Limit (µg/L)
Antimony	EPA 6020B	HNO_3, pH <2	180	1
Arsenic	EPA 6020B	HNO_3, pH <2	180	1
Barium	EPA 6020B	HNO_3, pH <2	180	5
Beryllium	EPA 6020B	HNO_3, pH <2	180	1
Cadmium	EPA 6020B	HNO_3, pH <2	180	0.2
Chromium, total	EPA 6020B	HNO_3, pH <2	180	1
Cobalt	EPA 6020B	HNO_3, pH <2	180	15
Fluoride#	EPA 300	None, <6ºC	28	1,000
Lead	EPA 6020B	HNO_3, pH <2	180	1
Lithium	EPA 6020B	HNO_3, pH <2	180	10
Mercury	EPA 7470A	HNO_3, pH <2	28	0.2
Molybdenum	EPA 6020B	HNO_3, pH <2	180	5
Selenium	EPA 6020B	HNO_3, pH <2	180	1
Thallium	EPA 6020B	HNO_3, pH <2	180	2
Radium 226 and 228 combined^	EPA 903.1/904.0	HNO_3, pH <2	None	1 picocurie per liter (pCi/L)

[#] *Listed in both Appendix III and Appendix IV*

^Requires a larger sample volume (minimum 2 liter)

5.1 Optional Additional Analyses

To interpret groundwater monitoring data and determine the appropriate statistical methods for use in comparison of background and downgradient data sets, an understanding of aquifer connectivity and water types may be required. To determine if samples are collected from comparable aquifer units the predominant water type will be determined using Piper and Stiff diagrams.

Piper and Stiff diagrams are a graphical representation of the major anion and cation composition of a water sample and are useful in establishing if groundwater samples are from the same or a similar aquifer unit. To generate Piper and Stiff diagrams additional analytical data beyond that collected during routine sampling will be required. The additional analytical requirements are shown in the table below.

Constituent	Analytical method	Preservation	Hold Time (Days)	Reporting Limit (µg/L)
Bicarbonate, carbonate and total alkalinity	ASM 2320B	None, 6ºC	14	10,000
Magnesium	EPA 6020B	HNO_3, pH <2	180	1,000
Sodium	EPA 6020B	HNO_3, pH <2	180	1,000
Potassium	EPA 6020B	HNO_3, pH <2	180	500

6 DATA EVALUATION

In accordance with 40 CFR 257.93 data collected from eight samples from each background well will be used to calculate background concentrations for each constituent at each site. Background concentrations for each constituent will be calculated using an appropriate statistical method for each background well and constituent pair at the site, selected based on the distribution of the data in accordance with 40 CFR 257.93.

The data collected from background and downgradient monitoring wells will be compared using an appropriate statistical method, to be determined based on the distribution of data for each constituent, to assess if downgradient concentrations are consistent with background concentrations for each constituent. The statistical method used for this analysis will be one, or a combination, of the four statistical methods described below and in 40 CFR 257.93(f) and will meet the performance standards outlined in 40 CFR 257.93(g).

A combination of statistical methods may be applied depending on the statistical distribution observed for each specified constituent in each monitoring well. The four specific statistical procedures provided in 40 CFR 257.93(f) are: (1) a parametric analysis of variance followed by multiple comparison procedures to identify statistically significant evidence of contamination; (2) an analysis of variance based on ranks followed by multiple comparison procedures to identify statistically significant evidence of contamination; (3) a tolerance or prediction interval procedure; and (4) a control chart approach.

The potential for seasonal and spatial variability as well as temporal trends will be considered when selecting the statistical method for comparison. Data will also be displayed graphically using box-and–whisker plots to aid in interpretation of the statistical analysis.

In order to select the appropriate method for statistical analysis for each constituent at each monitoring well, the distribution type for each constituent/well pair will be calculated. Normally distributed data will use parametric methods for comparisons and non-normally distributed data will use non-parametric methods, consistent with the requirements outlined in 40 CFR 257.93(g).

Statistical comparisons will be performed using a confidence level of 99 percent (alpha of 0.01) for comparisons of individual data point to background concentrations, and a confidence level of 95 percent (alpha of 0.05) where multiple data points will be compared to background, consistent with 40 CFR 257.93(g).

TABLES

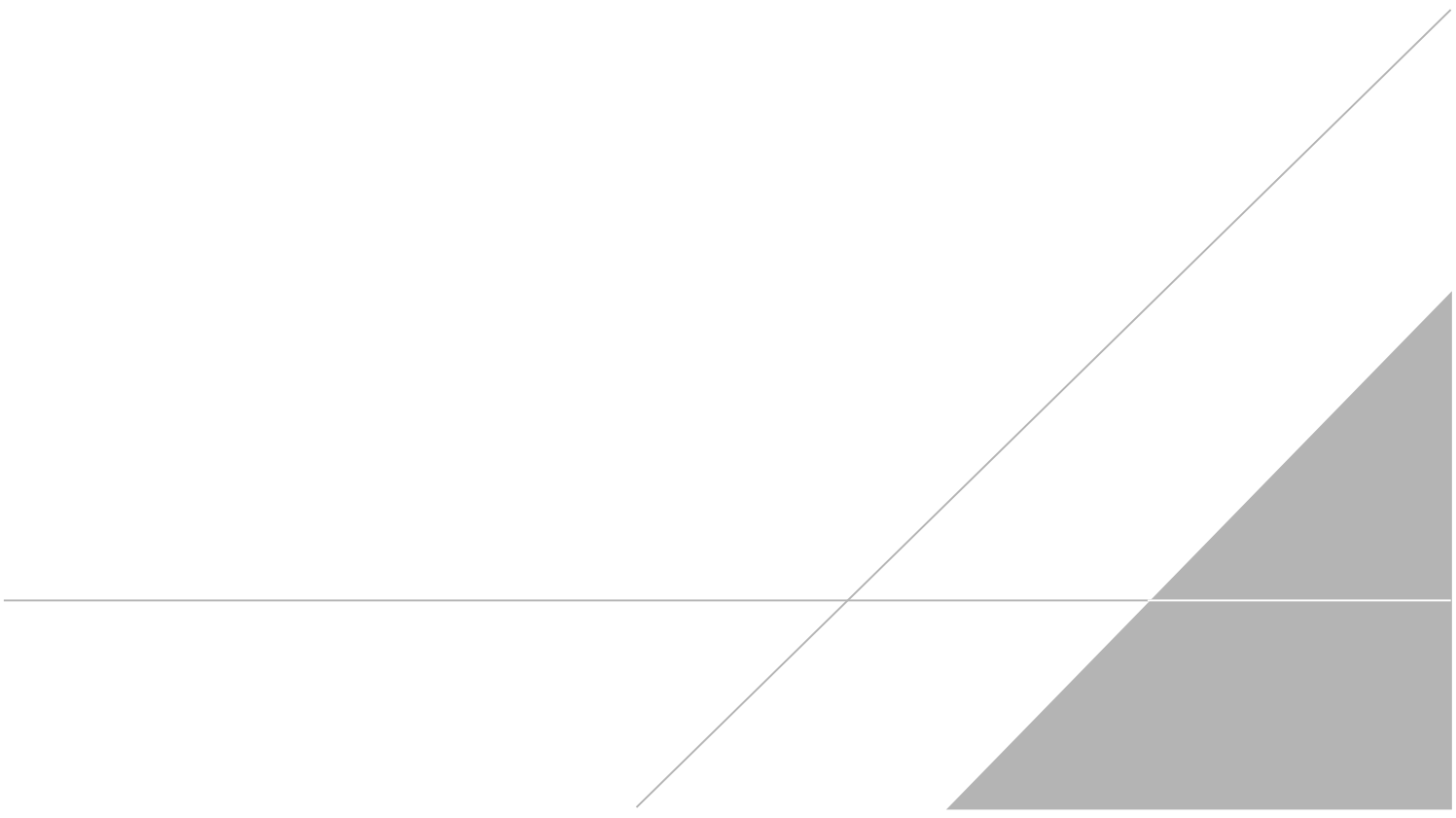

Table 1
Monitoring Well Construction Summary
Consumers Energy Co.
J.R. Whiting Generating Facility
Erie, Michigan

ARCADIS Design & Consultancy for natural and built assets

MW ID	Former MW ID	Site Coordinates				Date Installed	Geologic Unit of Screen Interval	Well Construction	Well Screen Length (ft)	Screen Interval (ft bgs)	Static DTW (ft below TOC)	Total Depth
		Northing	Easting	Ground Surface Elevation (ft above msl)	TOC Elevation (ft above msl)							
Downgradient MW												
JRW MW-15001	---	108330.83	13374236.18	589.60	590.71	10/26/2015	Limestone	2" PVC, 10 slot	10	78 - 88	21.34	91.25
JRW MW-15002	---	108651.05	13374586.78	590.60	592.31	10/28/2015	Limestone	2" PVC, 10 slot	10	81 - 91	21.89	94.39
JRW MW-15003	---	108321.86	13374980.23	589.60	591.36	10/29/2015	Limestone	2" PVC, 10 slot	10	81 - 91	19.87	94.28
JRW MW-15004	---	107881.56	13375045.59	590.80	592.52	10/30/2015	Limestone	2" PVC, 10 slot	10	86 - 96	23.27	99.60
JRW MW-15005	---	107545.15	13374686.90	592.70	594.25	11/2/2015	Limestone	2" PVC, 10 slot	10	86 - 96	25.28	99.48
JRW MW-15006	---	107843.22	13374281.80	590.30	592.01	11/4/2015	Limestone	2" PVC, 10 slot	10	81 - 91	25.30	94.36
Background MW												
JRW MW-15007	82-MW-1	109293.21	13373656.23	587.10	588.38	5/4/1982	Dolomite/Limestone	2" SS with galvanized riser	3	84 - 87	Not developed	
JRW MW-15008	82-MW-2	110906.21	13373613.03	588.40	587.88	5/4/1982	Dolomite/Limestone	2" SS with galvanized riser	3	94 - 97	Not developed	
JRW MW-15009	79-MW-3	109884.39	13374455.32	585.30	586.11	NA	NA	NA	NA	NA	Not developed	
JRW MW-15010	93-MW-4	110458.57	13373631.59	587.10	588.09	6/28/1993	Dolomite/Limestone	2" SS with galvanized riser	3	60 - 63	Not developed	
JRW MW-15011	93-MW-5	109790.80	13373648.04	587.50	588.71	6/30/1993	Dolomite/Limestone	2" SS with galvanized riser	3	62 - 65	Not developed	
JRW MW-15012	93-MW-6	110169.45	13374463.62	585.80	587.19	7/1/1993	Dolomite/Limestone	2" SS with galvanized riser	3	66 - 69	Not developed	

Notes:
ft = feet
bgs = below ground surface
TOC = top of casing
NR = Not recorded
NA = Not applicable
msl = mean sea level

FIGURES

Typical Background Monitoring Well
Pictures

Typical Surface Impoundment Monitoring Well
Pictures

Surface Impoundment Monitoring Wells							
Pt #	Northing	Easting	Ground	Top Casing	Name	Latitude	Longitude
5902	107843.22	13374281.80	590.3	592.01	JRW MW-15006	41.792150	-83.446597
5904	107545.15	13374686.90	592.7	594.25	JRW MW-15005	41.791322	-83.445125
5906	107881.56	13375045.59	590.8	592.52	JRW MW-15004	41.792233	-83.443797
5908	108321.86	13374980.23	589.6	591.36	JRW MW-15003	41.793444	-83.444017
5910	108651.05	13374586.78	590.6	592.31	JRW MW-15002	41.794358	-83.445447
5912	108330.83	13374236.18	589.6	590.71	JRW MW-15001	41.793492	-83.446744
Background Monitoring Wells							
Pt #	Northing	Easting	Ground	Top Casing	Name	Latitude	Longitude
5915	109293.21	13373656.23	587.1	588.38	JRW MW-15007	41.796147	-83.448833
5917	109790.80	13373648.04	587.5	588.71	JRW MW-15011	41.797514	-83.448844
5919	110458.57	13373631.59	587.1	588.09	JRW MW-15010	41.799347	-83.448878
5921	110906.21	13373613.03	588.4	587.88	JRW MW-15008	41.800575	-83.448928
5923	110169.45	13374463.62	585.8	587.19	JRW MW-15012	41.798528	-83.445839
5925	109884.39	13374455.32	585.3	586.11	JRW MW-15009	41.797747	-83.445881
Survey Control Points							
Pt #	Northing	Easting	Plant Elev	NAVD88	Name	Latitude	Longitude
1	107278.26	13374902.72	590.9	589.99	TP	41.790583	-83.444344
2	108903.66	13374018.38	600.0	599.20	TP	41.795069	-83.447522
4	111273.97	13373688.48	600.1	599.18	TP	41.801583	-83.448636
7	108765.66	13374471.45	577.9	577.09	TP	41.794678	-83.445867
9	108697.62	13372712.75	577.2	576.31	NE Sec. 15	41.794542	-83.452317
10	108610.28	13367111.76	580.4	579.56	BM Q178	41.794467	-83.472856
1918	108101.94	13374607.57	590.4	589.51	TP	41.792850	-83.445394
2168	109013.11	13374349.04	600.8	600.00	TP	41.795358	-83.446306
3081	108683.22	13373439.66	578.0	577.05	CP	41.794481	-83.449653

Elevations are NAVD88 from Benchmark (BM) Q 178 per NGS Data Sheet (Not Shown, Approximately 1.1 miles West of Northeast Corner Section 15. On 11-19-2015, a level loop was performed between BM and Control Point (CP) #3081. A second loop was done from CP to Traverse Point (TP) #1918 and to TP #2168. On 11-20-15, a loop was performed utilizing TP #1918 to determine elevations on Monitoring Wells at Top of Pipe on Pond 1 & 2 and TP #1 (not shown). Another loop was performed from TP #2168, determining elevations for MWs and TP #4 & #2 on Pond 6. Ground elevations at base of MW pipe were obtained on 11-10-15 by GPS observation.

Elevation Basis

BM Q 187
Elevation = 579.56' NAVD88

Coordinate Basis

State Plane Coordinates Michigan South Zone 2113
MDOT CORS VRS (G12AUS)

Legend

-- CCR UNIT Monitoring Well
-- Background Monitoring Well
-- Traverse Point
-- Section Corner

GRAPHIC SCALE

100 0 50 100 200 400
(IN FEET)
1 inch = 100 ft.

SF-19884	Sheet 34, Pond 1 & 2																DN.	RST	11-24-15
SF-19884	Sheet 35, Pond 6																FLD.	DEE	11-10-15
																	CHKD.		
	FIELD BOOK NO. 1997A										A	12/7/15	Changes per email request		RST		APP.		
DRAWING NO.	REFERENCE DRAWINGS	REV.	DATE	DESCRIPTION	BY	APP.	REV.	DATE	DESCRIPTION	BY	APP.	REV.	DATE	DESCRIPTION	BY		APP.	DEPARTMENT HEAD	

Consumers Energy

SHERIDAN SURVEYING CO.
910 Fifth Street Michigan Center, MI 49254

Whiting Plant Monitoring Wells
CCR Monitoring

Sec. 11 & 14
City of Luna Pier

SAP WO #25477976

T8S, R8E
Monroe County

SCALE: 1" = 100'
CE FILENAME: 22374base.dwg
SSC FILENAME: 3708_SPCadj.dwg

Drawing No. SG-22374
Sheet 1
Rev. A

APPENDIX A

Low Stress (Low Flow) Purging and Sampling of Groundwater Monitoring Wells SOP (Procedure CHEM-2.7.06)

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

Written or Revised by Katharyn L Schlueter Date 08/07/09
Level I or Above

Technical Review by Gordon L Cattell Date 08/07/09
Level II or Above (not author)

Technical Approval by Emil Blaj Date 08/07/09
Level III

This electronically produced document has been reviewed and approved by the above-named individuals. The original document bearing the approval signatures is maintained on file by Consumers Energy, Laboratory Services.

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

1.0 SCOPE

1.1 This procedure is a general method for collecting low stress/low flow ground water samples from monitoring wells. Upon approval by the responsible party, this procedure may be used as a substitute for macro-purging techniques where 3 to 5 well volumes have traditionally been purged prior to sampling. The low stress/low flow method is the preferred technique for ground water monitoring wells located at the former Manufactured Gas Plant (MGP) sites of Consumers Energy.

1.2 The presented technique applies to monitoring wells that have an inner casing with a nominal diameter of at least 1.0 inch, and maximum-screened lengths of ten feet per interval.

1.3 The technique is appropriate for collection of ground water samples that will be analyzed for: volatile and semi-volatile organics including pesticides and polychlorinated biphenyls (PCBs), total and dissolved metals, and various other analytes such as sulfates, cyanides, and nitrates/nitrites.

1.4 The technique is also appropriate when the following conditions are desired: lower turbidity in the sample containers, significantly less purge water for disposal, and higher analyte repeatability.

2.0 APPLICABLE DOCUMENTS AND REFERENCES

2.1 CHEM-1.1.02, Chemistry Department Procedure Requirements.

2.2 Ground Water Issue, Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures, Puls and Barcelona, USEPA, Office of Research and Development, Office of Solid Waste and Emergency Response, EPA/540/S-95/504, April 1996.

2.3 Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Ground Water Samples From Monitoring Wells, USEPA Region 1, SOP No GW 0001, Revision 2, July 30, 1996.

2.4 Technical Guidance on Low-Flow Purging and Sampling and Passive Sampling, D M and G L Nielson, The Nielson Environmental Field School, NEFS-TG001-99, December 1999.

2.5 Manufacturer Operation Manual, as appropriate.

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

2.6 Standard Guide for Purging Methods for Wells Used for Ground-Water Quality Investigations, D6452-99, American Society for Testing and Materials.

2.7 MDEQ RRD Operational Memorandum 2, Attachment 5, Sampling and Analysis, October 2004, Revision.

2.8 Field worksheets (Attachments A-D).

3.0 DEFINITIONS

3.1 COC – Chain of Custody

3.2 NAPL – Non-aqueous Phase Liquids

3.3 LNAPL – Light Non-aqueous Phase Liquids

3.4 DNAPL – Dense Non-aqueous Phase Liquids

3.5 DTW – Depth-to-Groundwater

4.0 SUMMARY OF METHOD

4.1 Once depth-to-water is measured; a suitable pumping device is lowered to the target depth, generally mid-screen. Ground water is purged from the well casing at a slow rate, typically 100-500 mL/minute. While drawdown is measured and minimized, the purged water is diverted to a flow cell that contains several probes for indicating stabilization parameters, such as pH, conductively, etc. Once the parameters have stabilized within pre-determined limits, the purged water stream is diverted from the flow cell to sample containers for collection of proper test parameters.

5.0 PREREQUISITES

5.1 MEASURING AND TEST EQUIPMENT

5.1.1 Flow-cell, hand-held monitor, and sonde, containing in-line probes calibrated for at least dissolved oxygen and oxidation-reduction potential (ORP). If necessary, pH and conductivity may be monitored with external monitors, although in-line probes are recommended. Turbidity or other probes/monitors may be added as site-specific requirements dictate.

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

5.1.2 Adjustable rate groundwater pumping devices including: Peristaltic pump with pump head and electrical power source; bladder pump(s) with controller and a source of compressed air; gear pump (Keck or "bullet"), with controller and electrical power source. Gear and bladder pumps should be constructed of stainless steel or PTFE.

5.1.3 Tubing of the appropriate size, length, and material.

5.1.4 Interface probe for determining the presence or absence of NAPLs.

5.1.5 Water level measuring device with a minimum 0.01-foot accuracy.

5.1.6 Flow measurement supplies such as a rotometer or graduated cylinder with a stopwatch.

5.1.7 Portable PID meter, calibrated the same day as use.

5.1.8 Decontamination supplies, including deionized water, brushes, buckets, and commercially available 2-propanol soaked wipes.

5.1.9 Sample bottles with appropriate preservatives.

5.1.10 Field hazardous materials kit, including eyewash, sampling gloves, goggles, earplugs, etc.

5.1.11 Purge water collection device, such as a sturdy plastic bucket.

5.2 REAGENTS

5.2.1 Assorted standards as needed to fully calibrate the above system.

5.3 CALIBRATION REQUIREMENTS

5.3.1 All meters, probes, etc must be calibrated according to manufacturer's instructions. Periodic checks are recommended during or at the end of the day to ensure the calibration curves. Written documentation is required for all calibrations and periodic checks.

5.3.1.1 In general, daily recalibration will be required. In some cases where a periodic check indicates the calibration curves are still valid, no daily calibration may be necessary.

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

5.4 QUALITY CONTROL DOCUMENTS AND RECORDS

5.4.1 Historical documentation, including well construction data (eg, screen depth), well location map, and field data from a previous sampling event.

5.4.2 Material Safety Data Sheets (MSDSs) for all reagents taken to the job site.

5.4.3 A field log book or field worksheet must be kept at each sampling event (see Attachments A-D). The following should be documented:

5.4.3.1 Field instrumentation calibration data.

5.4.3.2 Monitoring well identification number and physical condition.

5.4.3.3 Monitoring well data such as casing material, casing diameter, and screen length.

5.4.3.4 Monitoring well depth and DTW, measurement technique, date and time of measurement.

5.4.3.5 Presence and thickness of NAPLs and detection method.

5.4.3.6 Sample tubing material, diameter, length, placement, and pump type.

5.4.3.7 Pumping rate, water level, water quality indicator values, date and time of measurements.

5.4.3.8 Identification of any unacceptable water quality indicator values.

5.4.3.9 Time and date of sample collection.

5.4.3.10 Sample ID and control number.

5.4.3.11 Field observations.

5.4.3.12 Sampler’s name or initials.

5.4.4 The COC must contain the analytical parameters requested, sample time and date, sampler’s name or initials, site location, sample ID, control number, preservatives added, and filtration status.

5.4.5 The sample labels must contain the sample ID, control number, sample time and date, sampler's initials, preservative, filtration status, and analytical parameter requested.

5.4.6 Field worksheets (Attachments A-D).

5.4.6.1 Monitoring Well Sampling Worksheet (Attachment A)

5.4.6.2 Monitoring Well Depth-To-Water Measurements Worksheet (Attachment B)

5.4.6.3 Flowcell/Sonde Calibration and Periodic Checks Worksheets (Attachment C)

5.4.6.4 Field Screening of Monitoring Wells Via PID (Attachment D)

5.5 PERSONNEL REQUIREMENTS

5.5.1 All tests and data reporting shall be performed by certified persons of Level I or above, in the appropriate discipline. (The project report shall be issued and reviewed by a certified person of Level II or above, in the appropriate discipline. The project report, if so indicated on the work request [or form similar in intent], may require approval from a certified person of Level III, in the appropriate discipline.)

5.6 ENVIRONMENTAL CONDITIONS

See Section 6.0.

6.0 PRECAUTIONS

6.1 The site-specific Health and Safety Plan is used to identify any physical or chemical precautions and actions to be taken to prevent injury. A pre-job briefing shall be conducted prior to initiating sampling.

6.2 Observe normal safety practices as specified in the latest online revision of the Environmental and Laboratory Services Accident Prevention Manual and the Consumers Energy Chemical Hygiene Plan in Lotus Notes.

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

7.0 LIMITATIONS AND ACTIONS

7.1 This technique is generally not suitable for very low-yield wells (<50 mL/minute with continued drawdown).

7.2 Even with pre-planning, a number of problems may be encountered which will challenge the sampler. These include: insufficient yield, failure of one or more key indicator parameters to stabilize, cascading, and equipment failure. Each of these problems will be addressed on a case-by-case basis and their impact can be minimized by consulting the references in Section 2.

7.3 This method does not address the collection of light or dense non-aqueous phase liquids (LNAPLs and DNAPLs). Collection of these sample types is both atypical and non-standardized and must therefore be addressed on an as-needed basis.

8.0 ACCEPTANCE CRITERIA

Refer to Section 9.3.9.3 in this procedure.

9.0 PROCEDURE

9.1 Orient the equipment and yourself upwind of the monitoring wells if possible.

9.2 DETERMINATION OF DEPTH-TO-GROUNDWATER (DTW)

9.2.1 Start at either the well known, or believed to have, the least contaminated groundwater and proceed systematically to the well known, or believed to have, the highest level of contamination.

9.2.2 Check the well casing protector, lock, locking cap, and well casing for obvious damage or evidence of tampering. Record any abnormal observations.

9.2.3 The sampler may desire to minimize contamination from the ground and provide a clean area for laying down equipment. This can be accomplished by cutting a section from a sheet of plastic and fitting it around the well casing protector.

9.2.4 Remove the well cap. At some sites, it may be necessary to remove all well caps first, then proceed to 9.2.5. This will be determined prior to any field events.

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

9.2.5 If the site has not been characterized yet, or there is insufficient history, it will be useful to determine the concentration of organic vapors in the heads case. Using a portable, calibrated, PID meter measure and record the organic vapor concentration as follows: (1) At the highest risk breathing zone elevation, defined here as the point located at roughly 6" above the center of the top of the well casing. (2) At 0-6" within the well casing.

9.2.6 If the well casing does not have a reference point, make one. The reference point is typically a V-cut or an indelible mark in the well casing.

9.2.7 Measure and record the DTW to 0.01 feet. Duplicate the reading. Hold the tape against the reference point when making the reading. Care should be taken to minimize disturbance of the water column.

9.2.8 Measure and record the thickness and depth of any NAPLs.

9.2.9 If desired or required by the site plan, measure the depth of the well. Care should be taken to minimize disturbance of the water column and any sediment that has accumulated.

9.2.10 Decontaminate the electronic tape and interface meter. Wipe dry using a clean Kaydry-type material. Rinse with DI water and wipe dry again. If organic contamination is suspected, the sampler must decontaminate accordingly before proceeding. One option is to use commercially prepared decontamination wipes that are saturated with 2-propanol.

9.2.11 If the monitoring well will be sampled the same day and will remain in visual range and/or without a reasonable risk of tampering, loosely recap the well and leave the well casing protector unlocked. Otherwise, secure the well as if not returning.

9.2.12 If a sheet of plastic has been fitted around the well casing protector, leave it in place if the well will be sampled the same day.

9.2.13 Continue with the determination of DTW on the rest of the monitoring wells. Continue with purging and sampling when appropriate (ie, large distance between wells).

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

9.3 PURGING

9.3.1 If not already determined at the laboratory or by prior sampling events, determine the type of pump to be used (operation of each pump type will not be covered here).

9.3.2 For ease of use and portability, a peristaltic pump may generally be used for any well where DTW plus casing height above grade does not exceed 15 feet.

9.3.3 Keck (gear or "bullet") and bladder pumps can be used in any instance where there is sufficient water in the casing to completely submerge the pump and intake screen at all times.

9.3.4 Use well installation and historical data to determine the length of tubing needed to place the pump intake or tubing at the desired sample depth, generally mid-screen. Attach the tubing to the pump and prepare to lower the tubing or tubing/pump down the well. To keep from introducing contamination into the monitoring well, never allow the tubing or tubing/pump to touch bare ground.

9.3.5 Install the tubing or pump/tubing. Slowly lower the pump, tubing, and any safety cable and electrical lines into the monitoring well. Final placement is generally at mid-screen. Typically, the intake must be kept at least 2 feet above the bottom of the well to prevent disturbance and resuspension of any sediment or NAPL present in the bottom of the well. Once the desired depth is reached, clamp or otherwise secure the tubing to prevent the pump/tubing from dropping any lower. Record the depth to which the pump was lowered.

9.3.6 Before starting the pump, wait a few minutes and measure the water level again. Record this level. This short waiting period allows for reduced turbidity and reequilibrium of the water level. Leave the electronic tape in the well for later use.

9.3.7 Attach the in-line flow cell. Start the pump and collect roughly 100 mL/minute. Start with a faster or slower pumping rate if historical data suggests to do so.

9.3.8 Collect all water for proper disposal.

9.3.9 Monitor and record the water quality parameters and water level every 3-5 minutes.

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

9.3.9.1 Ideally, a steady flow rate should be maintained that results in a stabilized water level. Pumping rates should be reduced or increased to ensure stabilization of the water level in the well. Avoid entrainment of air in the tubing.

9.3.9.2 Record the time of the readings and the pump rate.

9.3.9.3 The well is considered stabilized and ready for sample collection when the indicator parameters have stabilized for three consecutive readings as follows:

- ± 0.1 pH units
- ± 3% conductivity units (specific conductance)
- ± 10 mV for redox potential (Eh/ORP)
- ± 10% for DO and turbidity
- Temperature – For information only. Record only.

Dissolved oxygen and turbidity usually require the longest time to achieve stabilization. (Above criteria may not apply to very clean wells.)

9.4 SAMPLE COLLECTION

9.4.1 The pump must not be removed from the well between purging and sample collection. It is recommended that the pump not be turned off between purging and sample collection. Continue to collect excess groundwater for proper disposal.

9.4.2 Disconnect or bypass the flow cell.

9.4.3 Collect samples at the same flow rate as the purging rate. Minimize potential contamination from dust, rain, etc by shielding the open bottles as needed.

9.4.4 Samples will be collected directly into the sample containers. Minimize aeration by allowing the water to flow down the side of the container rather than splashing against the bottom of the bottle. Avoid placing the sample tubing below the liquid level of the sample being collected. Label the containers and chill immediately.

9.4.5 VOC samples must be collected first except as noted below for Low Level Mercury. Check for air bubbles in the container before proceeding to collecting the next parameter. Carbonacious waters will naturally produce bubbles in the containers, which cannot, and should not, be removed.

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

NOTE: A sample for low level mercury should be the first sample collected when multiple analyte containers will be filled. Low level mercury sample bottles should be pre-cleaned and individually stored in Ziploc®-style plastic bags. Use clean nitrile gloves for each sample collection point, immediately prior to handling any bagged sample bottles.

When collecting a sample from a monitoring well:

- Remove the sample bottle from the plastic bag and remove the cap.
- The bottle should be thoroughly rinsed with the sample stream, holding the sample tubing very close to, not within, the open bottle (approximately 1/8"). Never place the sample tubing within the bottle.
- Fill to approximately ¼" below the bottle threads, affix a label, cap the bottle, and return it to the plastic bag.
- Place the bagged bottle in a cooler designated only for low level mercury.

9.4.6 Semi-volatile samples must be collected next, followed by any other parameters that do not require filtration.

9.4.7 Samples that require only filtration with no additional preparation steps should be collected using in-line filters. Filtered samples are typically collected last One exception is collection for available cyanide, which must be collected last due to the potential for cross-contamination from the lead carbonate reagent.

9.4.8 Once all samples from the monitoring well are collected, remove the tubing or pump/tubing. Record the stop time, if required. In addition, the total volume purged can be calculated and recorded.

9.4.9 Cap and secure the monitoring well.

9.4.10 In general, the purged water is poured on to the ground next to the monitoring well. Whether to collect in a drum or to use another strategy will be determined prior to starting any field activities.

9.4.11 Continue with sampling all of the other monitoring wells.

9.5 FIELD QUALITY CONTROL (QC) SAMPLES

9.5.1 Field QC samples must be collected to determine if sample collection and handling procedures have adversely affected the quality of the ground water samples. All QC samples are treated the same as samples with regard to volume, bottle type, preservatives, and any pretreatment.

9.5.2 TYPES OF QC SAMPLES

9.5.2.1 Trip Blank – For VOCs only. Consists of DI water in a VOC vial (contains preservative) and is prepared at the lab prior to the field event. The vial is left capped and chilled while sampling. Used to determine if sample holding and transport has introduced contamination into the samples.

9.5.2.2 Field Blank – Consists of DI water in an appropriate bottle with the appropriate preservative. Obtained from the lab prior to the sampling event and can prepare for a variety of analytes. The bottle is uncapped while sampling to indicate contamination that may have occurred during the operation.

9.5.2.3 Equipment Blank – DI water is exposed to the sample path at any time decontamination needs to be verified. Collect for any suspect parameter and treat it exactly the same as if collecting a sample.

9.5.2.4 Sample Duplicate – One monitoring well per 20 will be selected for collection of a duplicate sample. This is simply an additional set of the sample collected in exactly the same manner as the original sample. The sample type is used to determine precision.

9.5.2.5 Matrix Spike and Matrix Spike Duplicate – One monitoring well per 20 will be selected. These are additional sets of samples collected in exactly the same manner as the sample is collected. This sample type is used to determine accuracy but can also indicate matrix bias.

9.6 DECONTAMINATION

9.6.1 **General Considerations**

9.6.1.1 All nondedicated sampling equipment that is to be reused must be decontaminated prior to its reuse.

9.6.1.2 All disposable tubing will be properly discarded and new tubing used in its place. No tubing will be reused.

9.6.1.3 All equipment washings/rinsates must be collected for proper disposal.

9.6.1.4 The flow cell may be cleaned using the procedure in Section 9.6.2.1 or a manufacturer recommended procedure. Special attention must be paid to care of the probes on the sonde portion of the unit.

9.6.1.5 To avoid cross-contamination, pumps that are contaminated with NAPLs will be isolated and decontaminated at the laboratory.

9.6.2 **Between Well and End-of-Day Decontamination Process**

9.6.2.1 Flow Cell

A. In the case of the flow cell when new tubing will be used, a double rinse at half volume using deionized water is typically adequate. Continue with sampling. If the sample location is historically not contaminated, this step may be omitted.

B. If NAPLs, odors, or colors are present and cannot be flushed out, assess if the probes are fouled by spot-checking the calibration curves. If the probes are not fouled, no further action is necessary since the flow cell does not contact the sample. Continue with sampling.

C. If the probes are fouled, contact the MGP sample coordinator at the laboratory for guidance.

D. At the end of the day, the in-line flow cell should be free of sediment and NAPLs. Fill the cell with tap water, insert the sonde, and store.

9.6.3 **Pumps**

9.6.3.1 Peristaltic pumps need to only have the pump head tubing and sample tubing replaced.

9.6.3.2 If the equipment, such as the peristaltic pump case, is contaminated with organic material, wipe down with commercially available wipes presaturated with 2-propanol. If the organic material does not dislodge, stop now, isolate for decontamination at the lab, and use different equipment for the next monitoring well.

9.6.4 **Specific Bladder and Keck (gear or bullet) Pump Decontamination Measures**

9.6.4.1 Pump pre-rinse – Operate the pump in a deep basin containing 1-5 gallons of deionized water and continue through several cycles.

9.6.4.2 Pump wash – Operate the pump in a deep basin containing 1-5 gallons of nonphosphate detergent solution, such as Alconox. Operate through several cycles.

9.6.4.3 Pump rinse – Operate the pump in a deep basin containing 1-5 gallons of DI water. Continue for several cycles.

9.6.4.4 Disassemble pump, if required, and continue with 9.6.4.5. If not required, go to 9.6.4.7.

9.6.4.5 Pre-rinse, wash, and rinse as above, scrubbing as needed at the wash stage.

9.6.4.6 Reassemble the pump.

9.6.4.7 Store the pump so as to keep it clean until needed.

10.0 CALCULATIONS

None

11.0 DATA REPORTING

Refer to Section 5.4 in this procedure. At a minimum the COC shall be stored in the project folder.

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

Sample

Consumers Energy Company
Chemistry Section – Laboratory Services Department
Monitoring Well Sampling Worksheet

MW_ID		**Today's Date**		**Control Number**	
Location					
MW Reference Name			**GPS Grid Reference**		
Top-of-Casing Elevation (ft)		**Depth-to-Screen Bottom (ft)**		**Depth-to-MidScreen (ft)**	
Screen Length (ft)		**Casing ID (in)**		**Typical Purge Volume**	
Protective Casing Mount					
Comments					

Field Measurements

Depth-to-Water (ft)		**HC Layer Detected**		**PID Reading (ppm)**					
Time	**pH**	**Temp**	**Sp Cond**	**DO**	**DO**	**ORP**	**Pump Rate Indicate**	**Water Level**	**Turbidity**
Hr : Min	Units	°C	µS/cm	ppm	% Sat	mV	mL/min gal/min	Draftdown (ft)	NTU
3-5 Min	± 0.1	na	± 3%	± 10%	± 10%	± 10%	See Notes	<0.33	± 10%
Completed By >>				**Total Pump Time >>**			**Total Purge Volume >>**		

Acceptance criteria are low-flow general acceptance. Pump rate should be <500 mL/min for low-flow and <1 gal/min for high-volume.

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

Monitoring Well Depth-to-Water Measurements

Site: _____

Analyst: _____

Date: _____

Project No: _____

Method: Electronic Tape

Tape ID: Solinst, Model 122, S/N 122001406-1

Sample

Well ID Number	Time of Measurement	Trial 1 DWL, ft	Trial 2 DWL, ft	Depth to Bottom of Screen, ft	Remarks

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

Project Sonde Check; As-Found Readings & Recalibration

I. *Site or Project Tracking*

Site or Project : _____ Chem. Control # : _____

II. *System Identifiers*

Monitor Brand, Model & S/N:	YSI 650MDS S/N 08C100135
Sonde Brand, Model & S/N:	YSI 6820V2 S/N 08C101426
Flow Cell Brand & Model:	YSI 6160
DO Probe Brand, Model & S/N:	YSI 6150 S/N 08C101539
Turbidity Probe Brand, Model & S/N:	YSI 6136 S/N 08C101363
pH With ORP Brand, Probe Model & Lot:	YSI 6565 Lot Number 08B*26
Conductivity & Temperature Probe Model & S/N:	YSI No additional information

Sample

III. *pH Check*

Standard vs As-found, pH Units	Standard Source	Catalog # & Lot #	Exp. Date
4.00			
7.00			
10.00			

Analyst Initials: _____ Date & Time: _____

As-Found Evaluation

Are the readings within +/- 0.10 of their calibration points? Yes No

If 'No' **and** you are at the start of a project, then recalibration is **required**.

If 'No' and you are **within, or at the end** of project, indicate whether recalibration has been performed. Yes No

Note: If recalibration was performed, the solutions listed above were used.

IV. *ORP Check With Zobell Solution*

Standard vs As-found, mV	Source	Catalog # & Lot #	Exp. Date
231			

Analyst Initials: _____ Date & Time: _____

As-Found Evaluation

Is the reading in the 221-241mV range? Yes No

If 'No' **and** you are at the start of a project, then recalibration is **required**.

If 'No' and you are **within, or at the end** of project, indicate whether recalibration has been performed. Yes No

Note: If recalibration was performed, the solution listed above was used.

V. *DO Check With DI Water; 100% Saturation*

As-Found: _____ Analyst Initials, Date & Time: _____

As-Found Evaluation

Is the reading in the 90-110 % saturation range? Yes No

If 'No' **and** you are at the start of a project, then recalibration is **required**.

If 'No' and you are **within, or at the end** of project, indicate whether recalibration has been performed. Yes No

Note: If recalibration was performed, lab DI water was used.

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

Project Sonde Check; As-Found Readings & Recalibration

Site or Project : _____ Chem. Control # : _____

VI. *Conductivity Check*

Standard vs As-Found, us	Source	Catalog # & Lot #	Exp. Date
0 (DI Water)	Lab DI System	- - - -	- - - -

Analyst Initials: _____ Date & Time: _____

As-Found Evaluation

Is the reading +/- 3% of the reference point? Yes No

If 'No' **and** you are at the start of a project, then recalibration is **required**.

If 'No' and you are **within, or at the end** of project, indicate whether recalibration has been performed. Yes No

Note: If recalibration was performed, the solutions listed above were used.

Linearity Check

Standard vs As-Found, us	Source	Catalog # & Lot #	Exp. Date

Analyst Initials: _____ Date & Time: _____

VII. *Turbidity Check*

Standard vs As-Found, NTU	Source	Catalog # & Lot #	Exp. Date
0 (DI Water)	Lab DI System	- - - -	- - - -

Analyst Initials: _____ Date & Time: _____

As-Found Evaluation

Is the reading +/- 10% of the reference point? Yes No

If 'No' **and** you are at the start of a project, then recalibration is **required**.

If 'No' and you are **within, or at the end** of project, indicate whether recalibration has been performed. Yes No

Note: If recalibration was performed, the solutions listed above were used.

Linearity Check

Standard vs As-Found, NTU	Source	Catalog # & Lot #	Exp. Date

Analyst Initials: _____ Date & Time: _____

Reviewed By _____ Date _____

TITLE: LOW STRESS (LOW FLOW) PURGING AND SAMPLING OF GROUND WATER MONITORING WELLS

Field Screening of Monitoring Wells Via PID

Project Information

Site: _____

Project No: _____

Date: _____

Sample

Instrument Information

Instrument ID and Serial Number: _____

Calibration (Span) Gas ID, Lot Number Concentration, etc: _____

Zero Gas ID, Lot Number, Concentration, etc: _____

Periodic Calibration Checks

Time	Analyst	Cal Gas Conc, ppm v/v	Display Conc, ppm v/v

Monitoring Well Screening

MW ID	Time	Analyst	Breathing Zone Display Conc	0-6" Within Casing Display Conc
Background Air				NA

APPENDIX B

Chain-of-Custody, Handling, Packing and Shipping SOP (Procedure CHEM-1.2.04)

TITLE: CHAIN OF CUSTODY REQUIREMENTS (CoC)

1.0 PURPOSE

To provide guidance for uniform preparation of a Chain-of-Custody document.

2.0 SCOPE

The Chain-of-Custody (CoC) document is required for all samples where the analysis results are used for environmental reporting. It may also be used as requested by the customer for other forms of reporting. This method provides guidance for the use of the CoC document.

3.0 DEFINITIONS

Chain-of-Custody (CoC) – A document that is a management tool used to verify sample identification information, sample inventory and sample possession from the time the sample is collected to the time the sample is received by a laboratory.

4.0 REFERENCE DOCUMENTS

4.1 Chapter 1 – SW-846, Test Method for Evaluating Solid Waste, USEPA

4.2 ASTM Method D 5283-92, Standard Practice for Generation of Environmental Data Related to Waste Management Activities: Quality Assurance and Quality Control Planning and Implementation

4.3 ASTM Method D 4840-95, Standard Guide for Sampling Chain-of-Custody Procedures

4.4 Chemistry Department Standard Operating Procedures, as applicable

4.5 Laboratory Services Quality Assurance (LSQA) Procedure Manual, as applicable

5.0 PROCEDURE

5.1 Prior to sampling, the sample team shall be provided with CoC forms. It shall be the responsibility of the on-site supervisor or designated representative to ensure that CoC requirements, sample collection protocol and proper sample handling protocol are initiated on-site.

TITLE: CHAIN OF CUSTODY REQUIREMENTS (CoC)

5.2 A sample is considered under custody if one or more of the following criteria are met:

- The sample is in the sampler's possession.
- The sample is within the sampler's view after being in possession.
- The sample was in the sampler's possession and then placed in a secure container to prevent tampering.
- It is in a designated secure area.

5.3 Each CoC shall identify basic site information and include the following:

- The sampling site name, project name or other site/project identification.
- The initials of the sampling teams.
- Project Leader or report distribution personnel.
- If a site sketch or other documents are to be found with the CoC.
- Necessary remarks as required.

5.4 Each sample entry into the CoC shall include the following:

- Date of sample collection.
- Time of sample collection.
- Type of sample matrix (soil, water, vapor, product, etc).
- Sample identification, name or description.
- Sample depth, if applicable.
- Number of sample containers.
- Specific analytical test parameters. In some cases the specific test parameters may not be known at the time of sample collection. However, the samples are collected in accordance with the protocol for a general group of analytes (e.g., dissolved metals, volatile organic compounds) and the specific test analytes are determined after the sampling event. In these cases, the entry for the analytical test parameter is not required.

5.5 The original of the CoC record shall accompany the samples and a copy should be maintained by the on-site supervisor.

5.6 When transferring the possession of samples, the individuals relinquishing and the individuals receiving the samples should sign, date and note the time on the CoC record.

5.7 In cases where the sample leaves the originator's immediate control, such as shipment to the laboratory by a common carrier (e.g., Federal Express or

TITLE: CHAIN OF CUSTODY REQUIREMENTS (CoC)

Consumers Energy's internal mail) a seal should be placed on the shipping container to detect unauthorized entry to the samples. Any shipping containers that arrive at the Laboratory with the seals damaged should be evaluated to ascertain if the contents have been in valid custody.

5.8 In the event samples requiring the CoC protocol arrive at the Laboratory without the CoC document, the Laboratory shall complete the CoC document upon sample login and under the supervision of the assigned Laboratory Project Leader or Area Coordinator. The person completing the CoC shall enter the statement "CoC completed by the Laboratory upon receipt of sample(s)" in the remarks section of the CoC and initial the entry.

5.9 A sample CoC form is attached (Attachment A).

5.10 Other CoC formats and forms may be used as long as the CoC meets the recommendations of this procedure.

5.11 The CoC shall be stored in the project folder and retained according to CHEM-1.1.7, Record Retention.

QA Review Katharyn L Schlueter Date 02/27/08
Chemistry Quality Assurance Coordinator

Administrative Approval Gordon L Cattell Date 02/27/08
Chemistry Department Supervisor

This electronically produced document has been reviewed and approved by the above-named individuals. The original document bearing the approval signatures is maintained on file by Consumers Energy, Laboratory Services.

TITLE: CHAIN OF CUSTODY FORM (CoC)

CHAIN OF CUSTODY

Consumers Energy

CONSUMERS ENERGY COMPANY – LABORATORY SERVICES

135 WEST TRAIL ST., JACKSON, MI 49201 • (517) 788-1251 • FAX (517) 788-2533

SAMPLING SITE: | PROJECT NUMBER: | ANALYSIS REQUESTED | PAGE ____ OF ____

SAMPLING TEAM: | DATE SHIPPED: | SITE SKETCH ATTACHED? CIRCLE ONE: YES NO | SEND REPORT TO: ____ PHONE: ____

CE CONTROL #	SAMPLE DATE	SAMPLE TIME	SAMPLE MATRIX	SAMPLE DESCRIPTION / LOCATION	DEPTH	# OF CONTAINERS	REMARKS

RELINQUISHED BY: (SIGNATURE)	DATE / TIME	RECEIVED BY: (SIGNATURE)
RELINQUISHED BY: (SIGNATURE)	DATE / TIME	RECEIVED BY: (SIGNATURE)
RELINQUISHED BY: (SIGNATURE)	DATE / TIME	RECEIVED BY: (SIGNATURE)

COMMENTS

ORIGINAL TO LAB COPY TO CUSTOMER

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