Assessment of Corrective Measures

DE Karn Bottom Ash Pond
Coal Combustion Residual Unit

Consumers Energy Company

DE Karn Power Plant
Essexville, Michigan

September 2019

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Prepared For
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Executive Summary

On April 17, 2015, the United States Environmental Protection Agency (USEPA) published the final rule for the regulation and management of Coal Combustion Residuals (CCR) under the Resource Conservation and Recovery Act (RCRA) (the CCR Rule), as amended July 30, 2018. The CCR Rule, which became effective on October 19, 2015 (amendment effective August 29, 2018), applies to the DE Karn (Karn) Bottom Ash Pond. The CCR Rule 40 CFR §257.96(a) requires that an owner or operator initiate an assessment of corrective measures (ACM) to prevent further release, to remediate any releases, and to restore impacted areas to original conditions if any Appendix IV constituent has been detected at a statistically significant level exceeding a Groundwater Protection Standard (GWPS). Per §257.96(a), the ACM must be completed within 90 days. The CCR Rule allows up to an additional 60 days to complete the ACM if a demonstration is made that more time is needed due to site-specific conditions or circumstances.

The ACM is required whenever an Appendix IV constituent has been detected at a statistically significant level exceeding the established federal GWPS. TRC has prepared this ACM for the Karn Bottom Ash Pond, on behalf of Consumers Energy, to evaluate the effectiveness of potential corrective measures in meeting the requirements and objectives of selecting a remedy that is protective of human health and the environment, achieves the GWPS, and source control. The requirements for conducting the ACM are contained in federal rules and state rules promulgated under Michigan's Natural Resources and Environmental Protection Act (NREPA), Part 115, Solid Waste Management, as amended by Public Act 640 of 2018.

On January 14, 2019, Consumers Energy provided notification that arsenic was present at statistically significant levels above the federal GWPS in five of the six downgradient monitoring wells at the Karn Bottom Ash Pond. This notification was followed up with a Response Action Plan submitted to the Michigan Department of Environment, Great Lakes, and Energy (EGLE [1]) on March 15, 2019 laying out the preliminary understanding of water quality and actions that were underway to mitigate or eliminate unacceptable risk associated with the identified release from the CCR unit. This plan necessitated the development and submittal of the ACM under the timeframes provided under the CCR Rule.

As documented in the October 12, 2018 Notification of Intent to Initiate Closure letter submitted in accordance with §257.102(g), Consumers Energy intends to close the Karn Bottom Ash Pond under the CCR Rule's closure by removal provisions in §257.102(c). Consumers Energy has also

[1] Effective Monday, April 22, 2019, the Michigan Department of Environmental Quality (MDEQ) became known as the Michigan Department of Environment, Great Lakes, and Energy (EGLE).

submitted a closure work plan to EGLE (Golder, April 2018) that included a multiple lines of evidence approach for verifying CCR removal. The closure work plan was reviewed and approved by EGLE on December 20, 2018. CCR removal has been completed for the Karn Bottom Ash Pond and results will be documented in a CCR removal documentation report.

The groundwater nature and extent has been defined, as required in §257.95(g)(1). The nature and extent characterization was performed using additional data collected from existing groundwater monitoring wells. The nature and extent data consist of data collected from the downgradient CCR monitoring well networks as well as from the Karn Landfill state monitoring well network and porewater compliance monitoring program between March 2016 and April 2019. Based on this network, installation of additional downgradient monitoring wells was not necessary.

Nature and Extent (N&E) Evaluation Wells	
Karn Bottom Ash Pond Wells	**N&E Delineation Wells**
DEK-MW-15001[2]	MW-01
DEK-MW-15002	MW-03
DEK-MW-15003	MW-06
DEK-MW-15004	MW-08
DEK-MW-15005	MW-10
DEK-MW-15006	MW-12
DEK-MW-18001	MW-14
	MW-16
	MW-22
	MW-23
	OW-10
	OW-11
	OW-12

Although arsenic concentrations exceed the GWPS in on-site groundwater monitoring locations, arsenic is delineated within the limits of the property owned by Consumers Energy and there are **currently no adverse effects on human health or the environment** from either surface water or groundwater due to CCR management at the Karn Bottom Ash Pond.

Several groundwater remediation alternatives evaluated in this ACM are considered technically feasible to reduce on-site groundwater concentrations to below the GWPS as discussed in Sections 4 and 5. Consumers Energy plans to utilize an adaptive management strategy for

[2] Monitoring well DEK-MW-15001 was decommissioned on April 18, 2018 due to the installation of the new Karn Lined Impoundment

selecting the final groundwater remedy for the Karn Bottom Ash Pond in coordination with the specified CCR source material management strategies. Under this remedy selection strategy, measures that remove source material, reduce infiltration, and/or minimize the potential for future migration during the closure process may be implemented to address existing conditions followed by monitoring and evaluation of the performance after closure. Adjustments will be made to the corrective measure remedy, as needed, to achieve the remedial goals (*e.g.* GWPS and/or risk/exposure/pathway-based criteria).

Consumers Energy will continue executing the self-implementing groundwater compliance schedule in conformance with §257.90 - §257.98, which includes semiannual assessment monitoring in accordance with §257.95 to monitor groundwater conditions and inform the remedy selection. The next semiannual assessment monitoring event is scheduled to occur in October 2019 with results summarized in the 2019 Annual Groundwater Monitoring Report issued in January 2020.

Consumers Energy will, as soon as feasible, select remedies for impacted groundwater at the Karn Bottom Ash Pond that, at a minimum, meets the federal standards of §257.97(b) and state standards of R 299.4444(2). It is anticipated that the remedy selection process for addressing impacted groundwater will proceed following implementation of the specified CCR source material management strategies. A public meeting with interested and affected parties will be scheduled in accordance with §257.96(e) and R 299.4443(4) once one or more preferred remedial approach(es) for groundwater are identified. A final report describing the selected remedy and how it meets the standards specified in §257.97 will be prepared following selection of a final remedy.

Section 1
Introduction

On April 17, 2015, the United States Environmental Protection Agency (USEPA) published the final rule for the regulation and management of Coal Combustion Residuals (CCR) under the Resource Conservation and Recovery Act (RCRA) (the CCR Rule), as amended July 30, 2018. The CCR Rule, which became effective on October 19, 2015 (amendment effective August 29, 2018), applies to the DE Karn (Karn) Bottom Ash Pond. The CCR Rule 40 CFR §257.96(a) requires that an owner or operator initiate an assessment of corrective measures (ACM) to prevent further release, to remediate any releases, and to restore impacted areas to original conditions if any Appendix IV constituent has been detected at a statistically significant level exceeding a Groundwater Protection Standard (GWPS). Per §257.96(a), the ACM must be completed within 90 days. The CCR Rule allows up to an additional 60 days to complete the ACM if a demonstration is made that more time is needed due to site-specific conditions or circumstances. A certification from a qualified professional engineer attesting that the demonstration is accurate is required. The owner or operator must include the certified demonstration in the annual groundwater monitoring and corrective action report required by §257.90(e). For informational purposes, the 60-day extension is included in this report as Appendix A.

1.1 Purpose/Objectives

The purpose of this report is to present the ACM for the Karn Bottom Ash Pond in satisfaction of the requirements of the CCR Rule §257.96 and the requirement to initiate an assessment of corrective measures pursuant to R 299.4443(1) of Michigan Part 115. TRC has prepared this ACM for the Karn Bottom Ash Pond, on behalf of Consumers Energy, to evaluate the effectiveness of potential corrective measures in meeting the requirements and objectives of selecting a remedy that is protective of human health and the environment, achieves the GWPS, and source control. This report also serves to document substantial progress towards the requirements for feasibility studies contained in Part 201 of the act.

Consumers Energy previously evaluated source material management technologies and determined to utilize a source removal strategy for closure of the Karn Bottom Ash Pond as documented in Section 3.1 of this ACM. Closure by removal was the method of closure for the Karn Bottom Ash Pond selected and implemented by Consumers Energy prior to triggering the requirements for assessing corrective measures. The performance standards that must be achieved in order to close by removal are anticipated to support some of the performance standards for the assessment of corrective measures, especially with respect to addressing source control. Based on the strategy, this ACM focuses on the evaluation of viable alternatives for groundwater management in conjunction with the selected closure method – closure by removal - source material control option without specifically evaluating construction of a final cover or other impermeable cap.

Table 1 provides a visual evaluation of the relative effectiveness of each groundwater treatment alternative. Balancing criteria were selected based on remedy selection criteria in §257.97 and R 299.4444. In addition, R 299.4443 for an ACM under Part 115 requires the ACM to comply with the requirements for feasibility studies contained in Part 201. As such, the balancing criteria encompass the criteria for remedial action selection under Section 20120(1).

Each groundwater treatment alternative was evaluated with regards to each balancing criterion based on its anticipated effectiveness, implementability, and sustainability. Color-coding is used to categorize each alternative on a scale from ineffective to highly effective. The evaluation of each alternative is discussed in Section 4.

This ACM was initiated on April 14, 2019, following the January 14, 2019 *Notification of Appendix IV Constituent Exceeding Groundwater Protection Standard per* §257.95(g), which documented that arsenic was present at statistically significant levels above the federal GWPS in five of the six downgradient monitoring wells at the Karn Bottom Ash Pond. Consumers Energy notified the Michigan Department of Environment, Great Lakes, and Energy (EGLE) in the Response Action Plan submitted on March 15, 2019 that this ACM would be submitted by September 11, 2019. The professional engineer certification attesting to the accuracy of the demonstration justifying the 60-day time extension was placed in the operating record on July 12, 2019.

1.2 Assessment of Corrective Measures Requirements

1.2.1 Federal Requirements

In accordance with §257.96, this ACM evaluates the effectiveness of potential corrective measures in meeting the requirements and objectives of the remedy specified in §257.97, including protectiveness of human health and the environment, achievement of the GWPS, and source control. Remedy selection shall commence upon completion of this assessment and will be completed as soon as feasible. The ACM is an analysis of the effectiveness of potential corrective measures and addresses the following factors:

- The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination;
- The time required to begin and complete the remedy; and
- The institutional requirements, such as state or local permit requirements or other requirements that may affect implementation of the remedy.

These requirements are the basis for evaluation of each corrective measures approach tabulated for comparison in Table 1. Description of the potential remedy approaches are provided in Section 3 and then discussed in context of applicability at the Karn Bottom Ash Pond based on site-specific characteristics in Section 4. The remedy evaluation summary is discussed in Section 5 leading to considerations and limitations in selection of a remedy presented in Section 6.

The ACM will be considered completed when it is placed in the facility's operating record as required by §257.105(h)(10). In addition to providing notification to EGLE that the ACM has been placed in the facility's operating record; the report is being submitted in satisfaction of the timelines in the Response Action Plan.

1.2.2 State Requirements

On December 28, 2018, the State of Michigan enacted Public Act No. 640 of 2018 (PA 640) to amend the Natural Resources and Environmental Protection Act, also known as Part 115 of PA 451 of 1994, as amended (a.k.a., Michigan Part 115 Solid Waste Management). The December 2018 amendments to Part 115 were developed to provide the State of Michigan oversight of CCR impoundments and landfills and to better align existing state solid waste management rules and statutes with the CCR Rule. This alignment would ensure compliance with the federal CCR standards through a state-approved permitting program that would be deemed to be "equivalent to" or "as protective as" through an administrative application that would be reviewed and authorized by US EPA. It should be noted that the Michigan statute does not act in lieu of the federal standards until such a time as the US EPA authorizes the permit program after a public notice and comment on the elements of the program that are authorized.

Michigan's Part 115 references Michigan's Part 201 (Environmental Cleanup) which adopts by reference the requirements for feasibility studies. This ACM has been prepared in compliance with the requirements for feasibility studies contained in Part 201 and includes an analysis of the effectiveness of potential corrective measures in meeting the requirements and objectives of the remedy. Requirements for evaluating effectiveness of potential remedies under Michigan rules are the same as those under the CCR Rule with the exception that state rules allow cost to be a balancing consideration for selecting a remedy.

1.3 Program Summary

The CCR Rule applies to the Karn Bottom Ash Pond and the Karn Lined Impoundment. In accordance with the schedule defined in §257.90(b)(1) for existing CCR units, a groundwater monitoring system was installed around the Karn Bottom Ash Pond as required by §257.91, and background groundwater monitoring well sampling has been completed as required by §257.93. Separately, the schedule and requirements for new CCR units provided in §257.90(b)(2) were satisfied for the Karn Lined Impoundment upon its initial receipt of CCR on June 7, 2018.

As documented in the January 14, 2019 *Notification of Appendix IV Constituent Exceeding Groundwater Protection Standard per* §257.95(g), arsenic was present at statistically significant levels above the federal GWPS in one or more downgradient monitoring wells at the Karn Bottom Ash Pond, thus necessitating the development of this ACM. Currently, the Karn Lined Impoundment remains in Detection Monitoring.

Evaluation of groundwater under the CCR Rule focused on the following constituents that were collected *unfiltered* in the field:

CCR Rule Monitoring Constituents	
Appendix III	**Appendix IV**
Boron	Antimony
Calcium	Arsenic
Chloride	Barium
Fluoride	Beryllium
pH	Cadmium
Sulfate	Chromium
Total Dissolved Solids (TDS)	Cobalt
	Fluoride
	Lead
	Lithium
	Mercury
	Molybdenum
	Radium 226/228
	Selenium
	Thallium

Prior to remedy selection, Consumers Energy will also collect a sufficient number of samples to evaluate Michigan state-specific constituents as follows:

Additional Monitoring Constituents (Michigan Part 115)	
Detection Monitoring	**Assessment Monitoring**
Iron	Copper
	Nickel
	Silver
	Vanadium
	Zinc

1.4 Bottom Ash Pond Closure

Consumers Energy evaluated source material management technologies and determined to close the Karn Bottom Ash Pond under the CCR Rule's closure by removal provisions in §257.102(c) as referenced in Section 11519b(9)(a) in P.A. 640. Consumers Energy submitted the *DE Karn Generating Facility Revised Bottom Ash Pond Closure Work Plan*, (Golder, April 2018) to the EGLE for review to meet objectives for state and federal requirements and EGLE provided written agreement with the plan on December 20, 2018. Consumers Energy also provided formal Notification of Intent to Initiate Closure of the Karn Bottom Ash Pond to the EGLE on October 12, 2018, per §257.102(g).

Consumers Energy ceased hydraulic loading to the Karn Bottom Ash Pond in June 2018 and allowed the area to dewater by gravity. Consumers Energy then operated a construction dewatering system to allow for excavation of the vertical and lateral extent of CCR that commenced on March 20, 2019 and has operated through the construction and restoration period. The excavation extended to six inches below known CCR elevations established from previous investigations. Excavated CCR has been placed in the neighboring Weadock Landfill that consists of a fully encapsulating soil-bentonite slurry wall keyed into a competently confining clay unit. The Karn Bottom Ash Pond is currently being restored by backfilling and grading the surface with clean fill in accordance with the plan to promote stormwater drainage, minimize ponding of surface water, and to reduce the potential of infiltration and migration of residual arsenic and any future constituents of concern (COCs). Groundwater chemistry already appears to be improving as a result of discontinuing the hydraulic loading to the Karn Bottom Ash Pond, and is expected to further improve following the completed source removal. With the CCR removal complete, Consumers Energy is preparing the documentation report of the removal activities, which will be submitted to EGLE, and placed in the operating record.

Section 2
Hydrogeology/Current Conditions

The Karn Bottom Ash Pond is located north of the JC Weadock Power Plant, east of the Saginaw River, south and west of Saginaw Bay (Figure 1). A discharge channel separates the Karn Power Plant from the Weadock Power Plant within the property owned by Consumers Energy. The Karn Power Plant began generating electricity in 1959. Two power generating units (Units 1 & 2) are coal-fueled and two units (Units 3 & 4) are oil- and natural gas-fueled. The coal-fired boilers are scheduled to permanently cease operation in 2023 based on the Michigan Public Service Commission (MPSC) approving the Integrated Resource Plan (IRP) for Consumers Energy on June 7, 2019 to retire those units.

2.1 Description of CCR Units

The locations of the Karn Bottom Ash Pond and Karn Lined Impoundment are shown on Figure 1. Previously, the Karn Bottom Ash Pond was used for receiving sluiced bottom ash and was the primary settling/detention structure for the National Pollutant Discharge Elimination System (NPDES) treatment system prior to discharge. Consumers Energy provided notification of initiation of closure for the Karn Bottom Ash Pond on October 12, 2018 to implement the certified closure plan by removal of CCR under the self-implementing requirements and schedule of the CCR Rule.

In preparation for removal of the Karn Bottom Ash Pond, the new impoundment (Karn Lined Impoundment) was constructed meeting the requirements of the CCR Rule and the operational needs at the Karn Power Plant. The liner system for the new impoundment is an alternative composite liner system consisting of primary and secondary composite liners each consisting of 60-mil High Density Polyethylene (HDPE) geomembrane (GM) overlaying a 236-mil geosynthetic clay liner (GCL).[3] There is also a leachate collection system consisting of 175-mil GSE HyperNet geonet located between the primary and secondary liner system. The Karn Lined Impoundment began receipt of CCR and non-CCR on June 7, 2018 when it replaced the Karn Bottom Ash Pond operations.

The Karn Bottom Ash Pond and Karn Lined Impoundment are located adjacent to the licensed DE Karn 1&2 Solid Waste Disposal Area consisting of 174-acres designated as the DE Karn Landfill. Consumers Energy received the Solid Waste Construction Permit No. 0195 on December 12, 1986 for constructing the Type III Landfill and is currently licensed – License No. 9442 issued on June 26, 2015. This landfill ceased receiving CCR prior to the Effective Date of

[3] Golder Associates Inc. 2018. *Bottom Ash Lined Impoundment Liner System Design Certification Report, DE Karn Generating Facility, Essexville, Michigan.* April.

the CCR Rule (October 19, 2015) and is completing construction of the final cover construction in Calendar Year 2019.

The DE Karn Landfill is being monitored in accordance with the EGLE-approved *Hydrogeological Monitoring Plan, Rev. 3, DE Karn Solid Waste Disposal Area* (December 19, 2017) (HMP). In addition to the HMP, the DE Karn 1&2 Solid Waste Disposal Area is currently authorized under a permit (Groundwater Discharge Authorization GWE-0005) issued pursuant to Part 31 [4] to discharge to the unusable aquifer directly underlying the solid waste t. Compliance monitoring pursuant to Part 31 and Part 115 [5] detailed in the revised HMP was approved by the EGLE on January 8, 2018.

2.2 Geologic/Hydrogeologic Setting

The majority of the Karn Bottom Ash Pond area is comprised of surficial CCR and sand fill. USGS topographic maps and aerial photographs dating back to 1938, in addition to field descriptions of subsurface soil, indicate the area was largely developed by reclaiming low-lands through construction of breakwater dikes that ultimately were developed into perimeter dikes and subsequent ash filling.

The surficial fill consists of a mixture of varying percentages of ash, sand, and clay-rich fill ranging from 5 to 15 feet thick. Below the surficial fill, native alluvium and lacustrine soils are present at varying depths. Generally, there is a well graded sand unit present to depths of 10-30 feet below ground surface (ft bgs) overlying a clay till which is observed at depths ranging from 25 to 75 ft bgs. In general, the alluvium soils (sands) are deeper along the Saginaw River and there are shallower lacustrine deposits (clays, silts and sands deposited in or on the shores of glacial lakes) at other areas. The clay till acts as a hydraulic barrier that separates the shallow groundwater from the underlying sandstone. A sandstone unit, which is part of the Saginaw Formation, was generally encountered at 80-90 ft bgs.

The Karn Bottom Ash Pond is bounded by several surface water features (Figure 1): the Saginaw River to the west, Saginaw Bay (Lake Huron) to the north and east, and a discharge channel to the south. In general, shallow groundwater is encountered at a similar elevation relative to the surrounding surface water features. Groundwater flow in the upper aquifer is largely controlled by the surface water elevations of Saginaw River and Saginaw Bay. In the vicinity of the Karn Bottom Ash Pond, the shallow groundwater flow is generally radial, flowing outward from the pond area toward the surrounding surface water bodies.

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[4] Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act (NREPA), Public Act 451 of 1994.

[5] Part 115, Solid Waste Management, of the Natural Resources and Environmental Protection Act (NREPA), Public Act 451 of 1994.

In previous investigations to the south, bedrock groundwater was generally encountered around 578 feet NAVD88, which is several feet lower than the shallow groundwater. Groundwater flow direction was generally to the northeast under a very shallow gradient. Given the different groundwater flow regime in the bedrock than the shallow saturated unit, bedrock wells near the surface water bodies are several feet below the surface water elevation. Based on the fact that the shallow sand and the bedrock are separated by over 50 ft of clay, the bedrock unit does not appear to be hydraulically connected to the shallow sand.

2.3 Environmental Setting and Monitoring Network

In accordance with §257.91, Consumers Energy is maintaining a groundwater monitoring system for the Karn Bottom Ash Pond, which consists of 10 monitoring wells (four background monitoring wells and six downgradient monitoring wells) that are screened in the uppermost aquifer. The monitoring well locations are shown on Figure 1.

Four monitoring wells located south of the Karn Bottom Ash Pond provide data on background groundwater quality that has not been impacted by a CCR Unit (MW-15002, MW-15008, MW-15016, and MW-15019). Analysis for the establishment of these wells as background is detailed in the *Groundwater Statistical Evaluation Plan* for the Karn Bottom Ash Pond, dated October 17, 2017. Due to the regional hydrogeology and operational history of the Karn Power Plant, a hydraulically upgradient location is not available to monitor the Karn Bottom Ash Pond. The area where background wells are located, while not upgradient, is not impacted by any CCR units and therefore is consistent with the requirements of §257.91(a)(1). Background groundwater quality data from these four background wells are additionally used for the CCR groundwater monitoring program at for the Weadock Landfill and Weadock Bottom Ash Pond.

Groundwater around the Karn Bottom Ash Pond is radial; therefore, six downgradient wells (DEK-MW-15001 through DEK-MW-15006) that were installed and spaced along the circumference of the Karn Bottom Ash Pond continue to accurately represent the quality of groundwater passing the waste boundary that ensures detection of groundwater contamination such that all potential contaminant pathways are monitored.

2.4 On-Site Groundwater Flow Conditions

Groundwater movement relative to the Karn Bottom Ash Pond area is consistently expressed as radial flow throughout the monitoring period starting with the commencement of the groundwater monitoring program (December 2015). Groundwater elevations relative to the Karn Bottom Ash Pond range from 580 to 588 ft NAVD88 and groundwater is typically encountered at elevations consistent to the surrounding surface water features, flowing outward toward the bounding surface water features. Groundwater elevations measured during the most recent CCR monitoring event (April 2019) were used to construct the shallow groundwater contour map (Figure 2).

The figure shows that current groundwater flow continues to radiate outward from the Karn Bottom Ash Pond area toward the surface water. The average mean hydraulic gradient throughout the Karn Bottom Ash Pond area in April 2019 was 0.0044 ft/ft. Using the mean hydraulic conductivity of 15 ft/day (ARCADIS, 2016) and an assumed effective porosity of 0.3, the estimated average seepage velocity was 0.22 ft/day or 79 ft/year, which is slightly lower than previous estimates. Due to the operational changes of the bottom ash pond and the progress of the landfill capping activities, the gradient between the bottom ash pond area and the surrounding surface water bodies appears to be flattening out as compared to previous quarters, as expected.

2.5 Nature and Extent of Environmental Impacts

Since arsenic has been detected at the Karn Bottom Ash Pond at statistically significant levels above the respective GWPS, the nature and extent of the release is described below to meet the requirements of §257.95(g)(1).

2.5.1 Potential Extent of CCR Source Materials

In addition to ongoing groundwater monitoring activities, characterization activities for the CCR and underlying materials at the Karn Bottom Ash Pond was completed in 2017 (Golder, 2018; Appendix B). This work included collecting and analyzing samples from twelve soil borings located between 0 and 38 ft bgs in and around the Karn Bottom Ash Pond for select metals and other constituent(s) that could potentially be used as indicators of groundwater impacts. Compositional analysis showed that CCR present generally contained arsenic, boron, and selenium concentrations that exceeded Michigan Part 201 nonresidential drinking water protection or groundwater surface water interface (GSI) protection criteria for soils. Leaching and compositional analysis was also performed on soil and CCRs to spatially determine the potential leachability of constituents above health-based criteria. These end members were then compiled to form a subsurface excavation profile that determined the initial depth of excavation before other lines of evidence are sought to determine if the limits of excavation will be satisfied based on the Quality Assurance protocol developed and detailed in the closure work plan submitted to EGLE (Golder, April 2018).

The evaluation of the leachability and compositional data from the characterization work in combination with ongoing groundwater monitoring activities has yielded evidence that the remaining ponded CCRs and historical sluice water are the likely source of observed downgradient groundwater impact. Native sand underlying the ponded CCR generally contained lower concentrations of metals. In fact, the relative enrichment of the media with leachable inorganics generally decreased from the surface of the unit as samples were taken closer to and into native sand.

2.5.2 Groundwater: Potential Receptors and Exposure Pathways

The primary potential exposure pathway relevant to this ACM is the drinking water (DW) pathway and attainment of the GWPS. The GSI exposure pathway is also relevant and will be considered during the final remedy selection. Due to the physical/chemical properties of the Appendix III and Appendix IV constituents, volatilization is unlikely to occur; therefore, the groundwater volatilization to indoor/ambient air pathways are not relevant.

Relevant Groundwater Exposure Pathways		
Exposure Pathway	**Applicable Criteria**	**Potential Source Areas**
GSI	Michigan Part 201	Karn Bottom Ash Pond,
Drinking Water	Michigan Part 201/ Federal GWPS	Karn Bottom Ash Pond,

2.5.3 Characterization of Groundwater

Following the initial and subsequent assessment monitoring sampling events (April and May 2018), the compliance well groundwater concentrations for Appendix IV constituents at the Karn Bottom Ash Pond were compared to the GWPSs to determine if a statistically significant exceedance had occurred in accordance with §257.93 as detailed in the *Statistical Evaluation of Initial Assessment Monitoring Sampling Event* (TRC, January 2019). The statistical evaluation of the May 2018 Appendix IV constituents showed arsenic was present at statistically significant levels (i.e., lower confidence limit exceeded the GWPS). The remaining Appendix IV constituents were not present at statistically significant levels during the May 2018 assessment monitoring event. Therefore, for the purposes of this ACM, COCs include arsenic.

	Constituent	GWPS	Units	GWPS Exceedance [6]
Appendix IV	Antimony	6	µg/L	
	Arsenic	21	µg/L	✓
	Barium	2,000	µg/L	
	Beryllium	4	µg/L	
	Cadmium	5	µg/L	
	Chromium	100	µg/L	
	Cobalt	15	µg/L	
	Fluoride	4,000	µg/L	
	Lead	15	µg/L	
	Lithium	180	µg/L	
	Mercury	2	µg/L	
	Molybdenum	100	µg/L	
	Radium 226+228	5	pCi/L	
	Selenium	50	µg/L	
	Thallium	2	µg/L	

µg/L: micrograms per liter; pCi/L: picoCuries per liter

Consumers Energy placed a notification of the statistical exceedances into the operating record on January 14, 2019 as required in §257.95(g) and within the timeframe required by §257.105(h)(8). In addition, as required in §257.95(g)(1), nature and extent groundwater sampling was conducted as described below.

The nature and extent characterization was performed using additional data collected from existing groundwater monitoring wells. The nature and extent data consist of Appendix III and IV constituents collected from the downgradient CCR monitoring well network and select Appendix III and IV constituents collected from the Karn Landfill state monitoring well network and porewater compliance monitoring program between March 2016 and April 2019. Based on this network, installation of additional downgradient monitoring wells was not necessary.

[6] An exceedance occurs when the lower confidence limit of the downgradient data is above the GWPS.

Nature and Extent (N&E) Evaluation Wells	
Karn Bottom Ash Pond Wells	**N&E Delineation Wells**
DEK-MW-15001[7]	MW-01
DEK-MW-15002	MW-03
DEK-MW-15003	MW-06
DEK-MW-15004	MW-08
DEK-MW-15005	MW-10
DEK-MW-15006	MW-12
DEK-MW-18001	MW-14
	MW-16
	MW-22
	MW-23
	OW-10
	OW-11
	OW-12

Given the proximity of the Karn Bottom Ash Pond to the Karn Landfill at the Karn property, the nature and extent of contamination was assessed from a site-wide perspective rather than on a per CCR unit basis. The nature and extent of groundwater impacted by a release from the Karn Bottom Ash Pond overlaps with groundwater impacted by operation of the Karn Landfill. Additionally, looking at impacted groundwater on a site-wide basis was more practical from a risk mitigation standpoint, given:

- the likely age of the release(s);
- a long operational history of ash management
- the historical use of CCR as fill; and
- The influence of geochemistry on several of the Appendix IV constituent concentrations in groundwater.

These factors combined make it difficult, if not impossible, to determine the quantity of the material released from the CCR unit as required by the CCR Rule.

The distribution of Appendix IV constituents (i.e., arsenic) in the shallow water-bearing unit as compared to the GWPS is presented in Figure 3. Two categories were assigned, as follows:

- White – No Statistically Significant Exceedances

[7] Monitoring well DEK-MW-15001 was decommissioned on April 18, 2018 due to the installation of the new KLI

- Orange – Statistically Significant GWPS Exceedance: the lower confidence limit is above the GWPS

Arsenic

The groundwater impacts related to arsenic appear to be concentrically located around the Karn Bottom Ash Pond. The highest concentrations of arsenic have been observed at DEK MW-15003, a well located to the north of the bottom ash pond and associated with the "highest" elevation of mounded groundwater relative to the Bottom Ash Pond. The other groundwater monitoring wells are relatively consistent in the same concentration limit but also located in "lesser" mounded areas. Recent data shows that groundwater quality is improving for select constituents (e.g., downward trends in arsenic concentrations) since sluicing to the Karn Bottom Ash Pond ceased in June 2018 when the bottom ash and transport water was diverted to the Karn Lined Impoundment. The influence of the bottom ash sluice water loading or changes in redox geochemistry impacted by the sluice water loading is still being evaluated as additional data collection events are completed.

Arsenic in the nature and extent wells located along the landfill perimeter bordering Saginaw Bay also exhibit concentrations above the GWPS. Although arsenic is present above the GWPS, the drinking water pathway is not complete as there are no drinking water wells on-site (Figure 4).

Due to the presence of the surrounding surface water bodies, another relevant pathway is the GSI pathway. Transect/porewater GSI compliance sampling data collected quarterly under the Part 115 HMP shows that biogeochemical conditions are contributing to the reduction of arsenic in groundwater as arsenic concentrations in transect push-point samples located along the water's edge of Saginaw Bay are much lower than the arsenic concentrations observed in the perimeter dike wells. Compliance has been demonstrated by evaluating the total chronic loading based upon the authorization for the mixing zone.

Other Potential Constituents of Concern

In addition to arsenic, additional Appendix III and Appendix IV constituents shown below have also been identified as potential COCs based on their concentrations compared to state cleanup criteria (i.e., Part 201).

	Constituent	DW Exceedance	GSI Exceedance
Appendix III	Boron	✓	✓
	Chloride		✓
	Sulfate	✓	✓
	Total Dissolved Solids (TDS)	✓	✓
	pH	✓	✓
Appendix IV	Antimony		✓
	Arsenic	✓	✓
	Lithium	✓	
	Molybdenum	✓	✓
	Selenium	✓	✓

2.5.4 Risk Evaluation

Although arsenic has been identified in the groundwater at concentrations exceeding applicable criteria, an evaluation of risk demonstrates that there are **currently no adverse effects on human health or the environment** from either surface water or groundwater due to CCR management at the Karn Bottom Ash Pond. The property is owned and operated by Consumers Energy and groundwater is not used for drinking water. There are no on-site drinking water wells, so the drinking water pathway is not complete (Figure 4).

The groundwater located immediately beneath the Karn Bottom Ash Pond has the potential to vent to the adjacent surface water features as depicted by groundwater contours (Figure 2). This groundwater has been determined to be "*groundwater not in an aquifer*" by the Water Resources Commission on August 26, 1986. This determination grants Groundwater Discharge Exemption GWE-005 based on the ability to demonstrate no substantial change in discharge. Compliance with this performance standard is measured and monitored through the hydrogeological monitoring reports submitted to the EGLE on a quarterly basis. The designation of "*groundwater not in an aquifer*" is only a usability determination and is not a restriction on water usage itself, per se. Therefore, a covenant restricting future withdrawal of groundwater would be appropriate, if deemed necessary following source removal and capping activities to mitigate this risk pathway.

As discussed above, the Karn Power Plant and Karn Bottom Ash Pond is also bounded by the Saginaw River on one side and Saginaw Bay on the other side; therefore, if portions of the property are not addressed through active remediation (e.g., source removal), it may be appropriate to mitigate those risks by revising the monitoring associated with the existing mixing-zone based GSI criteria (EGLE, 2015). Compliance for the GSI pathway is currently assessed as a part of the Michigan Part 115 HMP monitoring program for the Karn Landfill through the collection of transect push-point samples collected from venting groundwater near the water's edge of Saginaw Bay. Data evaluations completed to date continue to demonstrate GSI pathway compliance under the state program[8].

[8] TRC. 2019. *DE Karn 1&2 Solid Waste Disposal Area License Requirements – Groundwater Quality Monitoring Results for the Second Quarter 2019*. July.

Section 3
Identification of Remedial Options to Develop Corrective Measure Alternatives

In order to perform a thorough assessment of the corrective measure alternatives, Consumers Energy identified and evaluated several technologies for both CCR source material management and groundwater remediation. Section 3.1 describes the previously selected source material management option and Section 3.2 identifies and briefly describes the applicable groundwater remediation technologies. Additional remediation technologies may be evaluated at a later date if determined to be applicable through additional data collection/evaluation or identification of an emerging technology. The assessment of the corrective measure alternatives is detailed in Section 4.

3.1 CCR Source Material Management

Consumers Energy evaluated source material management technologies and determined to close the Karn Bottom Ash Pond under the CCR Rule's closure by removal provisions in §257.102(c) as documented in the January 2018 Closure Plan that is available on Consumers Energy's CCR Rule Compliance Data and Information webpage (https://www.consumersenergy.com/community/sustainability/environment/waste-management/coal-combustion-residuals).

3.1.1 No Action

A source material management strategy of no action involves making no efforts to contain or remove CCR as it currently exists, or as it will exist at the end of the useful life of the unit. CCR would be left in the unit without construction of a low permeability cover or additional containment. A no action CCR source material management strategy is not considered viable due to its ineffectiveness of reducing potential exposures to the CCR material or potential migration of CCR material beyond the confines of the specified unit. A no action CCR source material management strategy is not a regulatory option per the CCR Rule, but was included as a comparative baseline option for the evaluation of corrective measure alternatives.

3.1.2 Bottom Ash Pond Closure by CCR Removal

A source material management strategy of closure by removal involves removing and decontaminating all areas impacted by releases from the CCR unit per the provisions in §257.102(c). CCR removal has been completed and results will be documented in a Karn

Bottom Ash Pond CCR removal documentation report provided to EGLE upon completion.

The first phase of the closure includes CCR removal and documentation. Excavation has been completed to remove CCR to elevations identified during investigations with visual observations and laboratory testing made to confirm the CCR removal objective is achieved. Documentation of CCR removal has been performed to provide lines of evidence to validate the extent of the excavation and visual observations made in the field.

Leaching and compositional analysis performed on soil and CCRs was used to spatially determine the extent of CCR removal delineated by health-based standards of CCR constituents. These data were compiled to form a subsurface excavation profile that determined the threshold depth of excavation before other lines of evidence were deployed to validate satisfaction with the limits of excavation based on the Quality Assurance protocol developed and detailed in the closure work plan submitted to EGLE (Golder, April 2018). This workplan was reviewed and approved by EGLE on December 20, 2018 and is included as Appendix B. The approved workplan provides additional details regarding the multiple lines of evidence approach to CCR removal. With the CCR removal complete, Consumers Energy is preparing the documentation report of the removal activities, which will be submitted to EGLE, and placed in the operating record. The excavated area is currently being restored by backfilling and grading with clean fill to promote stormwater drainage and minimize the potential for ponding of surface water or future infiltration of precipitation into the excavated footprint.

3.2 CCR – Impacted Groundwater Management Technologies

Several management technologies exist to reduce or eliminate potential risks of CCR-impacted groundwater migration to downgradient receptors. Institutional Controls (ICs) in the form of deed/access restrictions may also be used in conjunction with other remediation technologies to address unacceptable risks to potential receptors. The following list of viable management technologies will be further assessed and reviewed herein:

- Groundwater Monitoring (No Source Removal);
- Post Source Removal Monitoring;
- Groundwater Capture/Control;
- Impermeable Barrier;
- Active Geochemical Sequestration; and,
- Passive Geochemical Sequestration.

Each of these technology options are described in the following subsections and evaluated in Section 4 relative to anticipated effectiveness of the potential corrective measure in meeting the requirements and objectives of the remedy as described under §257.96(c) and R299.4443.

3.2.1 Alternative 1: Groundwater Monitoring (No Source Removal)

Long-term groundwater monitoring relies on physical, chemical, and/or biological *in situ* processes to act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of constituents in the subsurface environment. This groundwater management technology includes implementation of a long-term groundwater monitoring approach in conjunction with a No Action source material management strategy.

Regular monitoring of select groundwater monitoring wells for specific constituents is conducted to ensure COCs in groundwater are stable or attenuating over time.

3.2.2 Alternative 2a: Post Source Removal Monitoring

Post source removal groundwater monitoring is a strategy that can be implemented in combination with a closure in place or closure by removal CCR source material management strategy. Similar to the long-term groundwater monitoring strategy discussed in Section 3.2.1, this approach relies on physical, chemical, and/or biological in situ processes to act without human intervention to reduce the residual mass, toxicity, mobility, volume, or concentration of constituents in the subsurface environment; however, it can be demonstrated that source control/removal would expedite the reduction in concentrations of COCs to levels below regulatory criteria.

For this technology to be effective, the contaminant source areas must be limited in extent, and any residual constituents are separated from any nearby receptors by a sufficient time of groundwater travel (affected by distance, permeability, and/or hydraulic gradient) such that any naturally-occurring *in situ* remediation process may effectively eliminate the potential for the contaminant to reach the receptor at concentrations above applicable criteria.

Regular monitoring of select groundwater monitoring wells for specific constituents is conducted to ensure COCs in groundwater are attenuating over time.

3.2.3 Alternative 2b: Groundwater Capture/Control

Groundwater capture approaches are utilized to provide hydraulic control to reduce or prevent the mobility of COCs from migrating off-site and/or to surface water receptors. Capture of groundwater can be accomplished through the use of a conventional vertical groundwater extraction well network screened within the water bearing zone(s), horizontal groundwater extraction wells, or recovery trenches used to intercept groundwater flow. System components for an extraction management strategy typically include extraction points, pumps, electrical feed, well vaults, flow meters, and other miscellaneous appurtenances, and a discharge/treatment option for extracted groundwater. The efficiency of each approach is dependent on site-specific contaminant and hydrogeologic conditions.

3.2.4 Alternative 2c: Impermeable Barrier

Impermeable barriers can be installed below the ground surface to inhibit the lateral flow of groundwater. An impermeable barrier typically consists of a sheet pile or slurry containment wall. A slurry wall is a mixture of soil, water, and bentonite clay that is placed into trenches to create an impermeable vertical wall. A sheet pile wall consists of driven rigid materials (pilings) into the ground to form an impermeable barrier.

Impermeable barriers are often used in conjunction with a groundwater capture/control approach to reduce the number of wells required to reduce or prevent COC migration from the CCR unit. Barriers installed without groundwater extraction can be useful in preventing COC migration; however, altered flow conditions due to the barrier may cause water and COC migration around or beneath the installed barrier.

3.2.5 Alternative 2d: Active Geochemical Sequestration

Active geochemical sequestration can be an effective *in situ* groundwater treatment technology to either remove or transform COCs. Active geochemical sequestration relies on an energy dependent operating delivery system to introduce amendments continuously or at scheduled intervals to alter the natural geochemistry to conditions favorable for a reduction in mass or mobility of the COCs. Performance monitoring would determine the effectiveness and operation schedule. One example technology for this category would be Air Sparging. *In situ* treatment of coal ash related constituents in groundwater may be feasible via Air Sparging. Typically, injection below the water table of air, pure oxygen, or other gases is used to remove contaminants by volatilization or bioremediation; however, the technology can also be used to immobilize contaminants through chemical changes such as precipitation.

3.2.6 Alternative 2e: Passive Geochemical Sequestration

Passive geochemical sequestration can be an effective *in situ* groundwater treatment technology to either remove or transform COCs. Geochemical amendments are introduced through discrete direct injection events or trenching rather than continuously as through an active geochemical sequestration approach. One example would be using a Permeable Reactive Barrier installed between the contaminant source and the point(s) of compliance. A Permeable Reactive Barrier is a wall of a designed reactive material constructed *in situ* and perpendicular to the path of groundwater flow using conventional trenching techniques. Permeable Reactive Barriers are constructed with materials that destroy, transform, or enhance the degradation of the constituents or trap the constituents through adsorption or precipitation. The reactive amendment is blended into the trench to form a continuous, flow-through barrier across the plume. The permeability of the installed Permeable Reactive Barrier is targeted to be higher than the native aquifer materials so that the flow through the wall is not impeded at the time of installation or throughout the wall's operational life. Performance monitoring would determine the effectiveness and schedule consideration for reapplication of the amendment.

Section 4
Evaluation of Corrective Measure Alternatives

Section 4 describes the evaluation of the corrective measure alternatives for groundwater remediation identified in Section 3. Each identified alternative has been assessed using the CCR Rule and Michigan Part 115 corrective measure balancing criteria.

Table 1 provides a visual evaluation of the relative effectiveness of each groundwater treatment alternative to address COCs identified in Section 2.5.3. Each groundwater treatment alternative was evaluated with regards to each balancing criterion based on its anticipated effectiveness, implementability, and sustainability. Color-coding is used to categorize the alternative on a scale from ineffective to highly effective. The evaluation of each alternative is discussed in the following sub-sections. The relative effectiveness of each alternative compared to other alternatives based on the summation of the balancing criteria ratings is also included in Table 1.

The discussion in this section highlights the benefits and drawbacks of each option based on currently available data. Additionally, potential COCs will be considered during final remedy selection. The evaluation of these technologies is based on literature review of remediation profiles using these technologies with characteristics similar to the Karn Bottom Ash Pond, government guidance documents, and previous activities. The extent and magnitude of COC-impacted groundwater will be considered for evaluation of the final remedy.

Balancing criteria were selected based on remedy selection criteria in §257.97 and R299.4444 described in Section 4.1. In addition, R299.4443 for an ACM under Part 115 requires the ACM to comply with the requirements for feasibility studies contained in Part 201. As such, the balancing criteria encompass the criteria for remedial action selection under Section 20120(1).

4.1 Groundwater Management Balancing Criteria

The evaluation process for groundwater management technologies contained herein will generally consist of a weighted comparison of each alternative based on the benefits and drawbacks of each option for eliminating the drinking water exposure and relevant GSI pathways, addressing the ACM factors required in §257.96 and R299.4443 of Part 115, and considering the following remedy selection balancing criteria specified in §257.97, R299.4444 of Part 115, and Section 20120 of Part 201 :

- Effectiveness in Protecting Health, Safety, Welfare, and the Environment;
- Long-Term Uncertainties;
- Persistence, Toxicity, Mobility, and Propensity to Bioaccumulate of the Hazardous Substances;

- Short- and Long-Term Adverse Health Effects;
- Cost of Remedial Action including Long-Term Maintenance;
- Reliability of the Alternatives;
- Potential for Future Response Activity Costs if Alternative Fails;
- Potential Threats associated with Excavation, Transportation, Redisposal, or Containment;
- Ability to Monitor Remedial Performance; and,
- Public's Perspective about Extent to which the Proposed Remedial Action Effectively Addresses Requirements.

The selected corrective measures, as determined during the final remedy selection process described in Section 6, will be based on the balance between these various criteria for each alternative, rather than basing the corrective measure selection on only one of the criteria (e.g., reliability).

Analysis of viable alternatives for groundwater management identified in Section 3 are evaluated in conjunction with closure by CCR removal as the source material control option. Source removal by excavating CCR and extraction of local groundwater has been implemented as a source control strategy. Therefore, groundwater management alternatives will be retained for consideration in conjunction with source removal. Each alternative is discussed in the following sub-sections and are summarized in Table 1.

4.2 Alternative 1: No Source Control Action with Long Term Groundwater Monitoring and Institutional Controls (Baseline)

A source material management strategy of no action involves making no efforts to contain or remove CCR as it currently exists, or as it will exist at the end of the useful life of the unit. CCR would be left in the unit without construction of a low permeability cover or additional containment. A no action CCR source material management strategy is not considered viable due to its ineffectiveness of reducing potential exposures to the CCR material or potential migration of CCR material beyond the confines of the specified unit, nor is it a regulatory option. The no action CCR source material management strategy was included in the alternatives evaluation to provide a comparative baseline for other corrective measures alternatives.

Typically, a long-term groundwater monitoring approach works best where contaminant source areas have been effectively removed, remediated, and any residual constituents are separated from any nearby receptors by a sufficient time of groundwater travel (affected by distance, permeability, and/or hydraulic gradient) such that any naturally-occurring in situ remediation process may effectively eliminate the potential for the contaminant to reach the receptor at concentrations above applicable criteria. As no efforts to contain or remove CCR would be implemented under this alternative, long-term groundwater monitoring is not considered viable due to the ineffectiveness in protecting health, safety, welfare, and the environment, and the length of time needed to achieve the remedial goals. This alternative also has a high likelihood for additional future response activities as the reliability is low.

4.3 Alternative 2a: Source Removal with Post-Remedy Monitoring

Source removal and post-remedy groundwater monitoring generally offers an advantage over other options considered in that no active remediation system requires installation or maintenance, thus reducing costs, potential threats associated with excavation and material transportation, and long-term uncertainties. As discussed in Section 2.1, Closure by removal was the method of closure selected for the Karn Bottom Ash Pond prior to triggering the requirements for assessing corrective measures; therefore, post-excavation placement of a cap was not considered within this alternative. This approach is likely effective for the Karn Bottom Ash Pond since the contaminant source has been removed. Residual constituents are separated from any nearby receptors such that any naturally-occurring *in situ* remediation process may effectively eliminate the potential for the contaminant to reach the receptor at concentrations above the applicable criteria. Although groundwater chemistry already appears to be improving as a result of discontinuing the hydraulic loading to the Karn Bottom Ash Pond, and is expected to further improve following source removal, there still is some uncertainty surrounding how changes in redox conditions may affect contaminant transport. Since this groundwater monitoring remedy with source removal relies on naturally occurring processes that are often hard to predict, this alternative has a relatively high potential need for additional future response activities. Post-remedy monitoring could be initiated immediately following source removal utilizing the existing monitoring well network. Monitoring would continue until two consecutive rounds of data are below the GWPS for arsenic.

4.4 Alternative 2b: Source Removal with Groundwater Capture/Control

A groundwater extraction system, if designed, installed, operated, and maintained appropriately in conjunction with source removal could offer an effective remediation solution. A groundwater extraction and treatment system is currently operating as an interim measure downgradient of the Solid Waste Disposal Area. Water levels measured at monitoring wells and piezometers in proximity to the extraction system show that the system is locally influencing water levels before venting to Saginaw Bay. A construction dewatering system has been in operation at the Karn Bottom Ash Pond since March 20, 2019 and has operated through the excavation and restoration activities.

Additional groundwater extraction can be accomplished using wells screened within water bearing zones (as with the existing groundwater extraction system) or with recovery trenches.

Necessary system components for an extraction management strategy include extraction points, pumps, electrical feed, well vaults, flow meters, and other miscellaneous appurtenances. Due to the expected complexity of trench construction near Saginaw Bay and the Karn Bottom Ash Pond, capital costs associated with a trench construction would likely surpass costs expected of an equally effective groundwater extraction well system.

Design and operation of a system shall consider arsenic migration control, potential changes in oxidation state within water bearing zones that could cause unwanted scale formation in well screens and/or extraction equipment, or the introduction of facultative bacteria within the water bearing zone causing unwanted biogrowth that could affect rates of extraction, or in the case of arsenic, increased solubility and mobilization due to the creation of a more reduced aquifer condition. A routine system inspection and maintenance program would be required to maximize groundwater recovery rates while minimizing system downtime resulting from chemical and/or biological activity.

The existing extraction system has demonstrated effectiveness at capturing groundwater prior to venting to Saginaw Bay, but Consumers Energy continues to seek opportunities to optimize groundwater capture along a boundary that is exhibiting hydraulic changes internal and external to the Karn Landfill. The presence of an existing system also reduces the costs associated with this alternative. Reliability of a groundwater capture/control system is higher than active or passive geochemical sequestration, as it has been proven effective, but is less reliable than an impermeable barrier due to operation, maintenance, and overall effectiveness.

4.5 Alternative 2c: Source Removal with Impermeable Barrier

An impermeable barrier wall, constructed of either sheet pile or slurry, could be installed to restrict the groundwater flow paths directly from the Karn Bottom Ash Pond to Saginaw Bay. The impermeable wall would need to be installed into the clay confining unit underlying the uppermost groundwater aquifer. In order to evaluate this alternative further, groundwater modeling would be performed to assess the need for groundwater extraction.

An impermeable barrier would effectively minimize the movement of impacted groundwater, providing better protection than remediation relying on physical, chemical, or biological processes. However, due to the high capital cost of construction, the cost of remedial action is higher than other options considered. Installation of an impermeable barrier combined with groundwater extraction would have considerably longer construction duration when compared to other options considered.

4.6 Alternative 2d: Source Removal with Active Geochemical Sequestration

As already observed along the Karn Landfill perimeter bordering Saginaw Bay, transect/porewater GSI compliance sampling data indicates that biogeochemical conditions are already contributing to the reduction of arsenic in groundwater as arsenic concentrations in transect push-point samples located along the water's edge of Saginaw Bay are much lower than the arsenic concentrations observed in the perimeter dike wells. An active geochemical sequestration system would be designed and installed to enhance the natural biogeochemical processes already occurring. Consumers Energy is further evaluating the geochemical processes that are naturally occurring to better understand what enhancements are viable and appropriate.

Air Sparge is one geochemical sequestration option that could be an effective *in situ* groundwater treatment technology to either remove or transform COCs. Air Sparge can immobilize contaminants through chemical changes (e.g., oxidation of arsenic, its subsequent complexation with iron hydroxides, and precipitation). Aeration increases dissolved oxygen concentration in the groundwater and causes an accompanying increase in oxidation reduction potential (redox).

Installing air sparge wells, potentially in a curtain configuration perpendicular to flow of groundwater, offers a remedial option for select COCs by creating a reactive (oxidizing) zone in an attempt to remove arsenic through precipitation with dissolved minerals and sorption on metal/iron oxyhydroxides. Similar to other *in situ* approaches, a limiting process with this *in-situ* remedial approach is the delivery of the compounds within the area of interest. Creating enough contact with target constituents can be difficult in heterogeneous and fine-grained materials. A long term (approximately three months) Air Sparge pilot test (ARCADIS, 2015) demonstrated that the aquifer is suitable for air sparging (and likely other *in situ*, injection-based remedies) and confirmed arsenic reduction via this method; however, the nature of the in situ soil matrix and aquifer geochemistry provided challenges in achieving the GWPS of 21 μg/L with a conventional air sparge system. Like the groundwater capture system alternative, design and operation of an active geochemical sequestration system also needs to consider COC migration control and potential changes in oxidation state within water bearing zones that could cause adverse effects such as unwanted scale formation (e.g., fouling) in well screens. System operation and maintenance would be required to monitor operational parameters (e.g., pressures, temperatures, flow rates, etc.), and conduct routine maintenance on the system (e.g., filter cleaning and change-out, blower valve, belt and oil maintenance, etc.). Reliability of an active geochemical sequestration system is also considered lower when compared to other remedial alternatives due to the increased amount of operation, maintenance, and overall effectiveness. Installation of an active geochemical sequestration system would take longer than implementing groundwater monitoring or capture utilizing existing systems.

Furthermore, the efficacy of using passive and active geochemical sequestration would need to be further evaluated to determine if the act of sequestration has the potential to result in unanticipated consequences resulting in the mobilization of other metals that are currently not identified as COCs.

4.7 Alternative 2e: Source Removal with Passive Geochemical Sequestration

Passive geochemical sequestration, such as a Permeable Reactive Barrier, offers a remediation option for select COCs with no active operational costs other than periodic performance monitoring once installed. However, remediation of other COCs may not be equally effective, and therefore such COCs may pass through the Permeable Reactive Barrier with limited-to-no treatment prior to discharge. Although the Permeable Reactive Barrier offers a relatively low-cost remedial alternative, long term performance cannot be guaranteed, and wall failure would not be easily repaired without considerable reconstruction efforts.

The pH and redox conditions in the subsurface environment will control the solubility of arsenic into groundwater. In low pH and oxidized aquifer conditions, dissolved arsenic resides in a low solubility oxidized ionic state [As^{5+}]. At high pH and reduced aquifer conditions, dissolved arsenic resides in a higher solubility reduced ionic state [As^{3+}]. The presence of organic carbon and aerobic bacteria will also impact the concentration of arsenic in groundwater; both tend to create reduced groundwater conditions, thereby increasing the solubility/mobility of arsenic in the subsurface.

Ferric (oxidized) iron and zero-valent (reduced) iron (ZVI) have been demonstrated to be effective in the removal of arsenic in groundwater by way of adsorption onto the iron surfaces. Once adsorbed, the [As^{5+}] and [As^{3+}] ions will form complexes with iron corrosion products including ferrous hydroxide and ferric oxyhydroxides, and then become occluded by successive layers of corrosion products.

To address arsenic in the uppermost aquifer, the Permeable Reactive Barrier could be constructed using ZVI (with sulfide and organic carbon amendments to sustain the reduced environmental condition in this zone).

Arsenic removal by reactive in situ chemistry has been implemented in pilot and full- scale field installations; however, to develop confidence of its success and exact construction specifications, the proposed Permeable Reactive Barrier would require an extensive bench treatability study, if a Permeable Reactive Barrier wall was to be implemented. The effectiveness and reliability of passive geochemical sequestration is low compared to other options. The uncertainty of this alternative results in a relatively high potential for future response activities if it fails or proves to be ineffective. The use of chemical additions may cause changes in groundwater chemistry that result in increases in the persistence, toxicity, or mobility of groundwater constituents that would not occur with only monitoring, groundwater capture or control, or an impermeable barrier. Permeable Reactive Barrier wall construction would take a similar amount of time to implement as an impermeable barrier. Localized injections may be implemented slightly quicker but will still take longer than groundwater monitoring or capture using the existing systems. Furthermore, the efficacy of using passive and active geochemical sequestration would need to be further evaluated to determine if the act of sequestration has the potential to result in unanticipated consequences resulting in the mobilization of other metals that are currently not identified as constituents of concern.

Section 5
Remedy Selection Summary

This ACM has been completed to meet the requirements of §257.96 and to begin the process of selecting corrective measure(s) for groundwater. The CCR source material management strategy is summarized in Section 5.1. The results of the assessment of groundwater remediation technologies are summarized in Section 5.2.

5.1 CCR Source Material Management

Consumers Energy has completed the removal of CCR consistent with the timeline for closure of the Karn Bottom Ash Pond under the DE Karn Bottom Ash Pond Closure Plan and the CCR Rule's closure by removal provisions in §257.102(c). Consumers Energy ceased hydraulic loading to the Karn Bottom Ash Pond in June 2018 and allowed the area to dewater by gravity. Consumers Energy then operated a construction dewatering system to allow for excavation of the vertical and lateral extent of CCR that commenced on March 20, 2019 and has operated through the construction and restoration period. The excavation extended to six inches below known CCR elevations established from previous investigations. Excavated CCR has been placed in the neighboring Weadock Landfill that consists of a fully encapsulating soil-bentonite slurry wall keyed into a competently confining clay unit. The Karn Bottom Ash Pond is currently being restored by backfilling and grading the surface with a clean fill in accordance with the plan to promote stormwater drainage, minimize ponding of surface water, reduce the potential of infiltration and migration of arsenic and any future COCs. Groundwater chemistry already appears to be improving as a result of discontinuing the hydraulic loading to the Karn Bottom Ash Pond and is expected to further improve following the completed source removal. With the CCR removal complete, Consumers Energy is preparing the documentation report of the removal activities, which will be submitted to EGLE, and placed in the operating record.

5.2 Groundwater Management

This ACM Report provides a high-level assessment of groundwater remediation technologies that could potentially address site-specific COCs (i.e., arsenic) under known groundwater conditions. Currently, the assessment of remedial technologies is based on the remediation of arsenic. Based on the evaluation discussed in Section 4, long term groundwater monitoring in coordination with a no action CCR source material management strategy (Alternative 1) is not viable, and as discussed above, is a non-regulatory option that was included only as a comparative baseline for the alternative evaluation process. The remaining alternatives evaluated in this ACM are considered technically feasible final groundwater management strategies to be evaluated following source removal.

Consumers Energy plans to utilize an adaptive management strategy for selecting the final groundwater remedy for the Karn Bottom Ash Pond in coordination with the specified CCR source material management strategy. Under this remedy selection strategy, corrective measures may be implemented to address existing conditions followed by monitoring and evaluation of the corrective measure performance. Adjustments will be made to the corrective measure remedy, as needed, to achieve the remedial goals.

The groundwater management remedy for the Karn Bottom Ash Pond will, as soon as feasible, select a final remedy that, at a minimum, meets the standards of §257.96(b) and R299.4444(2) as outlined in Section 6. Although arsenic has been identified groundwater at concentrations exceeding applicable criteria, an evaluation of risk demonstrates that there are **currently no adverse effects on human health or the environment** from either surface water or groundwater due to CCR management at the Karn Bottom Ash Pond. Consumers Energy will continue to evaluate groundwater management alternatives, considering the assumptions and data limitations identified below.

5.3 Assumptions and Limitations

The groundwater monitoring system at the Karn Bottom Ash Pond has measured groundwater quality in the groundwater monitoring system over a relatively short period of time (2015 to 2019). Baseline conditions for the Karn Bottom Ash Pond were established based on a minimum eight samples collected on a quarterly basis over two years. This short baseline period limits the confidence in assessing the potential variability in groundwater quality over time based on hydrological and groundwater chemistry changes.

Since beginning CCR groundwater monitoring in 2015, Consumers Energy has ceased hydraulic loading to the Karn Bottom Ash Pond, operated a construction dewatering system, excavated the vertical and lateral extent of CCR as will be documented in the CCR Removal report, and restored the Karn Bottom Ash Pond by backfilling and grading the surface with a low permeability soil to reduce the potential of infiltration and migration of arsenic and any future COCs. Additionally, Consumers Energy continued the final cover construction at the Karn Landfill with construction to be completed in Calendar Year 2019.

Operational changes of the Karn Bottom Ash Pond and the substantial completion of the Karn Landfill capping construction have yielded a flatter gradient between the bottom ash pond area and the surrounding surface water bodies as compared to previous quarters, as expected. The reduction of hydraulic loading and recharge of the aquifer are expected to have changed equilibrium groundwater conditions (e.g., from aerobic to anaerobic). Appendix III and IV constituents may be impacted by changes in redox conditions.

Any remedial strategy depending on geochemical sequestration will need to implicitly include an analysis of the relative stability of groundwater chemistry, including an assessment of future uncertainty based on factors such as fluctuations in groundwater or surface elevations, redox indicators, etc. The efficacy of using passive and active geochemical sequestration would also need to be evaluated to determine if the act of sequestration has the potential to result in unanticipated consequences resulting in the mobilization of other metals that are currently not identified as constituents of concern.

Section 6
Next Steps

6.1 Selection of Remedy

The remedy selection process commences following the submittal of the ACM. Consumers Energy will, as soon as feasible, select a remedy that, at a minimum, meets the standards of §257.97(b) and R299.4444(2) that specify that remedies must:

1. Be protective of human health and the environment;
2. Attain the groundwater protection standard as specified pursuant to §257.95(h) and be able to attain groundwater protection standard specified in R299.4441;
3. Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of constituents in Appendix IV, PA 640 Section 11511a(3) and Section 11519b(2) constituents to this part into the environment;
4. Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems;
5. Control the source or sources of releases so as to reduce or eliminate, to the maximum extent practicable, further releases of PA 640 Section 11511a(3) and Section 11519b(2) constituents into the environment that may pose a threat to human health or the environment; and,
6. Comply with standards for management of wastes as specified in §257.98(d) and R299.4445(4).

Upon completion of the ACM leading up to the selection of remedy, Consumers Energy will prepare a semiannual report describing the progress in selecting and designing the remedy in accordance with §257.97. Preferred remedial technologies may be further evaluated as part of the remedy selection process to address site-specific conditions associated with long- and short-term effectiveness and protectiveness, implementability, the practicable capability of Consumers Energy, including a consideration of the technical and economic capability, and other considerations, and the degree to which community concerns are addressed by a potential remedy or remedies.

6.2 Public Meeting Requirement

Consumers Energy will discuss the ACM results in a public meeting with interested and affected parties in accordance with §257.96(e) and R 299.4443(4) prior to selecting a remedy.

The public meeting will be conducted at least 30 days prior to the selection of remedy in accordance with §257.96(e).

Consumers Energy will notify stakeholders when the public meeting has been scheduled.

6.3 Final Remedy Selection

A final report describing the selected remedy and how it meets the standards specified in §257.97 will be prepared following selection of a final remedy. Consumers Energy must obtain a certification from a qualified professional engineer that the remedy selected meets the requirements of §257.97. The final report will be considered completed when it is placed in the facility's operating record as required by §257.105(h)(12).

Based on the results of the corrective measures assessment pursuant to R299.4443, Consumers Energy will propose to the EGLE director a remedy that, at a minimum, meets the standards specified in R299.4444(2). Consumers Energy will within 14 days of selecting a remedy, submit to the director a proposed remedial action plan which is in compliance with Part 201 of the act and which describes the selected remedy and how it also meets the standards of Part 201 of the act.

6.4 Continued Groundwater Monitoring

Consumers Energy will continue executing the self-implementing groundwater compliance schedule in conformance with §257.90 - §257.98, which includes semiannual assessment monitoring in accordance with §257.95 to monitor groundwater conditions and inform the remedy selection. The next semiannual assessment monitoring event is scheduled to occur in October 2019 with results summarized in the 2019 Annual Groundwater Monitoring Report issued in January 2020.

Section 7
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Golder Associates Inc. April 2018. D.E. Karn Generating Facility Revised Bottom Ash Pond Closure Work Plan, Essexville, Michigan. Prepared for Consumers Energy Company.

TRC. October 2017. Groundwater Statistical Evaluation Plan – DE Karn Power Plant, Bottom Ash Pond, Essexville, Michigan. Prepared for Consumers Energy Company.

TRC Environmental Corporation. January 2018. Annual Groundwater Monitoring Report – DE Karn Power Plant, Bottom Ash Pond CCR Unit. Prepared for Consumers Energy Company.

TRC Environmental Corporation. January 2019. 2018 Annual Groundwater Monitoring Report – DE Karn Power Plant, Bottom Ash Pond CCR Unit. Prepared for Consumers Energy Company.

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USEPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance. Office of Conservation and Recovery. EPA 530/R-09-007.

USEPA. April 2015. 40 CFR Parts 257 and 261. Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule. 80 Federal Register 74 (April 17, 2015), pp. 21301-21501 (80 FR 21301).

USEPA. July 2018. 40 CFR Part 257. Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals from Electric Utilities; Amendments to the National Minimum Criteria (Phase One, Part One); Final Rule. 83 Federal Register 146 (July 30, 2018), pp. 36435-36456 (83 FR 36435).

Tables

Table 1
Summary Of
Remedial Action Selection
Alternative Evaluation

Site/Impoundment Name: DE Karn Bottom Ash Pond

Option #		1	2				
CCR Source Management		None	CCR Removal				
Option #		a	a	b	c	d	e
Groundwater Management (all options will include ICs)		Long Term Groundwater Monitoring & Institutional Controls (ICs) 1	Post Source Removal Monitoring 2a	Groundwater Capture/Control 2b	Impermeable Barrier (e.g., slurry wall) with Groundwater Capture/Control 2c	Active Geochemical Sequestration (e.g., Air Sparge) 2d	Passive Geochemical Sequestration (e.g. PRB) 2e
Balancing Criteria	**Rule Reference**						
i. Effectiveness in Protecting Health, Safety, Welfare, and the Environment	§257.96(c)(1) §257.97(b)(1) R 299.4444(2)(a) Section 20120(1)(a)						
ii. Long-Term Uncertainties	§257.96(c)(1) Section 20120(1)(b)						
iii. Persistence, Toxicity, Mobility, and Propensity to Bioaccumulate of the Hazardous Substances	§257.96(c)(1) Section 20120(1)(c)						
iv. Short- and Long-Term Adverse Health Effects from Exposure	§257.96(c)(1) §257.97(d)(4) R 299.4444(4)(e) Section 20120(1)(d)						
v. Cost of Remedial Action including Long-Term Maintenance	Section 20120(1)(e)						
vi. Reliability of the Alternatives	§257.96(c)(1) §257.97(c)(1)(vii) §257.97(c)(3)(ii) R 299.4444(3)(a)(vii) R 299.4444(3)(c)(ii) Section 20120(1)(f)						
vii. Potential for Future Response Activity Costs if Alternative Fails	§257.96(c)(1) §257.97(c)(1)(viii) R 299.4444(3)(a)(viii) Section 20120(1)(g)						
viii. Potential Threats associated with Excavation, Transportation, Redisposal, or Containment	§257.96(c)(1) §257.97(c)(1)(iv) R 299.4444(3)(a)(iv) Section 20120(1)(h)						
ix. Ability to Monitor Remedial Performance	Section 20120(1)(i)						
x. Public's Perspective about Extent to which the Proposed Remedial Action Effectively Addresses Requirements	§257.97(c)(4) R 299.4444(3)(e) Section 20120(1)(j)						
	Relative Effectiveness						

Ineffective, not implementable, and/or not sustainable.

Effectiveness is unsure, challenging implementation, and/or sustainability reduced by at least one operational factor.

Effective, implementable, and/or sustainable.

Notes:
(1) Except as otherwise noted, balancing criteria encompass criteria in the CCR Rule §257.97, Michigan Part 115 R 299.4444, and Michigan Part 201, Section 20120 for remedy selection.
(2) Consumers Energy intends to close the Karn Bottom Ash Pond under the RCRA Rule's closure by removal provisions in §257.102(C). CCR Removal has been completed in accordance with the April 2018 Closure Work Plan.

Figures

LEGEND

- BACKGROUND MONITORING WELL
- DEK BOTTOM ASH POND & LINED IMPOUNDMENT MONITORING WELL
- DEK BOTTOM ASH POND MONITORING WELL
- DEK LINED IMPOUNDMENT MONITORING WELL
- DECOMMISSIONED MONITORING WELL
- JCW BOTTOM ASH POND MONITORING WELL
- JCW LANDFILL CCR WELL
- MONITORING WELL (STATIC WATER LEVEL ONLY)
- LEACHATE HEADWELL
- SURFACE WATER GAUGING STATION
- NATURE AND EXTENT WELL
- SLURRY WALL (APPROXIMATE)
- EXTENT OF GEOSYNTHETICS (KARN LINED IMPOUNDMENT)

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO, 2018.
2. WELL LOCATIONS SURVEYED BY ROWE PROFESSIONAL SERVICES COMPANY ON 11/4/2015.
3. NOAA/NATIONAL OCEANIC SERVICE GREAT LAKES GAUGING STATION, ESSEXVILLE, MI (ID: 9075035).

PROJECT:

CONSUMERS ENERGY COMPANY
DE KARN AND JC WEADOCK POWER PLANTS
ESSEXVILLE, MICHIGAN

TITLE:

SITE MAP

DRAWN BY:	S. MAJOR	PROJ NO.:	322173-001
CHECKED BY:	K. AMONETTE		
APPROVED BY:	D. LITZ		**FIGURE 1**
DATE:	SEPTEMBER 2019		

TRC

1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
www.trccompanies.com

FILE NO.: 322173-001-007.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
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LEGEND

- BACKGROUND MONITORING WELL
- DEK BOTTOM ASH POND & LINED IMPOUNDMENT MONITORING WELL
- DEK BOTTOM ASH POND MONITORING WELL
- DEK LINED IMPOUNDMENT MONITORING WELL
- DECOMMISSIONED MONITORING WELL
- JCW BOTTOM ASH POND MONITORING WELL
- JCW LANDFILL CCR WELL
- MONITORING WELL (STATIC WATER LEVEL ONLY)
- LEACHATE HEADWELL
- SURFACE WATER GAUGING STATION
- NATURE AND EXTENT WELL
- SLURRY WALL (APPROXIMATE)
- EXTENT OF GEOSYNTHETICS (KARN LINED IMPOUNDMENT)
- GROUNDWATER ELEVATION CONTOUR (2' INTERVAL, DASHED WHERE INFERRED)
- (580.50) GROUNDWATER ELEVATION
- (NM) NOT MEASURED

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO, 2018.
2. WELL LOCATIONS SURVEYED BY ROWE PROFESSIONAL SERVICES COMPANY ON 11/4/2015.
3. NOAA/NATIONAL OCEANIC SERVICE GREAT LAKES GAUGING STATION, ESSEXVILLE, MI (ID: 9075035).
4. GROUNDWATER ELEVATIONS DISPLAYED IN FEET RELATIVE TO THE NORTH AMERICAN VERTICAL DATUM OF 1988.
5. DATA FROM APRIL 7, 2019. NO DATA RECORDED AT NOAA GAUGING STATION ON APRIL 8, 2019.

0 1,000 2,000 Feet

1 " = 1,000 '
1:12,000

PROJECT:
CONSUMERS ENERGY COMPANY
DE KARN AND JC WEADOCK POWER PLANTS
ESSEXVILLE, MICHIGAN

TITLE:
SHALLOW GROUNDWATER CONTOUR MAP APRIL 2019

DRAWN BY:	S. MAJOR	PROJ NO.:	322173-001
CHECKED BY:	K. AMONETTE	**FIGURE 2**	
APPROVED BY:	D. LITZ		
DATE:	SEPTEMBER 2019		

TRC
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FILE NO.: 322173-001-008x.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

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Path: E:\ConsumersEnergy\CCR_GW\2017_269767\322173-001-008x.mxd

Constituent	GWPS
Antimony	6 ug/L
Arsenic	21 ug/L
Barium	2,000 ug/L
Beryllium	4 ug/L
Cadmium	5 ug/L
Chromium	100 ug/L
Cobalt	15 ug/L
Fluoride	4,000 ug/L
Lead	15 ug/L
Lithium	180 ug/L
Mercury	2 ug/L
Molybdenum	100 ug/L
Radium-226/228	5 pCi/L
Selenium	50 ug/L
Thallium	2 ug/L

LEGEND

- DEK BOTTOM ASH POND & LINED IMPOUNDMENT MONITORING WELL
- DEK BOTTOM ASH POND MONITORING WELL
- DEK LINED IMPOUNDMENT MONITORING WELL
- DECOMMISSIONED MONITORING WELL
- DEK LANDFILL HMP
- NATURE AND EXTENT WELL
- NO STATISTICALLY SIGNIFICANT EXCEEDANCES
- STATISTICALLY SIGNIFICANT GWPS EXCEEDANCE
- SLURRY WALL (APPROXIMATE)
- EXTENT OF GEOSYNTHETICS (KARN LINED IMPOUNDMENT)
- POREWATER SAMPLING AREA

WELL ID
CONSTITUENT(S) EXCEEDING GWPS

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO, 2018.
2. MONITORING WELL AND SLURRY WALL LOCATIONS PROVIDED BY CEC; SG21733SHT2 REVB.DWG DATED 11/21/2018.
3. GWPS (GROUNDWATER PROTECTION STANDARD) IS THE HIGHER OF THE MAXIMUM CONTAMINANT LEVEL (MCL)/REGIONAL SCREENING LEVEL FROM 83 FR 36435 (RSL) AND UPPER TOLERANCE LIMIT (UTL) AS ESTABLISHED IN TRC'S TECHNICAL MEMORANDUM DATED OCTOBER 15, 2018.
4. AN EXCEEDANCE OF THE GWPS OCCURS WHEN THE LOWER CONFIDENCE LIMIT OF THE DOWNGRADIENT DATA EXCEEDS THE GWPS.

0 600 1,200 Feet

1 " = 600 '

1:7,200

PROJECT:

CONSUMERS ENERGY COMPANY
DE KARN POWER PLANT
ESSEXVILLE, MICHIGAN

TITLE:

NATURE AND EXTENT SUMMARY
GWPS EXCEEDANCES

DRAWN BY:	S. MAJOR	PROJ NO.:	322172-001
CHECKED BY:	K. AMONNETTE		
APPROVED BY:	D. LITZ		**FIGURE 3**
DATE:	SEPTEMBER 2019		

TRC
1540 Eisenhower Place
Ann Arbor, MI 48108-3284
Phone: 734.971.7080
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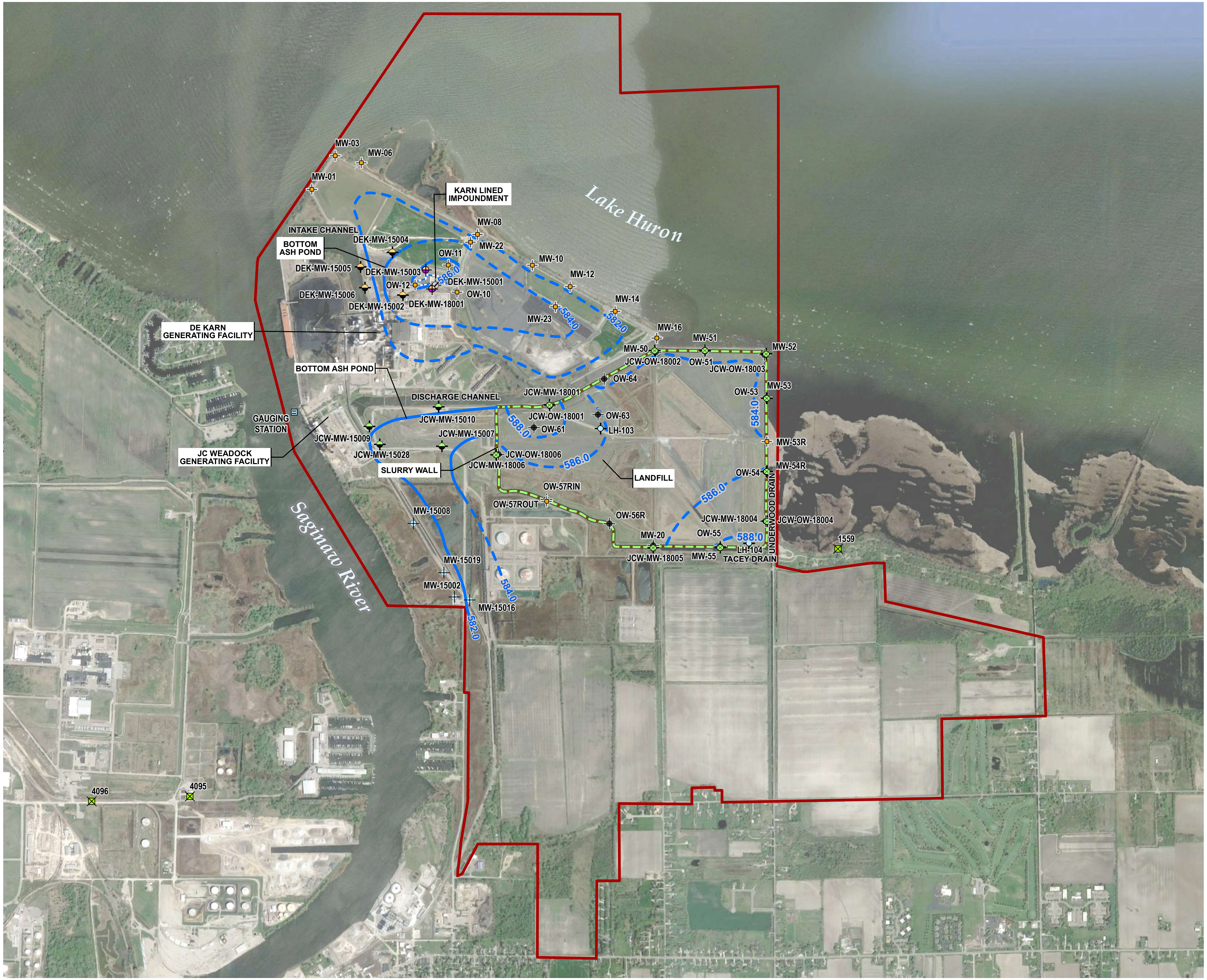
FILE NO.: 322172-ExceedancesNE_ACM.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 9/10/2019, 12:13:50 PM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: E:\ConsumersEnergy\CCR_GW\2017_269767\322172-ExceedancesNE_ACM.mxd



LEGEND

- BACKGROUND MONITORING WELL
- DEK BOTTOM ASH POND & LINED IMPOUNDMENT MONITORING WELL
- DEK BOTTOM ASH POND MONITORING WELL
- DEK LINED IMPOUNDMENT MONITORING WELL
- DECOMMISSIONED MONITORING WELL
- JCW BOTTOM ASH POND MONITORING WELL
- JCW LANDFILL CCR WELL
- MONITORING WELL (STATIC WATER LEVEL ONLY)
- LEACHATE HEADWELL
- SURFACE WATER GAUGING STATION
- NATURE AND EXTENT WELL
- DRINKING WATER WELL
- SLURRY WALL (APPROXIMATE)
- EXTENT OF GEOSYNTHETICS (KARN LINED IMPOUNDMENT)
- PROPERTY BOUNDARY
- GROUNDWATER ELEVATION CONTOUR (2' INTERVAL, DASHED WHERE INFERRED)

NOTES

1. BASE MAP IMAGERY FROM GOOGLE EARTH PRO, 2018.
2. WELL LOCATIONS SURVEYED BY ROWE PROFESSIONAL SERVICES COMPANY ON 11/4/2015.
3. NOAA/NATIONAL OCEANIC SERVICE GREAT LAKES GAUGING STATION, ESSEXVILLE, MI (ID: 9075035).
4. GROUNDWATER ELEVATIONS DISPLAYED IN FEET RELATIVE TO THE NORTH AMERICAN VERTICAL DATUM OF 1988.
5. DRINKING WATER WELL LOCATIONS FROM THE STATE OF MICHIGAN WELLOGIC DATABASE, 7/18/2019.
6. GROUNDWATER ELEVATION DATA RECORDED.

0 1,600 3,200 Feet

1 " = 1,600 '

1:19,200

PROJECT:

CONSUMERS ENERGY COMPANY
DE KARN AND JC WEADOCK POWER PLANTS
ESSEXVILLE, MICHIGAN

TITLE:

PROPERTY BOUNDARY AND SURROUNDING FEATURES

DRAWN BY:	S. MAJOR	PROJ NO.:	322173-001
CHECKED BY:	K. AMONETTE		
APPROVED BY:	D. LITZ		**FIGURE 4**
DATE:	SEPTEMBER 2019		

TRC
1540 Eisenhower Place
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FILE NO.: 322173-001-013x.mxd

TRC - GIS

Coordinate System: NAD 1983 StatePlane Michigan South FIPS 2113 Feet Intl (Foot)
Map Rotation: 0

Plot Date: 9/6/2019, 11:23:36 AM by SMAJOR -- LAYOUT: ANSI B(11"x17")
Path: E:\ConsumersEnergy\CCR_GW\2017_269767\322173-001-013x.mxd

Appendix A
Demonstration for 60-Day Extension

Consumers Energy
Count on Us®

A CMS Energy Company

Date: July 12, 2019

To: Operating Record

From: Harold D. Register, Jr., P.E. HDR

RE: Demonstration for 60-Day Extension for Assessment of Corrective Measures
Professional Engineer Certification
DE Karn Bottom Ash Pond

Professional Engineer Certification Statement [§257.96(a)]

Consumers Energy has determined that the analysis of the effectiveness of potential corrective measures in meeting all of the requirements and objectives of a selected remedy described in §257.97 cannot be achieved within the 90-day timeline to complete the Assessment of Corrective Measures for DE Karn Bottom Ash Pond due to site-specific conditions that are changing based on initiating closure activities. Notification was made October 12, 2018 that closure activities had been initiated. Groundwater monitoring data collected to date indicates changing conditions that can influence factors that must be considered in the assessment, including source evaluation, plume delineation, groundwater assessment, and source control. The final published rule allows for a single 60 day extension based on site-specific conditions or circumstances.

I hereby attest that, having reviewed the detection and assessment monitoring documentation and being familiar with the provisions of Title 40 of the Code of Federal Regulations §257.96, that the demonstration justifying a 60-day time extension to the 90-day completion period of the Assessment of Corrective Measures is accurate for DE Karn Bottom Ash Pond in accordance with the requirements of §257.96(a). This will now set the deadline for completing the Assessment of Corrective Measures for September 11, 2019.

Harold D. Register Jr.

Signature

STATE OF MICHIGAN
HAROLD D. REGISTER, JR.
ENGINEER
No.
6201056266
LICENSED PROFESSIONAL ENGINEER

07/12/2019

July 12, 2019

Date of Certification

Harold D. Register, Jr., P.E.

Name

6201056266

Professional Engineer Certification Number

Appendix B
Closure Work Plan

Consumers Energy

A CMS Energy Company

Environmental Services

April 12, 2018

Phil Roycraft
Michigan Department of Environmental Quality
Waste Management & Radiological Protection Division
Saginaw Bay District Office
401 Ketchum St, Suite B
Bay City, Michigan 48708

TRANSMITAL OF DE KARN REVISED BOTTOM ASH POND CLOSURE BY REMOVAL PLAN DATED APRIL 9, 2018; WASTE DATA SYSTEM NUMBER 392503

Dear Mr. Roycraft,

This revised workplan submittal has been prepared to address comments provided by Michigan Department of Environmental Quality (MDEQ) on January 31, 2018 on the *"D.E. Karn Generating Facility Bottom Ash Pond Closure Work Plan"* (Revised Closure Work Plan), dated November 29, 2017 and as a follow-up to our meeting on February 13, 2018. This work plan is being submitted to request agreement from the Michigan Department of Environmental Quality (MDEQ) on Consumers Energy's plan to close the DE Karn Bottom Ash Pond by removal of CCR in accordance with the self-implementing schedule and requirements of the CCR Rule.

The DE Karn Bottom Ash Pond has a certified closure plan pursuant to 40 CFR 257.102(c) depicting closure by removal for this CCR unit enclosed with the response. Consumers Energy will provide MDEQ with necessary notifications as closure commences as well as provide opportunities to observe elements of field activities.

Please feel free to contact me with any questions that you may have about this submittal.

Sincerely,

Harold D. Register J.

Harold D. Register, Jr., P.E.
Senior Engineer
Landfill Operations Compliance
Phone: (517) 788-2982
Email: harold.registerjr@cmsenergy.com

cc: Ms. Lori Babcock, MDEQ Saginaw Bay District Office
Mr. Gary Schwerin, MDEQ Saginaw Bay District Office
Mr. Caleb Batts, Consumers Energy Karn-Weadock

Enclosures:

1) *"D.E. Karn Generating Facility Revised Bottom Ash Pond Closure Work Plan"* dated April 9, 2018.
2) Redline Track-Changes Version from November 29, 2017
3) "*Transmittal of DE Karn Bottom Ash Pond Closure By Removal Plan Response to Comments,*" dated January 31, 2018 and Follow-Up from Meeting on February 13, 2018

Enclosure 1

"D.E. Karn Generating Facility Revised Bottom Ash Pond Closure Work Plan" dated April 9, 2018

Bottom Ash Pond
Closure Work Plan

D.E. KARN GENERATING FACILITY

REVISED BOTTOM ASH POND CLOSURE WORK PLAN

Essexville, Michigan

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

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

April 9, 2018 **1667572**

Golder Associates

Table of Contents

List of Tables

List of Figures

List of Appendices

1.0 CLOSURE WORK PLAN OVERVIEW AND OBJECTIVES

This revised closure work plan has been prepared to request agreement from the Michigan Department of Environmental Quality (MDEQ) on Consumers Energy Company's (CEC) plan to remove coal combustion residual (CCR) from the Bottom Ash Pond at the D.E. Karn Generating Facility (DE Karn) located in Essexville, Michigan. Specifically, the Bottom Ash Pond is an "existing CCR surface impoundment" which will be closed by removal of CCR in accordance with self-implementing requirements of the CCR Resource Conservation and Recovery Act (RCRA) Rule (40 CFR 257 Subpart D) ("CCR RCRA Rule").

This document provides a general description of the following:

- Plans for removal of waste
- Multiple lines of evidence to document waste removal including the basis for an objective waste removal standard to address potential long-term sources of groundwater impacts
- Schedule for implementing the work
- Performance monitoring after waste removal in accordance with the CCR RCRA Rule

An objective standard of 90 percent CCR removal has been established through analysis of site-specific CCR and soils. Although the purpose of this closure work plan is to define methods for removal of CCR as a regulated waste, the 90 percent removal criteria is based on chemical analyses that have shown the criteria to be protective of groundwater based on non-residential drinking water and groundwater and surface water interaction (GSI) criteria.

Closure of the Bottom Ash Pond is being driven by CEC's plan to comply with the CCR RCRA Rule. CEC plans to initiate closure of the Bottom Ash Pond in 2018. To comply with closure timeframe requirements of the CCR RCRA Rule and maintain project schedule and procurement of a closure construction contract, CEC requests MDEQ approval of this closure work plan by January 31, 2018.

CEC is proposing the same CCR removal and similar documentation procedures approved by the MDEQ for closing J.H. Campbell Generating Facility Bottom Ash Pond 3N (JHC Bottom Ash Pond 3N). JHC Bottom Ash Pond 3N was closed by removal of CCR in March 2017 through June 2017. Closure was documented in the *J.H. Campbell Generating Facility Bottom Ash Pond 3N CCR Removal Documentation Interim Report* (JHC Bottom Ash Pond 3N Closure Report) submitted to the MDEQ on June 20, 2017 and approved on July 18, 2017.

Revisions made to the original closure work plan submitted in November 2017 to address clarifications requested by the MDEQ via email on January 31, 2018 include:

- Clarifying thresholds for CCR/sand mixtures based on selenium

- Clarifying colorimetric analysis for the third line of evidence for the quality assurance plan for removal
- Clarifying the positioning for the camera and resolution of imagery for the pictures.

2.0 FACILITY BACKGROUND

DE Karn is a coal-fueled power generating facility located in Essexville, Michigan. The Bottom Ash Pond began operation in 1959. An overview map of DE Karn and ash disposal area is shown in Figure 1 – D.E. Karn Site Layout Map. The DE Karn Solid Waste Disposal Area consists of two distinct areas of disposal – a permitted landfill undergoing closure and an active surface impoundment (Bottom Ash Pond).

The active Bottom Ash Pond is an unlined surface impoundment that receives sluiced bottom ash. The Bottom Ash Pond was designated an “existing CCR surface impoundment” under the CCR RCRA Rule, as it was directly receiving and storing commingled CCR and non-CCR wastewaters as of the effective date of the CCR RCRA Rule.

A new lined surface impoundment is planned to be constructed to comply with liner design criteria under 40 CFR 257.70-72. Once constructed, bottom ash will be directed to the lined impoundment for treatment. The impoundment is scheduled to be complete by July 2018 to facilitate anticipated cessation of receipt of CCR and non-CCR wastewaters in the Bottom Ash Pond in the fourth quarter of 2018 or first quarter of 2019. CEC will provide the Notice of Initiation of Closure pursuant to 40 CFR 257.102(g).

3.0 REGULATORY BACKGROUND

CEC has identified the Bottom Ash Pond at DE Karn as an “existing CCR surface impoundment” under the CCR RCRA Rule, as it was directly receiving and storing commingled CCR and low volume miscellaneous wastewaters as of the effective date of the CCR RCRA Rule (October 19, 2015). As such, there are specific criteria and schedules under the CCR RCRA Rule for CEC to conduct closure.

The Bottom Ash Pond is located immediately adjacent to the 171-acre solid waste disposal area in the DE Karn Solid Waste Disposal Area operating license. The Bottom Ash Pond is permitted under Michigan’s Natural Resources and Environmental Protection Act (NREPA) Part 31 as part of the National Pollution Discharge Elimination System (NPDES). A solid waste disposal area construction permit authorizing conditions for storage and/or disposal was not issued for the Bottom Ash Pond pursuant to solid waste authorities, since the wastewaters containing CCR discharging into the Bottom Ash Pond are considered to be “other wastes regulated by statute” as defined in Rule 110 of the Part 115 Solid Waste Rules. This regulatory exception to authorize activity only under the NPDES permit is limited in scope and application with respect to the disposal and end of life considerations of CCR from this unit.

4.0 SELF-IMPLEMENTATION OF CLOSURE BY REMOVAL OF CCR

CEC intends to close the Bottom Ash Pond by removal of CCR in accordance with self-implementing requirements under the CCR RCRA Rule. Upon approval of this closure work plan, CEC intends for this document to serve as an agreement with MDEQ on applicable elements of its self-implementing plan to achieve closure in accordance with the CCR RCRA Rule. Documentation and certifications necessary under the CCR RCRA Rule will be provided to MDEQ as part of the notification requirements to the relevant State Director detailed in 40 CFR 257.106. Additionally, the applicable certifications and documents will be posted to the CCR Rule Compliance Data and Information publicly-accessible website pursuant to 40 CFR 257.107.

As part of closure self-implementation, the United States Environmental Protection Agency (EPA) required an initial closure plan certified by a qualified professional engineer to be placed in the operating record and posted on a publicly-accessible internet site for existing CCR surface impoundments by October 17, 2016. The initial closure plan indicated that the Bottom Ash Pond would be closed with CCR in-place. However, CEC since determined it was feasible to close the Bottom Ash Pond by removal of CCR. A certified plan for closure of the Bottom Ash Pond by removal of CCR will be independently generated, placed in the CCR unit operating record, and posted on CEC's publicly-accessible internet site subsequent to MDEQ acceptance of this closure work plan.

4.1 Narrative Summary of Closure

The Bottom Ash Pond will be closed by removal of all visible CCR. This is consistent with the clearly visible demarcation of CCR and underlying substrate witnessed in site investigations, as shown in photographs provided in Appendix A – Site Boring Photographs. It is also in accordance with 40 CFR 257.102(c), which states "CCR removal and decontamination of the CCR unit are complete when constituent concentrations throughout the CCR unit and any areas affected by releases from the CCR unit have been removed and groundwater monitoring concentrations do not exceed the groundwater protection standard established pursuant to 257.95(h)." The CCR RCRA Rule also prescribes the closure timeframe for existing CCR surface impoundments as five years from the commencement of closure activities [40 CFR 257.102(f)(1)(ii)].

The Bottom Ash Pond will be closed in compliance with the CCR RCRA Rule using a phased approach which will include: 1) physical removal of CCR for purposes of removing regulated waste and sources of potential long-term groundwater contamination; and 2) use of the balance of the five-year closure timeframe provided for in 40 CFR 257.102(f)(1)(ii) to demonstrate the concentrations of Appendix IV constituents of concern do not exceed groundwater protection standards established pursuant to 257.95(h). This compliance monitoring schedule is provided in Figure 2 – D.E. Karn Bottom Ash Pond Closure Schedule.

The lateral boundaries of the Bottom Ash Pond are defined by the perimeter drainage ditches to the east and west and the shoulder of an access road to the north. The southern boundary is defined by the edge of an overflow gravel parking area north of DE Karn. Permanent 4:1 (H:V) slopes will be used to tie into existing grades at the lateral limits and access the vertical extents of the CCR. The lateral extent of the Bottom Ash Pond is shown in Figure 3 – Lateral Extent of CCR Unit.

Excavation of CCR will reach approximate depths of 5 to 30 feet below the existing grade. Proposed excavation contours are provided in Figure 4 – Bottom Ash Pond Depth of CCR Excavation. After CCR are removed from the ponds, the area will be backfilled with clean fill to promote stormwater drainage and minimize the potential for ponding of surface water.

4.2 CCR Removal and Documentation – Phase I

The first phase of closure activities will be CCR removal and documentation. Descriptions of activities to remove CCR and document adequate removal are provided below along with background and basis for the various lines of evidence.

4.2.1 CCR Excavation and Documentation Summary

This section provides a list of the tasks to be completed during excavation and documentation and provides more details regarding method development and rationale. Excavation will be performed to remove CCR to elevations identified during site investigations; visual observations will be made to confirm the CCR removal objective is met. Documentation of CCR removal will then be performed to provide lines of evidence that validate the extent of the excavation and visual observations made in the field. During CCR removal and documentation, the following tasks will be completed:

- Excavation
  - The Bottom Ash Pond will be dewatered by actively pumping decant in a manner that maintains NPDES permitted effluent limits
  - Hydraulic structures will be abandoned in-place or removed
  - CCR removal will be complete when the following are achieved:
    - The selected contractor meets lateral and vertical excavation limits determined from previous site investigations
    - Visual observations determine that the CCR removal objective has been met
- Documentation and final certification
  - Final excavation grades will be compared to known elevations of CCR from previous site investigations
  - Photographs will be taken to document CCR removal in excavated areas
  - Quantitative colorimetric analysis will be completed to confirm CCR removal meets objective limits

- As an alternative to quantitative colorimetric testing, microscopic quantification of CCR content as described in the JHC Bottom Ash Pond 3N Closure Report will be used to confirm CCR removal if excavated areas are influenced by soils that do not pass the site-specific colorimetric cutoff value selected for closure of the Bottom Ash Pond

Results will be documented in a Bottom Ash Pond CCR removal documentation report. More detailed descriptions and supporting information on activities to document CCR removal are included in the subsequent sections.

4.2.1.1 Removal Criteria Background

CEC is proposing to conduct this assessment based on removal criteria that were developed for closing the Bottom Ash Ponds at CEC's other plants with similar CCR characteristics. When developing CCR removal criteria for Bottom Ash Ponds, characteristics of CCR were evaluated to determine the feasibility of different methods to document CCR removal including color, density, particle size, and particle shape. Based on previous experience of evaluating the material characteristics; color as determined by visual inspection and confirmed by colorimetric analysis was determined to be superior to other documentation methods such as centrifuge separation, petrography via microscope, or scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM/EDX) at sites where the CCR is darker than the underlying native sand material.

Laboratory testing of sand and CCR samples collected from the DE Karn Bottom Ash Pond indicated there is a distinguishable color difference between CCR and the native soil, and visual inspection and colorimetric analysis are effective in assessing the presence of CCR in a mixture with native sand. The density of the CCR and native sands is too similar for centrifugal separation, and sieving is not practical due to the range of particle sizes for the different materials. In addition, SEM/EDX would be limited to the assessment of very small samples and require specialist equipment that could not be feasibly implemented as a field screening method. Colorimetry allows evaluation of larger sample sizes and is easily adapted to the field; thus, allowing the potential for additional sampling to verify reproducibility of results. Therefore, colorimetry was selected as the final and preferred line of evidence to identify and quantify CCR present in samples collected from the Bottom Ash Pond excavation footprint. Some color variability may exist in native soils at the base of the excavation footprint at DE Karn. If native soil color variability is encountered at one of the grid nodes, field microscopic quantification of CCR content will be utilized to confirm the CCR removal objective was met.

Twelve CCR and nine underlying soil samples were collected by drilling from the Bottom Ash Pond. CCR samples were obtained from two borings located in the Bottom Ash Pond (three samples from each boring) and an additional six additional borings located on and around the edges of the Bottom Ash Pond (one sample from each boring). Underlying soil samples were collected at deeper depths from the same eight borings; two samples were collected from one of the two borings located in the Bottom Ash Pond. The selected samples were compared to the MDEQ Cleanup Criteria Requirements for Response Activity, R 299.48 Generic Soil Cleanup Criteria for Non-residential Category GSI protection and drinking water protection criteria to determine which constituent(s) could be used as indicators of potential groundwater impacts.

Barium, chromium (III), copper, lead, and zinc were not assessed as indicator constituents; because they were not detected in CCR or native soils at concentrations greater than their respective GSI protection criteria. Cadmium, silver, and thallium were also not considered; because they were not detected in CCR at concentrations above their respective method detection limits.

Arsenic, boron, mercury, and selenium were detected in CCR samples at concentrations that exceeded their respective GSI protection criteria. Of these, the average concentrations of arsenic and selenium also exceeded GSI protection criteria in the sand samples; indicating that, even with complete removal of CCR, they may still occur in native sands at concentrations that exceed their respective criteria. Mercury was only detected in one CCR sample and one sand sample; both exceeded the GSI protection criteria, which is equal to the detection limit of 50 µg/kg. Given mercury was not detected in most samples, it was not considered further in selecting a threshold for CCR removal. Based on the average concentrations of boron in CCR and sand, a mixture of CCR and sand containing less than 75 percent CCR would meet the GSI protection criteria for boron.

To identify a numerical threshold for CCR removal, Golder evaluated the ratio of CCR and underlying soil that would reduce soluble concentrations of arsenic, boron, mercury, and selenium. The concentrations of soluble arsenic, boron, mercury, and selenium in the 12 CCR and 9 sand samples were assessed with the Synthetic Precipitation Leaching Procedure (SPLP, EPA Method 1312). Graphs of total concentrations and concentrations in SPLP leachate for arsenic, boron, and selenium are provided in Figure 5 – Total and SPLP Leachate Concentrations of Arsenic, Boron, and Selenium. Arsenic and boron were no longer considered, since concentrations in SPLP leachate from CCR or native soils were not detected above the respective GSI protection criteria. Mercury was also no longer considered, because it was not detected in SPLP leachate at concentrations above the respective method detection limit. Analysis of the SPLP leachates showed that mixtures of sand and CCR containing less than approximately 30 percent CCR would meet the respective GSI protection criteria for selenium.

Based on Figure 5, the threshold for selenium is approximately 30 percent CCR. However, visual field determination of a sand/CCR mixture of 70 percent sand/30 percent CCR would be difficult. Therefore, to be conservative, the threshold of 10 percent CCR (i.e., native soil) was selected based on the GSI protection criteria for selenium.

4.2.2 Documentation of CCR Removal Overview

An objective standard of 90 percent CCR removal has been established through analysis of site-specific CCR and soils. Although the purpose of this closure work plan is to define methods for removal of CCR as a regulated waste, the 90 percent removal criteria is based on chemical analyses that have shown the criteria to be protective of groundwater based on non-residential drinking water and GSI criteria. Verification of CCR removal will be documented based on the following three lines of evidence:

- First line of evidence – comparison of interim excavation termination grades to known elevations of CCR from previous site characterizations and engineering records
- Second line of evidence – photographic documentation including periodic photographs of CCR removal progression and photographs of excavated areas at random grid nodes
- Third line of evidence – quantitative colorimetric analysis of CCR content at random grid nodes to confirm CCR removal
  - As an alternative to quantitative colorimetric testing, microscopic quantification of CCR content will be used to confirm CCR removal, if excavated areas are influenced by soils that do not pass the site-specific colorimetric cutoff value selected for closure of the Bottom Ash Pond

This multiple lines of evidence approach provides a predictable and reliable means to objectively measure concentrations of CCR based on physical sample properties and is based on lab analyses that demonstrate it is also protective of groundwater. The approach takes advantage of the clear visible demarcation between CCR and the underlying soil observed during previous removal activities and in soil borings.

4.2.2.1 Documentation of Excavation Grades – First Line of Evidence

The first line of evidence to assess CCR removal activities will be to confirm that excavations are completed to at least the elevation established as the base of CCR from existing information. The elevation of the base of CCR was established based on historical facility information and drilling and sampling completed in the Bottom Ash Pond in May 2016 and June 2017. Descriptions of sample materials were used to prepare boring logs for each boring. The boring logs are included in Appendix B – Soil Boring Logs. The boring logs identified CCR to a depth of 7.9 feet (6.6 feet of CCR submerged below 1.3 feet of water) in the east end of the Bottom Ash Pond [elevation 585.8 feet (NAVD88)] and 12.7 feet (11.3 feet of CCR submerged below 1.4 feet of water) in the west end of the Bottom Ash Pond [elevation 580.3 feet (NAVD88)]. In the perimeter berms surrounding the Bottom Ash Pond, CCR was observed at depths ranging from 10.8 feet [elevation 583.1 feet (NAVD88)] to 22.1 feet [elevation 575.3 feet (NAVD88)].

Once the excavation has met the lateral and vertical limits, visual observations for the presence of CCR will be completed and documented. Excavated areas that do not meet the CCR removal objective within the lateral CCR removal limits will be excavated further until the CCR removal objective is met.

4.2.2.2 Photographic Documentation – Second Line of Evidence

Consistent with MDEQ guidance, Sampling Strategies and Statistics Training Materials for Part 201 Cleanup Criteria (S3TM); a 50-foot grid will be established across the excavation area for assessment, and the grid nodes to be sampled will be selected using a random number generator (the outer extent of the grid depends on the materials encountered during excavation). Photographic documentation will be completed on 50 percent of the nodes followed by hand sampling and colorimetric analysis at a further 25 percent of the total number of nodes.

Each grid node will be inspected visually to identify residual CCR materials that are present on the exposed surface of the excavation. If CCR is visible, additional material will be removed.

When no or only minor visible signs of CCR are observed, photographs and written descriptions will be taken at 50 percent of the grid nodes to document the material left in place. The photography procedure will be standardized such that it includes the following elements:

- Photographs will be taken of the general area-wide excavation
- Photographs will be taken of a representative sample measuring approximately one-square-foot area of surficial materials present at the base of the excavation at each grid node
- Photographs will be taken from a standardized height of approximately 2.5 feet above the excavated surface with a pixel resolution of 4608 x 3456 (i.e., 15.9 megapixels) to ensure the same area and level of detail is obtained by each photograph

4.2.2.3 Colorimetric Confirmation – Third Line of Evidence

A colorimetric analysis method that utilizes a colorimeter to precisely measure the color of a soil sample will be used to verify CCR removal. The analysis is conducted in accordance with ASTM E1347, Standard Test Method for Color and Color-Difference Measurement by Tristimulus Colorimetry. The method involves measuring the color value for a field sample and comparing this value to a cutoff color value to determine the presence of CCR in the sample.

The cutoff color value was developed based on measured color values of known (i.e., developed in the laboratory) mixtures of CCR obtained from the Bottom Ash Pond and native soil obtained from beneath the Bottom Ash Pond at DE Karn. Measured color values for each sample are shown in Figure 6 – Site-Specific Colorimetric Analysis, which includes the cutoff RGB integer value of 9.4 million established for use in the field. Measured RGB integer values above this cutoff correspond to samples of clean and light-colored native sand containing less than 10 percent CCR. Field samples with measured RGB integer values less than the cutoff value will be analyzed with microscopy to quantify CCR content as an alternative third line of evidence.

The majority of color values measured for the native soil samples were above the color value measured for the 10 percent CCR mixture validating the cutoff value for field use. Because it is possible that some sand samples may have lower color values than 9.4 million value (e.g., typically sand from areas of the excavation with a high organic content), it is possible that some samples that do not pass the initial colorimetric analysis may be accepted following additional microscopic analysis, as described in the following section.

Colorimetry is easily adapted to use in the field and can be performed on replicate samples (three to five readings are typical), which increases the reproducibility of the analysis and allows for rapid response if the readings yield inconsistent results. Because the method has been validated in the laboratory, it does not rely on a field expert's judgement when examining CCR.

Soil samples will be collected from the area of the excavation at randomly-selected locations using the same grid node methodology developed for the photographic documentation. Fifty percent of the photographed grid nodes will be randomly selected for colorimetric quantification of CCR content. The samples will be tested in the field to evaluate the presence of CCR materials. These samples will only be collected from grid openings after the excavation has reached a depth such that there are no or only minor visible signs of CCR present in the material on the excavation base and walls.

4.2.2.4 Field Microscopic Quantification of CCR Content – Alternative Third Line of Evidence

As previously discussed, color as determined by visual inspection and confirmed by colorimetric analysis was determined to be superior to other documentation methods; because CCR is significantly darker than the native sand material at DE Karn. However, our experience documenting CCR removal at JHC Bottom Ash Pond 3N demonstrated that some color variability existed in soils at the base of the excavation footprint that could not be anticipated. If similar conditions exist at the DE Karn Bottom Ash Pond, field microscopic quantification of CCR content will be utilized to confirm the CCR removal objective was met as an alternative line of physical evidence to confirm CCR removal. Field samples will be compared to premixed standards to verify CCR content.

4.3 Post-Excavation Monitoring – Phase II

After removal of CCR in Phase I, CEC will use the balance of the five-year closure timeframe provided for in 40 CFR 257.102(f)(1)(ii) to demonstrate the concentrations of Appendix IV constituents of concern do not exceed groundwater protection standards established pursuant to 257.95(h) for two consecutive sampling events.

The current RCRA CCR groundwater monitoring system for the DE Karn Bottom Ash Pond consists of six downgradient groundwater monitoring wells and four background monitoring wells. Monitoring wells were installed during the fourth quarter of 2015 to commence a compliance program pursuant to 40 CFR

257.91(e)(1). This monitoring well network is anticipated to be used to determine compliance with groundwater protection standards and achievement with the standard of closure by removal pursuant to 40 CFR 257.102(c).

The initial Annual Groundwater Monitoring and Corrective Action Report will be certified by January 31, 2018 with notifications to the State Director and public posting to the CCR Rule Compliance Data and Information website by March 2, 2018. A schedule of the groundwater implementation program is provided in Figure 2- D.E. Karn Bottom Ash Pond Closure Schedule. CEC is using the development of the background monitoring as a baseline to demonstrate that the closure by removal of CCR standard has been achieved. If that standard cannot be achieved upon the removal and verification that CCR has been removed to the 10 percent threshold standard, then the necessary technical requirements are in place to implement an assessment monitoring program and corrective actions, if necessary.

Groundwater samples collected at DE Karn will be submitted for the analyses specified in 40 CFR 257, Appendix III and IV. The analytical methods and reporting limits for each constituent are summarized in Table 1 – RCRA CCR Constituents from Appendix III and Appendix IV.

Given that there are differences between the CCR RCRA Rule monitoring requirements and MDEQ requirements (e.g. field-filtering); a more detailed groundwater monitoring program will be provided to MDEQ upon excavation and verification of CCR removal that will include a Sampling and Analysis Plan (SAP), definition of groundwater monitoring system, and coordination with groundwater sampling protocols and analyses pursuant to State groundwater monitoring requirements.

5.0 SUMMARY

The intent of this closure work plan is to communicate and achieve agreement with the MDEQ on CEC's plans to self-implement closure by removal of waste from within the Bottom Ash Pond to comply with the CCR RCRA Rule 40 CFR 257.102(c) as well as to facilitate management of plant process wastewaters. CEC anticipates providing a notification of intent to initiate closure by October 2018 and, subsequently, obtaining certified closure of the Bottom Ash Pond by October 2023. To meet critical compliance milestones and maintain project schedule and procurement of a closure construction contract, CEC requests MDEQ approval of this revised closure work plan by May 1, 2018.

6.0 CLOSING

This revised closure work plan is respectfully submitted to CEC. If you have questions or require additional information, please contact Mark Bergeon at (920) 491-2500.

Sincerely,

GOLDER ASSOCIATES INC.

Hugh Davies
Senior Project Geochemist

Mark Bergeon, PG
Program Leader, Associate

TABLES

Table 1 – RCRA CCR Constituents from Appendix III and Appendix IV

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

FIGURES

REFERENCES

1. AERIAL BASE MAP IMAGE FROM © CNES 2016, DISTRIBUTION AIRBUS DS GEO SA / AIRBUS DS GEO INC., PHOTO DATE: MAY 6, 2016.
2. HORIZONTAL DATUM AND COORDINATES SHOWN BASED ON MICHIGAN STATE PLANE COORDINATE SYSTEM, NORTH AMERICAN DATUM 1983 (NAD83), SOUTH ZONE, INTERNATIONAL FOOT.

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO

REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO
	2017-09-22	ISSUED FOR FINAL REPORT	JSH	SDA	JDP	MAB	

SIGNATURE

NAME: JOHN D. PULS

MICHIGAN P.E. No.: 6201055778

Consumers Energy

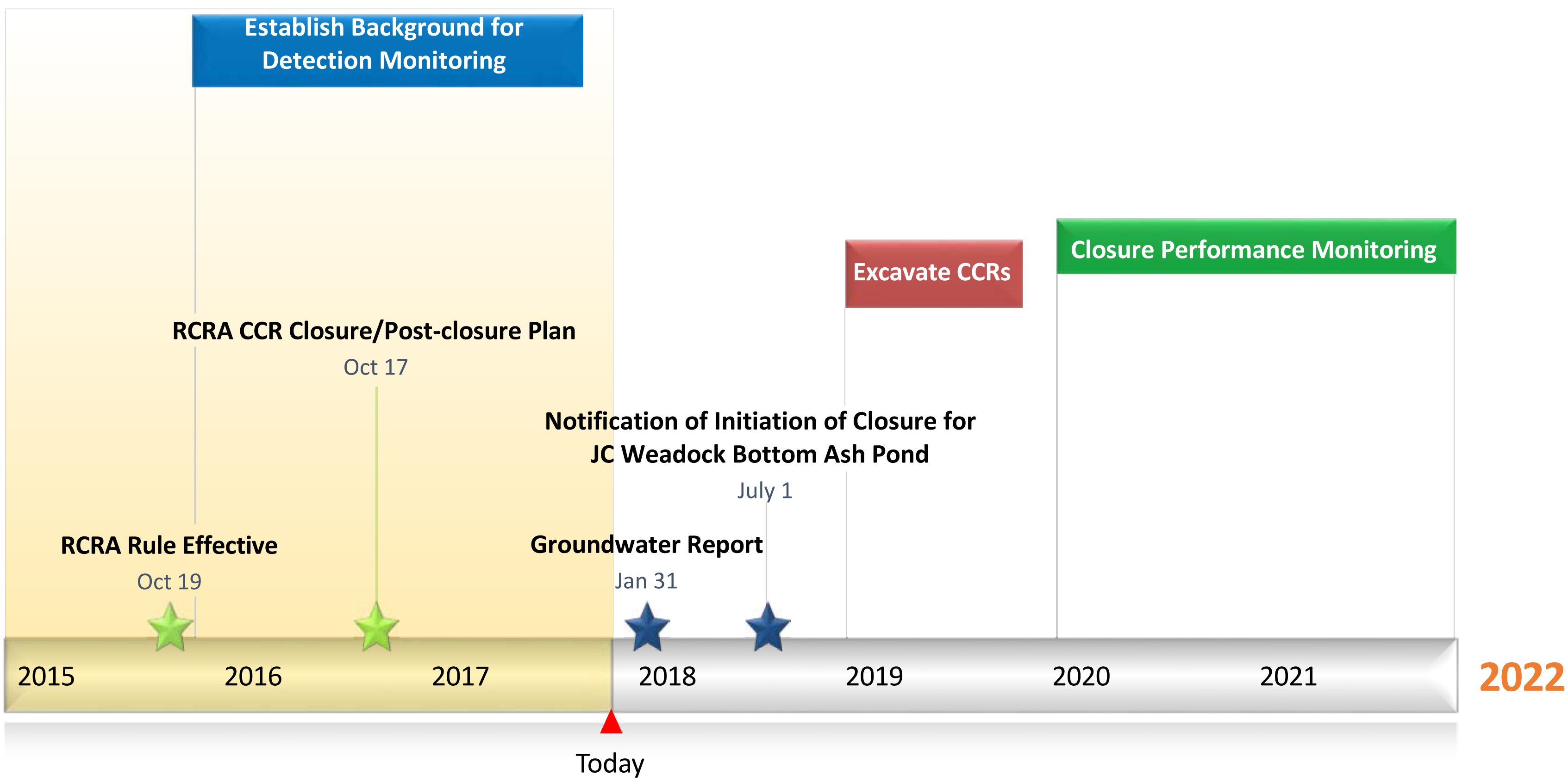
D.E. KARN GENERATING FACILITY
ESSEXVILLE, MI

SITE LAYOUT MAP

BOTTOM ASH POND CLOSURE PLAN

SCALE: AS SHOWN
JOB: 1667572.0006
DRAWING NO.
FIGURE: 1
REV.

Figure 2 – D.E. Karn Bottom Ash Pond Closure Schedule



LEGEND

- INCLINOMETER
- MONITORING WELL
- OBSERVATION WELL
- PIEZOMETER
- ELECTRIC BOX
- CATCH BASIN
- GAS VALVE
- LIGHT POLE
- POWER POLE
- POST (WOOD/METAL)
- OVERHEAD ELECTRIC LINE
- ABOVE GROUND GAS LINE
- TOP OF BANK
- TOE OF SLOPE
- STORMWATER CULVERT
- GRAVEL SURFACE / TRAVELED PATHWAY
- LATERAL EXTENT OF BOTTOM ASH POND

SURVEY NOTES

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

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

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

SEE SURVEY CONTROL / DATUM NOTES ON SHEET 2.

AERIAL BASE MAP IMAGE FROM © CNES 2016, DISTRIBUTION AIRBUS DS GEO SA / AIRBUS DS GEO INC., PHOTO DATE: MAY 6, 2016.

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO

REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO
	2017-09-22	ISSUED FOR FINAL REPORT	JSH	SDA	JDP	MAB	

SIGNATURE
NAME
JOHN D. PULS
MICHIGAN P.E. No.
6201055778

Consumers Energy
D.E. KARN GENERATING FACILITY
ESSEXVILLE, MI

LATERAL EXTENT OF CCR UNIT

BOTTOM ASH POND CLOSURE PLAN

SCALE: AS SHOWN
JOB: 1667572.0006
DRAWING NO.
FIGURE 3
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CUT/FILL TABLE (- = CUT, + = FILL)			
NUMBER	MIN. DEPTH (FT)	MAX. DEPTH (FT)	COLOR
1	-30	-25	
2	-25	-20	
3	-20	-15	
4	-15	-10	
5	-10	-5	
6	-5	0	
7	0	5	

CUT/FILL VOLUMES

CCR EXCAVATION:

Existing Grade (5/23/2016 survey) vs. Proposed CCR Excavation:

CUT: **168,345 CY**
(149,902 CY above El. 581.61 / 18,443 CY below El. 581.61)

CLEAN BACKFILL:

Existing Grade (5/23/2016 survey) with Proposed CCR Excavation vs. Proposed Backfill to 1% Final Cover:

FILL: **102,307 CY**

LEGEND

EXISTING

- INCLINOMETER
- MONITORING WELL
- OBSERVATION WELL
- PIEZOMETER
- ELECTRIC BOX
- CATCH BASIN
- GAS VALVE
- LIGHT POLE
- POWER POLE
- POST (WOOD/METAL)
- BOREHOLE (GEOPROBE, JUNE 2017)
- BOREHOLE (GEOPROBE, MAY 2016)
- OVERHEAD ELECTRIC LINE
- ABOVE GROUND GAS LINE
- UNDERGROUND STORM LINE
- TOP OF BANK
- TOE OF SLOPE
- GRAVEL SURFACE / TRAVELED PATHWAY

PROPOSED

- 595 PROPOSED CCR EXCAVATION GRADE ELEVATION CONTOUR (5 ft INTERVAL)
- 594 PROPOSED CCR EXCAVATION GRADE ELEVATION CONTOUR (1 ft INTERVAL)
- PROPOSED LIMIT OF CLEARING AND GRUBBING (SEE NOTE 6)
- PROPOSED FUTURE LVMW BURIED PIPING (BY OTHERS)

CCR REMOVAL NOTES

1. ESTIMATED EXCAVATION GRADES OF THE BOTTOM ASH POND WERE DEVELOPED BASED ON HISTORICAL INVESTIGATION INFORMATION, PRIMARILY THE MAY 2016 AND JUNE 2017 BORING DATA.
2. THREE WEEKS PRIOR TO ASH EXCAVATION, THE CONTRACTOR WILL SUBMIT A CCR REMOVAL SEQUENCE PLAN IN ACCORDANCE WITH THE SPECIFICATIONS FOR THE OWNER'S REPRESENTATIVE TO REVIEW.
3. PRIOR TO CONDUCTING CCR REMOVAL, THE OWNER'S SURVEYOR SHALL PERFORM AN EXISTING CONDITIONS SURVEY TO DETERMINE THE BASIS FOR CONTRACT PAY ITEMS.
4. CONTRACTOR TO DEVELOP AND SUBMIT DEWATERING PLAN IN ACCORDANCE WITH THE SPECIFICATIONS.
5. THE CONTRACTOR SHALL PLACE EXCAVATED CCR'S AS SHOWN ON SHEET 9 AND IN ACCORDANCE WITH THE SPECIFICATIONS.
6. PROPOSED LIMITS OF CLEARING AND GRUBBING SHOWN ARE APPROXIMATE. APPROXIMATE TOTAL AREA IS 64,149 SF (1.48 ACRES). VEGETATION BOUNDARIES AND CLEARING AND GRUBBING LIMITS MAY VARY AT THE TIME OF CONSTRUCTION.

REFERENCE DRAWINGS	REV	DATE	DESCRIPTION	DR	BY	CHK	APP	CO

REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO
	2017-09-22	ISSUED FOR FINAL REPORT	JSH	SDA	JDP	MAB	

SIGNATURE

NAME: JOHN D. PULS

MICHIGAN P.E. No.: 6201055778

Consumers Energy

D.E. KARN GENERATING FACILITY
ESSEXVILLE, MI

BOTTOM ASH POND DEPTH OF CCR EXCAVATION

BOTTOM ASH POND CLOSURE PLAN

SCALE: AS SHOWN
JOB: 1667572.0006
DRAWING NO.
FIGURE 4
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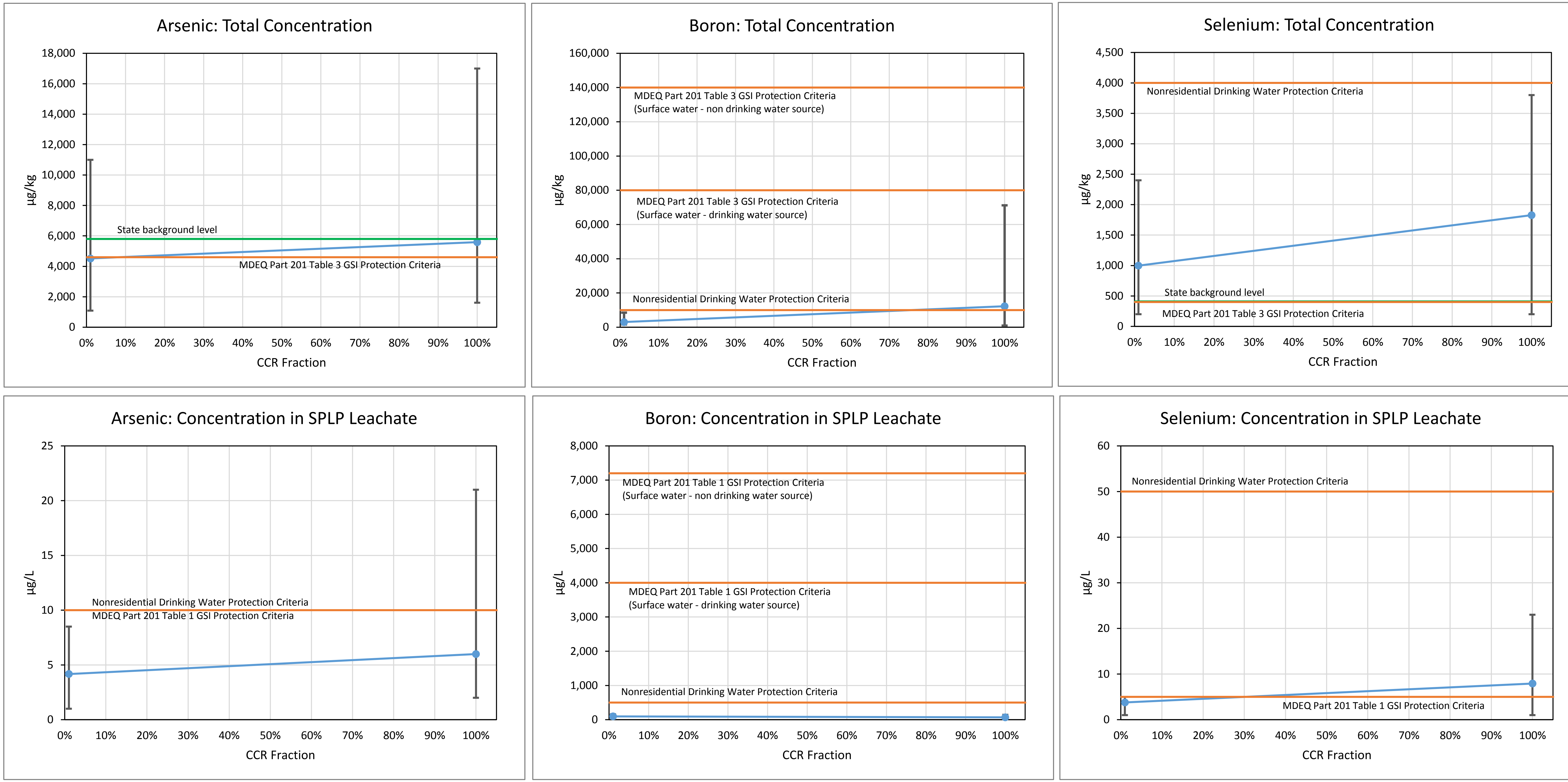
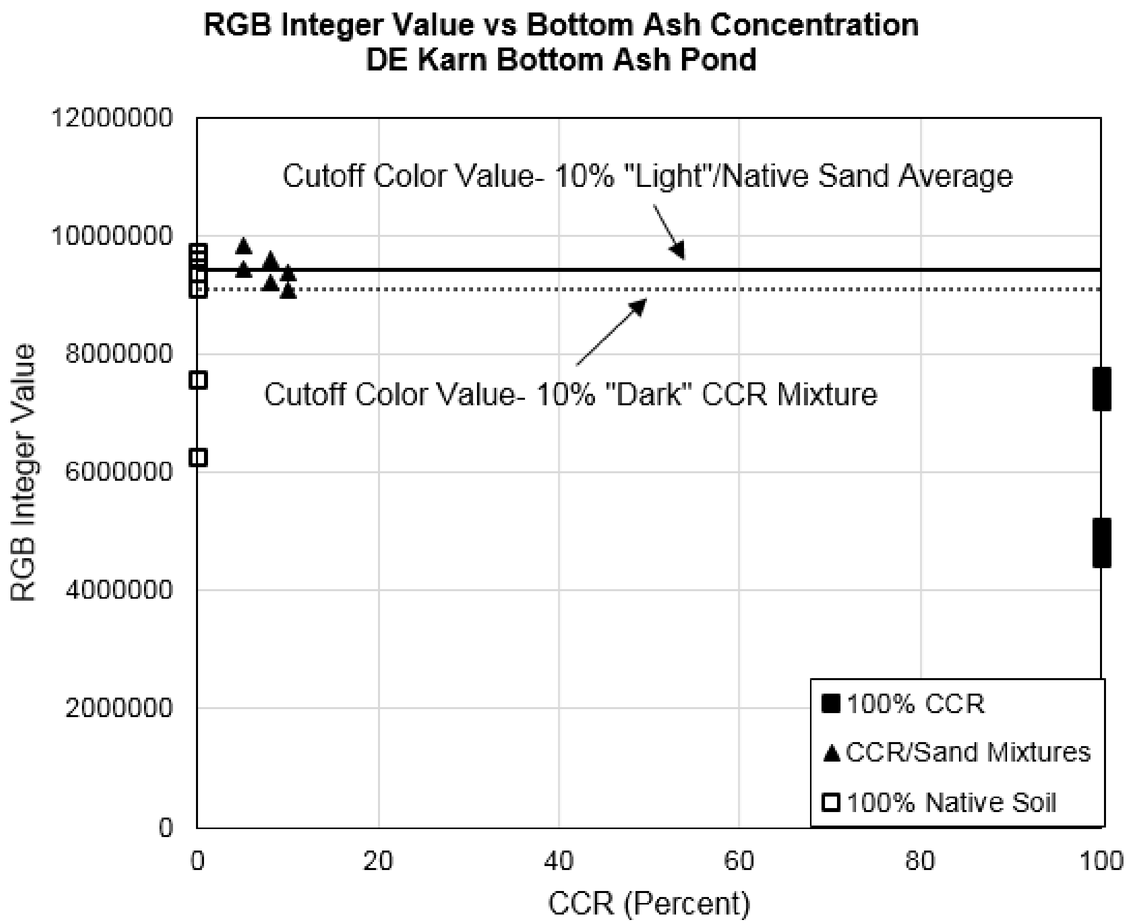


Notes: Groundwater: Nonresidential Drinking Water Criteria from MDEQ Part 201 Table 1
GSI Protection Criteria from MDEQ Part 201 Table 3

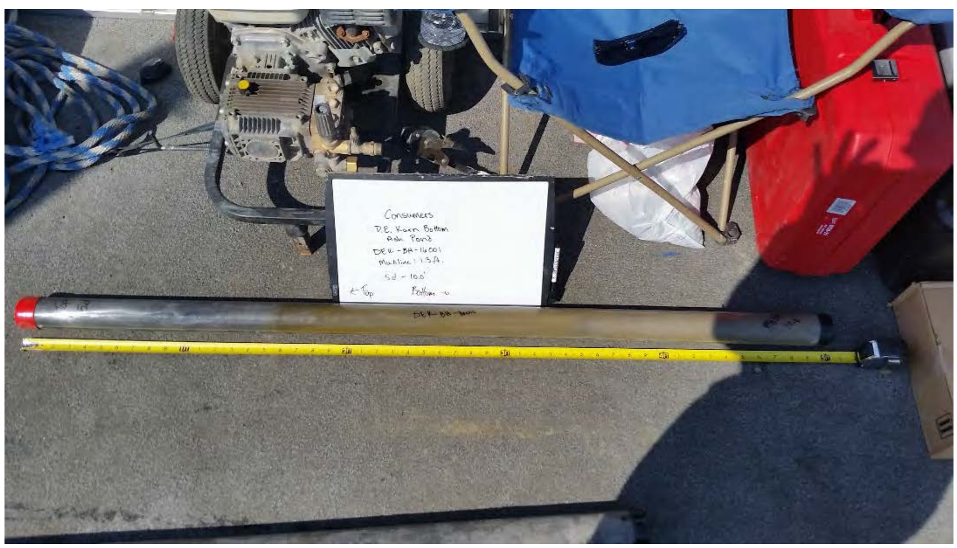
Created by: MJ
Reviewed by: HD
Approved by: MB
9/13/2017 1667572.0006.03

Figure 5
Total and SPLP Leachate Concentrations of Arsenic, Boron, and Selenium
DE Karn Bottom Ash Pond
Consumers Energy Company
Golder Associates

Figure 6 – Site-Specific Colorimetric Analysis



APPENDIX A
SITE BORING PHOTOGRAPHS

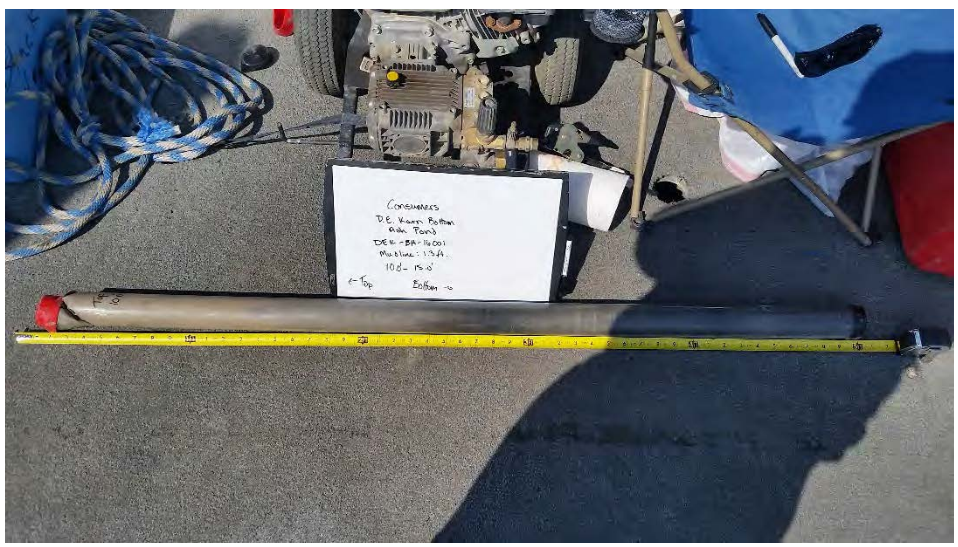
PHOTOGRAPH 1 Bottom Ash Pond DEK-BH-16001: 0.0 – 5.0 ft	
PHOTOGRAPH 2 Bottom Ash Pond DEK-BH-16001: 5.0 – 10.0 ft	

PHOTOGRAPH 3

Bottom Ash Pond
DEK-BH-16001:
5.0 – 7.0 ft
(CCR and Native Soil Contact)

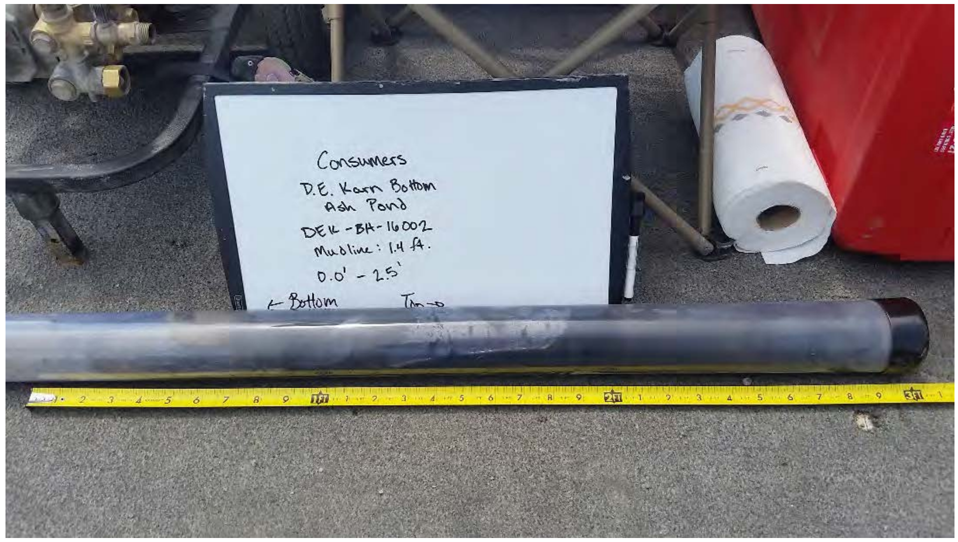
PHOTOGRAPH 4

Bottom Ash Pond
DEK-BH-16001:
10.0 – 15.0 ft



PHOTOGRAPH 5

Bottom Ash Pond
DEK-BH-16002:
0.0 – 2.5 ft



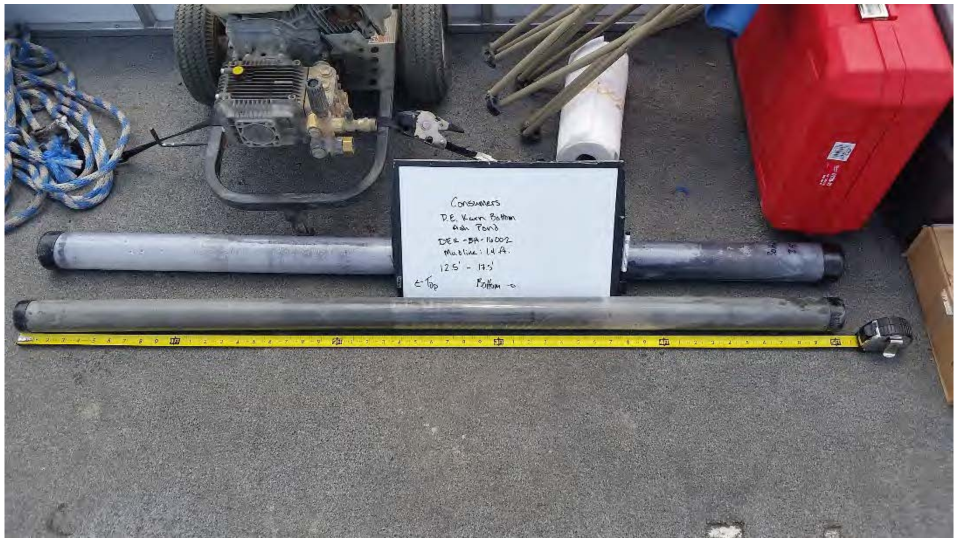
PHOTOGRAPH 6

Bottom Ash Pond
DEK-BH-16002:
2.5 – 7.5 ft

PHOTOGRAPH 7 Bottom Ash Pond DEK-BH-16002: 7.5 – 12.5 ft	
PHOTOGRAPH 8 Bottom Ash Pond DEK-BH-16002: 10.0 – 12.5 ft (CCR and Native Soil Contact)	

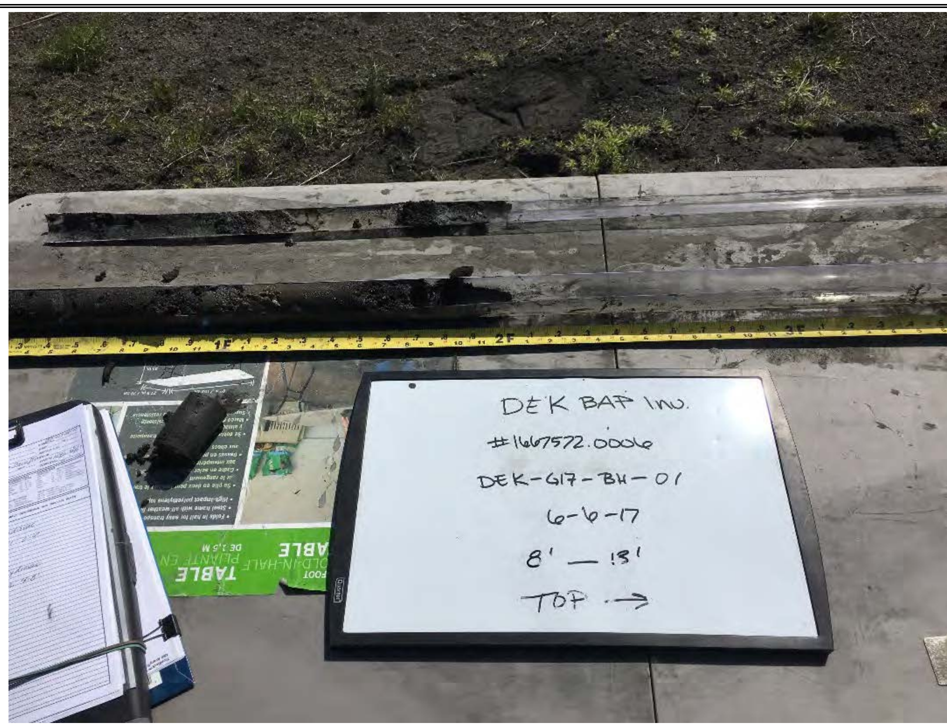
PHOTOGRAPH 9

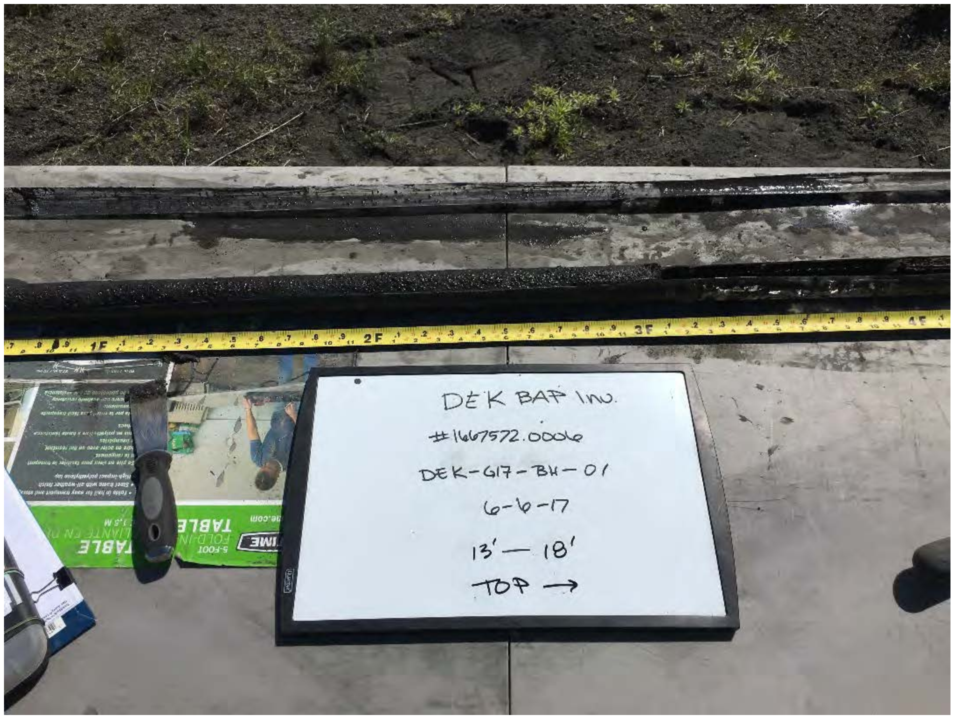
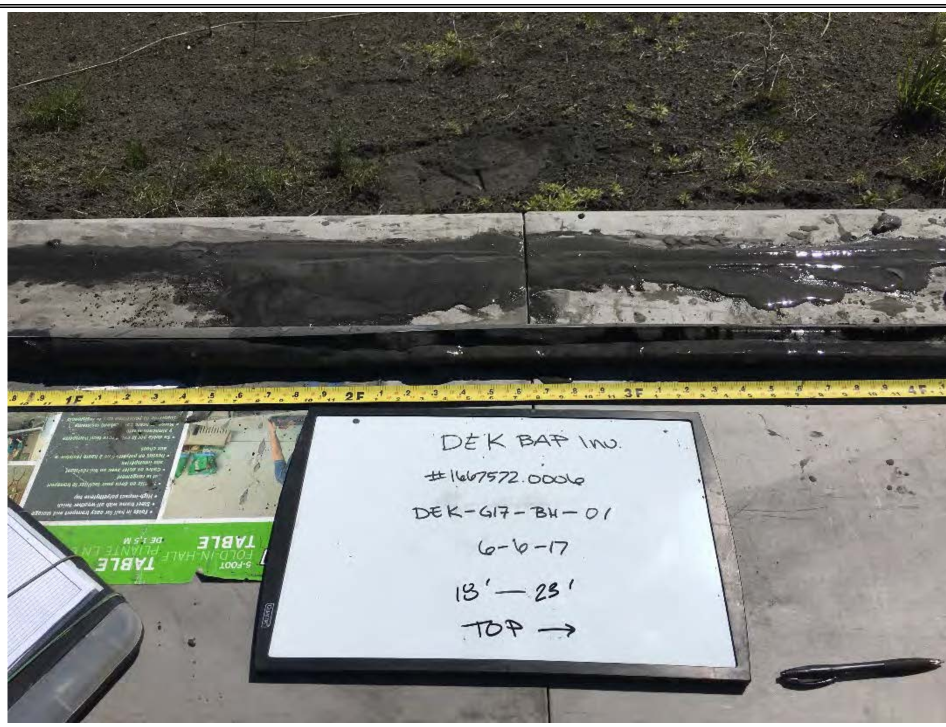
Bottom Ash Pond
DEK-BH-16002:
12.5 – 17.5 ft

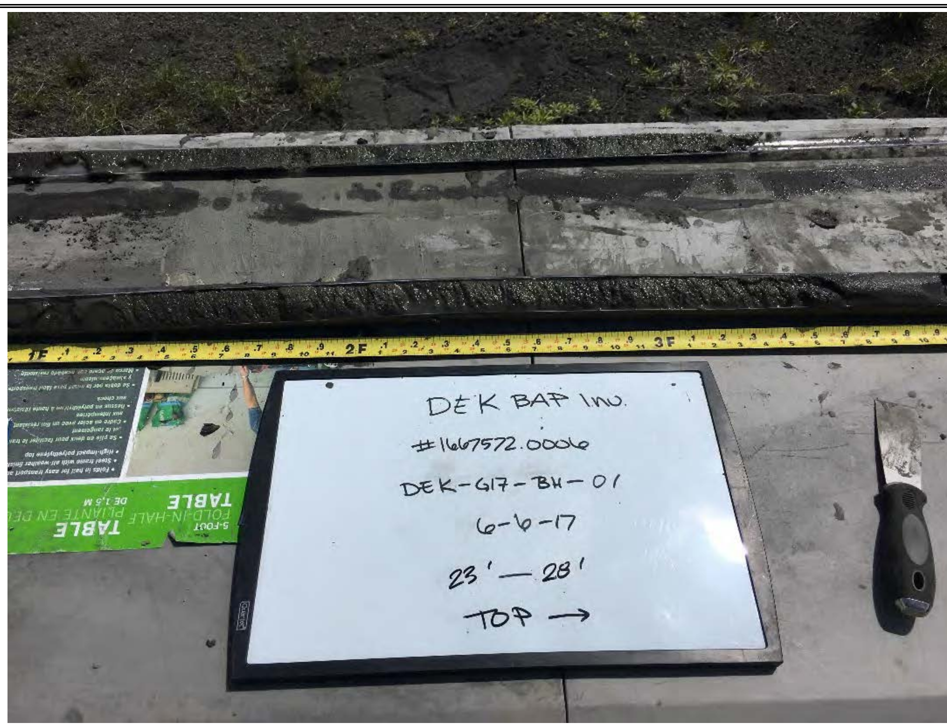


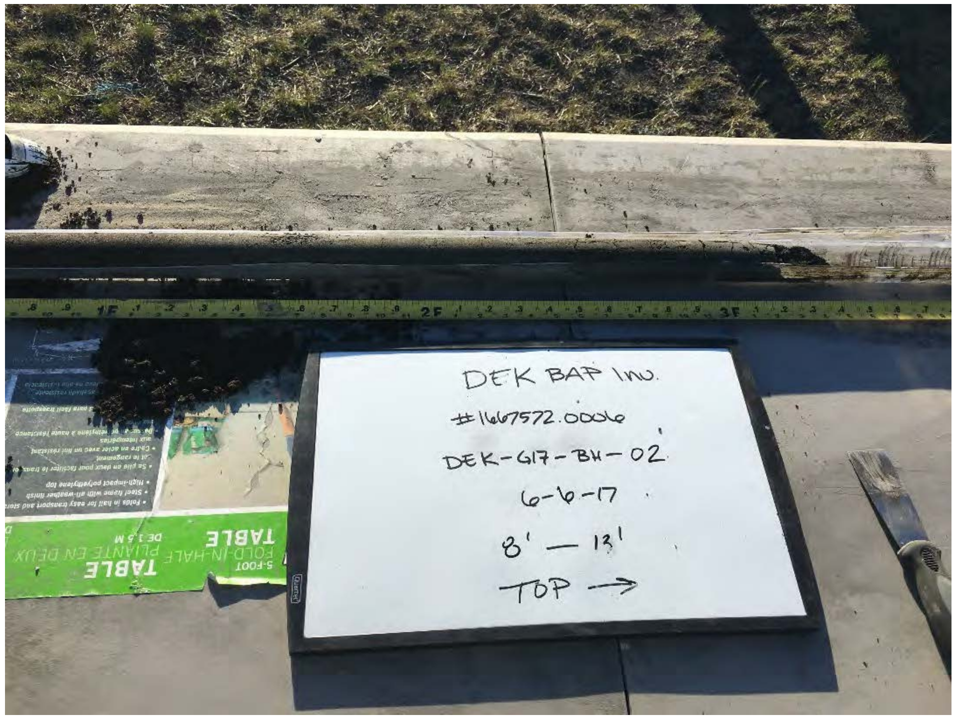
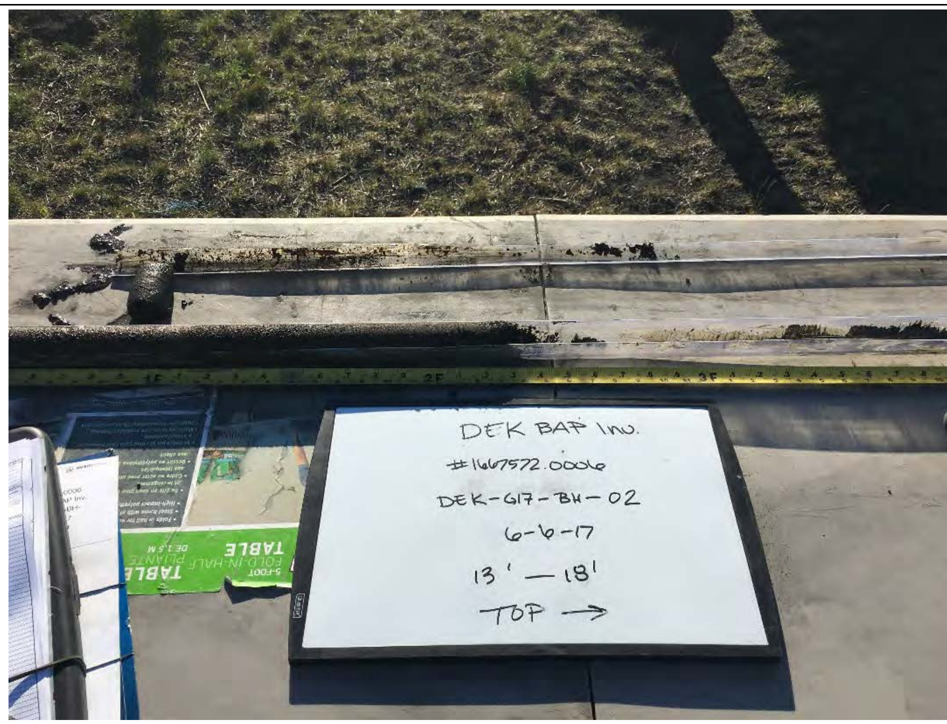
PHOTOGRAPH 10

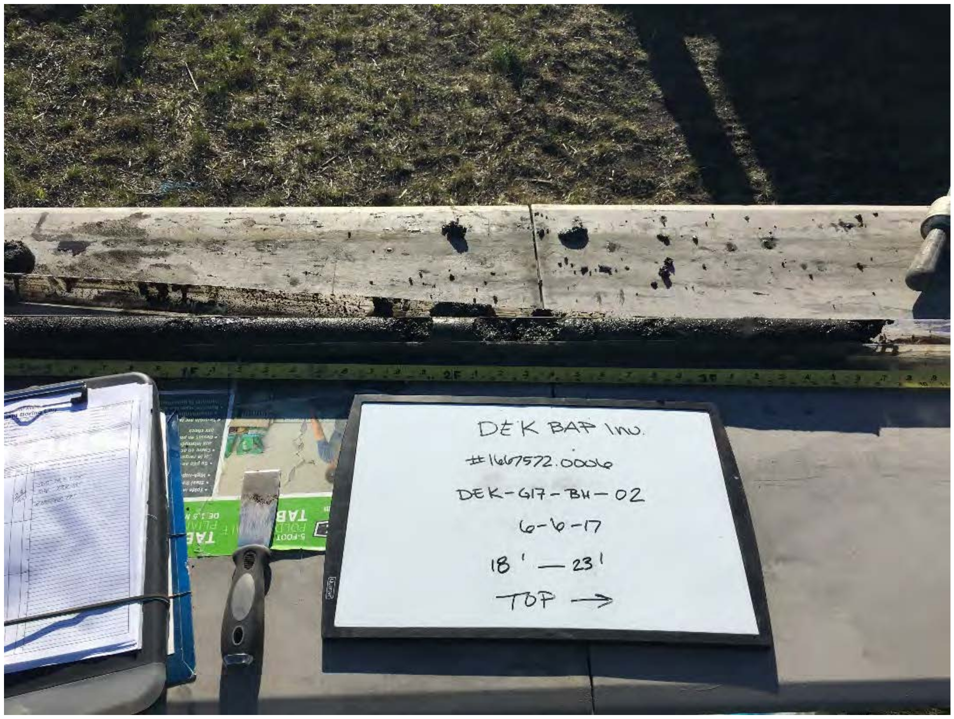
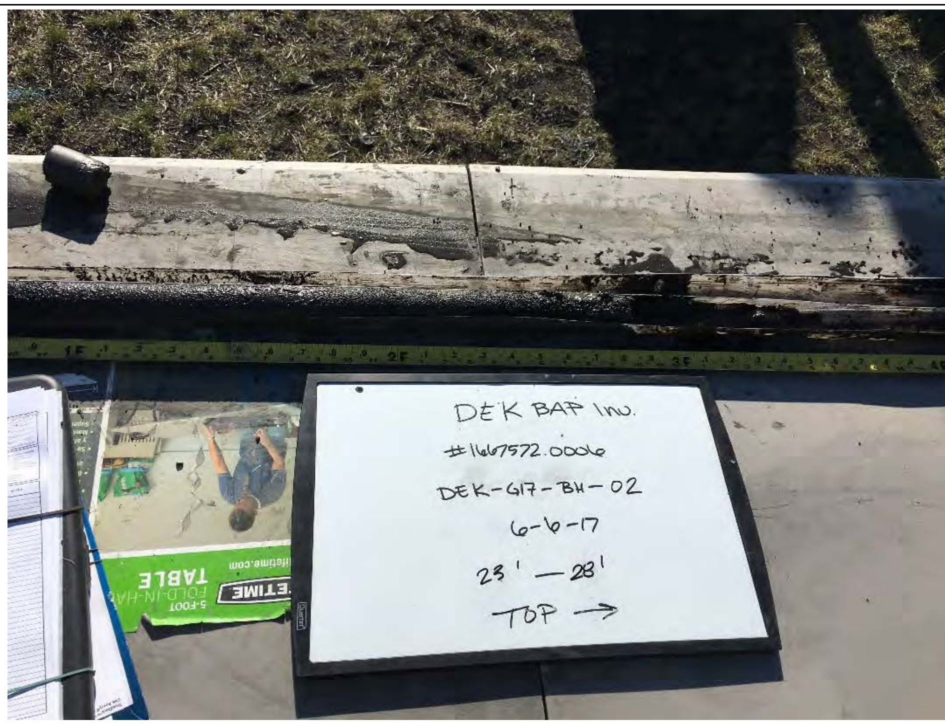
Bottom Ash Pond
DEK-G17-BH-01:
8.0 – 13.0 ft



PHOTOGRAPH 11 Bottom Ash Pond DEK-G17-BH-01: 13.0 – 18.0 ft	
PHOTOGRAPH 12 Bottom Ash Pond DEK-G17-BH-01: 18.0 – 23.0 ft	

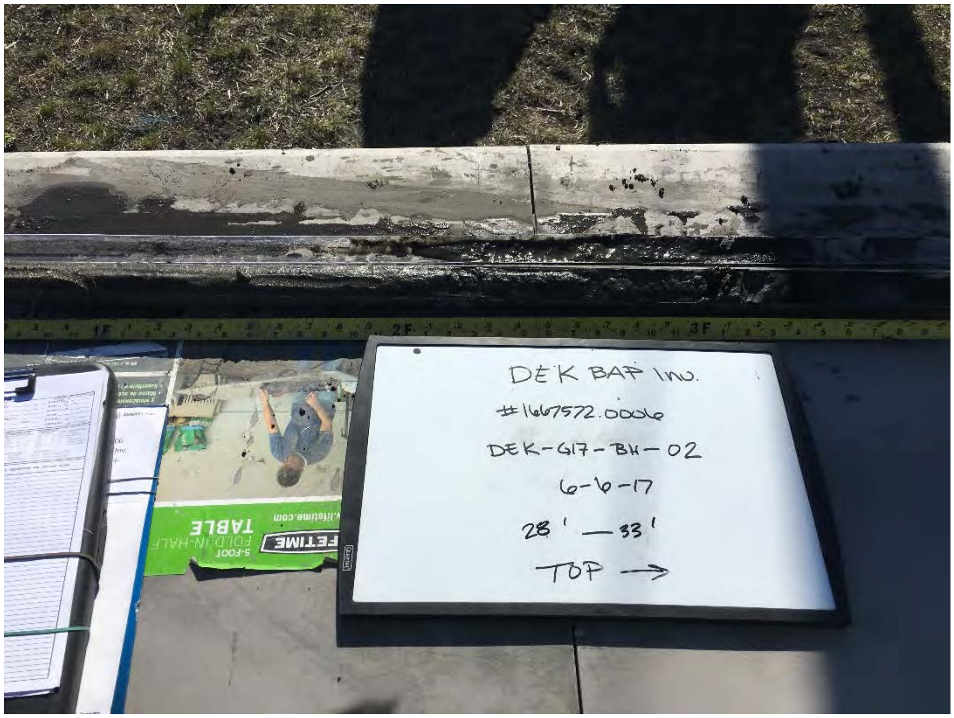
PHOTOGRAPH 13 Bottom Ash Pond DEK-G17-BH-01: 22.0 – 23.0 ft (CCR and Native Soil Contact)	
PHOTOGRAPH 14 Bottom Ash Pond DEK-G17-BH-01: 23.0 – 28.0 FT	

PHOTOGRAPH 15 Bottom Ash Pond DEK-G17-BH-02: 8.0 – 13.0 ft	
PHOTOGRAPH 16 Bottom Ash Pond DEK-G17-BH-02: 13.0 – 18.0 ft	

PHOTOGRAPH 17 Bottom Ash Pond DEK-G17-BH-02: 18.0 – 23.0 ft	
PHOTOGRAPH 18 Bottom Ash Pond DEK-G17-BH-02: 23.0 – 28.0 ft	

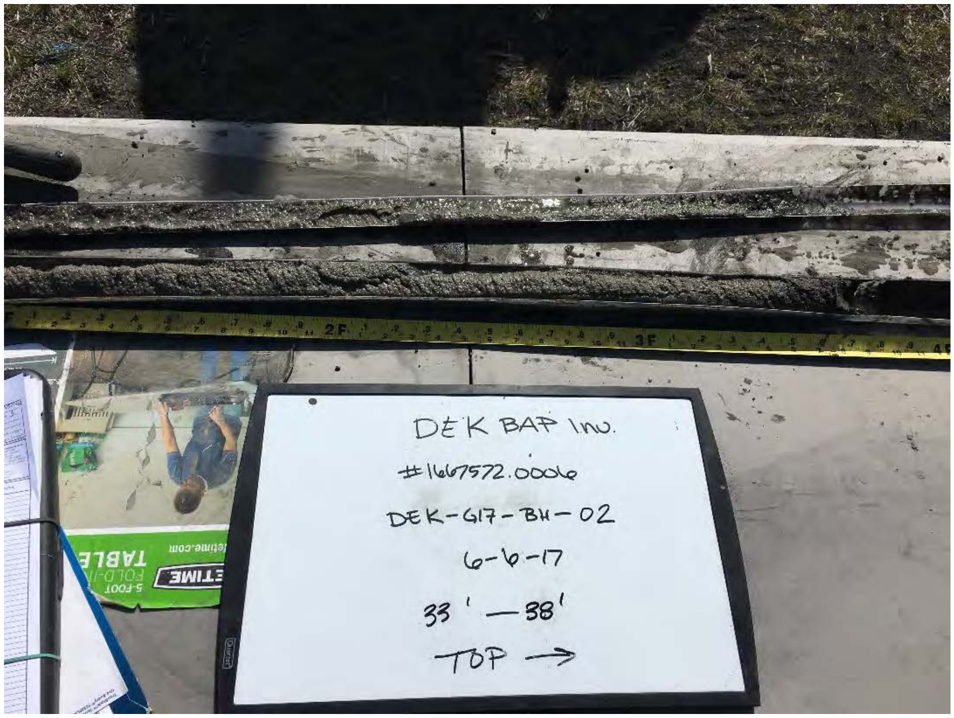
PHOTOGRAPH 19

Bottom Ash Pond
DEK-G17-BH-02:
28.0 – 33.0 ft

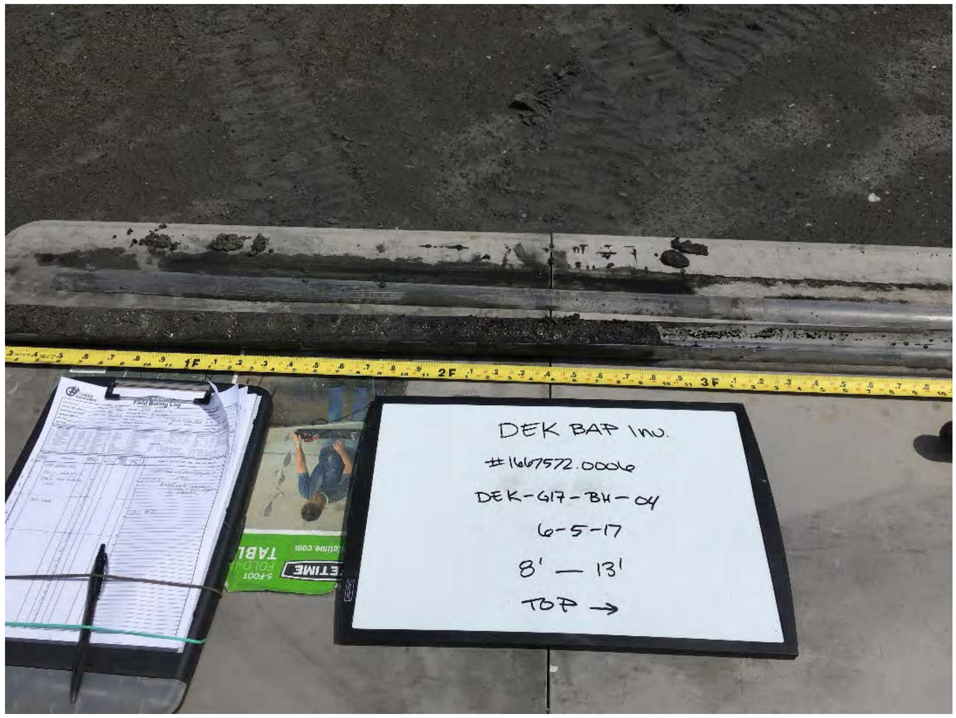
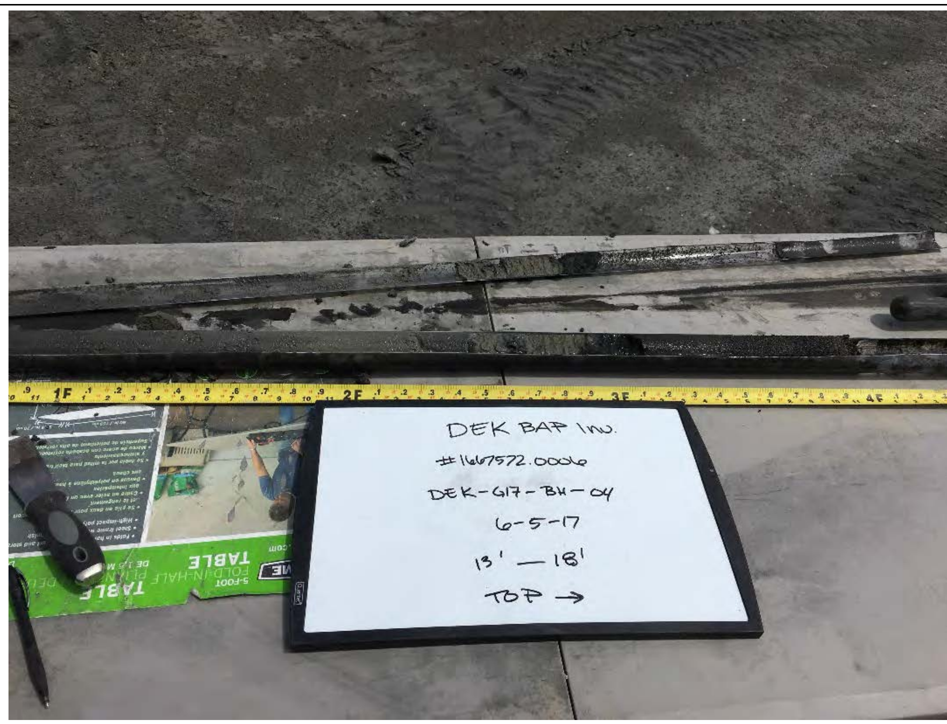


PHOTOGRAPH 20

Bottom Ash Pond
DEK-G17-BH-02:
30.0 – 31.0 ft
(CCR and Native Soil Contact)

PHOTOGRAPH 21 Bottom Ash Pond DEK-G17-BH-02: 33.0 – 38.0 ft	
PHOTOGRAPH 22 Bottom Ash Pond DEK-G17-BH-03: 13.0 – 18.0 ft	

PHOTOGRAPH 23 Bottom Ash Pond DEK-G17-BH-03: 13.0 – 14.0 ft (CCR and Native Soil Contat)	
PHOTOGRAPH 24 Bottom Ash Pond DEK-G17-BH-03: 18.0 – 23.0 ft	

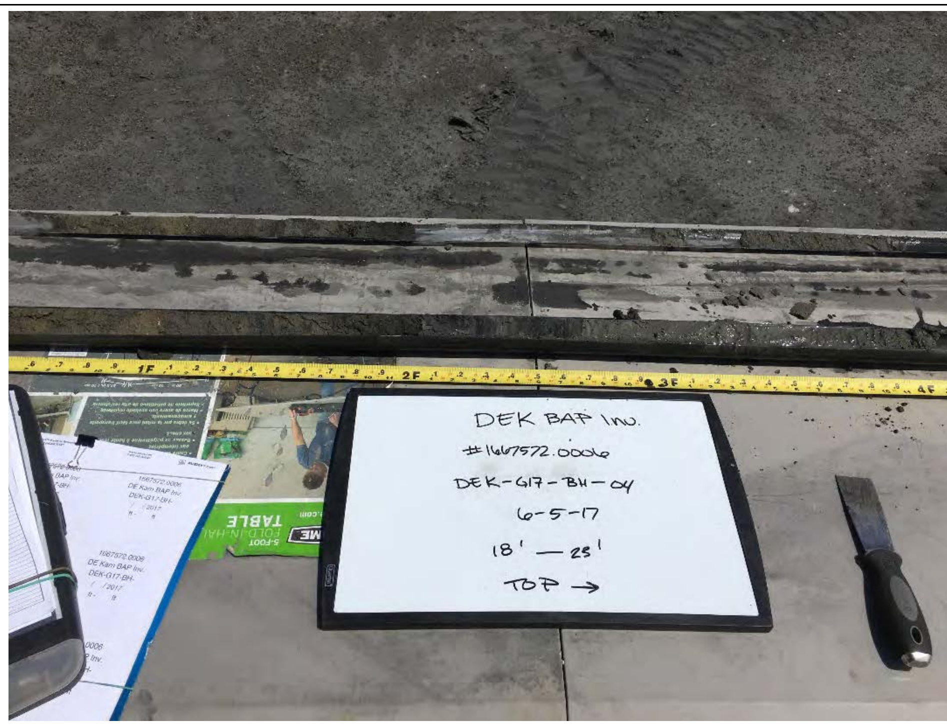
PHOTOGRAPH 25 Bottom Ash Pond DEK-G17-BH-04: 8.0 – 13.0 ft	
PHOTOGRAPH 26 Bottom Ash Pond DEK-G17-BH-04: 13.0 – 18.0 ft	

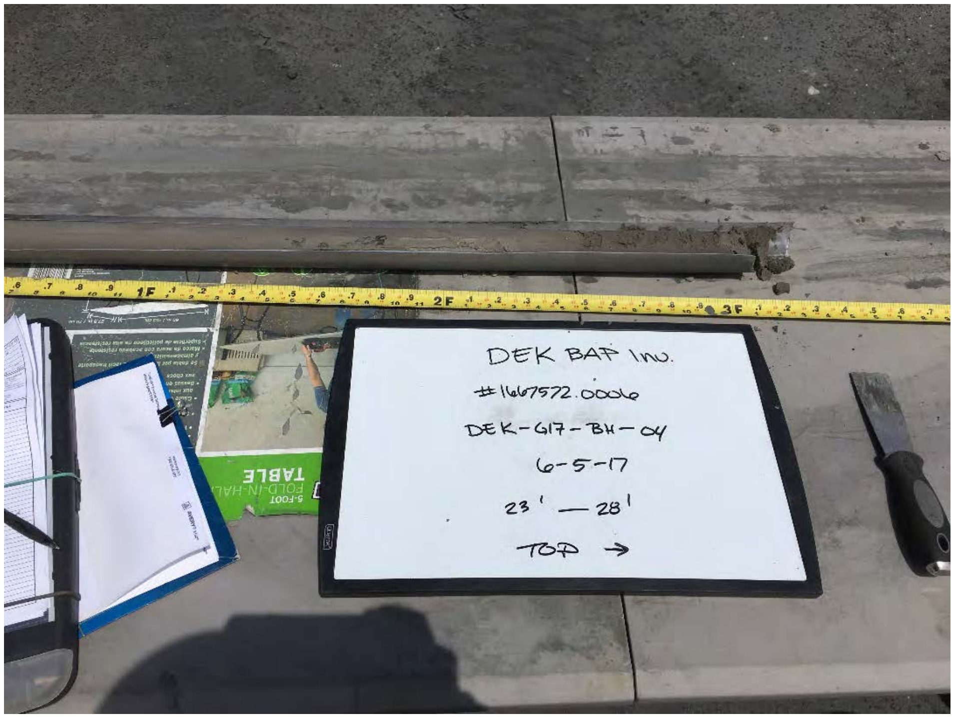
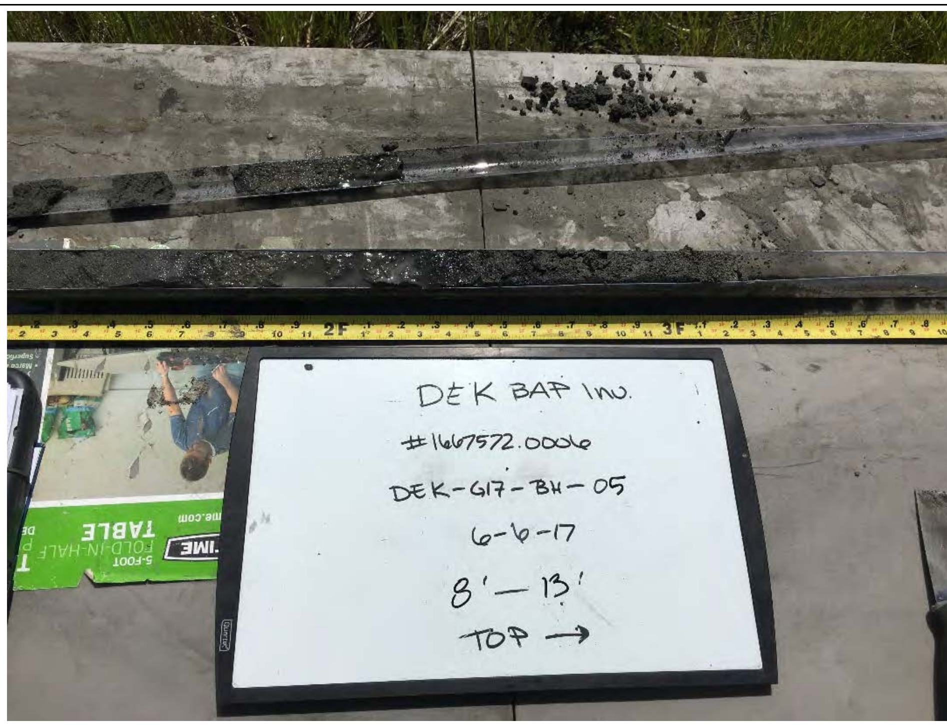
PHOTOGRAPH 27

Bottom Ash Pond
DEK-G17-BH-04:
15.0 – 16.0 ft
(CCR and Native Soil Contact)

PHOTOGRAPH 28

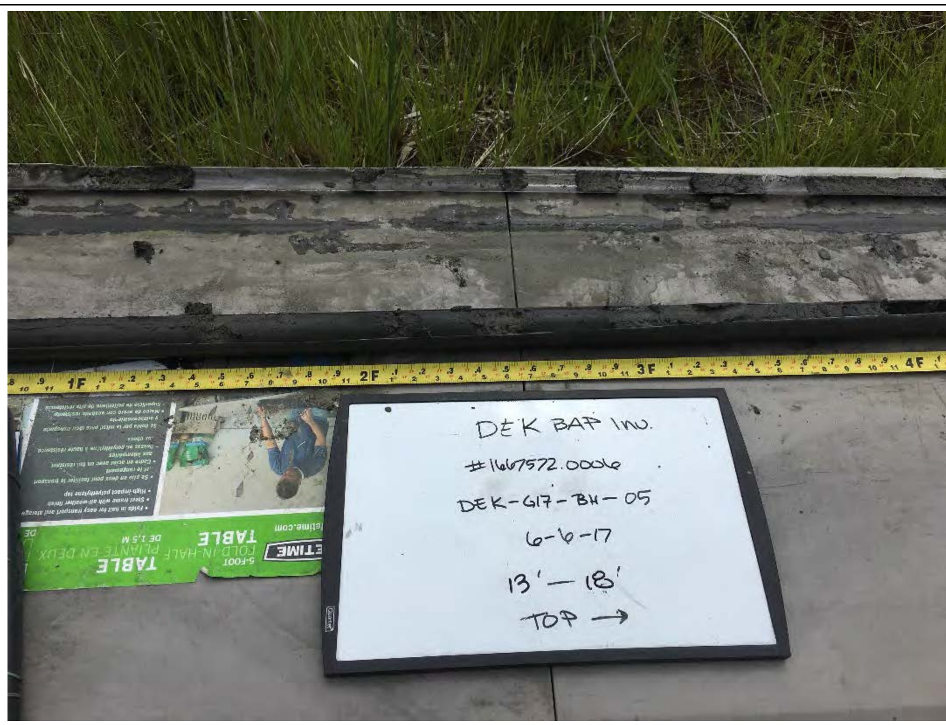
Bottom Ash Pond
DEK-G17-BH-04:
18.0 – 23.0 ft



PHOTOGRAPH 29 Bottom Ash Pond DEK-G17-BH-04: 23.0 – 28.0 ft	
PHOTOGRAPH 30 Bottom Ash Pond DEK-G17-BH-05: 8.0 – 13.0 ft	

PHOTOGRAPH 31

Bottom Ash Pond
DEK-G17-BH-05:
10.0 – 11.0 ft

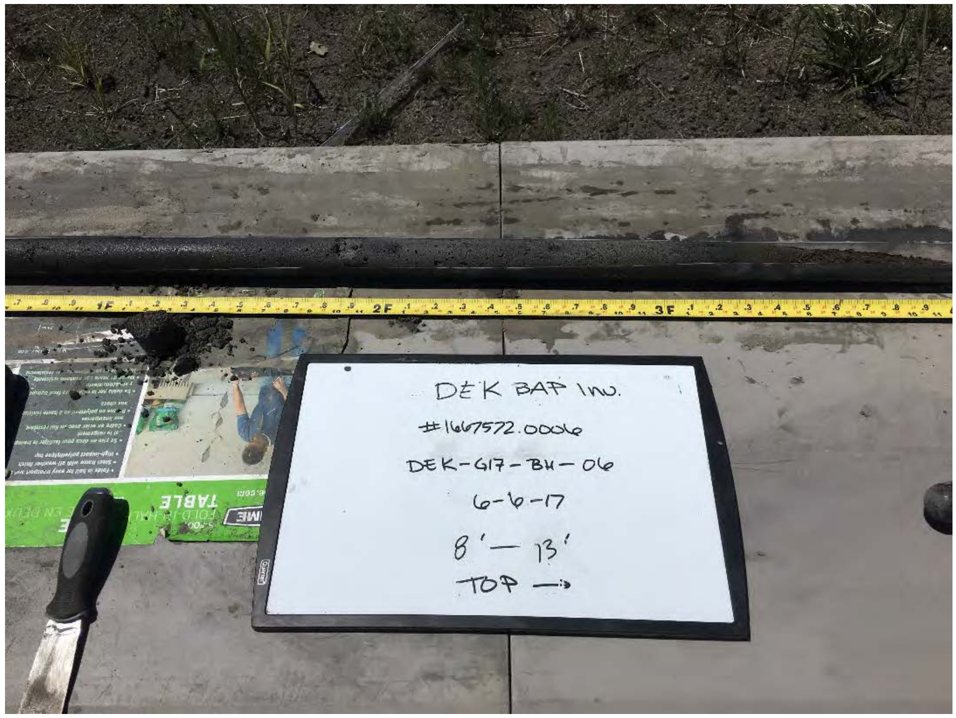


PHOTOGRAPH 32

Bottom Ash Pond
DEK-G17-BH-05:
13.0 – 18.0 ft

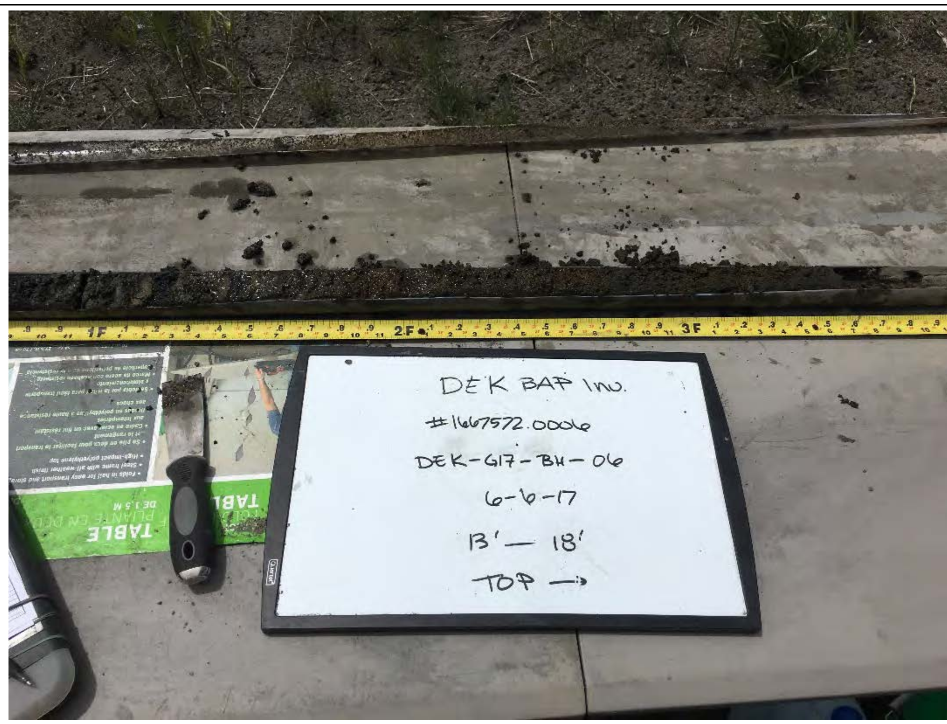
PHOTOGRAPH 33

Bottom Ash Pond
DEK-G17-BH-06:
8.0 – 13.0 ft



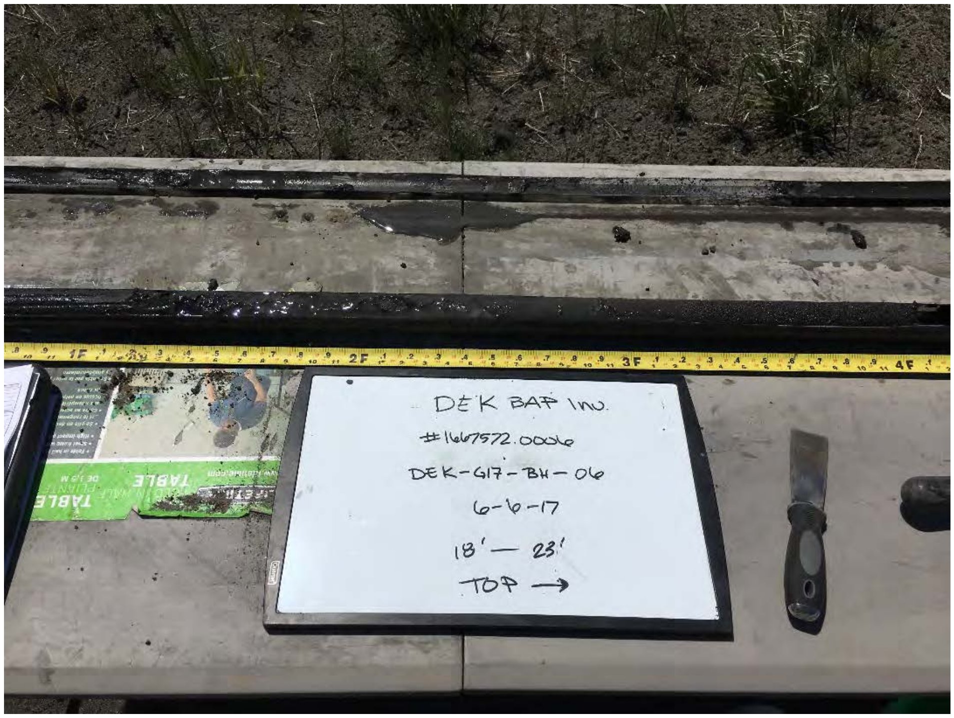
PHOTOGRAPH 34

Bottom Ash Pond
DEK-G17-BH-06:
13.0 – 18.0 ft



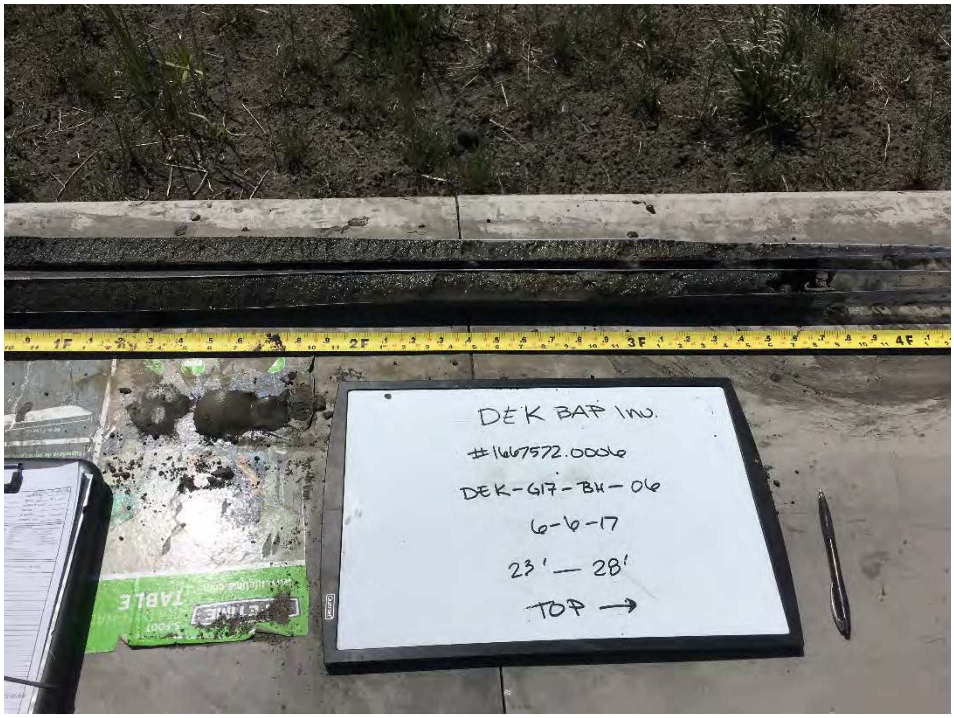
PHOTOGRAPH 35

Bottom Ash Pond
DEK-G17-BH-06:
18.0 – 23.0 ft



PHOTOGRAPH 36

Bottom Ash Pond
DEK-G17-BH-06:
22.0 – 23.0 ft

PHOTOGRAPH 37 Bottom Ash Pond DEK-G17-BH-06: 23.0 – 28.0 ft	

APPENDIX B
SOIL BORING LOGS

PROJECT: DE Karn Bottom Ash Pond
PROJECT NUMBER: 1655284
LOCATION: E end of Bottom Ash Pond
CLIENT: Consumers

RECORD OF BOREHOLE DEK-BH-16001

DRILLING METHOD: Sonic
DRILLING DATE: 5-16-16
DRILL RIG: Sonic

DATUM: NAVD88
AZIMUTH: ---
NAD83 MI PLANE-S COORDS: N 783049.6, E 13262678

GS ELEVATION (ft): 593.7
TOC ELEVATION: ---

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION (VEGETATION:)	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	RUN: NUMBER	RUN: REC / ATT	SAMPLES: NUMBER	SAMPLES: TYPE	POCKET PENETROMETER (tons/ft²)	LAB TESTS: ENVIRONMENTAL (SPLP & TOTAL METALS)	LAB TESTS: GRAIN SIZE DISTRIBUTION	NOTES WATER LEVELS
0	Sonic	0.0 - 1.3 WATER.			592.4 / 1.3								
		1.3 - 7.9 (CCR) COAL COMBUSTION RESIDUALS, some slag and unburnt coal, black to gray, wet, soft to firm.			585.8 / 7.9	1	5.00 / 5.00	1	SONIC		●		
5								2	SONIC		●		
						2	5.00 / 5.00	3	SONIC		●		
		7.9 - 13.7 (SC) CLAYEY SAND, fine to medium, low plasticity, some gravel, trace shell pieces, brown to gray, cohesive, w>PL, hard.	SC		580.0 / 13.7			4	SONIC		●	●	PP = 4.5+ tsf TV = 6.25-7.25 tsf
10													
15		13.7 - 16.3 (SP) SAND, poorly graded, medium to fine, gray, non-cohesive, wet, compact.	SP		577.4	3	5.00 / 5.00	5	SONIC		●	●	

Boring completed at 16.3 ft.

NOTES:
1. Auger refusal at 16.3 feet.
2. Drilled from a barge.
3. Mud line at 1.3 feet.

DEPTH SCALE: 1 in to 5 ft
DRILLING CONTRACTOR: Ann Arbor Tech Serv.
DRILLER: Dave/Jim

LOGGED: MMJ
CHECKED: JRP
DATE:

Golder Associates

PROJECT: DE Karn Bottom Ash Pond
PROJECT NUMBER: 1655284
LOCATION: W end of Bottom Ash Pond
CLIENT: Consumers

RECORD OF BOREHOLE DEK-BH-16002

DRILLING METHOD: Sonic
DRILLING DATE: 5-16-16
DRILL RIG: Sonic

DATUM: NAVD88
AZIMUTH: ---
NAD83 MI PLANE-S COORDS: N 783007.5, E 13262943

GS ELEVATION (ft): 593
TOC ELEVATION: ---

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION (VEGETATION:)	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	RUN NUMBER	RUN REC / ATT	SAMPLES NUMBER	SAMPLES TYPE	POCKET PENETROMETER (tons/ft²)	LAB TESTS: ENVIRONMENTAL (SPLP & TOTAL METALS)	LAB TESTS: GRAIN SIZE DISTRIBUTION	NOTES WATER LEVELS
0	Sonic	0.0 - 1.4 WATER.			591.6 1.4								
		1.4 - 12.7 (CCR) COAL COMBUSTION RESIDUALS, some slag and unburnt coal, black to gray, wet, soft.				1	2.50 / 2.50	1	SONIC		●		
5						2	3.00 / 5.00	2	SONIC		●	●	
10					580.3 12.7	3	5.00 / 5.00	3	SONIC		●		
15		12.7 - 18.9 (SP) SAND, poorly graded, fine to medium, brownish gray, non-cohesive, wet, loose to compact.	SP		574.1	4	4.60 / 5.00	4	SONIC		●		
20		Boring completed at 18.9 ft. NOTES: 1. Drilled from a barge. 2. Mud line at 1.4 feet.											
25													
30													
35													
40													

Golder Associates

DEPTH SCALE:1 in to 5 ft
DRILLING CONTRACTOR: Ann Arbor Tech Serv.
DRILLER: Dave/Jim

LOGGED: MMJ
CHECKED: JRP
DATE:

RECORD OF BOREHOLE DEK-G17-BH-01

PROJECT: DE Karn BAP Inv.
PROJECT NUMBER: 1667572.0006
LOCATION: Bottom Ash Pond
CLIENT: Consumers Energy Company

DRILLING METHOD: GeoProbe
DRILLING DATE: 06-06-17
DRILL RIG: Geo 6620DT

DATUM: NAVD88
AZIMUTH: ---
NAD83 MI PLANE-S COORDS: N 783350.6, E 13262389.9

GS ELEVATION (ft): 597.4
TOC ELEVATION: ---

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION (VEGETATION:)	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	RUN NUMBER	RUN REC / ATT	SAMPLES NUMBER	SAMPLES TYPE	POCKET PENETROMETER (tons/ft²)	LAB TESTS: ENVIRONMENTAL (SPLP & TOTAL METALS)	LAB TESTS: GRAIN SIZE DISTRIBUTION	NOTES WATER LEVELS
0	Hydro Vacuum	0.0 - 18.4 (CCR) COAL COMBUSTION RESIDUALS - Bottom Ash, fine to coarse, light gray to black, dry to wet.				1	1.00 / 8.00	1	GRAB				
8	Geoprobe							2	GRAB				
10						2	1.60 / 5.00						
13								3	GP				13 ft ▼
15						3	3.00 / 5.00	4	GP				13-18.4' some slag
18.4					579.0 / 18.4			5	GP				
		18.4 - 21.3 (SM) SILTY SAND and (CCR) COAL COMBUSTION RESIDUALS - Bottom Ash, fine, brown, wet.	SM		576.1	4	4.80 / 5.00	6	GP				
		21.3 - 22.1 (CL-ML) CLAYEY SILT and (CCR) COAL COMBUSTION RESIDUALS, brown to black, moist, soft.	CL-ML		575.3 / 22.1			7, 8, 9	GP, GP, GP				
25		22.1 - 28.0 (SP) SAND, poorly graded, fine to medium, dark brown, wet, loose.	SP		569.4	5	4.00 / 5.00	10	GP				
28		Boring completed at 28.0 ft.						11	GP				

NOTES:
1. Hydro vacuumed to 8 feet bgs to confirm no utilities.

Golder Associates

DEPTH SCALE:1 in to 5.6 ft
DRILLING CONTRACTOR: Mateco
DRILLER: Steve/Tim

LOGGED: JTT
CHECKED: JTT
DATE: 6/8/2017

PROJECT: DE Karn BAP Inv.
PROJECT NUMBER: 1667572.0006
LOCATION: Bottom Ash Pond
CLIENT: Consumers Energy Company

RECORD OF BOREHOLE DEK-G17-BH-02

DRILLING METHOD: GeoProbe
DRILLING DATE: 06-06-17
DRILL RIG: Geo 6620DT

DATUM: NAVD88
AZIMUTH: ---
NAD83 MI PLANE-S COORDS: N 783296.8, E 13262641.3

SHEET 1 of 1
GS ELEVATION (ft): 605.4
TOC ELEVATION: ---

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION (VEGETATION:)	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	RUN NUMBER	RUN REC / ATT	SAMPLES NUMBER	SAMPLES TYPE	POCKET PENETROMETER (tons/ft²)	LAB TESTS: ENVIRONMENTAL (SPLP & TOTAL METALS)	LAB TESTS: GRAIN SIZE DISTRIBUTION	NOTES WATER LEVELS
0	Hydro Vacuum	0.0 - 29.7 (CCR) COAL COMBUSTION RESIDUALS - Bottom Ash, fine to coarse, light gray to black, dry to wet.											
5						1	1.00 / 8.00	1	GRAB				
	Geoprobe							2	GRAB				
10						2	3.20 / 5.00	3	GP				8-17.4' some yellow/rust color oxidation, trace slag
								4	GP				
15						3	2.30 / 5.00	5	GP				
								6	GP				18 ft ▼
20						4	3.60 / 5.00	7	GP				18-28' some slag
								8	GP				
25						5	2.80 / 5.00	9	GP				
								10	GP				
30		29.7 - 30.0 (CL-ML) CLAYEY SILT and (CCR) COAL COMBUSTION RESIDUALS, dark gray, moist.	CL-ML		575.7 / 30.0	6	3.60 / 5.00	11	GP				
								12	GP				
		30.0 - 38.0 (SP) SAND, poorly graded, fine to medium, light brown, wet, loose.	SP					13	GP				
35						7	3.60 / 5.00	14	GP				
					567.4			15	GP				
40		Boring completed at 38.0 ft.											
45													

NOTES:
1. Hydro vacuumed to 8 feet bgs to confirm no utilities.

Golder Associates

DEPTH SCALE:1 in to 5.6 ft
DRILLING CONTRACTOR: Mateco
DRILLER: Steve/Tim

LOGGED: JTT
CHECKED: JTT
DATE: 6/8/2017

DUL_BOREHOLE (BC ASH POND) 1667572.0006 DE KARN BAP INVESTIGATION.GPJ DUL.GOLDER.GDT 6/13/17

RECORD OF BOREHOLE DEK-G17-BH-03

SHEET 1 of 1

PROJECT: DE Karn BAP Inv.
PROJECT NUMBER: 1667572.0006
LOCATION: Bottom Ash Pond
CLIENT: Consumers Energy Company

DRILLING METHOD: GeoProbe
DRILLING DATE: 06-05-17
DRILL RIG: Geo 6620DT

DATUM: NAVD88
AZIMUTH: ---
NAD83 MI PLANE-S COORDS: N 783090.8, E 13262921.2

GS ELEVATION (ft): 596.3
TOC ELEVATION: ---

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION (VEGETATION:)	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	RUN NUMBER	RUN REC / ATT	SAMPLES NUMBER	SAMPLES TYPE	POCKET PENETROMETER (tons/ft²)	LAB TESTS: ENVIRONMENTAL (SPLP & TOTAL METALS)	LAB TESTS: GRAIN SIZE DISTRIBUTION	NOTES WATER LEVELS
0	Hydro Vacuum	0.0 - 13.9 (CCR) COAL COMBUSTION RESIDUALS - Bottom Ash, fine to coarse, dark gray to black, dry.				1	1.00 / 8.00	1	GRAB				
8	Geoprobe					2	2.60 / 5.00	2	GRAB				8-13' some oxidation, some pebble-sized grains
								3	GP				
					582.4 / 13.9			4	GP				
13.9		13.9 - 20.0 (SP) SAND, poorly graded, fine to medium, light brown, trace clay, trace shell fragments, moist to wet, loose.	SP			3	4.50 / 5.00	5	GP				
								6	GP				
18						4	3.20 / 5.00	7	GP				18 ft ▼
20		20.0 - 21.0 (CL-ML) SILTY CLAY, light brown, moist, soft.	CL-ML		576.3 / 20.0			8	GP				
21		21.0 - 22.0 (SP) SAND, poorly graded, fine to medium, light brown, trace pebbles, trace organics, wet, loose.	SP		575.3 / 21.0			9	GP				
22					574.3 / 22.0			10	GP				

Boring completed at 23.0 ft.

NOTES:
1. Hydro vacuumed to 8 feet bgs to confirm no utilities.

DEPTH SCALE: 1 in to 5.6 ft
DRILLING CONTRACTOR: Mateco
DRILLER: Steve/Tim

LOGGED: JTT
CHECKED: JTT
DATE: 6/8/2017

Golder Associates

RECORD OF BOREHOLE DEK-G17-BH-04

SHEET 1 of 1

PROJECT: DE Karn BAP Inv.
PROJECT NUMBER: 1667572.0006
LOCATION: Bottom Ash Pond
CLIENT: Consumers Energy Company

DRILLING METHOD: GeoProbe
DRILLING DATE: 06-05-17
DRILL RIG: Geo 6620DT

DATUM: NAVD88
AZIMUTH: ---
NAD83 MI PLANE-S COORDS: N 782897.4, E 13262880.1

GS ELEVATION (ft): 597.7
TOC ELEVATION: ---

SOIL PROFILE

VEGETATION:

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	ELEV. / DEPTH (ft)
0.0 - 15.2	Hydro Vacuum (0 - 8); Geoprobe (8 - 28)	(CCR) COAL COMBUSTION RESIDUALS - Bottom Ash, fine to coarse, light gray to black, moist to wet.		582.5 / 15.2
15.2 - 20.0	Geoprobe	(SP) SAND, poorly graded, fine to medium, light brown to gray, some silt, trace organics, trace shell fragments, wet, loose.	SP	577.7 / 20.0
20.0 - 21.0	Geoprobe	(CH) CLAY, plastic, light brown, moist, soft.	CH	576.7 / 21.0
21.0 - 25.5	Geoprobe	(SP) SAND, poorly graded, fine to medium, light brown, wet, loose.	SP	572.2 / 25.5
25.5 - 28.0	Geoprobe	(CL) CLAY, some silt, light brown, moist, stiff.	CL	569.7

Boring completed at 28.0 ft.

NOTES:
1. Hydro vacuumed to 8 feet bgs to confirm no utilities.

RUN

NUMBER	REC / ATT
1	1.00 / 8.00
2	2.80 / 5.00
3	4.00 / 5.00
4	4.00 / 5.00
5	3.00 / 5.00

SAMPLES

NUMBER	TYPE
1	GRAB
2	GRAB
3	GP
4	GP
5	GP
6	GP
7	GP
8	GP
9	GP
10	GP
11	GP
12	GP
13	GP

POCKET PENETROMETER (tons/ft²)

LAB TESTS: ENVIRONMENTAL (SPLP & TOTAL METALS); GRAIN SIZE DISTRIBUTION

NOTES / WATER LEVELS

0-8' some oxidation

8 ft ▼

12.8-13' with organics, black to reddish brown, some oxidation

13-14.6' some slag

21-23' trace organic silt, trace shell fragments

DEPTH SCALE:1 in to 5.6 ft
DRILLING CONTRACTOR: Mateco
DRILLER: Steve/Tim

LOGGED: JTT
CHECKED: JTT
DATE: 6/8/2017

Golder Associates

RECORD OF BOREHOLE DEK-G17-BH-05

SHEET 1 of 1

PROJECT: DE Karn BAP Inv.
PROJECT NUMBER: 1667572.0006
LOCATION: Bottom Ash Pond
CLIENT: Consumers Energy Company

DRILLING METHOD: GeoProbe
DRILLING DATE: 06-06-17
DRILL RIG: Geo 6620DT

DATUM: NAVD88
AZIMUTH: ---
NAD83 MI PLANE-S COORDS: N 782900, E 13262550.3

GS ELEVATION (ft): 593.9
TOC ELEVATION: ---

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION (VEGETATION:)	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	RUN NUMBER	RUN REC / ATT	SAMPLES NUMBER	SAMPLES TYPE	POCKET PENETROMETER (tons/ft²)	LAB TESTS: ENVIRONMENTAL (SPLP & TOTAL METALS)	LAB TESTS: GRAIN SIZE DISTRIBUTION	NOTES WATER LEVELS
0	Hydro Vacuum	0.0 - 10.8 (CCR) COAL COMBUSTION RESIDUALS - Bottom Ash, fine to coarse, dark gray to white, moist to wet.				1	1.00 / 8.00	1	GRAB				0-8' with unburnt coal and slag
5													5 ft ▼
8	Geoprobe					2	3.20 / 5.00	2	GRAB				
10.8		10.8 - 18.0 (SP) SAND, poorly graded, fine to medium, light brown, trace silt, wet, loose.	SP		583.1 / 10.8			3	GP				
13						3	3.80 / 5.00	4	GP				
15								5	GP				
18		Boring completed at 18.0 ft.			575.9			6	GP				17-18' trace organics and shell fragments

NOTES:
1. Hydro vacuumed to 8 feet bgs to confirm no utilities.

Golder Associates

DEPTH SCALE:1 in to 5.6 ft
DRILLING CONTRACTOR: Mateco
DRILLER: Steve/Tim

LOGGED: JTT
CHECKED: JTT
DATE: 6/8/2017

RECORD OF BOREHOLE DEK-G17-BH-06

SHEET 1 of 1

PROJECT: DE Karn BAP Inv.
PROJECT NUMBER: 1667572.0006
LOCATION: Bottom Ash Pond
CLIENT: Consumers Energy Company

DRILLING METHOD: GeoProbe
DRILLING DATE: 06-06-17
DRILL RIG: Geo 6620DT

DATUM: NAVD88
AZIMUTH: ---
NAD83 MI PLANE-S COORDS: N 783195, E 13262466.1

GS ELEVATION (ft): 598.4
TOC ELEVATION: ---

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION (VEGETATION:)	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	RUN NUMBER	REC / ATT	SAMPLE NUMBER	SAMPLE TYPE	POCKET PENETROMETER (tons/ft²)	ENVIRONMENTAL (SPLP & TOTAL METALS)	GRAIN SIZE DISTRIBUTION	NOTES WATER LEVELS
0	Hydro Vacuum	0.0 - 19.8 (CCR) COAL COMBUSTION RESIDUALS - Bottom Ash, fine to coarse, dark gray to brown, dry to wet.											
5						1	1.00 / 8.00	1	GRAB				
								2	GRAB				
10	Geoprobe					2	3.50 / 5.00	3	GP				
								4	GP				13-17' some oxidation, some slag
15						3	3.50 / 5.00						15 ft ▼
								5	GP				17-18' some slag
								6	GP				
20		19.8 - 21.8 SILT and (CCR) COAL COMBUSTION RESIDUALS - Bottom Ash, brown to light gray, wet.			578.6 / 19.8	4	4.00 / 5.00	7	GP				
		21.8 - 22.5 (CL-ML) CLAYEY SILT, high plasticity, dark gray to brown, moist.	CL-ML		576.6 / 575.9			8	GP				
		22.5 - 28.0 (SP) SAND, poorly graded, fine to medium, brown, wet, loose.	SP		22.5			9 / 10	GP / GP				
25						5	3.50 / 5.00	11	GP				
					570.4			12	GP				
		Boring completed at 28.0 ft.											

NOTES:
1. Hydro vacuumed to 8 feet bgs to confirm no utilities.

Golder Associates

DEPTH SCALE:1 in to 5.6 ft
DRILLING CONTRACTOR: Mateco
DRILLER: Steve/Tim

LOGGED: JTT
CHECKED: JTT
DATE: 6/8/2017

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Enclosure 2

Redline Track Changes from:

"*D.E. Karn Generating Facility Bottom Ash Pond Closure Work Plan*" (Closure Work Plan), dated November 29, 2017

D.E. KARN GENERATING FACILITY

REVISED BOTTOM ASH POND CLOSURE WORK PLAN

Essexville, Michigan

Bottom Ash Pond
Closure Work Plan

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

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

April 12, 2018 **1667572**

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1.0 CLOSURE WORK PLAN OVERVIEW AND OBJECTIVES

This revised closure work plan has been prepared to request agreement from the Michigan Department of Environmental Quality (MDEQ) on Consumers Energy Company's (CEC) plan to remove coal combustion residual (CCR) from the Bottom Ash Pond at the D.E. Karn Generating Facility (DE Karn) located in Essexville, Michigan. Specifically, the Bottom Ash Pond is an "existing CCR surface impoundment" which will be closed by removal of CCR in accordance with self-implementing requirements of the CCR Resource Conservation and Recovery Act (RCRA) Rule (40 CFR 257 Subpart D) ("CCR RCRA Rule").

This document provides a general description of the following:

- Plans for removal of waste
- Multiple lines of evidence to document waste removal including the basis for an objective waste removal standard to address potential long-term sources of groundwater impacts
- Schedule for implementing the work
- Performance monitoring after waste removal in accordance with the CCR RCRA Rule

An objective standard of 90 percent CCR removal has been established through analysis of site-specific CCR and soils. Although the purpose of this closure work plan is to define methods for removal of CCR as a regulated waste, the 90 percent removal criteria is based on chemical analyses that have shown the criteria to be protective of groundwater based on non-residential drinking water and groundwater and surface water interaction (GSI) criteria.

Closure of the Bottom Ash Pond is being driven by CEC's plan to comply with the CCR RCRA Rule. CEC plans to initiate closure of the Bottom Ash Pond in 2018. To comply with closure timeframe requirements of the CCR RCRA Rule and maintain project schedule and procurement of a closure construction contract, CEC requests MDEQ approval of this closure work plan by January 31, 2018.

CEC is proposing the same CCR removal and similar documentation procedures approved by the MDEQ for closing J.H. Campbell Generating Facility Bottom Ash Pond 3N (JHC Bottom Ash Pond 3N). JHC Bottom Ash Pond 3N was closed by removal of CCR in March 2017 through June 2017. Closure was documented in the *J.H. Campbell Generating Facility Bottom Ash Pond 3N CCR Removal Documentation Interim Report* (JHC Bottom Ash Pond 3N Closure Report) submitted to the MDEQ on June 20, 2017 and approved on July 18, 2017.

Revisions ~~were~~ made to the original closure work plan submitted in November 2017 to address clarifications requested by the MDEQ via email on January 31, 2018 include:~~.~~

- Clarifying thresholds for CCR/sand mixtures based on selenium;
- Clarifying colorimetric analysis for the third line of evidence for the quality assurance plan for removal; and
- Clarifying the positioning for the camera and resolution of imagery for the pictures.

2.0 FACILITY BACKGROUND

DE Karn is a coal-fueled power generating facility located in Essexville, Michigan. The Bottom Ash Pond began operation in 1959. An overview map of DE Karn and ash disposal area is shown in Figure 1 – D.E. Karn Site Layout Map. The DE Karn Solid Waste Disposal Area consists of two distinct areas of disposal – a permitted landfill undergoing closure and an active surface impoundment (Bottom Ash Pond).

The active Bottom Ash Pond is an unlined surface impoundment that receives sluiced bottom ash. The Bottom Ash Pond was designated an “existing CCR surface impoundment” under the CCR RCRA Rule, as it was directly receiving and storing commingled CCR and non-CCR wastewaters as of the effective date of the CCR RCRA Rule.

A new lined surface impoundment is planned to be constructed to comply with liner design criteria under 40 CFR 257.70-72. Once constructed, bottom ash will be directed to the lined impoundment for treatment. The impoundment is scheduled to be complete by July 2018 to facilitate anticipated cessation of receipt of CCR and non-CCR wastewaters in the Bottom Ash Pond in the fourth quarter of 2018 or first quarter of 2019. CEC will provide the Notice of Initiation of Closure pursuant to 40 CFR 257.102(g).

3.0 REGULATORY BACKGROUND

CEC has identified the Bottom Ash Pond at DE Karn as an “existing CCR surface impoundment” under the CCR RCRA Rule, as it was directly receiving and storing commingled CCR and low volume miscellaneous wastewaters as of the effective date of the CCR RCRA Rule (October 19, 2015). As such, there are specific criteria and schedules under the CCR RCRA Rule for CEC to conduct closure.

The Bottom Ash Pond is located immediately adjacent to the 171-acre solid waste disposal area in the DE Karn Solid Waste Disposal Area operating license. The Bottom Ash Pond is permitted under Michigan’s Natural Resources and Environmental Protection Act (NREPA) Part 31 as part of the National Pollution Discharge Elimination System (NPDES). A solid waste disposal area construction permit authorizing conditions for storage and/or disposal was not issued for the Bottom Ash Pond pursuant to solid waste authorities, since the wastewaters containing CCR discharging into the Bottom Ash Pond are considered to be “other wastes regulated by statute” as defined in Rule 110 of the Part 115 Solid Waste Rules. This regulatory exception to authorize activity only under the NPDES permit is limited in scope and application with respect to the disposal and end of life considerations of CCR from this unit.

4.0 SELF-IMPLEMENTATION OF CLOSURE BY REMOVAL OF CCR

CEC intends to close the Bottom Ash Pond by removal of CCR in accordance with self-implementing requirements under the CCR RCRA Rule. Upon approval of this closure work plan, CEC intends for this document to serve as an agreement with MDEQ on applicable elements of its self-implementing plan to achieve closure in accordance with the CCR RCRA Rule. Documentation and certifications necessary under the CCR RCRA Rule will be provided to MDEQ as part of the notification requirements to the relevant State Director detailed in 40 CFR 257.106. Additionally, the applicable certifications and documents will be posted to the CCR Rule Compliance Data and Information publicly-accessible website pursuant to 40 CFR 257.107.

As part of closure self-implementation, the United States Environmental Protection Agency (EPA) required an initial closure plan certified by a qualified professional engineer to be placed in the operating record and posted on a publicly-accessible internet site for existing CCR surface impoundments by October 17, 2016. The initial closure plan indicated that the Bottom Ash Pond would be closed with CCR in-place. However, CEC since determined it was feasible to close the Bottom Ash Pond by removal of CCR. A certified plan for closure of the Bottom Ash Pond by removal of CCR will be independently generated, placed in the CCR unit operating record, and posted on CEC's publicly-accessible internet site subsequent to MDEQ acceptance of this closure work plan.

4.1 Narrative Summary of Closure

The Bottom Ash Pond will be closed by removal of all visible CCR. This is consistent with the clearly visible demarcation of CCR and underlying substrate witnessed in site investigations, as shown in photographs provided in Appendix A – Site Boring Photographs. It is also in accordance with 40 CFR 257.102(c), which states "CCR removal and decontamination of the CCR unit are complete when constituent concentrations throughout the CCR unit and any areas affected by releases from the CCR unit have been removed and groundwater monitoring concentrations do not exceed the groundwater protection standard established pursuant to 257.95(h)." The CCR RCRA Rule also prescribes the closure timeframe for existing CCR surface impoundments as five years from the commencement of closure activities [40 CFR 257.102(f)(1)(ii)].

The Bottom Ash Pond will be closed in compliance with the CCR RCRA Rule using a phased approach which will include: 1) physical removal of CCR for purposes of removing regulated waste and sources of potential long-term groundwater contamination; and 2) use of the balance of the five-year closure timeframe provided for in 40 CFR 257.102(f)(1)(ii) to demonstrate the concentrations of Appendix IV constituents of concern do not exceed groundwater protection standards established pursuant to 257.95(h). This compliance monitoring schedule is provided in Figure 2 – D.E. Karn Bottom Ash Pond Closure Schedule.

The lateral boundaries of the Bottom Ash Pond are defined by the perimeter drainage ditches to the east and west and the shoulder of an access road to the north. The southern boundary is defined by the edge of an overflow gravel parking area north of DE Karn. Permanent 4:1 (H:V) slopes will be used to tie into existing grades at the lateral limits and access the vertical extents of the CCR. The lateral extent of the Bottom Ash Pond is shown in Figure 3 – Lateral Extent of CCR Unit.

Excavation of CCR will reach approximate depths of 5 to 30 feet below the existing grade. Proposed excavation contours are provided in Figure 4 – Bottom Ash Pond Depth of CCR Excavation. After CCR are removed from the ponds, the area will be backfilled with clean fill to promote stormwater drainage and minimize the potential for ponding of surface water.

4.2 CCR Removal and Documentation – Phase I

The first phase of closure activities will be CCR removal and documentation. Descriptions of activities to remove CCR and document adequate removal are provided below along with background and basis for the various lines of evidence.

4.2.1 CCR Excavation and Documentation Summary

This section provides a list of the tasks to be completed during excavation and documentation and provides more details regarding method development and rationale. Excavation will be performed to remove CCR to elevations identified during site investigations; visual observations will be made to confirm the CCR removal objective is met. Documentation of CCR removal will then be performed to provide lines of evidence that validate the extent of the excavation and visual observations made in the field. During CCR removal and documentation, the following tasks will be completed:

- Excavation
  - The Bottom Ash Pond will be dewatered by actively pumping decant in a manner that maintains NPDES permitted effluent limits
  - Hydraulic structures will be abandoned in-place or removed
  - CCR removal will be complete when the following are achieved:
    - The selected contractor meets lateral and vertical excavation limits determined from previous site investigations
    - Visual observations determine that the CCR removal objective has been met
- Documentation and final certification
  - Final excavation grades will be compared to known elevations of CCR from previous site investigations
  - Photographs will be taken to document CCR removal in excavated areas
  - Quantitative colorimetric analysis will be completed to confirm CCR removal meets objective limits

- As an alternative to quantitative colorimetric testing, microscopic quantification of CCR content as described in the JHC Bottom Ash Pond 3N Closure Report will be used to confirm CCR removal if excavated areas are influenced by soils that do not pass the site-specific colorimetric cutoff value selected for closure of the Bottom Ash Pond

Results will be documented in a Bottom Ash Pond CCR removal documentation report. More detailed descriptions and supporting information on activities to document CCR removal are included in the subsequent sections.

4.2.1.1 Removal Criteria Background

CEC is proposing to conduct this assessment based on removal criteria that were developed for closing the Bottom Ash Ponds at CEC's other plants with similar CCR characteristics. When developing CCR removal criteria for Bottom Ash Ponds, characteristics of CCR were evaluated to determine the feasibility of different methods to document CCR removal including color, density, particle size, and particle shape. Based on previous experience of evaluating the material characteristics; color as determined by visual inspection and confirmed by colorimetric analysis was determined to be superior to other documentation methods such as centrifuge separation, petrography via microscope, or scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM/EDX) at sites where the CCR is darker than the underlying native sand material.

Laboratory testing of sand and CCR samples collected from the DE Karn Bottom Ash Pond indicated there is a distinguishable color difference between CCR and the native soil, and visual inspection and colorimetric analysis are effective in assessing the presence of CCR in a mixture with native sand. The density of the CCR and native sands is too similar for centrifugal separation, and sieving is not practical due to the range of particle sizes for the different materials. In addition, SEM/EDX would be limited to the assessment of very small samples and require specialist equipment that could not be feasibly implemented as a field screening method. Colorimetry allows evaluation of larger sample sizes and is easily adapted to the field; thus, allowing the potential for additional sampling to verify reproducibility of results. Therefore, colorimetry was selected as the final and preferred line of evidence to identify and quantify CCR present in samples collected from the Bottom Ash Pond excavation footprint. Some color variability may exist in native soils at the base of the excavation footprint at DE Karn. If native soil color variability is encountered at one of the grid nodes, field microscopic quantification of CCR content will be utilized to confirm the CCR removal objective was met.

Twelve CCR and nine underlying soil samples were collected by drilling from the Bottom Ash Pond. CCR samples were obtained from two borings located in the Bottom Ash Pond (three samples from each boring) and an additional six additional borings located on and around the edges of the Bottom Ash Pond (one sample from each boring). Underlying soil samples were collected at deeper depths from the same eight borings; two samples were collected from one of the two borings located in the Bottom Ash Pond.

The selected samples were compared to the MDEQ Cleanup Criteria Requirements for Response Activity, R 299.48 Generic Soil Cleanup Criteria for Non-residential Category GSI protection and drinking water protection criteria to determine which constituent(s) could be used as indicators of potential groundwater impacts.

Barium, chromium (III), copper, lead, and zinc were not assessed as indicator constituents; because they were not detected in CCR or native soils at concentrations greater than their respective GSI protection criteria. Cadmium, silver, and thallium were also not considered; because they were not detected in CCR at concentrations above their respective method detection limits.

Arsenic, boron, mercury, and selenium were detected in CCR samples at concentrations that exceeded their respective GSI protection criteria. Of these, the average concentrations of arsenic and selenium also exceeded GSI protection criteria in the sand samples; indicating that, even with complete removal of CCR, they may still occur in native sands at concentrations that exceed their respective criteria. Mercury was only detected in one CCR sample and one sand sample; both exceeded the GSI protection criteria, which is equal to the detection limit of 50 µg/kg. Given mercury was not detected in most samples, it was not considered further in selecting a threshold for CCR removal. Based on the average concentrations of boron in CCR and sand, a mixture of CCR and sand containing less than 75 percent CCR would meet the GSI protection criteria for boron.

To identify a numerical threshold for CCR removal, Golder evaluated the ratio of CCR and underlying soil that would reduce soluble concentrations of arsenic, boron, mercury, and selenium. The concentrations of soluble arsenic, boron, mercury, and selenium in the 12 CCR and 9 sand samples were assessed with the Synthetic Precipitation Leaching Procedure (SPLP, EPA Method 1312). Graphs of total concentrations and concentrations in SPLP leachate for arsenic, boron, and selenium are provided in Figure 5 – Total and SPLP Leachate Concentrations of Arsenic, Boron, and Selenium. Arsenic and boron were no longer considered, since concentrations in SPLP leachate from CCR or native soils were not detected above the respective GSI protection criteria. Mercury was also no longer considered, because it was not detected in SPLP leachate at concentrations above the respective method detection limit. Analysis of the SPLP leachates showed that mixtures of sand and CCR containing less than approximately 30 percent CCR would meet the respective GSI protection criteria for selenium.

Based on Figure 5, the threshold for selenium is approximately ~~70~~ 30 percent CCR. However, visual field determination of a sand/CCR mixture of ~~30~~ 70 percent sand/~~70~~ 30 percent CCR would be difficult. Therefore, to be conservative, the threshold of 10 percent CCR (i.e., native soil) was selected based on the GSI protection criteria for selenium.

4.2.2 Documentation of CCR Removal Overview

An objective standard of 90 percent CCR removal has been established through analysis of site-specific CCR and soils. Although the purpose of this closure work plan is to define methods for removal of CCR as a regulated waste, the 90 percent removal criteria is based on chemical analyses that have shown the criteria to be protective of groundwater based on non-residential drinking water and GSI criteria. Verification of CCR removal will be documented based on the following three lines of evidence:

- First line of evidence – comparison of interim excavation termination grades to known elevations of CCR from previous site characterizations and engineering records
- Second line of evidence – photographic documentation including periodic photographs of CCR removal progression and photographs of excavated areas at random grid nodes
- Third line of evidence – ~~microscopic~~ quantitative colorimetric analysis ~~quantification~~ of CCR content at random grid nodes to confirm CCR removal
  - As an alternative to quantitative colorimetric testing, microscopic quantification of CCR content will be used to confirm CCR removal, if excavated areas are influenced by soils that do not pass the site-specific colorimetric cutoff value selected for closure of the Bottom Ash Pond

This multiple lines of evidence approach provides a predictable and reliable means to objectively measure concentrations of CCR based on physical sample properties and is based on lab analyses that demonstrate it is also protective of groundwater. The approach takes advantage of the clear visible demarcation between CCR and the underlying soil observed during previous removal activities and in soil borings.

4.2.2.1 Documentation of Excavation Grades – First Line of Evidence

The first line of evidence to assess CCR removal activities will be to confirm that excavations are completed to at least the elevation established as the base of CCR from existing information. The elevation of the base of CCR was established based on historical facility information and drilling and sampling completed in the Bottom Ash Pond in May 2016 and June 2017. Descriptions of sample materials were used to prepare boring logs for each boring. The boring logs are included in Appendix B – Soil Boring Logs. The boring logs identified CCR to a depth of 7.9 feet (6.6 feet of CCR submerged below 1.3 feet of water) in the east end of the Bottom Ash Pond [elevation 585.8 feet (NAVD88)] and 12.7 feet (11.3 feet of CCR submerged below 1.4 feet of water) in the west end of the Bottom Ash Pond [elevation 580.3 feet (NAVD88)]. In the perimeter berms surrounding the Bottom Ash Pond, CCR was observed at depths ranging from 10.8 feet [elevation 583.1 feet (NAVD88)] to 22.1 feet [elevation 575.3 feet (NAVD88)].

Once the excavation has met the lateral and vertical limits, visual observations for the presence of CCR will be completed and documented. Excavated areas that do not meet the CCR removal objective within the lateral CCR removal limits will be excavated further until the CCR removal objective is met.

4.2.2.2 Photographic Documentation – Second Line of Evidence

Consistent with MDEQ guidance, Sampling Strategies and Statistics Training Materials for Part 201 Cleanup Criteria (S3TM); a 50-foot grid will be established across the excavation area for assessment, and the grid nodes to be sampled will be selected using a random number generator (the outer extent of the grid depends on the materials encountered during excavation). Photographic documentation will be completed on 50 percent of the nodes followed by hand sampling and colorimetric analysis at a further 25 percent of the total number of nodes.

Each grid node will be inspected visually to identify residual CCR materials that are present on the exposed surface of the excavation. If CCR is visible, additional material will be removed.

When no or only minor visible signs of CCR are observed, photographs and written descriptions will be taken at 50 percent of the grid nodes to document the material left in place. The photography procedure will be standardized such that it includes the following elements:

- Photographs will be taken of the general area-wide excavation
- Photographs will be taken of a representative sample measuring approximately one-square-foot area of surficial materials present at the base of the excavation at each grid node
- Photographs will be taken from a standardized height of approximately 2.5 feet above the excavated surface with a pixel resolution of 4608 x 3456 (i.e., 15.9 megapixels) to ensure the same area and level of detail is obtained by each photograph

4.2.2.3 Colorimetric Confirmation – Third Line of Evidence

A colorimetric analysis method that utilizes a colorimeter to precisely measure the color of a soil sample will be used to verify CCR removal. The analysis is conducted in accordance with ASTM E1347, Standard Test Method for Color and Color-Difference Measurement by Tristimulus Colorimetry. The method involves measuring the color value for a field sample and comparing this value to a cutoff color value to determine the presence of CCR in the sample.

The cutoff color value was developed based on measured color values of known (i.e., developed in the laboratory) mixtures of CCR obtained from the Bottom Ash Pond and native soil obtained from beneath the Bottom Ash Pond at DE Karn. Measured color values for each sample are shown in Figure 6 – Site-Specific Colorimetric Analysis, which includes the cutoff RGB integer value of 9.4 million established for use in the field. Measured RGB integer values above this cutoff correspond to samples of clean and light-colored native sand containing less than 10 percent CCR. Field samples with measured RGB integer values less than the cutoff value will be analyzed with microscopy to quantify CCR content as an alternative third line of evidence.

The majority of color values measured for the native soil samples were above the color value measured for the 10 percent CCR mixture validating the cutoff value for field use. Because it is possible that some sand samples may have lower color values than 9.4 million value (e.g., typically sand from areas of the excavation with a high organic content), it is possible that some samples that do not pass the initial colorimetric analysis may be accepted following additional microscopic analysis, as described in the following section.

Colorimetry is easily adapted to use in the field and can be performed on replicate samples (three to five readings are typical), which increases the reproducibility of the analysis and allows for rapid response if the readings yield inconsistent results. Because the method has been validated in the laboratory, it does not rely on a field expert's judgement when examining CCR.

Soil samples will be collected from the area of the excavation at randomly-selected locations using the same grid node methodology developed for the photographic documentation. Fifty percent of the photographed grid nodes will be randomly selected for ~~microscopic~~ colorimetric quantification of CCR content. The samples will be tested in the field to evaluate the presence of CCR materials. These samples will only be collected from grid openings after the excavation has reached a depth such that there are no or only minor visible signs of CCR present in the material on the excavation base and walls.

4.2.2.4 Field Microscopic Quantification of CCR Content – Alternative Third Line of Evidence

As previously discussed, color as determined by visual inspection and confirmed by colorimetric analysis was determined to be superior to other documentation methods; because CCR is significantly darker than the native sand material at DE Karn. However, our experience documenting CCR removal at JHC Bottom Ash Pond 3N demonstrated that some color variability existed in soils at the base of the excavation footprint that could not be anticipated. If similar conditions exist at the DE Karn Bottom Ash Pond, field microscopic quantification of CCR content will be utilized to confirm the CCR removal objective was met as an alternative line of physical evidence to confirm CCR removal. Field samples will be compared to premixed standards to verify CCR content.

4.3 Post-Excavation Monitoring – Phase II

After removal of CCR in Phase I, CEC will use the balance of the five-year closure timeframe provided for in 40 CFR 257.102(f)(1)(ii) to demonstrate the concentrations of Appendix IV constituents of concern do not exceed groundwater protection standards established pursuant to 257.95(h) for two consecutive sampling events.

The current RCRA CCR groundwater monitoring system for the DE Karn Bottom Ash Pond consists of six downgradient groundwater monitoring wells and four background monitoring wells. Monitoring wells were installed during the fourth quarter of 2015 to commence a compliance program pursuant to 40 CFR

257.91(e)(1). This monitoring well network is anticipated to be used to determine compliance with groundwater protection standards and achievement with the standard of closure by removal pursuant to 40 CFR 257.102(c).

The initial Annual Groundwater Monitoring and Corrective Action Report will be certified by January 31, 2018 with notifications to the State Director and public posting to the CCR Rule Compliance Data and Information website by March 2, 2018. A schedule of the groundwater implementation program is provided in Figure 2- D.E. Karn Bottom Ash Pond Closure Schedule. CEC is using the development of the background monitoring as a baseline to demonstrate that the closure by removal of CCR standard has been achieved. If that standard cannot be achieved upon the removal and verification that CCR has been removed to the 10 percent threshold standard, then the necessary technical requirements are in place to implement an assessment monitoring program and corrective actions, if necessary.

Groundwater samples collected at DE Karn will be submitted for the analyses specified in 40 CFR 257, Appendix III and IV. The analytical methods and reporting limits for each constituent are summarized in Table 1 – RCRA CCR Constituents from Appendix III and Appendix IV.

Given that there are differences between the CCR RCRA Rule monitoring requirements and MDEQ requirements (e.g. field-filtering); a more detailed groundwater monitoring program will be provided to MDEQ upon excavation and verification of CCR removal that will include a Sampling and Analysis Plan (SAP), definition of groundwater monitoring system, and coordination with groundwater sampling protocols and analyses pursuant to State groundwater monitoring requirements.

5.0 SUMMARY

The intent of this closure work plan is to communicate and achieve agreement with the MDEQ on CEC's plans to self-implement closure by removal of waste from within the Bottom Ash Pond to comply with the CCR RCRA Rule 40 CFR 257.102(c) as well as to facilitate management of plant process wastewaters. CEC anticipates providing a notification of intent to initiate closure by October 2018 and, subsequently, obtaining certified closure of the Bottom Ash Pond by October 2023. To meet critical compliance milestones and maintain project schedule and procurement of a closure construction contract, CEC requests MDEQ approval of this revised closure work plan by ~~January 31~~May 1, 2018.

6.0 CLOSING

This revised closure work plan is respectfully submitted to CEC. If you have questions or require additional information, please contact Mark Bergeon at (920) 491-2500.

Sincerely,

GOLDER ASSOCIATES INC.

Hugh Davies
Senior Project Geochemist

Mark Bergeon, PG
Program Leader, Associate

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