CARDINAL
OPERATING COMPANY

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October 30, 2020

Mr. Andrew R. Wheeler, EPA Administrator
Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Mail Code 5304-P
Washington, DC 20460

**Subject: Cardinal Power Plant – Alternative Closure Demonstration**

Dear Administrator Wheeler:

Cardinal Operating Company hereby submits this request to the U.S. Environmental Protection Agency (EPA) for approval for a site-specific alternative deadline to initiate closure pursuant to 40 CFR § 257.103(f)(1) for the Bottom Ash Pond located at Cardinal Power Plant in Brilliant, Ohio.

Cardinal is requesting an extension pursuant to 40 CFR § 257.103(f)(1) to allow the impoundment to continue receiving CCR and non-CCR waste streams after April 11, 2021, in order to segregate and retrofit the pond into two separate reservoirs. One reservoir will be retrofitted with a State compliant NPDES liner, designed to receive low volume wastes only. The second reservoir will be retrofitted with a CCR compliant liner, designed to receive CCR wastes only.

Enclosed is a demonstration prepared by Sargent & Lundy that addresses all of the criteria in 40 CFR § 257.103(f)(1)(i)-(iii) and contains the compliance documentation required by 40 CFR § 257.103(f)(1)(iv). As allowed by the agency, in lieu of hard copies of these documents, electronic files were submitted to Kristen Hillyer, Frank Behan, and Richard Huggins via email.

If you have any questions regarding this submittal, please contact Nick Kasper at (614) 681-5160 or nkasper@ohioec.org.

Sincerely,

T M Alban

Thomas M. Alban
Vice President

cc: Kristen Hillyer
Frank Behan
Richard Huggins

CARDINAL
OPERATING COMPANY

## Cardinal Power Plant
## Bottom Ash Pond Complex

# Demonstration for a Site-Specific Alternative to Initiation of Closure Deadline

**Report SL-015687**

**Revision 0**

**October 29, 2020**

**Issue Purpose: Client Comment**

**Project No.: 13770-007**

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# EXECUTIVE SUMMARY

The Bottom Ash Pond (BAP) Complex at the Cardinal Power Plant in Brilliant, Ohio consists of two surface impoundments, the Bottom Ash Pond and Recirculation Pond, which are managed as a single coal combustion residual (CCR) unit. This unit does not meet the liner design criteria promulgated by 40 CFR Part 257 Subpart D ("the EPA CCR Rule"). Therefore, the Cardinal Power Plant must cease placing the CCR and non-CCR waste streams currently sent to the BAP Complex as soon as technically feasible but no later than April 11, 2021, unless an alternative deadline is granted by the EPA in accordance with 40 CFR 257.103. After evaluating several on- and off-site alternative disposal solutions for the waste streams currently sent to the BAP Complex – both permanent and temporary – the Cardinal Operating Company has concluded that no alternative disposal capacity is available for certain waste streams currently being sent to the BAP Complex, and that it was technically infeasible to obtain alternative disposal capacity for these waste streams on- or off-site by April 11, 2021. Accordingly, pursuant to 40 CFR 257.103(f)(1)(iv)(A), the Cardinal Operating Company has prepared the following workplan detailing its development of alternative disposal capacity to replace the BAP Complex.

The Cardinal Power Plant currently sends the following CCR and non-CCR waste streams to the BAP Complex: bottom ash transport water (CCR), metal cleaning waste water (non-CCR), plant services waste water (non-CCR), cooling tower blowdown and basin overflow (non-CCR), sump and drain water (non-CCR), coal pile run-off overflow (non-CCR), and Jet Bubbling Reactor waste water (non-CCR). After evaluating several options for providing alternative disposal capacity to the BAP Complex for these waste streams, the Cardinal Operating Company elected to install a multiple technology system: retrofitting the Recirculation Pond to handle the CCR waste streams and repurposing the Bottom Ash Pond into a non-CCR waste water basin. In addition to providing compliance with the EPA CCR Rule, this option separates the CCR and non-CCR waste streams currently being commingled in the BAP Complex, which gives the station more flexibility in complying with the EPA's recently-revised effluent limitation guidelines for steam electric power generating stations ("ELG Rule"). As such, this alternative disposal capacity provides a holistic solution for complying with both the EPA CCR and ELG Rules.

The Cardinal Operating Company will begin the development of this multiple technology solution by stopping all flows to the Recirculation Pond, then excavating the CCR currently stored therein, and finally retrofitting it with an EPA CCR Rule-compliant composite liner system. After the composite liner system has been installed and the retrofit work has been certified, the retrofitted pond will begin receiving CCR waste streams. The retrofitted pond is expected to be operational by November 30, 2021.

Once the Recirculation Pond has been retrofitted, the Cardinal Operating Company will begin repurposing the Bottom Ash Pond into a non-CCR waste basin. This work will be completed in two phases in order to continue sending non-CCR waste streams to the pond so that the plant can remain in compliance with its

NPDES permit during construction. In the first phase, the southern portion of the pond will be clean-closed and re-lined with a geomembrane liner. Once this first phase is complete, the non-CCR waste streams will be directed to the repurposed portion of the pond. This alternative disposal capacity for the BAP Complex's non-CCR waste streams is expected to be available by June 9, 2022.

Based on the scheduled completion dates for the retrofitted CCR pond and repurposed non-CCR waste basin, the Cardinal Operating Company is requesting the EPA allow the BAP Complex to continue receiving the noted CCR waste streams until November 30, 2021, and the noted non-CCR waste streams until June 9, 2022. Further details on the BAP Complex, the waste streams managed therein, and the Cardinal Operating Company's development of alternative disposal capacity for these waste streams are provided throughout this workplan.

# 1.0 DEVELOPMENT OF ALTERNATIVE CAPACITY

This section presents the option selected by the Cardinal Operating Company to provide alternative disposal capacity to the Cardinal Power Plant's Bottom Ash Pond Complex for the coal combustion residual (CCR) and non-CCR waste streams managed therein. In addition, this section provides background information on the Cardinal Power Plant, the Bottom Ash Pond Complex and the waste streams managed within them, the adverse impact to plant operations if the Bottom Ash Pond Complex was shutdown, the process the Cardinal Operating Company undertook to select the alternative disposal capacity currently being developed, and a narrative of the alternative disposal capacity design. Finally, an explanation and justification for the time being requested to operate the Bottom Ash Pond Complex beyond April 11, 2021 are also provided in this section.

## 1.1 BACKGROUND INFORMATION

### 1.1.1 CARDINAL POWER PLANT

The Cardinal Operating Company operates the Cardinal Power Plant ("Cardinal"), which is a coal-fired steam electric power generating station located in Brilliant, Ohio, adjacent to the Ohio River. The station's address is 306 County Road 7E, Brilliant, Ohio 43913. The plant consists of three operating units – Units 1, 2, and 3 – and has a combined nameplate capacity of approximately 1,800 MW. Unit 1 is owned by AEP Generation Resources Inc., the competitive generation subsidiary of American Electric Power. Units 2 and 3 are owned by Buckeye Power, Inc., a generation and transmission cooperative that operates the Cardinal Operating Company. The plant operates as a base-load generation asset to meet the day-to-day electricity demands of the 25 electric cooperatives that own and govern Buckeye Power, Inc. as well as the local communities serviced by AEP Generation Resources Inc.

### 1.1.2 BOTTOM ASH POND COMPLEX

#### 1.1.2.1 POND COMPLEX CHARACTERISTICS

Cardinal's Bottom Ash Pond (BAP) Complex consists of two surface impoundments, the BAP and the Recirculation Pond, which are managed as a single CCR unit. These ponds are adjacent to each other – the larger BAP is located north of the smaller Recirculation Pond – and are located south of Unit 3's power block and flue gas desulfurization (FGD) island. Both ponds are west of and adjacent to the Ohio River.

#### 1.1.2.2 POND COMPLEX INFLOWS & OPERATIONS

The primary purpose of the BAP Complex is to store bottom ash produced by Cardinal during power-generating operations. The bottom ash handling system at each of the station's three units sluices bottom ash transport water (BATW) via several pipes to the northwest corner of the BAP. Based on the Fact Sheet submitted with the Cardinal Operating Company's 2018 National Pollutant Discharge Elimination System (NPDES) permit application for the Cardinal station (Ref. 3), the plant sluices approximately 4.1 million gallons of BATW to the BAP Complex per day.

When bottom ash enters the BAP, the coarser ash particles tend to settle out of the transport water near the discharge point into the pond, while the finer ash particles tend to settle out further from the discharge point near the southern end of the pond. Waste water in the BAP ultimately flows into the Recirculation Pond through an overflow discharge structure located at the southeast side of the BAP. During normal plant operations, water in the Recirculation Pond is ultimately stored and recycled by the Recirculation Pumphouse and sent back to the station for use in the plant's fly ash-handling systems (*i.e.*, source water for sluicing fly ash to Fly Ash Reservoir (FAR) II). In extreme events (*e.g.*, large rainfall), excess water may be discharged to the adjacent Ohio River through Outfall 023, which is a drop outlet structure with a 36-inch-diameter pipe. This discharge is regulated by the station's active NPDES permit. A partition wall currently separates the portion of the Recirculating Pond that feeds into the Recirculating Pumphouse and the portion that discharges through Outfall 023.

In addition to BATW, the plant also conveys the following low-volume waste (LVW) streams to the BAP Complex: metal cleaning waste water, Unit 1 and 2 service water, Unit 3 cooling tower blowdown and basin overflow water, overflow water from the coal pile run-off pond, and storm water drainage from Unit 3. Per the aforementioned NPDES permit application, these streams have a collective average inflow into the BAP Complex of approximately 8.0 million gallons per day (MGD).

Table 1 summarizes the CCR and non-CCR waste streams sent to the BAP Complex. Per the aforementioned NPDES permit application, the maximum flows listed in the table are based on the 10-year, 24-hour storm event for the site.

Table 1 – Inflows into Cardinal Bottom Ash Pond Complex

| Waste Stream | Description | Average Flow, MGD (Max. Flow, MGD) |
|---|---|---|
| **CCR Waste Streams** | | **4.14** |
| Unit 1 & 2 Bottom Ash Transport Water | Sluice water containing bottom ash particles from the Unit 1 and 2 boilers | 2.30 |
| Unit 3 Bottom Ash Transport Water | Sluice water containing bottom ash particles from the Unit 3 boiler | 1.84 |
| **Non-CCR Waste Streams** | | **7.98**<br>**(17.55)** |
| Metal Cleaning Waste Water | Waste water from the tank used to store waste water from cleaning the Unit 1, 2, and 3 boilers | 0.0014 |
| Unit 1 & 2 Plant Services Waste Water | Waste water from the process water used to operate equipment in Units 1 and 2 (*e.g.*, heat exchangers) | 4.32 |
| Unit 3 Cooling Tower Blowdown | Waste water used to remove minerals collected in the Unit 3 cooling tower basin | 1.58 |
| Unit 3 Cooling Tower Basin Overflow | Overflow water from the Unit 3 cooling tower basin | 1.83 |
| Unit 3 Sump and Drain Water | Storm water collected by sumps and drains in the Unit 3 power block | 0.02<br>(1.60) |
| Coal Pile Run-Off Pond Overflow | Waste water collected by the station's Coal Pile Run-Off Pond. Includes storm water from:<br>• Coal pile,<br>• Coal truck unloading area,<br>• Unit 1, 2, and 3 FGD areas (including gypsum pile, limestone pile, and marine area run-off), and<br>• Unit 1 and 2 power block sumps and drains. | 0.23<br>(6.44) |
| Jet Bubbling Reactor (JBR) Waste Water | Waste water from the JBR in the Unit 1, 2, and 3 FGD system and associated storage tanks. Includes waste water from:<br>• JBR process water,<br>• Reagent feed tank,<br>• FGD reclaim water, and<br>• Byproduct storage tank. | 0.00<br>(1.78) |

Source: Cardinal 2018 NPDES Permit Application Fact Sheet (Ref. 3)

### 1.1.2.3 APPLICABLE REGULATIONS

#### *1.1.2.3.1 FEDERAL CCR RULE*

The BAP Complex has been regulated by the EPA CCR Rule (40 CFR Part 257 Subpart D, Ref. 1) since the rule went into effect in October 2015. Per the 2016 Water Infrastructure Improvements for the Nation (WIIN) Act, both the BAP and the Recirculation Pond will continue to be subject to the requirements prescribed in the EPA CCR Rule until the EPA approves a CCR permit program developed and submitted by the Ohio EPA. Because the Ohio EPA has yet to submit a proposed CCR permit program to the EPA, Ohio is currently considered a Nonparticipating State per 40 CFR 257.53. Consequently, this workplan and the alternative closure deadline requested herein for the BAP and the Recirculation Pond are subject to the approval of the EPA.

#### *1.1.2.3.2 FEDERAL ELG RULE*

In addition to the preceding EPA CCR Rule, the operation of the BAP Complex – specifically discharges through NPDES-permitted Outfall 023 – is also subject to compliance with the EPA's effluent limitation guidelines for steam electric power plants ("ELG Rule"). The 2020 update to the ELG Rule (Ref. 8) sets new limits for discharging BATW and other waste streams generated by steam electric power plants to waters of the U.S. Pursuant to the new 40 CFR 423.13(k)(1)(i) and (k)(2)(i)(A), the ELG Rule establishes a zero-liquid discharge (ZLD) standard for Cardinal's BATW – including any LVW streams that come into contact with BATW – unless the BATW is used in an FGD scrubber or under the following conditions:

- To maintain the bottom ash system's water balance during:
  - Significant precipitation events (10-year, 24-hour storm event or longer), and
  - Situations where excessive quantities of other waste streams regularly handled by the bottom ash system compromise the system's ability to handle recycled BATW;
- To maintain the bottom ash system's water chemistry, and
- To conduct maintenance when water volumes cannot be managed by redundancies, tanks, etc.

In any of the preceding situations, the plant would not be permitted to purge more than 10% of the bottom ash system's maximum volumetric capacity for BATW (calculated on a 30-day rolling average and excluding redundancies, maintenance systems, *etc*.).

Cardinal will be subject to the ZLD standard for BATW promulgated by the updated ELG Rule upon incorporation into the facility's NPDES permit by a date determined by the Ohio EPA. Pursuant to the station's NPDES permit, the Ohio EPA has approved a compliance end date of December 31, 2023. This complies with the new 40 CFR 423.13(k)(1)(i), which requires this NPDES permit modification to occur no later than December 31, 2025.

#### 1.1.2.4 FUTURE HANDLING OF CCR & NON-CCR WASTE STREAMS

The BAP Complex does not meet the liner design criteria promulgated by 40 CFR 257.71(a) and is therefore considered to be an unlined CCR surface impoundment. Thus, per 40 CFR 257.101(a)(1) and (a)(3), Cardinal must cease placing the CCR and non-CCR waste streams listed in Table 1 into the BAP Complex as soon as technically feasible and no later than April 11, 2021, unless an alternative deadline is granted by the EPA.

As detailed herein, the Cardinal Operating Company is requesting that the EPA allow Cardinal to continue sending certain CCR and non-CCR waste streams to the BAP Complex after April 11, 2021 while it develops alternative capacity to replace the BAP Complex because:

- No existing alternative disposal capacity is available on- or off-site for these waste streams,
- It was technically infeasible to develop the alternative capacity selected by April 11, 2021 for these waste streams, and
- FAR II, which the station uses to dispose of its fly ash transport water (FATW), will not cease operating until June 2021, and the BAP Complex provides the source water for the station's fly ash sluicing systems.

### 1.1.3 ADVERSE IMPACT TO PLANT OPERATIONS WITHOUT THE BAP COMPLEX

In order to generate power at Cardinal, it is necessary to dispose of the bottom ash produced from the combustion of pulverized coal in the station's boilers. Without a suitable replacement for the BAP Complex, the Cardinal plant would be forced to stop power-generating operations. Given that the plant is a base-load generation asset for 25 electric cooperatives (see Section 1.1.1), a forced shutdown would leave the electric grid susceptible to unplanned and prolonged outages.

## 1.2 GENERAL STRATEGY FOR COMPLIANCE WITH EPA REGULATIONS

The Cardinal Operating Company has evaluated several different handling and/or disposal alternatives for Cardinal's CCR and non-CCR waste streams since 2016, shortly after the EPA's new CCR Rule and the 2015 amendment to its ELG Rule both became effective. Given the ZLD standards established for both FATW and BATW in the 2015 ELG Rule (Ref. 9), waste streams which included (and still include) non-CCR waste streams that are commingled with FATW and BATW, Cardinal evaluated alternatives that either eliminated these waste streams or allowed for them to be recirculated back into plant systems. In this evaluation of ELG Rule compliance options, Cardinal also sought solutions that would be compliant with the new EPA CCR Rule. In essence, the Cardinal Operating Company has been seeking holistic solutions in regard to complying with both the EPA CCR and ELG Rules for alternative handling and/or disposal of Cardinal's CCR and non-CCR waste streams.

## 1.3 ALTERNATIVE DISPOSAL SOLUTIONS CONSIDERED

Prior to the August 2018 *Utility Solid Waste Activities Group* (*USWAG*) decision by the U.S. Court of Appeals for the D.C. Circuit (Ref. 2), in which the Court ordered the provisions in the EPA CCR Rule allowing unlined ash ponds to continue operating be vacated and remanded, the Cardinal Operating Company started evaluating available alternatives for replacing the existing BAP Complex. In accordance with the Cardinal Operating Company's desire for a holistic solution, this evaluation assessed not only permanent disposal solutions for Cardinal's BATW but also the LVW streams managed by the pond complex. This assessment is summarized in Section 1.3.3.

Pursuant to the recently-revised alternative closure requirements for CCR surface impoundments in the EPA CCR Rule, the Cardinal Operation Company also evaluated whether existing capacity is available on- or off-site for each waste stream currently sent to the BAP Complex. For those streams where existing capacity is not available, the Cardinal Operating Company evaluated whether it was technically feasible to obtain alternative disposal capacity – either temporary or permanent – by April 11, 2021. The following subsections discuss the alternative disposal solutions considered for each waste stream managed in the BAP Complex and how these waste streams were ultimately dispositioned.

### 1.3.1 EXISTING ON-SITE DISPOSAL SOLUTIONS

#### 1.3.1.1 BOTTOM ASH TRANSPORT WATER

Because BATW is a CCR waste stream, it must be disposed of in an active CCR unit. As documented on the Cardinal Operating Company's public CCR website (Ref. 4), Cardinal has three CCR units on-site: the BAP Complex, FAR II, and FAR I Landfill. FAR II is a CCR surface impoundment used by the station to store and treat its FATW, as well as leachate and contact storm water run-off from FAR I Landfill. However, like the BAP Complex, FAR II is not compliant with the liner design criteria promulgated by the EPA CCR Rule and is therefore subject to the closure-for-cause requirements promulgated by 40 CFR 257.101. Thus, FAR II would not be an acceptable alternative disposal facility for Cardinal's bottom ash even if the necessary mechanical equipment and piping were installed to divert BATW from the BAP Complex to FAR II.

Located adjacent to FAR II, the station's FAR I Landfill is an EPA CCR Rule-compliant disposal facility that is primarily used by the station to dispose of the gypsum byproduct from its FGD systems. This landfill has also been used to dispose of bottom ash that has been dredged from the BAP Complex and subsequently dewatered. While the landfill may receive bottom ash and has sufficient capacity to accommodate Cardinal's daily generation of bottom ash, the Ohio EPA prohibits industrial solid waste landfills like FAR I Landfill from receiving bulk or noncontainerized liquids wastes like Cardinal's BATW (Ref. 11). Thus, the station cannot utilize its landfill for directly disposing of its bottom ash while it has a wet bottom ash-handling system. Cardinal would need a bottom ash dewatering system or an entirely dry bottom ash-handling system to directly send its bottom ash to FAR I Landfill. Because Cardinal does not currently have either of these systems, the station does not presently have the means to directly dispose of its bottom ash in FAR I Landfill.

In summary, there is no alternative on-site disposal capacity to the BAP Complex available for Cardinal's wet-generated bottom ash because:

- The station's only other wet CCR disposal facility, FAR II, is not compliant with the EPA CCR Rule's liner design criteria and, like the BAP Complex, is subject to closure for cause, and
- Neither a dry bottom ash-handling system nor a bottom ash dewatering system are present at the station to allow for Cardinal to utilize its on-site CCR landfill, FAR I Landfill.

### 1.3.1.2 NON-CCR WASTE STREAMS

#### *1.3.1.2.1 METAL CLEANING WASTE WATER*

When Cardinal cleans a boiler during a scheduled unit outage, the resulting waste water is stored in the station's Metal Cleaning Waste Tank. When this tank is full, its contents are drained to the BAP Complex. Given the intermittent and infrequent nature of this flow, the Cardinal Operating Company has not scheduled another boiler clean until after alternative disposal capacity for the BAP Complex becomes available. Thus, metal cleaning waste water will no longer be sent to the BAP Complex.

#### *1.3.1.2.2 OTHER NON-CCR WASTE STREAMS*

Unlike the metal cleaning waste water, the remaining non-CCR waste streams sent to the BAP Complex are continuous flows and/or must be sent to the pond during significant storm events. The three continuous non-CCR waste streams sent to the BAP Complex – Unit 1 and 2 plant services waste water, Unit 3 cooling tower blowdown, and Unit 3 cooling tower basin overflow – are also significant flows that exceed or are similar to the flow rates for the Unit 1, 2, and 3 BATW. Cardinal primarily relies on the size of the BAP Complex to provide adequate time for sedimentation of the total suspended solids (TSS) present in these waste streams. This is necessary for the station to recirculate the water back into station operations or, if the station cannot handle the excess water from a significant storm event, to discharge it to the Ohio River via Outfall 023 in accordance with its NPDES permit.

The only other pond at the Cardinal site that is large enough to accept the plant services and cooling tower waste streams currently going into the BAP Complex (7.7 MGD total) is FAR II. However, as previously discussed, this pond is not an acceptable disposal alternative to the BAP Complex since it is also subject to the EPA CCR Rule's closure-for-cause requirements. Therefore, there is no alternative disposal capacity currently available at the Cardinal site for these three waste streams.

Although the Unit 3 sumps and drains, coal pile run-off pond, and JBR waste water flows are intermittently sent to the BAP Complex, it is necessary for these flows to be sent to the BAP Complex during significant storm events. Because the station has a limited means of recirculating the excess water introduced to its overall water balance during a significant rain event, it must discharge the surplus or risk overtopping / flooding. In particular, the coal pile run-off ponds receive storm water collected in several different areas of the plant in addition to storm water run-off from the coal pile. These relatively small ponds (each less than one acre) would be at risk of overtopping during a significant storm event if the excess water was not otherwise removed. Finally, like all the other flows discussed thus far, FAR II is not an acceptable alternative for these three waste streams. Thus, there is no alternative capacity currently available at the Cardinal site for the excess storm water collected in the Unit 3 sumps and drains, the coal pile run-off ponds, and the JBR area.

### 1.3.2 EXISTING OFF-SITE DISPOSAL SOLUTIONS

Although the EPA itself has acknowledged that it is not feasible to transport wet-generated CCR to an off-site disposal facility (Ref. 5), the Cardinal Operating Company performed its due diligence and evaluated the feasibility of temporarily transporting the average daily volume of BATW, Unit 1 and 2 plant services waste water, Unit 3 cooling tower blowdown, Unit 3 cooling tower basin overflow, Unit 3 sump and drain water, and coal pile run-off pond overflow to an off-site disposal facility until a permanent disposal facility could be installed on-site. Given that the JBR waste water flow is typically only present during significant storm events, these flows were not included in this evaluation. As previously mentioned, landfills are generally not permitted to receive bulk or noncontainerized liquids, so only waste water treatment plants (WWTPs) could be considered as potential disposal facilities for the waste water flows considered in this evaluation.

Although not covered in this workplan, the Cardinal Operating Company is also requesting an alternate deadline for ceasing flows to FAR II. Consequently, the CCR and non-CCR waste streams sent to this pond will also need to be transported to an off-site treatment facility. As demonstrated in the corresponding workplan for FAR II, Cardinal does not currently have alternative means of disposing the flows presented in Table 2. As shown in the table, an average flow of approximately 9.8 MGD of CCR and non-CCR waste water would need to be sent to a temporary facility off-site in addition to the noted BAP Complex waste streams.

To be a viable option, a WWTP would need to receive the average daily volume of the preceding CCR and non-CCR waste streams from the BAP Complex and FAR II, in addition to the waste water volume the WWTP currently treats. Therefore, per Table 1 and Table 2, the WWTP (or combination of WWTPs) would need to be capable of receiving an average flow of 21.9 MGD.

Table 2 – Inflows into Cardinal Fly Ash Reservoir II Requiring Alternative Disposal

| Waste Stream | Description | Average Flow, MGD |
|---|---|---|
| **CCR Waste Streams** | | **8.93** |
| Unit 1 & 2 Fly Ash Transport Water | Sluice water containing fly ash particles from the Unit 1 and 2 ESPs | 5.76 |
| Unit 3 Fly Ash Transport Water | Sluice water containing fly ash particles from the Unit 3 ESP | 3.17 |
| **Non-CCR Waste Streams** | | **0.88** |
| FAR I Landfill Leachate | Leachate collected and removed from FAR I Landfill | 0.09 |
| FAR I Landfill Contact Storm Water | Contact storm water from FAR I Landfill | 0.79 |

Source: Cardinal 2018 NPDES Permit Application Fact Sheet (Ref. 3)

Inquiries were placed with 11 WWTPs within 50 miles of the station to determine if any plants in the region were capable of handling the total or a significant portion of the 21.9 MGD of ash transport and non-CCR waste water from Cardinal. Of the four WWTPs that responded, two plants had a combined capacity of less than 10 MGD, and one indicated that the facility could not accept external waste water streams. A representative from the fourth WWTP stated that the plant had the rated capacity to accommodate the average volume of waste water produced at Cardinal but expressed concerns regarding the water chemistry.

Even if this specific WWTP's water chemistry concerns were alleviated, or if additional WWTPs responded stating that they had sufficient capacity, the Cardinal Operating Company would need to identify a means of transporting the waste water to one or more WWTPs. Given the station's existing ash-handling infrastructure, trucks with tank trailers would likely be the only transportation method that could be established for the station's ash transport and non-CCR waste streams prior to the April 11, 2021 deadline for ceasing all flows into Cardinal's ash ponds.

Based on an average continuous flow rate of 8,400 gpm, this scenario would require new tanks be installed at some interception point upstream of the BAP Complex to temporarily store the BATW and non-CCR waste streams currently going into the BAP Complex prior to being pumped into tank trucks. A similar system would be established near FAR I Landfill to collect its leachate and contact storm water run-off. Meanwhile, fly ash slurry temporarily stored in the tanks downstream of the station's Hydroveyors® would be directly pumped into the trucks' tank trailers. It should be noted that this scenario would require Cardinal to identify and obtain an alternate source of water for the fly ash-handling system in lieu of the water currently recycled from the BAP Complex.

Ohio state law limits the overall gross vehicle weight to 80,000 pounds (Ref. 6). Considering the weight of the CCR solids in the waste water being transferred to a WWTP and assuming an empty tank trailer weight of 12,000 pounds, a 7,000-gallon tank trailer would be the maximum tank trailer that would be permitted to transport waste water to an off-site WWTP. Therefore, over 3,100 daily trips would be required to transport 21.9 MGD of ash transport and non-CCR waste water to a WWTP. Even if Cardinal implemented an alternate means of handling its non-CCR waste water, it would require more than 1,800 daily trips to transport the 13.1 MGD of BATW and FATW generated by the station.

Even if the station could support the number of tank trucks to keep up with its daily production rate of transport and non-CCR waste water, there would be significant logistics concerns in coordinating that many trips to and from the station's property. The only way trucks can access the Cardinal site is via Ohio State Route 7 (SR-7). Based on traffic data compiled by the Ohio Department of Transportation (Ref. 7), the average annual daily traffic (AADT) in 2019 for commercial trucks along SR-7 near Cardinal was 1,770 trucks. Therefore, the 3,100 trips required to transport Cardinal's daily volume of ash transport and non-CCR waste water to an off-site WWTP would almost triple the daily volume of truck traffic currently on SR-7. This would impose significant congestion issues on this four-lane road along the Ohio River, an increased potential for traffic accidents, and an increase in air pollution emissions. Thus, in addition to being harmful to human health and the environment, it is impractical to route 3,100-trips worth of trucks per day to an off-site WWTP for several months until alternative ash disposal facilities are installed on-site.

Based on the lack of regional WWTPs available to process or even handle Cardinal's daily volume of ash transport and non-CCR waste water, and based on the impracticality and risks of coordinating the number of truck trips required to handle this volume of waste water, the Cardinal Operating Company has reached the same conclusion as the EPA (Ref. 5) regarding the off-site transportation of wet-generated ash: it is not feasible.

### 1.3.3 NEW ON-SITE DISPOSAL SOLUTIONS

Based on the preceding evaluations, no alternative disposal capacity currently exists on- or off-site for Cardinal's BATW, Unit 1 and 2 plant services waste water, Unit 3 cooling tower blowdown, Unit 3 cooling tower basin overflow, Unit 3 sump and drain water, coal pile run-off pond overflow, and JBR waste water. Consequently, the Cardinal Operating Company has been actively developing alternative disposal capacity for these waste streams. This subsection presents the process the Cardinal Operating Company underwent to ultimately select the alternative disposal capacity to replace the existing BAP Complex.

#### 1.3.3.1 EVALUATION OF ASH DISPOSAL METHODS

In the third quarter of 2018, Cardinal Operating Company started performing a detailed evaluation of different methods for disposing of Cardinal's fly ash in lieu of sluicing it to FAR II. A similar assessment was also performed for the station's bottom ash-handling system, which included an evaluation of the following options:

- Install geotextile filter tubes at FAR I Landfill,
- Construct a new surface impoundment on undeveloped land,
- Construct a concrete settling tank at FAR I Landfill, and
- Retrofit the BAP Complex.

#### *1.3.3.1.1 GEOTEXTILE FILTER TUBES*

Geotextile filter tubes are containers with oval-shaped cross sections that are composed of engineered fabric that can filter out fine particles within water. Thus, BATW lines could be routed directly to a series of these tubes to filter bottom ash particles out of the transport water. As the bottom ash particles are consolidated within each tube, filtered sluice water would percolate out of each tube onto an impermeable pad with appropriate run-off control measures. Once a tube is full of bottom ash particles, BATW would be redirected to another tube while the full tube continues to dewater. After the filtered ash has been sufficiently dewatered, the full tube would be cut open and loaded onto trucks for final disposal in FAR I Landfill.

For Cardinal, a series of geotextile filter tubes could be installed within the existing FAR I Landfill area. The tubes could be installed in a series of self-contained bays that would facilitate sequential operation of the tubes: one bay would feature a tube actively receiving BATW, a second bay would feature a tube being dewatered, and a third bay would feature a tube being reclaimed for landfilling. Collected filtrate from dewatering could be gravity-drained to a collection sump that would ultimately convey water to a new recirculation water storage tank. To comply with the revised ELG Rule, a new recirculation water system would be installed to pump water back to all three units for re-use in the existing bottom ash-handling system.

While geotextile filter tubes have been used as a method for dewatering bottom ash ponds, there would be challenges in operating and dewatering these tubes during below-freezing weather conditions and excessive rain events. Ultimately, these operational challenges convinced the Cardinal Operating Company that geotextile filter tubes are a technically infeasible replacement for the BAP Complex, and this option was removed from consideration as an alternative disposal option.

#### *1.3.3.1.2 NEW SURFACE IMPOUNDMENT*

The Cardinal Operating Company also considered replacing the BAP Complex with a new surface impoundment. Two potential locations on the station's property were identified as suitable for a new ash pond provided new dams were constructed to obtain the necessary long-term storage capacity. Pursuant to the EPA CCR Rule, the new ash pond would be lined with a composite liner system consisting of a geomembrane underlain by a compacted clay liner with a permeability no greater than $1 \times 10^{-7}$ cm/sec. A groundwater monitoring program for the new ash pond would be implemented, including the installation of upstream and downstream monitoring wells, to sample and test groundwater in accordance with the EPA CCR Rule. Like the geotextile filter tube option, a recirculation system for BATW would be installed for this option.

Although ash ponds are a proven technology for ash disposal, constructing a new surface impoundment would require a significantly longer design, permitting, and construction effort than the other options considered. Except for the plant proper, Cardinal's property is predominately hilly terrain. So while the two locations identified as potential sites for a new ash pond are currently undeveloped, it would require extensive design and construction efforts to pump BATW and route the corresponding piping to these locations, to install an EPA CCR Rule-composite liner system, and to construct the earth dams required to form a reservoir. This option would also require sufficient time to adequately establish the background groundwater conditions in accordance with the EPA CCR Rule's groundwater monitoring requirements. Finally, a significant amount of return piping would need to be installed to comply with the revised EPA ELG Rule. Overall, it was estimated that this option would take just over 3 years to develop from engineering and design through construction and commissioning.

Given the prolonged schedule required to design, permit, and construct a new surface impoundment relative to the other options evaluated, this option was removed from consideration as an alternative disposal option to replace the BAP Complex.

#### *1.3.3.1.3 CONCRETE SETTLING TANK*

In lieu of a traditional ash pond, bottom ash could be settled out of transport water by using self-supporting, cast-in-place reinforced concrete tanks. This option would feature a series of primary tanks where most of the ash particles would settle. Water from the primary tanks would overflow into a surge tank for settling of the finer ash particles. Like the previous two options, BATW in the surge tank would ultimately be recirculated back to the station to comply with the revised ELG Rule. Cardinal would sluice BATW to one primary tank at a time, switching to an empty tank as a given tank reaches capacity. Equipment would then be used to manually segregate and manipulate the ash in the full tank to promote dewatering. After this initial dewatering, ash would be recovered and transferred to an adjacent concrete pad to completely dewater. Like the pad proposed for the geotextile filter tube option, this dewatering pad would feature appropriate run-off control measures; it would also be sloped such that water drains back to the primary tank. Once the ash is sufficiently dry, it would be loaded onto trucks and disposed of in FAR I Landfill.

While concrete settling tanks have been used to handle bottom ash, this technology, like geotextile filter tubes, poses operational risks in inclement weather. The operation of these tanks and subsequent dewatering of ash collected therein would not be technically feasible during below-freezing weather conditions and excessive rain events. Thus, the Cardinal Operating Company also remove this option from consideration as a replacement for the BAP Complex.

#### *1.3.3.1.4 RETROFITTED BOTTOM ASH POND COMPLEX*

Given the existing BAP Complex's compliance with all other parts of the EPA CCR Rule, both the BAP and Recirculation Pond are suitable for future bottom ash disposal provided that they are retrofitted with EPA CCR Rule-compliant liner systems. In this scenario, both ponds would be dewatered and then lined with a composite liner system consisting of a geomembrane underlain by a compacted clay liner with a permeability no greater than $1\times10^{-7}$ cm/sec.

While this retrofit would obtain compliance with the EPA CCR Rule, the Cardinal Operating Company ultimately sought a holistic alternative disposal solution for all waste streams currently managed in the BAP Complex that achieved compliance with both the CCR and ELG Rules (see Section 1.2). Thus, the Cardinal Operating Company expanded the study of this option to evaluate different alternatives for retrofitting both ponds that evaluated factors including, but not limited to, impoundment size, handling of CCR and non-CCR waste streams, and modifications to existing station infrastructure (*e.g.*, BATW and LVW discharge pipes).

In order to comply with the recently-revised ELG Rule, BATW recovered from the reconfigured BAP Complex would need to be recirculated in station operations or diverted to the station's FGD systems prior to being discharged to the Ohio River. Target water quality standards were established for the recirculation water to determine the maximum TSS concentration levels that could be recirculated with minimal impact to the existing pumps and piping in the Recirculation Pumphouse, which would preclude the need for new equipment and thus allow the ponds to be retrofitted quicker. In early 2019, bottom ash samples were collected from various locations within the BAP Complex and subsequently tested. Based on the size distribution and average density of these bottom ash samples, it was determined that the Recirculation Pond's existing footprint was suitable to function as the station's primary and only bottom ash settling pond. After receiving these test results, the Cardinal Operating Company began evaluating whether to segregate the CCR and non-CCR waste streams, developing conceptual design drawings and process flow diagrams, updating the station's water balance to reflect the operational changes, and estimating the capital costs to fund the project.

Given that the existing Recirculation Pond footprint could promote enough sedimentation of the station's bottom ash particles to support recirculation, Cardinal Operating Company evaluated whether to combine both CCR and non-CCR waste streams in the retrofitted ash ponds or to segregate these waste streams. The former would allow the ponds to be retrofitted with minimal impacts to the existing infrastructure and thus would likely be the faster path to overall compliance with the EPA CCR and ELG Rules. However, this option would also prohibit the station from discharging any of its LVW streams since they would be considered BATW pursuant to the ELG Rule. Conversely, segregating these streams would provide the station with the means of discharging its LVW streams as needed but would require additional time to design and construct the infrastructure necessary to segregate the non-CCR waste streams from the CCR waste streams.

Regardless, the Cardinal Operating Company considered both alternatives to be technically feasible options for replacing the BAP Complex.

#### 1.3.3.2 OPTION SELECTED

Ultimately, the Cardinal Operating Company elected to comply with the EPA CCR and ELG Rules by reconfiguring the BAP Complex to separate CCR and non-CCR waste streams. Since the existing Recirculation Pond was determined to have sufficient size to settle out enough bottom ash particles to obtain the target recirculation water quality, this pond will handle only CCR waste streams (BATW) while the existing BAP will handle only non-CCR waste streams (LVW streams). The Recirculation Pond will therefore replace the existing BAP as Cardinal’s primary bottom ash disposal facility. Consequently, the BAP Complex’s Recirculation Pond will be retrofitted with an EPA CCR Rule-compliant liner system. Meanwhile, the BAP area within the Bottom Ash Pond Complex will be clean closed and then repurposed for use as an LVW storage pond.

In essence, the Cardinal Operating Company has opted to replace the BAP Complex with a multiple technology system that consists of a retrofitted Recirculation Pond and a repurposed BAP that functions as a non-CCR waste water basin.

#### 1.3.3.3 JUSTIFICATION OF OPTION SELECTED

Of the new, permanent on-site disposal alternatives considered to replace the BAP Complex, the multiple technology system selected – retrofit the Recirculation Pond and construct a non-CCR waste water basin in the BAP footprint – is the alternative disposal capacity option that could be implemented the fastest and is technically feasible. As discussed in their respective summaries, geotextile filter tubes and concrete settling tanks would have operational risks during inclement weather, especially during the winter. And while a new ash pond could be constructed on undeveloped land on Cardinal’s property, the hilly terrain and distance from the plant would require significant design, permitting, and construction schedules to implement the BATW piping to and from the impoundment, install the composite liner system, and to construct the dams necessary to form a reservoir. Conversely, the multiple technology system selected is taking advantage of the station’s existing infrastructure (e.g., transport piping and Recirculation Pumphouse), which reduces design and construction time. Moreover, the construction will be staged to provide alternative disposal capacity for all waste streams currently managed by the BAP Complex as soon as technically feasible. This is discussed in greater detail in Section 3.0.

## 1.4 CONCEPTUAL DESIGN OF RECONFIGURED BAP COMPLEX

This section describes the conceptual designs for the retrofitted Recirculation Pond and the repurposed BAP. Given the planned operational changes to these ponds and for clarity, the existing BAP and Recirculation Pond areas will be hereafter referred to as the North/LVW Pond and South Pond, respectively.

## 1.4.1 RETROFITTED SOUTH POND

### 1.4.1.1 CCR REMOVAL

Cardinal will initiate the retrofit of the South Pond by dewatering the existing pond and subsequently removing any accumulated bottom ash and any contaminated soils from the pond in accordance with 40 CFR 257.102(k)(1)(i). Initial dewatering will be accomplished by lowering the water levels in both the North and South Ponds to a water level that allows continuous operation of the Recirculation Pumphouse. The removed water will be directed to the Ohio River through permitted NPDES Outfall 023 using temporary pumps located along the perimeter dike. In order to fully dewater the South Pond, the current flow from the North Pond will be diverted via a temporary supply pipe connected to the Recirculation Pumphouse; the pipe will also allow the station to continue recovering water from the BAP Complex during the South Pond retrofit work. After the temporary pipe is installed, the South Pond will be dewatered by pumping the water stored therein to the North Pond, which will have the capacity available for this water after the initial dewatering effort, or through the permitted NPDES outfall. Once the dewatering process is complete, all CCR material and CCR-impacted soils will be removed from the pond and processed as required for transportation to and final disposal in FAR I Landfill.

### 1.4.1.2 COMPOSITE LINER DESIGN

After the CCR and CCR-impacted soils in the South Pond have been removed, the existing partition wall currently dividing the pond will be removed along with the existing water treatment system and its associated equipment. Once the partition wall has been removed, the pond equalization pipe from the North Pond's discharge structure will be removed and sealed in-place two feet below the bottom of the new EPA CCR Rule-compliant liner system.

Conceptually, the South Pond's new composite liner system will consist of (from bottom to top):

- 2-foot-thick clay layer,
- 60-mil high-density polyethylene (HDPE) geomembrane,
- 8-oz/sy non-woven geotextile, and
- A protective layer.

The protective layer installed above the other liner components will vary across the South Pond due to the varying frequency of future dredging operations in each portion of the pond. The northernmost portion of the pond will be dredged every three to five years, while the southernmost portion of the pond will be regularly dredged. The middle portion of the pond is not expected to be dredged. Based on these dredging frequencies, the protective layers in each portion of the pond will be as follows:

- Along the northern most portion:
    - 8-in.-thick gravel layer, and
    - 18-in.-thick riprap layer.

- Along the southern most portion:
    - 4-in.-thick gravel layer, and
    - 8-in.-thick concrete layer.
- Along the middle of the pond and the new dredge staging and dewatering area:
    - 8-in.-thick of gravel layer.

The lowest two layers of the composite liner system will comply with the design criteria for composite liners promulgated by the EPA CCR Rule. Pursuant to 40 CFR 257.70(b), a composite liner must be comprised of an upper geomembrane (at least 60-mil thick for HDPE geomembranes) and a lower component consisting of compacted soil that is at least 2-feet thick with a permeability no greater than $1\times10^{-7}$ cm/sec. Accordingly, the lower clay layer will be compacted to ensure its hydraulic conductivity does not exceed this EPA design criterion. The Cardinal Operating Company is also evaluating the potential of substituting geosynthetic clay liner (GCL) for clay materials to achieve this low permeability but is currently planning on using clay as noted.

The purpose of the gravel, riprap, and concrete components in the upper protective layer system is to protect the geomembrane from being damaged by equipment removing CCR from the retrofitted South Pond in the future. Similarly, the geotextile component will protect the geomembrane from tears induced by the sharp, angular aggregate in the protective layer.

#### 1.4.1.3 POND APPURTENANCES

In order to recover CCR stored in the retrofitted South Pond, a new dredge staging and bottom ash dewatering area will be constructed near the new BATW discharge point into the pond. As CCR is dredged from the South Pond, it will be temporarily stored on an area with an EPA CCR Rule-compliant liner to dewater before ultimately being transported to FAR I Landfill for final disposal. In addition, new perimeter berms will be constructed around the dewatering area to contain the water from the moist-to-wet CCR. Any run-off from the area will be directed back towards the retrofitted South Pond.

While the existing bottom ash handling pumps will continue to be used, the jet pumps under the units' bottom ash hoppers will be replaced to accommodate the increased pressure drop from the BATW pipe extension to the retrofitted South Pond. These new pumps will allow for the BATW system velocity to be maintained such that the bottom ash remains in suspension in the transport water as it is conveyed to the retrofitted South Pond. Treated BATW will continue to be recovered and recycled back into plant operations via the Recirculation Pumphouse, and any excess water or blowdown will be fed to the Unit 3 FGD system. The discharge of excess BATW through the Unit 3 FGD system is permitted by the ELG Rule.

### 1.4.2 REPURPOSED NORTH/LVW POND

After the South Pond has been retrofitted and is operational, the Cardinal Operating Company will begin repurposing the North Pond. Due to the small size of the retrofitted South Pond and the limited volume of water that can be recovered by the station's FGD system (see Section 1.5.3), the North Pond will need to continue receiving LVW streams even after the South Pond has been retrofitted. In order to repurpose the North Pond while it continues to receive LVW streams from the plant, the pond will be repurposed in two stages: the southern portion first, then the northern portion.

#### 1.4.2.1 CONSTRUCTION OF TEMPORARY LVW IMPOUNDMENT

Before the southern portion of the North Pond can be dewatered, the LVW streams going into the pond need to be isolated from the area. To accomplish this, a temporary impoundment will be constructed near the existing LVW discharge point in the northwest corner of the pond. This impoundment will be constructed by excavating out the bottom ash in the area to form a bowl, with the excavated material used to create a dike separating the area from the rest of the North Pond. Finally, a geomembrane liner will be installed over the bottom ash remaining on the pond floor to keep the LVW streams stored in the temporary impoundment separated from the underlying ash.

#### 1.4.2.2 CCR REMOVAL IN SOUTHERN PORTION

After the temporary LVW impoundment is constructed, the Cardinal Operating Company will initiate closure of the southern portion of the North Pond by dewatering it and subsequently removing any accumulated bottom ash and any contaminated soils from the pond in accordance with 40 CFR 257.102(c). Like the South Pond, all CCR material and CCR-impacted soils removed from this area of the North Pond will be processed as required for transportation to and final disposal in FAR I Landfill. Once the area has been decontaminated, it will be certified as closed and will then be ready to be repurposed as a non-CCR waste water basin.

#### 1.4.2.3 LINER DESIGN

Once the southern portion of the North Pond has been certified as clean-closed, the subgrade will be compacted and smooth-rolled until it is adequate to support the pond's new liner. Because the repurposed pond will not be receiving BATW (or any CCR in general), it will not require the same liner system as the South Pond. Instead, the North Pond's liner system will feature a 60-mil HDPE geomembrane in accordance with the Ohio EPA's liner design criteria. To complete the liner system, an 8-oz/sy non-woven geotextile will be placed above the geomembrane. After the liner system is installed, the southern portion of the North Pond will be available as alternative disposal capacity for the LVW streams currently going into the BAP Complex. Accordingly, Cardinal will then divert all LVW streams from the temporary impoundment to the re-lined southern portion of the North Pond.

#### 1.4.2.4 CCR REMOVAL & RE-LINING OF NORTHERN PORTION

Once the LVW streams are re-directed to the repurposed portion of the North Pond, all the CCR and CCR-impacted material in the remainder of the North Pond will be removed and transported to FAR I Landfill. This area will then be clean-closed per 40 CFR 257.102(c) and subsequently lined with a 60-mil HDPE geomembrane liner in accordance with Ohio EPA requirements. Like the southern portion, an 8-oz/sy non-woven geotextile will be placed above the geomembrane. After this area has been re-lined, the entire North Pond will be placed into service as the station's LVW Pond (*i.e.*, non-CCR waste basin).

### 1.4.3 IMPACTS TO STATION WATER BALANCE

Historically, Cardinal has recycled BATW stored in the BAP Complex for use in its wet fly ash-handling systems. Once these systems are converted to dry handling in June 2021, BATW will no longer need to be used for this purpose. Given the selected approach for developing alternative disposal capacity by segregating the station's BATW from its LVW streams, BATW will be recycled to the station in a closed loop system for use in the station's bottom ash-handling system. However, with the future segregation of the ponds within the BAP Complex, some BATW will need to be discharged from the closed-loop system to control the water inventory and chemistry. To accomplish this, a new blowdown line will be installed to transfer some BATW from the retrofitted South Pond to the Unit 3 FGD system. As previously noted, discharge of BATW through the station's FGD system is acceptable per the revised EPA ELG Rule. This flow is expected to provide the 1.84 MGD currently taken from the Unit 3 intake stream to operate the FGD system (Ref. 4).

## 1.5 EXPLANATION & JUSTIFICATION OF TIME REQUESTED

Per the visual timeline representation and narrative discussion of the project schedule presented in Sections 2.0 and 3.0, respectively, the Cardinal Operating Company is requesting to the EPA allow the South Pond and the North Pond to continue operating until November 30, 2021 and until June 9, 2022, respectively. During this period, the following CCR and non-CCR waste streams would be placed into the BAP Complex since they do not currently have alternative disposal options at Cardinal or offsite:

- Unit 1 and 2 BATW (until November 30, 2021),
- Unit 3 BATW (until November 30, 2021),
- Unit 1 and 2 plant services waste water (until June 9, 2022),
- Unit 3 cooling tower blowdown (until June 9, 2022),
- Unit 3 sump and drain water (until June 9, 2022),
- Coal pile run-off pond overflow (until June 9, 2022), and
- JBR waste water (until June 9, 2022).

As previously stated, metal cleaning waste water will not be placed into the BAP Complex until after the South Pond has been retrofitted.

The Cardinal Operating Company is requesting this additional time to continue operating the BAP Complex because of the need to continue operating the pond to supply water to its wet fly ash-handling systems until FAR II is replaced by a dry system, the time required to secure project funding from the electric cooperatives for which it serves, and the need to continue placing LVW streams into the northern portion of the BAP Complex until a portion of the repurposed LVW Pond is operational. These items are discussed in the following paragraphs. A detailed explanation and justification for the time required to repurpose the BAP Complex, starting with the engineering and design phase, is provided in the narrative of the project schedule in Section 3.0.

Finally, pursuant to the recently-revised alternative closure requirements in the EPA CCR Rule, the Cardinal Operating Company also evaluated whether temporary storage could be provided for the preceding CCR and non-CCR waste streams that will be sent to the BAP Complex until the South Pond is retrofitted and the North Pond is repurposed. This evaluation is summarized in a following paragraph.

### 1.5.1 WATER SOURCE FOR FLY ASH-HANDLING SYSTEM

Regardless of the option selected to replace the BAP Complex, the BAP Complex would need to remain operational to support Cardinal’s fly ash-handling system until it is converted into a dry system. As previously stated, Cardinal recycles water from the Recirculation Pond to sluice its fly ash to FAR II. Without the BAP Complex operating, the station would not be able to sluice to FAR II. Pursuant to the Cardinal Operating Company’s corresponding workplan for replacing FAR II, there is currently no alternative disposal capacity for the waste streams currently sent to FAR II. Thus, Cardinal must continue operating FAR II until the new dry fly ash-handling system is online. This system is currently being constructed at the site and is expected to be operational on June 7, 2021. Therefore, the BAP Complex would need to operate until at least June 7, 2021 regardless of the alternative disposal capacity selected to replace it.

### 1.5.2 PROJECT FUNDING & INITIATION

As part of the study of alternative disposal capacity options to replace the BAP Complex, Cardinal Operating Company developed capital cost estimates to assess the financial requirements for funding the project. These cost estimates were then used to obtain the necessary funding for the project. The alternative disposal capacity project for replacing the BAP Complex could not commence until the appropriate funds were approved and allocated.

In general, funding for environmental compliance projects is not approved until the corresponding environmental regulations are finalized. While this project addresses revisions to the EPA CCR Rule in response to the October 2018 mandate by the U.S. Court of Appeals for the D.C. Circuit that vacated and remanded provisions allowing unlined CCR surface impoundments like the North and South Ponds to continue operating (Ref. 2), these updates were not finalized by the EPA until late-August 2020. Given the project approval process utilized by the Cardinal Operating Company, it was not possible to initiate procurement and construction of the reconfigured BAP Complex on the basis of forecasted changes to the EPA CCR Rule due to the October 2018 court mandate. However, the Cardinal Operating Company successfully demonstrated the importance of complying with the anticipated changes to the EPA CCR Rule and the limited time available for achieving compliance. Consequently, the Cardinal Operating Company was able to authorize and commence developing alternative disposal capacity for the BAP Complex sooner than typically allowed for environmental compliance projects.

### 1.5.3 CONTINUED OPERATION OF NORTH POND AFTER SOUTH POND RETROFIT

As shown in the visual timeline representation of the project schedule (Section 2.0) and as described in the corresponding narrative (Section 3.0), alternative disposal capacity will be available for Cardinal's BATW by November 30, 2021 once the South Pond has been retrofitted. However, this pond cannot be used to handle the LVW streams currently going into the North Pond due to its size and the amount of water the station can recover in excess of BATW.

As previously stated, the Cardinal Operating Company determined that the South Pond had adequate area and storage volume to provide the detention time required to remove enough TSS from the BATW for the water to be recirculated into station operations. However, this water quality standard would not comply with the station's existing NPDES permit. Therefore, the station will not be able to discharge the waste water stored in this pond to the Ohio River once it is operational, even before the Ohio EPA incorporates the revised ELG Rule standards for BATW into the station's NPDES permit.

In lieu of discharging directly to the Ohio River from the retrofitted South Pond, the station could send excess water through its FGD system and then discharge it following appropriate treatment. As previously stated in Section 1.4.3, the Cardinal Operating Company plans on recycling 1.84 MGD of BATW from the retrofitted South Pond to operate the Unit 3 FGD system. However, this is the maximum volume of water that can be handled by the FGD system. Consequently, additional water placed into the retrofitted South Pond beyond BATW could not be discharged through the FGD system.

Given that the station would not be able to discharge water from the retrofitted South Pond directly to the Ohio River due to high TSS concentrations or to the Unit 3 FGD system due to its operating limits, sending the subject LVW streams to the retrofitted South Pond in addition to the station's BATW would put the pond at risk of overtopping. This would be considered an uncontrolled released of BATW from the impoundment in violation of the station's NPDES permit. Consequently, LVW streams need to continue being discharged into the North Pond until it has been repurposed as a non-CCR waste water basin, even after the South Pond has been retrofitted with an EPA CCR Rule-compliant composite liner system.

### 1.5.4 TEMPORARY DISPOSAL OF WASTE STREAMS

The Cardinal Operating Company considered two temporary disposal solutions for the CCR and non-CCR waste streams that will continue to be sent to the BAP Complex until the retrofitted South Pond and repurposed North Pond are operational on November 30, 2021 and June 9, 2022, respectively: tanks and water treatment trailers.

#### 1.5.4.1 STORAGE TANKS

Based on the Cardinal Operating Company's current forecast of obtaining permanent alternative disposal capacity to replace the BAP Complex, enough tanks would need to be procured and installed at the site to provide approximately one years' worth of storage for the BATW produced by the plant for approximately one year. Similarly, the station would need to install enough tanks to provide about 1.5 years' worth of storage for the non-CCR waste water produced by the plant. Given average daily inflows of 4.14 and 7.98 MGD of CCR and non-CCR waste water into the BAP Complex (see Table 1), these temporary tanks would need to provide almost 5.9 billion gallons-worth of storage. It is not technically feasible to install the number of tanks required to provide this storage capacity until the BAP Complex is reconfigured. Less storage capacity would be required if the tank contents could be regularly discharged or recirculated, but the tanks would need to be large enough to promote sedimentation of the TSS in the waste streams. The number and size of these tanks could be controlled if the waste could be transported off-site, but the logistics required for off-site transport, even if off-site disposal capacity was available, also make this temporary solution technically infeasible (see Section 1.3.2).

#### 1.5.4.2 WASTE WATER TREATMENT TRAILERS

While it is technically infeasible to use tanks to temporarily store and/or treat the large CCR and non-CCR flows currently going into the BAP Complex, waste water treatment trailers from a vendor that specializes in such technology may be capable of treating the BATW and non-CCR waste streams currently being sent to the BAP Complex. These trailers can remove TSS from and neutralize the pH in waste streams, among other treatment capabilities. The amount of waste water a trailer can treat is dependent on the water chemistry, but 1 MGD is generally achievable.

Given an average daily inflow of 12.1 MGD, it would take about 12 waste water treatment trailers to handle and treat the CCR and non-CCR waste streams currently going into the BAP Complex. While it may be feasible to find space on the plant site for 12 trailers, the implementation of this temporary system would require time to perform the engineering and design of piping to and from the trailers, modifications to Cardinal's NPDES permit, and installation of the system itself. Moreover, it should be recognized that there is only a limited number of these waste water treatment trailers available.

Assuming Cardinal is able to procure 12 waste water treatment trailers, they could not be installed near the BAP Complex given the limited open space available and the need to provide unimpeded access to the site to the contractor in charge of reconfiguring the BAP Complex. Assuming the station can allocate enough space near Unit 3 for 12 waste water treatment trailers (about 1,500 feet away from the current discharge point into the BAP Complex), it is expected that at least three months would be required to perform the necessary engineering and design work to divert the subject waste streams to the waste water treatment trailers and then route effluent from the trailers to an NPDES-permitted outfall. More design time would likely be necessary if any or all of the waste water treatment trailers had to be sited near FAR I Landfill due to space restrictions at the plant. Because the handling and treatment of these waste streams is being changed, the Cardinal Operating Company would need to modify its existing NPDES permit with the Ohio EPA to incorporate this new treatment method. Based on recent experience in obtaining permits from the Ohio EPA, it would be expected to take approximately six months to get this permit modification finalized. It would likely take another two months to install and commission this temporary system, assuming a contractor has already been procured by the time the modified NPDES permit is issued by the Ohio EPA.

Based on the preceding analysis, it is anticipated that the fastest feasible timeframe for which this temporary system could be designed, permitted, and installed is approximately 10 months. Therefore, if Cardinal were to proceed with implementing this temporary option for the waste streams currently going into the BAP Complex, it is anticipated that this system would be operational by September of 2021.

Although temporary waste water treatment tanks may provide a faster compliance timeline for the subject CCR and non-CCR waste streams by about two months and nine months, respectively (the retrofitted South Pond and the repurposed North Pond will be operational by November 30, 2021 and by June 9, 2022, respectively), it does not align with the Cardinal Operating Company's goal of developing a holistic solution that complies with both the EPA CCR and ELG Rules. Implementation of this temporary solution would only provide a temporary means for compliance with the EPA CCR and ELG Rules and would involve mobilization of additional construction traffic and resources to establish a temporary solution when a permanent one will be available a few months later. In general, the Cardinal Operating Company does not consider treating this volume of non-CCR waste streams in this manner an acceptable long-term means of compliance with the ELG Rule.

The alternative disposal capacity selected by the Cardinal Operating Company will ultimately bring Cardinal's BAP Complex into full compliance with both the EPA CCR and ELG Rules, and the reconfigured BAP Complex will allow Cardinal to permanently separate the CCR and non-CCR waste streams therein. As the EPA states in its preamble to the recent revisions to its CCR Rule (Ref. 10, p. 53536), "[T]here are many technical reasons that a facility might select one approach over another that have nothing to do with cost or convenience. For example…if a facility is trying to comply with multiple EPA regulations or moving away from the commingling of CCR and non-CCR waste streams, adopting a multiple technology approach may ultimately result in faster compliance overall, even if individual components could theoretically be adopted sooner."

Based on the preceding analysis, the Cardinal Operating Company does not consider temporary waste water treatment trailers to be in line with its goal of developing a holistic solution that brings the BAP Complex in compliance with both the EPA and ELG Rules or the intentions of the EPA when developing the revised alternative closure provisions for its CCR Rule. However, to preclude the interaction of LVW streams with bottom ash stored in the North Pond once the retrofitted South Pond starts receiving BATW, the Cardinal Operating Company plans to limit the area in which LVW will be placed in the non-compliant North Pond. Moreover, this limited area will be lined with a temporary geomembrane liner to minimize contact between LVW water and the bottom ash in this area.

# 2.0 PROJECT SCHEDULE: VISUAL TIMELINE

This section presents a visual timeline representation of the Cardinal Operating Company's schedule for retrofitting the South Pond in the BAP Complex and subsequently repurposing the North Pond as a non-CCR waste basin. Pursuant to 40 CFR 257.103(f)(iv)(1)(A)(*2*), the following visual timeline representation of the project schedule shows:

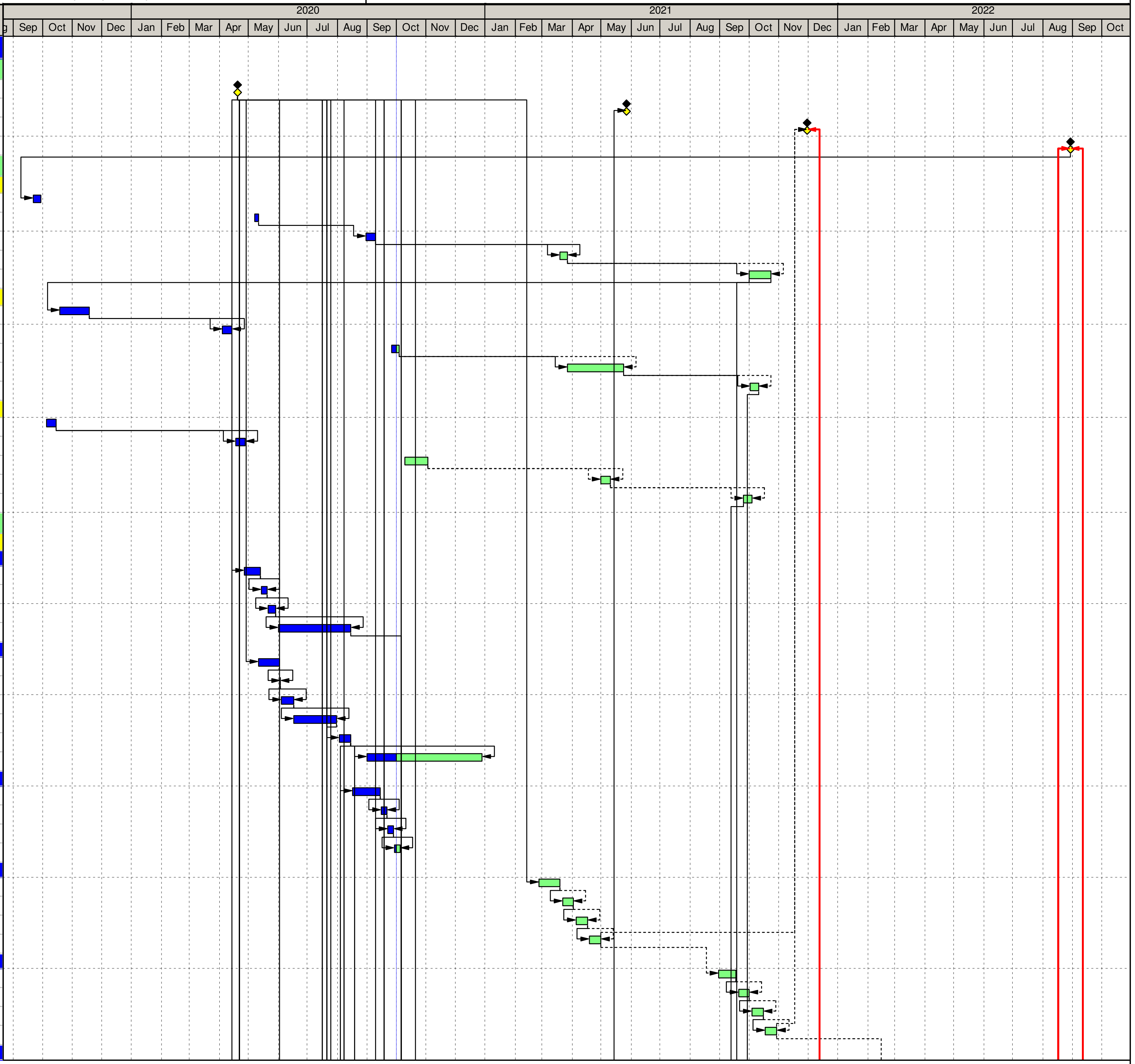
- How each phase and the steps within that phase interact with or are dependent on each other and the other phases,
- All of the steps and phases that can be completed concurrently,
- The total time needed to retrofit the South Pond and to repurpose the North Pond as a non-CCR waste basin.

As shown in its visual timeline representation, the project schedule is divided into the following phases:

- Engineering & Design;
- Procurement (Contractor Selection);
- Procurement (Equipment Fabrication & Delivery); and
- Construction, Startup, & Implementation.

See Section 3.0 for the corresponding narrative discussion of the project schedule.

| WBS | Activity ID | Activity Name | Rem Duration | Activity % Complete | Start | Finish |
|---|---|---|---|---|---|---|
| **CRD-BA0 Cardinal Level 3 Bottom Ash Detailed Design** | | | 498 | | 21-Sep-19 A | 29-Aug-22 |
| **CRD-BA0.67 Milestones** | | | 319 | | 20-Apr-20 A | 29-Aug-22 |
| | MS100 | Engineering Start | 0 | 100% | 20-Apr-20 A | |
| | MS110 | Start Construction | 0 | 0% | 27-May-21 | |
| | MS115 | CCR Compliance Documents - Final Certification | 0 | 0% | | 30-Nov-21* |
| | MS120 | Modification Complete | 0 | 0% | | 29-Aug-22* |
| **CRD-BA0.1 Outage Schedule** | | | 388 | | 21-Sep-19 A | 23-Oct-21 |
| **CRD-BA0.1.24 Unit No 1** | | | 219 | | 21-Sep-19 A | 23-Oct-21 |
| | OUTU1.001 | 2019 Fall Outage 0 | 0 | 100% | 21-Sep-19 A | 29-Sep-19 A |
| | OUTU1.002 | 2020 Spring Outage 40 | 0 | 100% | 07-May-20 A | 11-May-20 A |
| | OUTU1.003 | 2020 Fall Outage 10 | 0 | 100% | 31-Aug-20 A | 09-Sep-20 A |
| | OUTU1.004 | 2021 Spring Outage 9 | 9 | 0% | 19-Mar-21 | 27-Mar-21 |
| | OUTU1.005 | 2021 Fall Outage 23 | 23 | 0% | 01-Oct-21 | 23-Oct-21 |
| **CRD-BA0.1.25 Unit No 2** | | | 376 | | 19-Oct-19 A | 11-Oct-21 |
| | OUTU2.001 | 2019 Fall Outage 0 | 0 | 100% | 19-Oct-19 A | 18-Nov-19 A |
| | OUTU2.002 | 2020 Spring Outage 0 | 0 | 100% | 04-Apr-20 A | 13-Apr-20 A |
| | OUTU2.003 | 2020 Fall Outage 9 | 4 | 0% | 26-Sep-20 A | 04-Oct-20 |
| | OUTU2.004 | 2021 Spring Outage 59 | 59 | 0% | 27-Mar-21 | 24-May-21 |
| | OUTU2.005 | 2021 Fall Outage 10 | 10 | 0% | 02-Oct-21 | 11-Oct-21 |
| **CRD-BA0.1.1 Unit No 3** | | | 360 | | 05-Oct-19 A | 04-Oct-21 |
| | OUTU3.001 | 2019 Fall Outage | 0 | 100% | 05-Oct-19 A | 14-Oct-19 A |
| | OUTU3.002 | 2020 Spring Outage | 0 | 100% | 18-Apr-20 A | 27-Apr-20 A |
| | OUTU3.003 | 2020 Fall Outage | 24 | 0% | 10-Oct-20* | 02-Nov-20 |
| | OUTU3.004 | 2021 Spring Outage | 10 | 0% | 01-May-21* | 10-May-21 |
| | OUTU3.005 | 2021 Fall Outage | 10 | 0% | 25-Sep-21* | 04-Oct-21 |
| **CRD-BA0.69 Engineering & Design** | | | 412 | | 27-Apr-20 A | 29-Apr-22 |
| **CRD-BA0.69.1 General** | | | 399 | | 27-Apr-20 A | 29-Apr-22 |
| **CRD-BA0.69.1.24 Design Basis/Criteria** | | | 0 | | 27-Apr-20 A | 14-Aug-20 A |
| | GEN1000000.10 | Design Basis/Criteria - Prepare & Review | 0 | 100% | 27-Apr-20 A | 13-May-20 A |
| | GEN1000000.20 | Design Basis/Criteria - S&L Prepare & Submit Package to Cardinal | 0 | 100% | 14-May-20 A | 20-May-20 A |
| | GEN1000000.25 | Design Basis/Criteria - Cardinal review | 0 | 100% | 21-May-20 A | 29-May-20 A |
| | GEN1000000.30 | Design Basis/Criteria - Issue for Use | 0 | 100% | 01-Jun-20 A | 14-Aug-20 A |
| **CRD-BA0.69.1.25 General Arrangements** | | | 59 | | 11-May-20 A | 28-Dec-20 |
| | GEN2000000.10 | General Arrangements - Prepare & Review | 0 | 100% | 11-May-20 A | 02-Jun-20 A |
| | GEN2000000.16 | General Arrangements - Peer Review | 0 | 100% | 03-Jun-20 A | 03-Jun-20 A |
| | GEN2000000.20 | General Arrangements - S&L Prepare & Submit Package to Cardinal | 0 | 100% | 04-Jun-20 A | 16-Jun-20 A |
| | GEN2000000.25 | General Arrangements - Cardinal review | 0 | 100% | 17-Jun-20 A | 31-Jul-20 A |
| | GEN2000000.30 | General Arrangements - Issue for Use | 0 | 100% | 03-Aug-20 A | 14-Aug-20 A |
| | GEN2000000.60 | General Arrangements - Final Issue | 59 | 0% | 01-Sep-20 A | 28-Dec-20 |
| **CRD-BA0.69.1.26 Update Project Cost Estimate** | | | 3 | | 17-Aug-20 A | 05-Oct-20 |
| | GEN3000000.10 | Update Project Cost Estimate - Prepare & Review | 0 | 100% | 17-Aug-20 A | 14-Sep-20 A |
| | GEN3000000.20 | Update Project Cost Estimate - S&L Prepare & Submit Package to Cardinal | 0 | 100% | 15-Sep-20 A | 21-Sep-20 A |
| | GEN3000000.25 | Update Project Cost Estimate - Cardinal review | 0 | 100% | 22-Sep-20 A | 28-Sep-20 A |
| | GEN3000000.30 | Update Project Cost Estimate - Issue for Use | 3 | 0% | 29-Sep-20 A | 05-Oct-20 |
| **CRD-BA0.69.1.2 CCR Semi-Annual Progress Report #1** | | | 46 | | 26-Feb-21 | 30-Apr-21 |
| | GEN4000000.10 | CCR Semi-Annual Progress Report #1 - Prepare & Review | 16 | 0% | 26-Feb-21* | 19-Mar-21 |
| | GEN4000000.20 | CCR Semi-Annual Progress Report #1 - S&L Prepare & Submit Package to Cardinal | 10 | 0% | 22-Mar-21 | 02-Apr-21 |
| | GEN4000000.25 | CCR Semi-Annual Progress Report #1 - Cardinal review | 10 | 0% | 05-Apr-21 | 16-Apr-21 |
| | GEN4000000.30 | CCR Semi-Annual Progress Report #1 - Issue for Use | 10 | 0% | 19-Apr-21 | 30-Apr-21 |
| **CRD-BA0.69.1.3 CCR Semi-Annual Progress Report #2** | | | 43 | | 31-Aug-21 | 29-Oct-21 |
| | GEN5000000.10 | CCR Semi-Annual Progress Report #2 - Prepare & Review | 13 | 0% | 31-Aug-21* | 17-Sep-21 |
| | GEN5000000.20 | CCR Semi-Annual Progress Report #2 - S&L Prepare & Submit Package to Cardinal | 10 | 0% | 20-Sep-21 | 01-Oct-21 |
| | GEN5000000.25 | CCR Semi-Annual Progress Report #2 - Cardinal review | 10 | 0% | 04-Oct-21 | 15-Oct-21 |
| | GEN5000000.30 | CCR Semi-Annual Progress Report #2 - Issue for Use | 10 | 0% | 18-Oct-21 | 29-Oct-21 |
| **CRD-BA0.69.1.4 CCR Semi-Annual Progress Report #3** | | | 45 | | 28-Feb-22 | 29-Apr-22 |

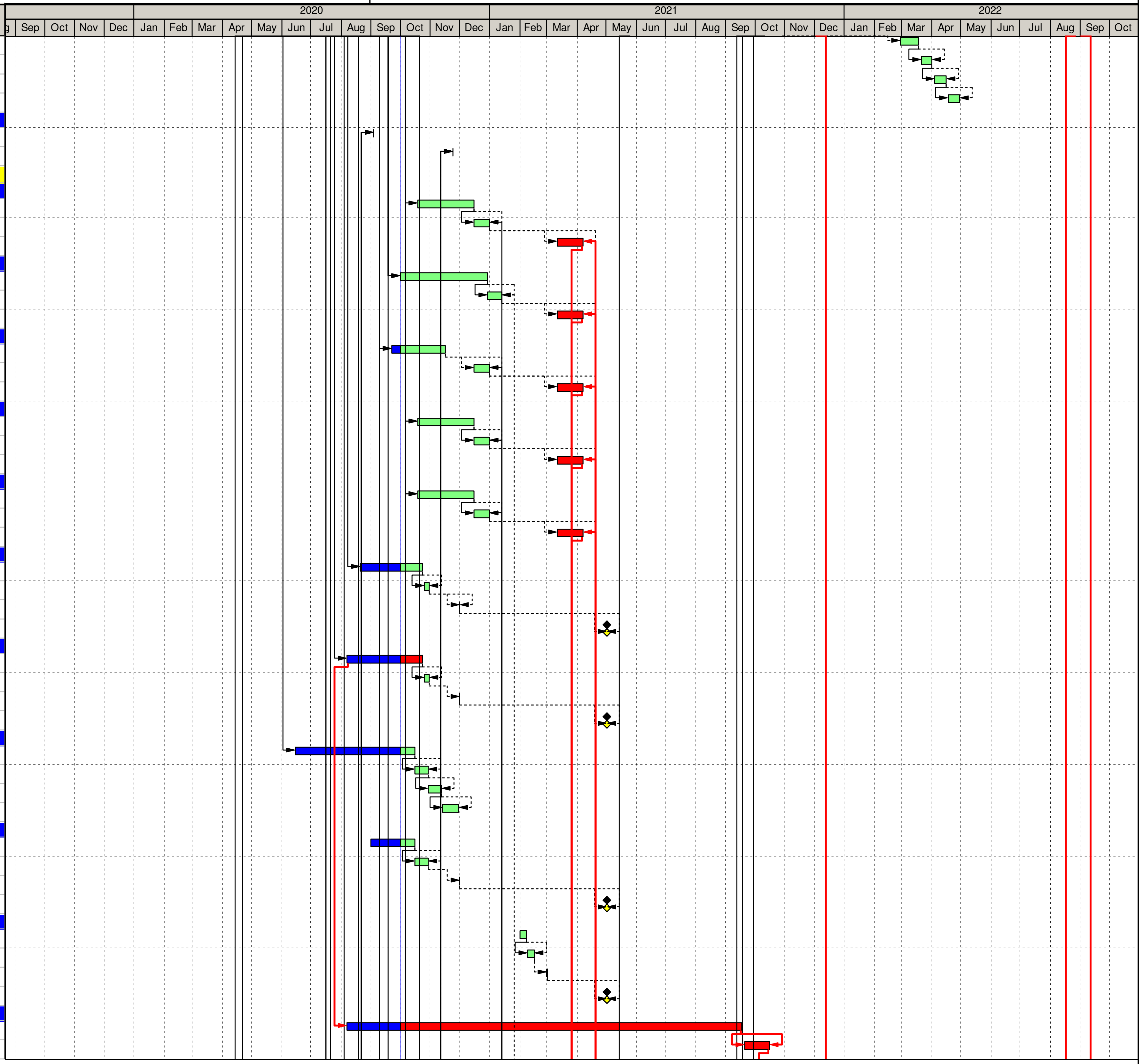


- 🟩 Remaining Level of Effort ◆
- 🟦 Actual Work
- 🟩 Remaining Work
- 🟥 Critical Remaining Work
- ◇ Baseline Milestone
- ◆ Milestone

***Engineering, Procurement & Construction Schedule by WBS***

Cardinal Level 3 Bottom Ash Detailed Design | Monthly Report Layout | Project ID:FPT4-CRD-BA0 | 28-Oct-20 17:16

| WBS | Activity ID | Activity Name | Rem Duration | Activity % Complete | Start | Finish |
|---|---|---|---|---|---|---|
| | GEN6000000.10 | CCR Semi-Annual Progress Report #3 - Prepare & Review | 15 | 0% | 28-Feb-22* | 18-Mar-22 |
| | GEN6000000.20 | CCR Semi-Annual Progress Report #3 - S&L Prepare & Submit Package to Cardinal | 10 | 0% | 21-Mar-22 | 01-Apr-22 |
| | GEN6000000.25 | CCR Semi-Annual Progress Report #3 - Cardinal review | 10 | 0% | 04-Apr-22 | 15-Apr-22 |
| | GEN6000000.30 | Semi-Annual Progress Report #3 - Issue for Use | 10 | 0% | 18-Apr-22 | 29-Apr-22 |
| | **CRD-BA0.69.1.1** | **Design Review** | 1 | | 03-Sep-20 A | 24-Nov-20 |
| | DR25 | 25% Design Review | 0 | 100% | 03-Sep-20 A | 03-Sep-20 A |
| | DR60 | 60% Design Review | 1 | 0% | 24-Nov-20 | 24-Nov-20 |
| | **CRD-BA0.69.2** | **Civil** | 304 | | 15-Jun-20 A | 30-Nov-21 |
| | **CRD-BA0.69.2.1** | **Civil General Notes & Details** | 118 | | 19-Oct-20 | 07-Apr-21 |
| | CIVIL01000.10 | Civil General Notes & Details - Prepare & Review | 40 | 0% | 19-Oct-20 | 15-Dec-20 |
| | CIVIL01000.30 | Civil General Notes & Details - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | CIVIL01000.60 | Civil General Notes & Details - Construction Issue | 20 | 0% | 11-Mar-21 | 07-Apr-21 |
| | **CRD-BA0.69.2.2** | **Temporary Erosion Control** | 130 | | 01-Oct-20 | 07-Apr-21 |
| | CIVIL01005.10 | Temporary Erosion Control - Prepare & Review | 60 | 0% | 01-Oct-20 | 29-Dec-20 |
| | CIVIL01005.30 | Temporary Erosion Control - Bid Issue | 10 | 0% | 30-Dec-20 | 13-Jan-21 |
| | CIVIL01005.60 | Temporary Erosion Control - Construction Issue | 20 | 0% | 11-Mar-21 | 07-Apr-21 |
| | **CRD-BA0.69.2.3** | **Pond Lining Drawings** | 130 | | 22-Sep-20 A | 07-Apr-21 |
| | CIVIL02000.10 | Pond Lining drawings - Prepare & Review | 33 | 0% | 22-Sep-20 A | 16-Nov-20 |
| | CIVIL02000.30 | Pond Lining drawings - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | CIVIL02000.60 | Pond Lining drawings - Construction Issue | 20 | 0% | 11-Mar-21 | 07-Apr-21 |
| | **CRD-BA0.69.2.4** | **Civil Sitework Demo Drawings** | 118 | | 19-Oct-20 | 07-Apr-21 |
| | CIVIL02005.10 | Civil Sitework Demo Drawings - Prepare & Review | 40 | 0% | 19-Oct-20 | 15-Dec-20 |
| | CIVIL02005.30 | Civil Sitework Demo Drawings - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | CIVIL02005.60 | Civil Sitework Demo Drawings - Construction Issue | 20 | 0% | 11-Mar-21 | 07-Apr-21 |
| | **CRD-BA0.69.2.5** | **Roads and Paving** | 118 | | 19-Oct-20 | 07-Apr-21 |
| | CIVIL03000.10 | Roads and Paving - Prepare & Review | 40 | 0% | 19-Oct-20 | 15-Dec-20 |
| | CIVIL03000.30 | Roads and Paving - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | CIVIL03000.60 | Roads and Paving - Construction Issue | 20 | 0% | 11-Mar-21 | 07-Apr-21 |
| | **CRD-BA0.69.2.10** | **PTI for Pond Retrofit Permitting** | 152 | | 21-Aug-20 A | 01-May-21 |
| | CIVIL06005.10 | PTI for Pond Retrofit Permitting - Prepare & Review | 17 | 0% | 21-Aug-20 A | 23-Oct-20 |
| | CIVIL06005.20 | PTI for Pond Retrofit Permitting - S&L Prepare & Submit Package to Cardinal | 5 | 0% | 26-Oct-20 | 30-Oct-20 |
| | CIVIL06005.25 | PTI for Pond Retrofit Permitting - Submittal to Ohio EPA | 1 | 0% | 01-Dec-20* | 01-Dec-20 |
| | CIVIL06005.30 | PTI for Pond Retrofit Permitting - Expected Approval | 0 | 0% | | 01-May-21* |
| | **CRD-BA0.69.2.11** | **ODNR Dam Modification Permit Support** | 152 | | 07-Aug-20 A | 01-May-21 |
| | CIVIL07000.10 | ODNR Dam Modification Permit Support - Prepare & Review | 17 | 0% | 07-Aug-20 A | 23-Oct-20 |
| | CIVIL07000.20 | ODNR Dam Modification Permit Support - S&L Prepare & Submit Package to Cardinal | 5 | 0% | 26-Oct-20 | 30-Oct-20 |
| | CIVIL07000.25 | ODNR Dam Modification Permit Support - Submittal to ODNR | 1 | 0% | 01-Oct-20* | 01-Dec-20 |
| | CIVIL07000.30 | ODNR Dam Modification Permit Support - Expected Approval | 0 | 0% | | 01-May-21* |
| | **CRD-BA0.69.2.19** | **CCR Work Plan Study** | 41 | | 15-Jun-20 A | 30-Nov-20 |
| | CIVIL18000.10 | CCR Work Plan Study - Prepare & Review | 11 | 0% | 15-Jun-20 A | 15-Oct-20 |
| | CIVIL18000.20 | CCR Work Plan Study - S&L Prepare & Submit Package to Cardinal | 10 | 0% | 16-Oct-20 | 29-Oct-20 |
| | CIVIL18000.25 | CCR Work Plan Study - Cardinal review | 10 | 0% | 30-Oct-20 | 12-Nov-20 |
| | CIVIL18000.30 | CCR Work Plan Study - Issue for Use | 10 | 0% | 13-Nov-20 | 30-Nov-20 |
| | **CRD-BA0.69.2.20** | **NPDES Modifications Permitting** | 152 | | 01-Sep-20 A | 01-May-21 |
| | CIVIL19000.10 | NPDES Modification Permitting - Prepare & Review | 11 | 0% | 01-Sep-20 A | 15-Oct-20 |
| | CIVIL19000.20 | NPDES Modification Permitting - S&L Prepare & Submit Package to Cardinal | 10 | 0% | 16-Oct-20 | 29-Oct-20 |
| | CIVIL19000.25 | NPDES Modification Permitting - Submittal to Ohio EPA | 1 | 0% | 01-Dec-20* | 01-Dec-20 |
| | CIVIL19000.30 | NPDES Modification Permitting - Expected Approval | 0 | 0% | | 01-May-21* |
| | **CRD-BA0.69.2.21** | **Construction SWPPP Permitting** | 65 | | 01-Feb-21 | 01-May-21 |
| | CIVIL20000.10 | Construction SWPPP Permitting - Prepare & Review | 6 | 0% | 01-Feb-21* | 08-Feb-21 |
| | CIVIL20000.20 | Construction SWPPP Permitting - S&L Prepare & Submit Package to Cardinal | 5 | 0% | 09-Feb-21 | 15-Feb-21 |
| | CIVIL20000.25 | Construction SWPPP Permitting - Submittal to Ohio EPA | 1 | 0% | 01-Mar-21* | 01-Mar-21 |
| | CIVIL20000.30 | Construction SWPPP Permitting - Expected Approval | 0 | 0% | | 01-May-21* |
| | **CRD-BA0.69.2.22** | **CCR Compliance Documentation: Loc Restrictions, Dsg & Operating Criteria,** | 294 | | 07-Aug-20 A | 30-Nov-21 |
| | CIVIL21000.10 | CCR Compliance Documentation - Prepare & Review | 244 | 0% | 07-Aug-20 A | 17-Sep-21 |
| | CIVIL21000.20 | CCR Compliance Documentation - S&L Prepare & Submit Package to Cardinal | 20 | 0% | 20-Sep-21 | 15-Oct-21 |



- 🟩 Remaining Level of Effort ◆
- 🟦 Actual Work
- 🟩 Remaining Work
- 🟥 Critical Remaining Work
- ◇ Baseline Milestone
- ◆ Milestone

***Engineering, Procurement & Construction Schedule by WBS***

Sargent & Lundy

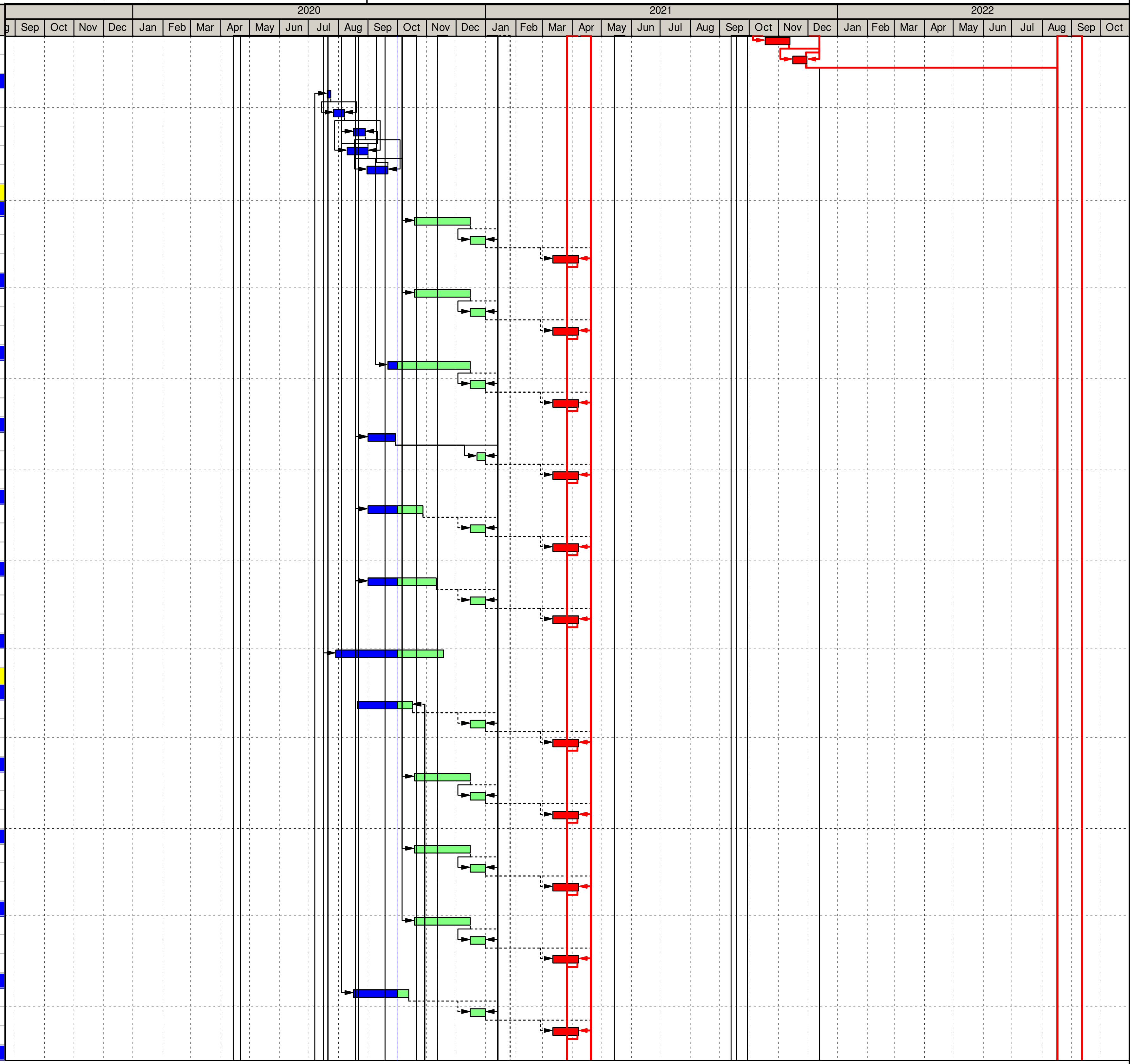
Cardinal Level 3 Bottom Ash Detailed Design

Monthly Report Layout

Project ID:FPT4-CRD-BA0

28-Oct-20 17:16

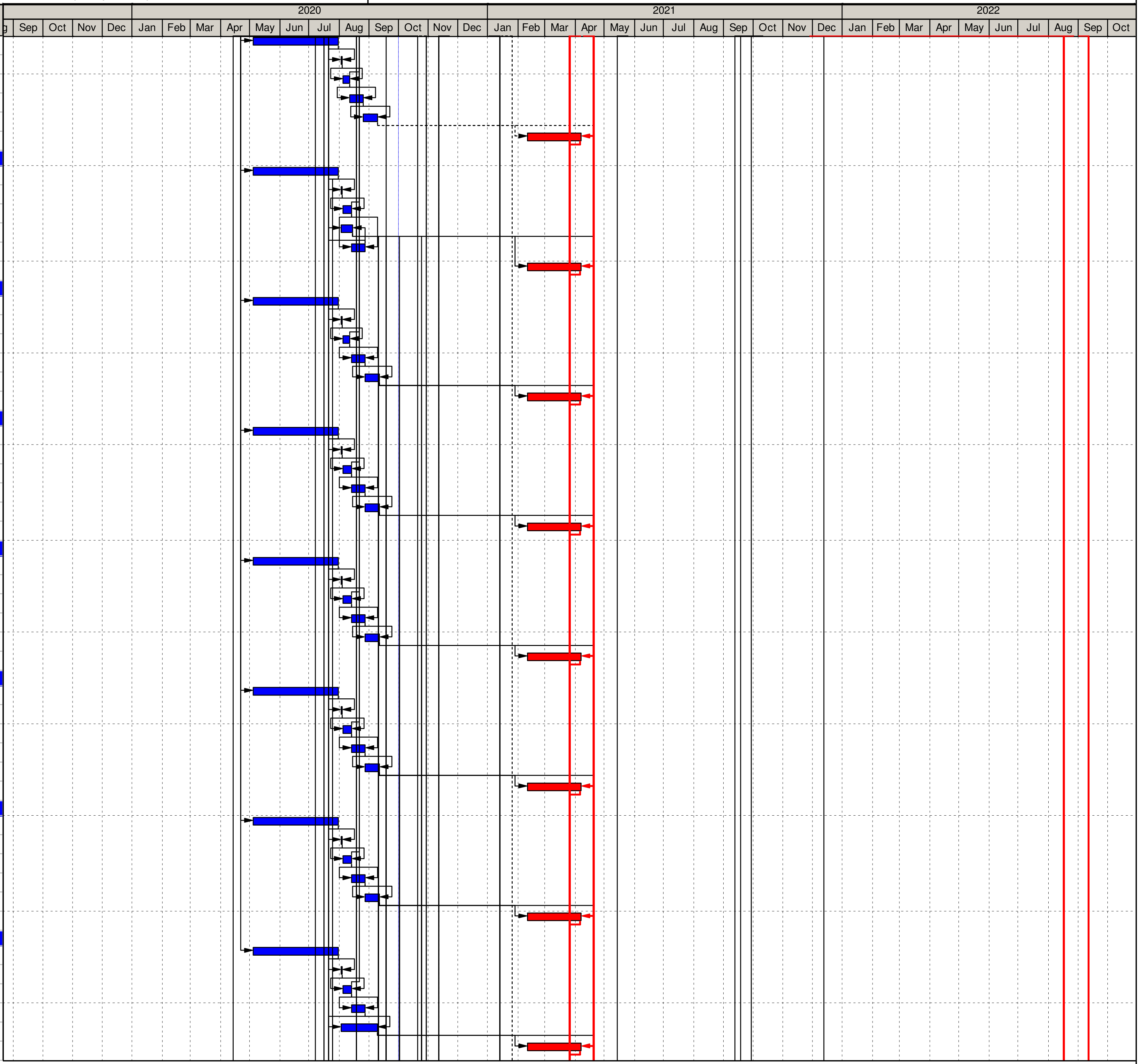
| WBS | Activity ID | Activity Name | Rem Duration | Activity % Complete | Start | Finish |
|---|---|---|---|---|---|---|
| | CIVIL21000.25 | CCR Compliance Documentation - Cardinal review | 20 | 0% | 18-Oct-21 | 12-Nov-21 |
| | CIVIL21000.30 | CCR Compliance Documentation - Issue for Use | 10 | 0% | 15-Nov-21 | 30-Nov-21 |
| | **CRD-BA0.69.2.65** | **Vndr Dwgs - Topographic & Bathymetric survey** | 0 | | 20-Jul-20 A | 21-Sep-20 A |
| | VTOPO00005.70 | Topographic & Bathymetric survey - Mobilize | 0 | 100% | 20-Jul-20 A | 24-Jul-20 A |
| | VTOPO00005.75 | Topographic & Bathymetric survey - Perform Mapping | 0 | 100% | 27-Jul-20 A | 07-Aug-20 A |
| | VTOPO00005.85 | Topographic & Bathymetric survey - Review Report | 0 | 100% | 17-Aug-20 A | 28-Aug-20 A |
| | VTOPO00005.80 | Topographic & Bathymetric survey - Submit Report | 0 | 100% | 10-Aug-20 A | 31-Aug-20 A |
| | VTOPO00005.90 | Topographic & Bathymetric survey - Final Reporrt | 0 | 100% | 31-Aug-20 A | 21-Sep-20 A |
| | **CRD-BA0.69.20** | **Structural** | 130 | | 29-Jul-20 A | 07-Apr-21 |
| | **CRD-BA0.69.20.56** | **Concrete General Notes & Details** | 118 | | 19-Oct-20 | 07-Apr-21 |
| | STR0100000.10 | Concrete General Notes & Details - Prepare & Review | 40 | 0% | 19-Oct-20 | 15-Dec-20 |
| | STR0100000.30 | Concrete General Notes & Details - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | STR0100000.60 | Concrete General Notes & Details - Construction Issue | 20 | 0% | 11-Mar-21 | 07-Apr-21 |
| | **CRD-BA0.69.20.57** | **Modify Outfall 023 Structure** | 118 | | 19-Oct-20 | 07-Apr-21 |
| | STR0200000.10 | Modify Outfall 023 Structure - Prepare & Review | 40 | 0% | 19-Oct-20 | 15-Dec-20 |
| | STR0200000.30 | Modify Outfall 023 Structure - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | STR0200000.60 | Modify Outfall 023 Structure - Construction Issue | 20 | 0% | 11-Mar-21 | 07-Apr-21 |
| | **CRD-BA0.69.20.58** | **Pipe Road Crossing Trenches** | 130 | | 21-Sep-20 A | 07-Apr-21 |
| | STR0300000.10 | Pipe Road Crossing Trenches - Prepare & Review | 52 | 30% | 21-Sep-20 A | 15-Dec-20 |
| | STR0300000.30 | Pipe Road Crossing Trenches - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | STR0300000.60 | Pipe Road Crossing Trenches - Construction Issue | 20 | 0% | 11-Mar-21 | 07-Apr-21 |
| | **CRD-BA0.69.20.59** | **Foundations - Misc. Pads and Pipe Supports** | 73 | | 01-Sep-20 A | 07-Apr-21 |
| | STR0400000.10 | Foundations - Misc. Pads and Pipe Supports - Prepare & Review | 0 | 100% | 01-Sep-20 A | 29-Sep-20 A |
| | STR0400000.30 | Foundations - Misc. Pads and Pipe Supports - Bid Issue | 5 | 0% | 23-Dec-20 | 31-Dec-20 |
| | STR0400000.60 | Foundations - Misc. Pads and Pipe Supports - Construction Issue | 20 | 0% | 11-Mar-21 | 07-Apr-21 |
| | **CRD-BA0.69.20.60** | **Pumphouse Bullkheads** | 130 | | 01-Sep-20 A | 07-Apr-21 |
| | STR0500000.10 | Pumphouse Bullkheads - Prepare & Review | 19 | 0% | 01-Sep-20 A | 27-Oct-20* |
| | STR0500000.30 | Pumphouse Bullkheads - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | STR0500000.60 | Pumphouse Bullkheads - Construction Issue | 20 | 0% | 11-Mar-21 | 07-Apr-21 |
| | **CRD-BA0.69.20.61** | **Structural Steel - Pipe supports and Auxiliary steel** | 130 | | 01-Sep-20 A | 07-Apr-21 |
| | STR0600000.10 | Structural Steel - Pipe supports and Auxiliary steel - Prepare & Review | 29 | 0% | 01-Sep-20 A | 10-Nov-20* |
| | STR0600000.30 | Structural Steel - Pipe supports and Auxiliary steel - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | STR0600000.60 | Structural Steel - Pipe supports and Auxiliary steel - Construction Issue | 20 | 0% | 11-Mar-21 | 07-Apr-21 |
| | **CRD-BA0.69.20.52** | **Civil/Structural Walkdowns** | 35 | | 29-Jul-20 A | 18-Nov-20 |
| | STR0700000.00 | Civil/Structural Walkdowns - Summary | 35 | 0% | 29-Jul-20 A | 18-Nov-20 |
| | **CRD-BA0.69.3** | **Mechanical** | 130 | | 04-May-20 A | 07-Apr-21 |
| | **CRD-BA0.69.3.31** | **Mechanical General Notes & Details** | 130 | | 21-Aug-20 A | 07-Apr-21 |
| | MECH010000.10 | Mechanical General Notes & Details - Prepare & Review | 12 | 0% | 21-Aug-20 A | 16-Oct-20 |
| | MECH010000.30 | Mechanical General Notes & Details - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | MECH010000.60 | Mechanical General Notes & Details - Construction Issue | 20 | 0% | 11-Mar-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.32** | **Demo drawings - BATW piping** | 118 | | 19-Oct-20 | 07-Apr-21 |
| | MECH010005.10 | Demo drawings - BATW piping - Prepare & Review | 40 | 0% | 19-Oct-20 | 15-Dec-20 |
| | MECH010005.30 | Demo drawings - BATW piping - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | MECH010005.60 | Demo drawings - BATW piping - Construction Issue | 20 | 0% | 11-Mar-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.34** | **Demo drawings - LVW piping** | 118 | | 19-Oct-20 | 07-Apr-21 |
| | MECH020005.10 | Demo drawings - LVW piping - Prepare & Review | 40 | 0% | 19-Oct-20 | 15-Dec-20 |
| | MECH020005.30 | Demo drawings - LVW piping - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | MECH020005.60 | Demo drawings - LVW piping - Construction Issue | 20 | 0% | 11-Mar-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.4** | **Demo drawings - Metal Cleaning Waste Tank Facility** | 118 | | 19-Oct-20 | 07-Apr-21 |
| | MECH021005.10 | Demo drawings - Metal Cleaning Waste Tank Facility - Prepare & Review | 40 | 0% | 19-Oct-20 | 15-Dec-20 |
| | MECH021005.30 | Demo drawings - Metal Cleaning Waste Tank Facility - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | MECH021005.60 | Demo drawings - Metal Cleaning Waste Tank Facility - Construction Issue | 20 | 0% | 11-Mar-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.5** | **Demo drawings - Chemical Treatment System** | 130 | | 17-Aug-20 A | 07-Apr-21 |
| | MECH022005.10 | Demo drawings - Chemical Treatment Systemy - Prepare & Review | 8 | 0% | 17-Aug-20 A | 12-Oct-20 |
| | MECH022005.30 | Demo drawings - Chemical Treatment System - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | MECH022005.60 | Demo drawings - Chemical Treatment System - Construction Issue | 20 | 0% | 11-Mar-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.36** | **P&ID - Symbol Sheet** | 40 | | 04-May-20 A | 07-Apr-21 |



| | |
|---|---|
| ▬ | Remaining Level of Effort ◆ |
| ◆ | Milestone |
| 🟦 | Actual Work |
| 🟩 | Remaining Work |
| 🟥 | Critical Remaining Work |
| ◇ | Baseline Milestone |

***Engineering, Procurement & Construction Schedule by WBS***

| WBS | Activity ID | Activity Name | Rem Duration | Activity % Complete | Start | Finish |
|---|---|---|---|---|---|---|
| | MECH040000.10 | P&ID - Symbol Sheet - Prepare & Review | 0 | 100% | 04-May-20 A | 31-Jul-20 A |
| | MECH040000.16 | P&ID - Symbol Sheet - Peer Review | 0 | 100% | 03-Aug-20 A | 04-Aug-20 A |
| | MECH040000.20 | P&ID - Symbol Sheet - S&L Prepare & Submit Package to Cardinal | 0 | 100% | 05-Aug-20 A | 11-Aug-20 A |
| | MECH040000.25 | P&ID - Symbol Sheet - Cardinal review | 0 | 100% | 12-Aug-20 A | 25-Aug-20 A |
| | MECH040000.30 | P&ID - Symbol Sheet - Design Issue | 0 | 100% | 26-Aug-20 A | 09-Sep-20 A |
| | MECH040000.60 | P&ID - Symbol Sheet - Construction Issue | 40 | 0% | 11-Feb-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.37** | **P&ID - Blowdown to FGD** | 40 | | 04-May-20 A | 07-Apr-21 |
| | MECH050000.10 | P&ID - Blowdown to FGD - Prepare & Review | 0 | 100% | 04-May-20 A | 31-Jul-20 A |
| | MECH050000.16 | P&ID - Blowdown to FGD - Peer Review | 0 | 100% | 03-Aug-20 A | 04-Aug-20 A |
| | MECH050000.20 | P&ID - Blowdown to FGD - S&L Prepare & Submit Package to Cardinal | 0 | 100% | 05-Aug-20 A | 13-Aug-20 A |
| | MECH050000.30 | P&ID - Blowdown to FGD - Design Issue | 0 | 100% | 03-Aug-20 A | 14-Aug-20 A |
| | MECH050000.25 | P&ID - Blowdown to FGD - Cardinal review | 0 | 100% | 14-Aug-20 A | 27-Aug-20 A |
| | MECH050000.60 | P&ID - Blowdown to FGD - Construction Issue | 40 | 0% | 11-Feb-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.38** | **P&ID - Existing system tie-ins (Recirc System)** | 40 | | 04-May-20 A | 07-Apr-21 |
| | MECH060000.10 | P&ID - Existing system tie-ins (Recirc System) - Prepare & Review | 0 | 100% | 04-May-20 A | 31-Jul-20 A |
| | MECH060000.16 | P&ID - Existing system tie-ins (Recirc System) - Peer Review | 0 | 100% | 03-Aug-20 A | 04-Aug-20 A |
| | MECH060000.20 | P&ID - Existing system tie-ins (Recirc System) - S&L Prepare & Submit Package to C | 0 | 100% | 05-Aug-20 A | 11-Aug-20 A |
| | MECH060000.25 | P&ID - Existing system tie-ins (Recirc System) - Cardinal review | 0 | 100% | 14-Aug-20 A | 27-Aug-20 A |
| | MECH060000.30 | P&ID - Existing system tie-ins (Recirc System) - Design Issue | 0 | 100% | 28-Aug-20 A | 11-Sep-20 A |
| | MECH060000.60 | P&ID - Existing system tie-ins (Recirc System) - Construction Issue | 40 | 0% | 11-Feb-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.39** | **P&ID - Existing system tie-ins (BATW U1-2)** | 40 | | 04-May-20 A | 07-Apr-21 |
| | MECH070000.10 | P&ID - Existing system tie-ins (BATW U1-2) - Prepare & Review | 0 | 100% | 04-May-20 A | 31-Jul-20 A |
| | MECH070000.16 | P&ID - Existing system tie-ins (BATW U1-2) - Peer Review | 0 | 100% | 03-Aug-20 A | 04-Aug-20 A |
| | MECH070000.20 | P&ID - Existing system tie-ins (BATW U1-2) - S&L Prepare & Submit Package to Car | 0 | 100% | 05-Aug-20 A | 13-Aug-20 A |
| | MECH070000.25 | P&ID - Existing system tie-ins (BATW U1-2) - Cardinal review | 0 | 100% | 14-Aug-20 A | 27-Aug-20 A |
| | MECH070000.30 | P&ID - Existing system tie-ins (BATW U1-2) - Design Issue | 0 | 100% | 28-Aug-20 A | 11-Sep-20 A |
| | MECH070000.60 | P&ID - Existing system tie-ins (BATW U1-2) - Construction Issue | 40 | 0% | 11-Feb-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.40** | **P&ID - Existing system tie-ins (BATW U3)** | 40 | | 04-May-20 A | 07-Apr-21 |
| | MECH080000.10 | P&ID - Existing system tie-ins (BATW U3) - Prepare & Review | 0 | 100% | 04-May-20 A | 31-Jul-20 A |
| | MECH080000.16 | P&ID - Existing system tie-ins (BATW U3) - Peer Review | 0 | 100% | 03-Aug-20 A | 04-Aug-20 A |
| | MECH080000.20 | P&ID - Existing system tie-ins (BATW U3) - S&L Prepare & Submit Package to Cardir | 0 | 100% | 05-Aug-20 A | 13-Aug-20 A |
| | MECH080000.25 | P&ID - Existing system tie-ins (BATW U3) - Cardinal review | 0 | 100% | 14-Aug-20 A | 27-Aug-20 A |
| | MECH080000.30 | P&ID - Existing system tie-ins (BATW U3) - Design Issue | 0 | 100% | 28-Aug-20 A | 11-Sep-20 A |
| | MECH080000.60 | P&ID - Existing system tie-ins (BATW U3) - Construction Issue | 40 | 0% | 11-Feb-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.41** | **P&ID - Existing system tie-ins (LVW)** | 40 | | 04-May-20 A | 07-Apr-21 |
| | MECH090000.10 | P&ID - Existing system tie-ins (LVW) - Prepare & Review | 0 | 100% | 04-May-20 A | 31-Jul-20 A |
| | MECH090000.16 | P&ID - Existing system tie-ins (LVW) - Peer Review | 0 | 100% | 03-Aug-20 A | 04-Aug-20 A |
| | MECH090000.20 | P&ID - Existing system tie-ins (LVW) - S&L Prepare & Submit Package to Cardinal | 0 | 100% | 05-Aug-20 A | 13-Aug-20 A |
| | MECH090000.25 | P&ID - Existing system tie-ins (LVW) - Cardinal review | 0 | 100% | 14-Aug-20 A | 27-Aug-20 A |
| | MECH090000.30 | P&ID - Existing system tie-ins (LVW) - Design Issue | 0 | 100% | 28-Aug-20 A | 11-Sep-20 A |
| | MECH090000.60 | P&ID - Existing system tie-ins (LVW) - Construction Issue | 40 | 0% | 11-Feb-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.1** | **P&ID - Unit 1 & 2 - Service Water System Tie-Ins** | 40 | | 04-May-20 A | 07-Apr-21 |
| | MECH081000.10 | Unit 1 & 2 - Service Water System Tie-Ins - Prepare & Review | 0 | 100% | 04-May-20 A | 31-Jul-20 A |
| | MECH081000.16 | Unit 1 & 2 - Service Water System Tie-Ins - Peer Review | 0 | 100% | 03-Aug-20 A | 04-Aug-20 A |
| | MECH081000.20 | Unit 1 & 2 - Service Water System Tie-Ins - S&L Prepare & Submit Package to Cardir | 0 | 100% | 05-Aug-20 A | 13-Aug-20 A |
| | MECH081000.25 | Unit 1 & 2 - Service Water System Tie-Ins - Cardinal review | 0 | 100% | 14-Aug-20 A | 27-Aug-20 A |
| | MECH081000.30 | Unit 1 & 2 - Service Water System Tie-Ins - Design Issue | 0 | 100% | 28-Aug-20 A | 11-Sep-20 A |
| | MECH081000.60 | Unit 1 & 2 - Service Water System Tie-Ins - Construction Issue | 40 | 0% | 11-Feb-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.6** | **P&ID - Ash Hopper Piping** | 40 | | 04-May-20 A | 07-Apr-21 |
| | MECH301000.10 | P&ID - Ash Hopper Piping - Prepare & Review | 0 | 100% | 04-May-20 A | 31-Jul-20 A |
| | MECH301000.16 | P&ID - Ash Hopper Piping - Peer Review | 0 | 100% | 03-Aug-20 A | 04-Aug-20 A |
| | MECH301000.20 | P&ID - Ash Hopper Piping - S&L Prepare & Submit Package to Cardinal | 0 | 100% | 05-Aug-20 A | 13-Aug-20 A |
| | MECH301000.25 | P&ID - Ash Hopper Piping - Cardinal review | 0 | 100% | 14-Aug-20 A | 27-Aug-20 A |
| | MECH301000.30 | P&ID - Ash Hopper Piping - Design Issue | 0 | 100% | 03-Aug-20 A | 09-Sep-20 A |
| | MECH301000.60 | P&ID - Ash Hopper Piping - Construction Issue | 40 | 0% | 11-Feb-21 | 07-Apr-21 |



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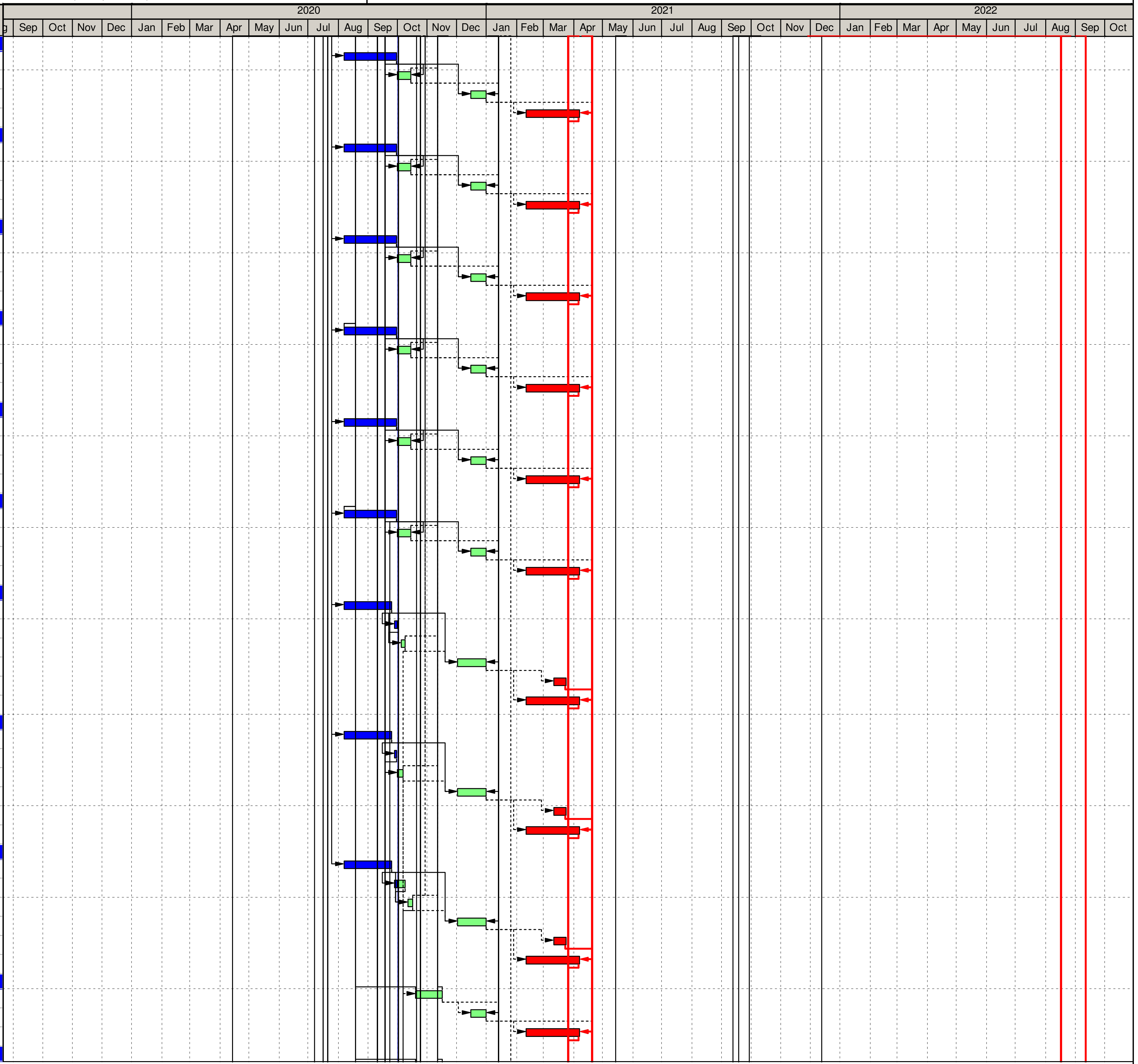
|---|---|
| 🟩 | Remaining Level of Effort ◆ |
| ◆ | Milestone |
| 🟦 | Actual Work |
| 🟩 | Remaining Work |
| 🟥 | Critical Remaining Work |
| ◇ | Baseline Milestone |

**Engineering, Procurement & Construction Schedule by WBS**

Sargent & Lundy

Cardinal Level 3 Bottom Ash Detailed Design | Monthly Report Layout | Project ID:FPT4-CRD-BA0 | 28-Oct-20 17:16

| WBS | Activity ID | Activity Name | Rem Duration | Activity % Complete | Start | Finish |
|---|---|---|---|---|---|---|
| | **CRD-BA0.69.3.43** | **LVW Overflow to Outfall 023 - Pipe Composite** | **130** | | **07-Aug-20 A** | **07-Apr-21** |
| | MECH110000.05 | LVW Overflow to Outfall 023 - Pipe Composite - Initial Layout | 0 | 100% | 07-Aug-20 A | 30-Sep-20 A |
| | MECH110000.10 | LVW Overflow to Outfall 023 - Pipe Composite - Prepare & Review | 10 | 0% | 01-Oct-20 | 14-Oct-20 |
| | MECH110000.30 | LVW Overflow to Outfall 023 - Pipe Composite - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | MECH110000.60 | LVW Overflow to Outfall 023 - Pipe Composite - Construction Issue | 40 | 0% | 11-Feb-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.44** | **Unit 1 BATW Lines to South pond - Iso/Composite (2 lines)** | **130** | | **07-Aug-20 A** | **07-Apr-21** |
| | MECH120000.05 | Unit 1 BATW Lines to South pond - Iso/Composite (2 lines) - Initial Layout | 0 | 100% | 07-Aug-20 A | 30-Sep-20 A |
| | MECH120000.10 | Unit 1 BATW Lines to South pond - Iso/Composite (2 lines) - Prepare & Review | 10 | 0% | 01-Oct-20 | 14-Oct-20 |
| | MECH120000.30 | Unit 1 BATW Lines to South pond - Iso/Composite (2 lines) - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | MECH120000.60 | Unit 1 BATW Lines to South pond - Iso/Composite (2 lines) - Construction Issue | 40 | 0% | 11-Feb-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.45** | **Unit 2 BATW Lines to South pond - Iso/Composite (2 lines)** | **130** | | **07-Aug-20 A** | **07-Apr-21** |
| | MECH130000.05 | Unit 2 BATW Lines to South pond - Iso/Composite (2 lines) - Initial Layout | 0 | 100% | 07-Aug-20 A | 30-Sep-20 A |
| | MECH130000.10 | Unit 2 BATW Lines to South pond - Iso/Composite (2 lines) - Prepare & Review | 10 | 0% | 01-Oct-20 | 14-Oct-20 |
| | MECH130000.30 | Unit 2 BATW Lines to South pond - Iso/Composite (2 lines) - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | MECH130000.60 | Unit 2 BATW Lines to South pond - Iso/Composite (2 lines) - Construction Issue | 40 | 0% | 11-Feb-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.46** | **Unit 3 BATW Lines to South pond - Iso/Composite (2 lines)** | **130** | | **07-Aug-20 A** | **07-Apr-21** |
| | MECH140000.05 | Unit 3 BATW Lines to South pond - Iso/Composite (2 lines) - Initial Layout | 0 | 100% | 07-Aug-20 A | 30-Sep-20 A |
| | MECH140000.10 | Unit 3 BATW Lines to South pond - Iso/Composite (2 lines) - Prepare & Review | 10 | 0% | 01-Oct-20 | 14-Oct-20 |
| | MECH140000.30 | Unit 3 BATW Lines to South pond - Iso/Composite (2 lines) - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | MECH140000.60 | Unit 3 BATW Lines to South pond - Iso/Composite (2 lines) - Construction Issue | 40 | 0% | 11-Feb-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.47** | **Reroute LVW discharge pipes** | **130** | | **07-Aug-20 A** | **07-Apr-21** |
| | MECH150000.05 | Reroute LVW discharge pipes - Initial Layout | 0 | 100% | 07-Aug-20 A | 30-Sep-20 A |
| | MECH150000.10 | Reroute LVW discharge pipes - Prepare & Review | 10 | 0% | 01-Oct-20 | 14-Oct-20 |
| | MECH150000.30 | Reroute LVW discharge pipes - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | MECH150000.60 | Reroute LVW discharge pipes - Construction Issue | 40 | 0% | 11-Feb-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.48** | **Blowdown to FGD - Iso** | **130** | | **07-Aug-20 A** | **07-Apr-21** |
| | MECH160000.05 | Blowdown to FGD - Iso - Initial Layout | 0 | 100% | 07-Aug-20 A | 30-Sep-20 A |
| | MECH160000.10 | Blowdown to FGD - Iso - Prepare & Review | 10 | 0% | 01-Oct-20 | 14-Oct-20 |
| | MECH160000.30 | Blowdown to FGD - Iso - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | MECH160000.60 | Blowdown to FGD - Iso - Construction Issue | 40 | 0% | 11-Feb-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.42** | **Temporary Piping Layout from North Pond to Recirc. Pumphouse** | **130** | | **07-Aug-20 A** | **07-Apr-21** |
| | MECH100000.05 | Temporary Piping Layout from North Pond to Recirc. Pumphouse - Initial Layout | 0 | 100% | 07-Aug-20 A | 25-Sep-20 A |
| | MECH100000.06 | Temporary Piping Layout from North Pond to Recirc. Pumphouse - Initial Analysis | 2 | 0% | 28-Sep-20 A | 02-Oct-20 |
| | MECH100000.10 | Temporary Piping Layout from North Pond to Recirc. Pumphouse - Model Review | 5 | 0% | 05-Oct-20 | 09-Oct-20 |
| | MECH100000.30 | Temporary Piping Layout from North Pond to Recirc. Pumphouse - Bid Issue | 20 | 0% | 02-Dec-20 | 31-Dec-20 |
| | MECH100000.50 | Temporary Piping Layout from North Pond to Recirc. Pumphouse - Final Analysis | 10 | 0% | 11-Mar-21 | 24-Mar-21 |
| | MECH100000.60 | Temporary Piping Layout from North Pond to Recirc. Pumphouse - Construction Issue | 40 | 0% | 11-Feb-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.2** | **Unit 1 & 2 - Service Water System Tie-Ins - Iso/Composite** | **130** | | **07-Aug-20 A** | **07-Apr-21** |
| | MECH141000.05 | Unit 1 & 2 - Service Water System Tie-Ins - Iso/Composite (2 lines) - Initial Layout | 0 | 100% | 07-Aug-20 A | 25-Sep-20 A |
| | MECH141000.06 | Unit 1 & 2 - Service Water System Tie-Ins - Iso/Composite (2 lines) - Initial Analysis | 0 | 100% | 28-Sep-20 A | 30-Sep-20 A |
| | MECH141000.10 | Unit 1 & 2 - Service Water System Tie-Ins - Iso/Composite (2 lines) - Model Review | 5 | 0% | 01-Oct-20 | 07-Oct-20 |
| | MECH141000.30 | Unit 1 & 2 - Service Water System Tie-Ins - Iso/Composite (2 lines) - Bid Issue | 20 | 0% | 02-Dec-20 | 31-Dec-20 |
| | MECH141000.50 | Unit 1 & 2 - Service Water System Tie-Ins - Iso/Composite (2 lines) - Final Analysis | 10 | 0% | 11-Mar-21 | 24-Mar-21 |
| | MECH141000.60 | Unit 1 & 2 - Service Water System Tie-Ins - Iso/Composite (2 lines) - Construction Is: | 40 | 0% | 11-Feb-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.8** | **Ash Hopper Piping - Iso/Composite** | **130** | | **07-Aug-20 A** | **07-Apr-21** |
| | MECH310000.05 | Ash Hopper Piping - Iso/Composite - Initial Layout | 0 | 100% | 07-Aug-20 A | 25-Sep-20 A |
| | MECH310000.06 | Ash Hopper Piping - Iso/Composite - Initial Analysis | 7 | 0% | 28-Sep-20 A | 09-Oct-20 |
| | MECH310000.10 | Ash Hopper Piping - Iso/Composite - Model Review | 5 | 0% | 12-Oct-20 | 16-Oct-20 |
| | MECH310000.30 | Ash Hopper Piping - Iso/Composite - Bid Issue | 20 | 0% | 02-Dec-20 | 31-Dec-20 |
| | MECH310000.50 | Ash Hopper Piping - Iso/Composite - Final Analysis | 10 | 0% | 11-Mar-21 | 24-Mar-21 |
| | MECH310000.60 | Ash Hopper Piping - Iso/Composite - Construction Issue | 40 | 0% | 11-Feb-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.49** | **Supports - Ash Piping** | **117** | | **20-Oct-20** | **07-Apr-21** |
| | MECH190000.10 | Supports - Ash Piping - Prepare & Review | 20 | 0% | 20-Oct-20 | 16-Nov-20 |
| | MECH190000.30 | Supports - Ash Piping - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | MECH190000.60 | Supports - Ash Piping - Construction Issue | 40 | 0% | 11-Feb-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.3** | **Supports - Unit 1 & 2 - Service Water System Tie-Ins** | **117** | | **20-Oct-20** | **07-Apr-21** |



🟩 Remaining Level of Effort ◆ ◆ Milestone

🟦 Actual Work

🟩 Remaining Work

🟥 Critical Remaining Work

◇ ◇ Baseline Milestone

***Engineering, Procurement & Construction Schedule by WBS***

Sargent & Lundy

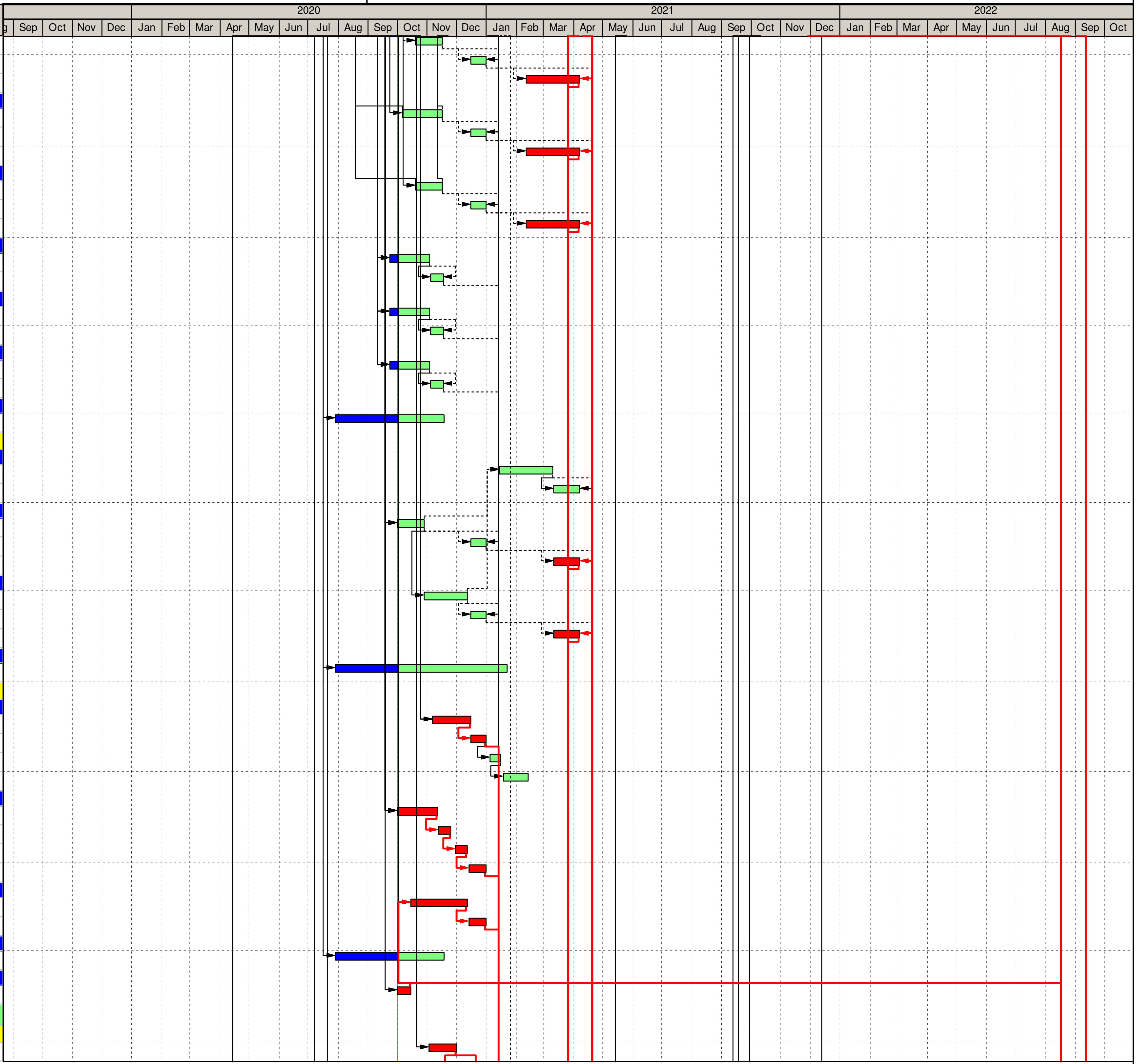
Cardinal Level 3 Bottom Ash Detailed Design

Monthly Report Layout

Project ID:FPT4-CRD-BA0

28-Oct-20 17:16

| WBS | Activity ID | Activity Name | Rem Duration | Activity % Complete | Start | Finish |
|---|---|---|---|---|---|---|
| | MECH191000.10 | Supports - Unit 1 & 2 - Service Water System Tie-Ins - Prepare & Review | 20 | 0% | 20-Oct-20 | 16-Nov-20 |
| | MECH191000.30 | Supports - Unit 1 & 2 - Service Water System Tie-Ins - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | MECH191000.60 | Supports - Unit 1 & 2 - Service Water System Tie-Ins - Construction Issue | 40 | 0% | 11-Feb-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.50** | **Supports - Blowdown to FGD** | 127 | | 06-Oct-20 | 07-Apr-21 |
| | MECH200000.10 | Supports - Blowdown to FGD - Prepare & Review | 30 | 0% | 06-Oct-20 | 16-Nov-20 |
| | MECH200000.30 | Supports - Blowdown to FGD - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | MECH200000.60 | Supports - Blowdown to FGD - Construction Issue | 40 | 0% | 11-Feb-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.7** | **Supports - Ash Hopper Piping** | 117 | | 20-Oct-20 | 07-Apr-21 |
| | MECH320000.10 | Supports - Ash Hopper Piping - Prepare & Review | 20 | 0% | 20-Oct-20 | 16-Nov-20 |
| | MECH320000.30 | Supports - Ash Hopper Piping - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | MECH320000.60 | Supports - Ash Hopper Piping - Construction Issue | 40 | 0% | 11-Feb-21 | 07-Apr-21 |
| | **CRD-BA0.69.3.51** | **Control Valve Data Sheets** | 34 | | 23-Sep-20 A | 17-Nov-20 |
| | MECH210000.10 | Control Valve Data Sheets - Prepare & Review | 24 | 0% | 23-Sep-20 A | 03-Nov-20 |
| | MECH210000.30 | Control Valve Data Sheets - Issue for Use | 10 | 0% | 04-Nov-20 | 17-Nov-20 |
| | **CRD-BA0.69.3.33** | **List - Pipelines** | 34 | | 23-Sep-20 A | 17-Nov-20 |
| | MECH020000.10 | List - Pipelines - Prepare & Review | 24 | 0% | 23-Sep-20 A | 03-Nov-20 |
| | MECH020000.30 | List - Pipelines - Issue for Use | 10 | 0% | 04-Nov-20 | 17-Nov-20 |
| | **CRD-BA0.69.3.35** | **List - Valves** | 34 | | 23-Sep-20 A | 17-Nov-20 |
| | MECH030000.10 | List - Valves - Prepare & Review | 24 | 0% | 23-Sep-20 A | 03-Nov-20 |
| | MECH030000.30 | List - Valves - Issue for Use | 10 | 0% | 04-Nov-20 | 17-Nov-20 |
| | **CRD-BA0.69.3.52** | **Mechanical Walkdowns** | 35 | | 29-Jul-20 A | 18-Nov-20 |
| | MECH220000.00 | Mechanical Walkdowns - Summary | 35 | 0% | 29-Jul-20 A | 18-Nov-20 |
| | **CRD-BA0.69.4** | **Electrical** | 130 | | 29-Jul-20 A | 07-Apr-21 |
| | **CRD-BA0.69.4.20** | **Wiring Drawings** | 60 | | 14-Jan-21 | 07-Apr-21 |
| | ELEC010000.10 | Wiring Drawings - Prepare & Review | 40 | 0% | 14-Jan-21 | 10-Mar-21 |
| | ELEC010000.60 | Wiring Drawings - Construction Issue | 20 | 0% | 11-Mar-21 | 07-Apr-21 |
| | **CRD-BA0.69.4.21** | **Cable Tabulations** | 130 | | 01-Oct-20 | 07-Apr-21 |
| | ELEC020000.10 | Cable Tabulations - Prepare & Review | 20 | 0% | 01-Oct-20 | 28-Oct-20 |
| | ELEC020000.30 | Cable Tabulations - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | ELEC020000.60 | Cable Tabulations - Construction Issue | 20 | 0% | 11-Mar-21 | 07-Apr-21 |
| | **CRD-BA0.69.4.22** | **Electrical Installation Drawings** | 110 | | 29-Oct-20 | 07-Apr-21 |
| | ELEC030000.10 | Electrical Installation Drawings - Prepare & Review | 30 | 0% | 29-Oct-20 | 11-Dec-20 |
| | ELEC030000.30 | Electrical Installation Drawings - Bid Issue | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | ELEC030000.60 | Electrical Installation Drawings - Construction Issue | 20 | 0% | 11-Mar-21 | 07-Apr-21 |
| | **CRD-BA0.69.4.23** | **Electrical Walkdowns - Summary** | 77 | | 29-Jul-20 A | 22-Jan-21 |
| | ELEC040000.00 | Electrical Walkdowns - Summary | 77 | 0% | 29-Jul-20 A | 22-Jan-21 |
| | **CRD-BA0.69.5** | **I&C** | 92 | | 29-Jul-20 A | 12-Feb-21 |
| | **CRD-BA0.69.5.27** | **Control Description- Logics** | 66 | | 06-Nov-20 | 12-Feb-21 |
| | IC01000000.10 | Control Description- Logics - Prepare & Review | 26 | 0% | 06-Nov-20* | 15-Dec-20 |
| | IC01000000.20 | Control Description- Logics - S&L Prepare & Submit Package to Cardinal | 10 | 0% | 16-Dec-20 | 31-Dec-20 |
| | IC01000000.25 | Control Description- Logics - Cardinal review | 10 | 0% | 04-Jan-21 | 15-Jan-21 |
| | IC01000000.30 | Control Description- Logics - Issue for Use | 20 | 0% | 18-Jan-21 | 12-Feb-21 |
| | **CRD-BA0.69.5.28** | **I/O Database/List** | 62 | | 02-Oct-20 A | 31-Dec-20 |
| | IC02000000.10 | I/O Database/List - Prepare & Review | 30 | 20% | 02-Oct-20 A | 11-Nov-20 |
| | IC02000000.30 | I/O Database/List - S&L Prepare & Submit Package to Cardinal | 10 | 0% | 12-Nov-20 | 25-Nov-20 |
| | IC02000000.31 | I/O Database/List - Cardinal review | 10 | 0% | 30-Nov-20 | 11-Dec-20 |
| | IC02000000.32 | I/O Database/List - Issue for Use | 12 | 0% | 14-Dec-20 | 31-Dec-20 |
| | **CRD-BA0.69.5.29** | **Instrument List and Details** | 52 | | 15-Oct-20 | 31-Dec-20 |
| | IC03000000.10 | Instrument List and Details - Prepare & Review | 40 | 0% | 15-Oct-20 | 11-Dec-20 |
| | IC03000000.30 | Instrument List and Details - Issue for Use | 12 | 0% | 14-Dec-20 | 31-Dec-20 |
| | **CRD-BA0.69.5.30** | **I&C Walkdowns** | 35 | | 29-Jul-20 A | 18-Nov-20 |
| | IC04000000.00 | I&C Walkdowns - Summary | 35 | 0% | 29-Jul-20 A | 18-Nov-20 |
| | **CRD-BA0.69.5.31** | **ARP Pressure Increase Instrument Evaluation** | 10 | | 01-Oct-20 | 14-Oct-20 |
| | IC05000000.00 | ARP Pressure Increase Instrument Evaluation | 10 | 0% | 01-Oct-20 | 14-Oct-20 |
| | **CRD-BA0.70** | **Procurement (Contractor Selection)** | 441 | | 27-Apr-20 A | 29-Jul-22 |
| | **CRD-BA0.70.54** | **Spec - General Work Specification** | 108 | | 02-Nov-20 | 07-Apr-21 |
| | PGWC000000.10 | Spec - General Work Specification - Prepare & Review | 20 | 0% | 02-Nov-20 | 01-Dec-20 |



🟩 Remaining Level of Effort ◆ ◆ Milestone

🟦 Actual Work

🟩 Remaining Work

🟥 Critical Remaining Work

◇ ◇ Baseline Milestone

***Engineering, Procurement & Construction Schedule by WBS***

Sargent & Lundy

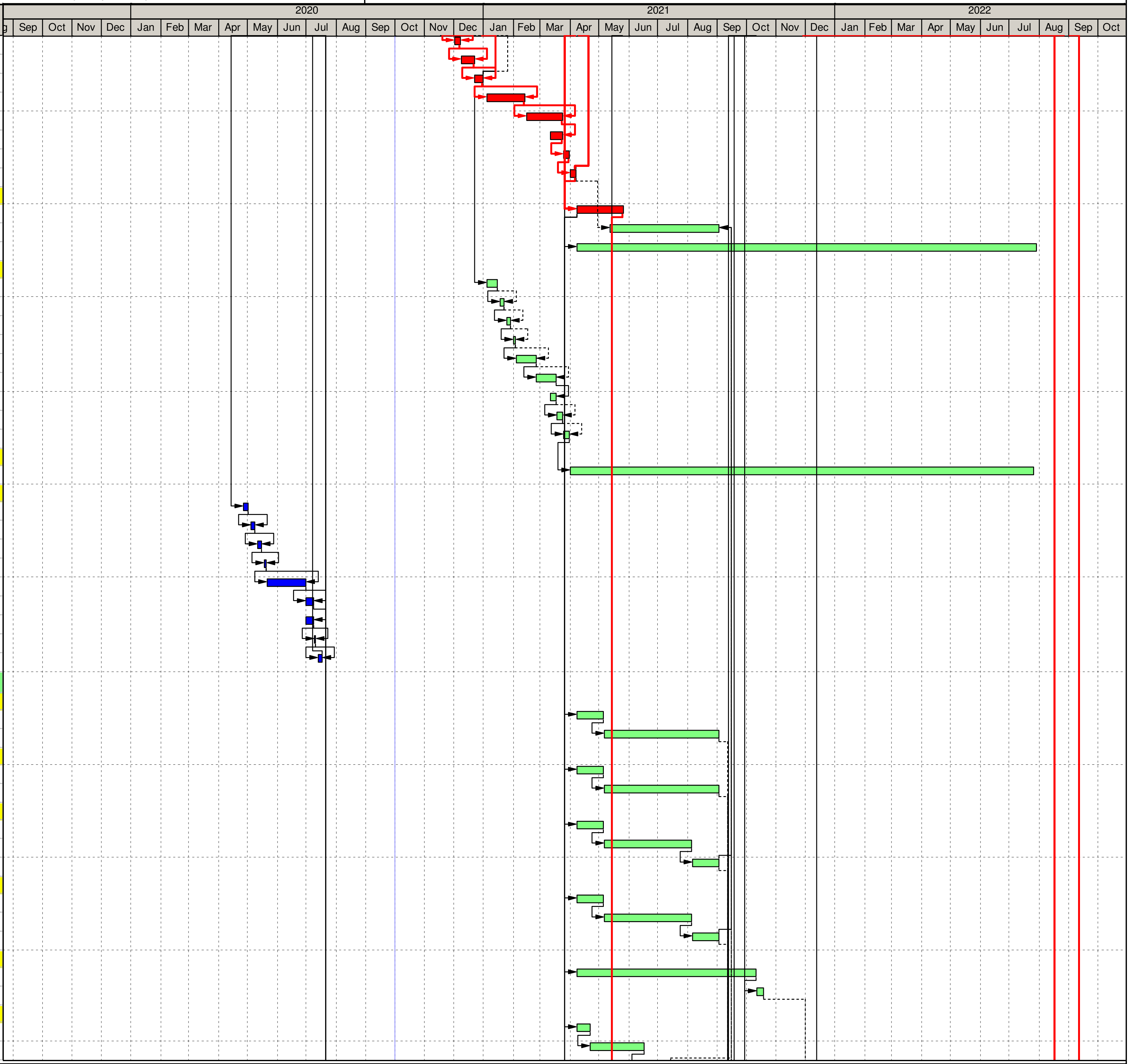
Cardinal Level 3 Bottom Ash Detailed Design

Monthly Report Layout

Project ID:FPT4-CRD-BA0

28-Oct-20 17:16

| WBS | Activity ID | Activity Name | Rem Duration | Activity % Complete | Start | Finish |
|---|---|---|---|---|---|---|
| | PGWC000000.20 | Spec - General Work Specification - S&L Prepare & Submit Package to Cardinal | 5 | 0% | 02-Dec-20 | 08-Dec-20 |
| | PGWC000000.25 | Spec - General Work Specification - Cardinal review | 10 | 0% | 09-Dec-20 | 22-Dec-20 |
| | PGWC000000.30 | Spec - General Work Specification - Bid Issue | 5 | 0% | 23-Dec-20 | 31-Dec-20* |
| | PGWC000000.40 | Spec - General Work Specification - Bid Period | 30 | 0% | 04-Jan-21 | 12-Feb-21 |
| | PGWC000000.50 | Spec - General Work Specification - Tech Bid Eval / Recommendation | 28 | 0% | 15-Feb-21 | 24-Mar-21 |
| | PGWC000000.52 | Spec - General Work Specification - Commercial Evaluation | 10 | 0% | 11-Mar-21 | 24-Mar-21 |
| | PGWC000000.55 | Spec - General Work Specification - Conform Spec for Contract | 5 | 0% | 25-Mar-21 | 31-Mar-21 |
| | PGWC000000.60 | Spec - General Work Specification - Award | 5 | 0% | 01-Apr-21 | 07-Apr-21* |
| | **CRD-BA0.70.64** | **Vndr Dwgs- General Work Specification** | 333 | | 08-Apr-21 | 29-Jul-22 |
| | VGWC000000.95 | General Work Specification - Mobilize | 35 | 0% | 08-Apr-21 | 26-May-21 |
| | VGWC000000.99 | General Work Specification - Procure / Fab / Deliver Materiaks | 80 | 0% | 12-May-21 | 02-Sep-21 |
| | VGWC000000.90 | General Work Specification - Interface | 333 | 0% | 08-Apr-21 | 29-Jul-22 |
| | **CRD-BA0.70.53** | **Spec - Construction Quality Assurance** | 63 | | 04-Jan-21 | 31-Mar-21 |
| | PCQA000000.10 | Spec - Construction Quality Assurance - Prepare & Review | 10 | 0% | 04-Jan-21 | 15-Jan-21 |
| | PCQA000000.20 | Spec - Construction Quality Assurance - S&L Prepare & Submit Package to Cardinal | 5 | 0% | 18-Jan-21 | 22-Jan-21 |
| | PCQA000000.25 | Spec - Construction Quality Assurance - Cardinal review | 5 | 0% | 25-Jan-21 | 29-Jan-21 |
| | PCQA000000.30 | Spec - Construction Quality Assurance - Bid Issue | 3 | 0% | 01-Feb-21 | 03-Feb-21 |
| | PCQA000000.40 | Spec - Construction Quality Assurance - Bid Period | 15 | 0% | 04-Feb-21 | 24-Feb-21 |
| | PCQA000000.50 | Spec - Construction Quality Assurance - Tech Bid Eval / Recommendation | 15 | 0% | 25-Feb-21 | 17-Mar-21 |
| | PCQA000000.52 | Spec - Construction Quality Assurance - Commercial Evaluation | 5 | 0% | 11-Mar-21 | 17-Mar-21 |
| | PCQA000000.55 | Spec - Construction Quality Assurance - Conform Spec for Contract | 5 | 0% | 18-Mar-21 | 24-Mar-21 |
| | PCQA000000.60 | Spec - Construction Quality Assurance - Award | 5 | 0% | 25-Mar-21 | 31-Mar-21 |
| | **CRD-BA0.70.63** | **Vndr Dwgs- Construction Quality Assurance** | 335 | | 01-Apr-21 | 26-Jul-22 |
| | VCQA000000.90 | Construction Quality Assurance - Contractor Interface | 335 | 0% | 01-Apr-21 | 26-Jul-22 |
| | **CRD-BA0.70.55** | **Spec - Topographic & Bathymetric Survey** | 0 | | 27-Apr-20 A | 17-Jul-20 A |
| | PTOPO00005.10 | Spec - Topographic & Bathymetric Survey - Prepare & Review | 0 | 100% | 27-Apr-20 A | 01-May-20 A |
| | PTOPO00005.20 | Spec - Topographic & Bathymetric Survey - S&L Prepare & Submit Package to Cardir | 0 | 100% | 04-May-20 A | 08-May-20 A |
| | PTOPO00005.25 | Spec - Topographic & Bathymetric Survey - Cardinal review | 0 | 100% | 11-May-20 A | 15-May-20 A |
| | PTOPO00005.30 | Spec - Topographic & Bathymetric Survey - Bid Issue | 0 | 100% | 18-May-20 A | 20-May-20 A |
| | PTOPO00005.40 | Spec - Topographic & Bathymetric Survey - Bid Period | 0 | 100% | 21-May-20 A | 30-Jun-20 A |
| | PTOPO00005.50 | Spec - Topographic & Bathymetric Survey - Tech Bid Eval / Recommendation | 0 | 100% | 01-Jul-20 A | 08-Jul-20 A |
| | PTOPO00005.52 | Spec - Topographic & Bathymetric Survey - Commercial Evaluation | 0 | 100% | 01-Jul-20 A | 08-Jul-20 A |
| | PTOPO00005.55 | Spec - Topographic & Bathymetric Survey - Conform Spec for Contract | 0 | 100% | 09-Jul-20 A | 10-Jul-20 A |
| | PTOPO00005.60 | Spec - Topographic & Bathymetric Survey - Award | 0 | 100% | 13-Jul-20 A | 17-Jul-20 A |
| | **CRD-BA0.71** | **Procurement (Equipment Fabrication & Delivery)** | 138 | | 08-Apr-21 | 18-Oct-21 |
| | **CRD-BA0.71.1** | **Clay** | 106 | | 08-Apr-21 | 02-Sep-21 |
| | PFDC000000.90 | Clay Procurment - Ordering | 20 | 0% | 08-Apr-21 | 05-May-21 |
| | PFDC000000.99 | Clay Procurment - Delivery | 86 | 0% | 06-May-21 | 02-Sep-21 |
| | **CRD-BA0.71.2** | **Gravel and Riprap** | 106 | | 08-Apr-21 | 02-Sep-21 |
| | PFDR000000.90 | Gravel & Riprap Procurement - Ordering | 20 | 0% | 08-Apr-21 | 05-May-21 |
| | PFDR000000.99 | Gravel & Riprap Procurement - Delivery | 86 | 0% | 06-May-21 | 02-Sep-21 |
| | **CRD-BA0.71.3** | **Geomembrane** | 106 | | 08-Apr-21 | 02-Sep-21 |
| | PFDG000000.90 | Geomembrane Procurement - Ordering | 20 | 0% | 08-Apr-21 | 05-May-21 |
| | PFDG000000.95 | Geomembrane Procurement - Fabrication | 66 | 0% | 06-May-21 | 05-Aug-21 |
| | PFDG000000.99 | Geomembrane Procurement - Delivery | 20 | 0% | 06-Aug-21 | 02-Sep-21 |
| | **CRD-BA0.71.4** | **Geotextile** | 106 | | 08-Apr-21 | 02-Sep-21 |
| | PFDX000000.90 | Geotextile Procurement - Ordering | 20 | 0% | 08-Apr-21 | 05-May-21 |
| | PFDX000000.95 | Geotextile Procurement - Fabrication | 66 | 0% | 06-May-21 | 05-Aug-21 |
| | PFDX000000.99 | Geotextile Procurement - Delivery | 20 | 0% | 06-Aug-21 | 02-Sep-21 |
| | **CRD-BA0.71.5** | **Concrete** | 138 | | 08-Apr-21 | 18-Oct-21 |
| | PFDT000000.90 | Concrete Procurement - Ordering | 133 | 0% | 08-Apr-21 | 11-Oct-21 |
| | PFDT000000.99 | Concrete Procurement - Delivery | 5 | 0% | 12-Oct-21 | 18-Oct-21 |
| | **CRD-BA0.71.6** | **Pipes and Valves** | 70 | | 08-Apr-21 | 14-Jul-21 |
| | PFDV000000.90 | Pipes & Valves Procurement - Ordering | 10 | 0% | 08-Apr-21 | 21-Apr-21 |
| | PFDV000000.95 | Pipes & Valves Procurement - Fabrication | 40 | 0% | 22-Apr-21 | 16-Jun-21 |



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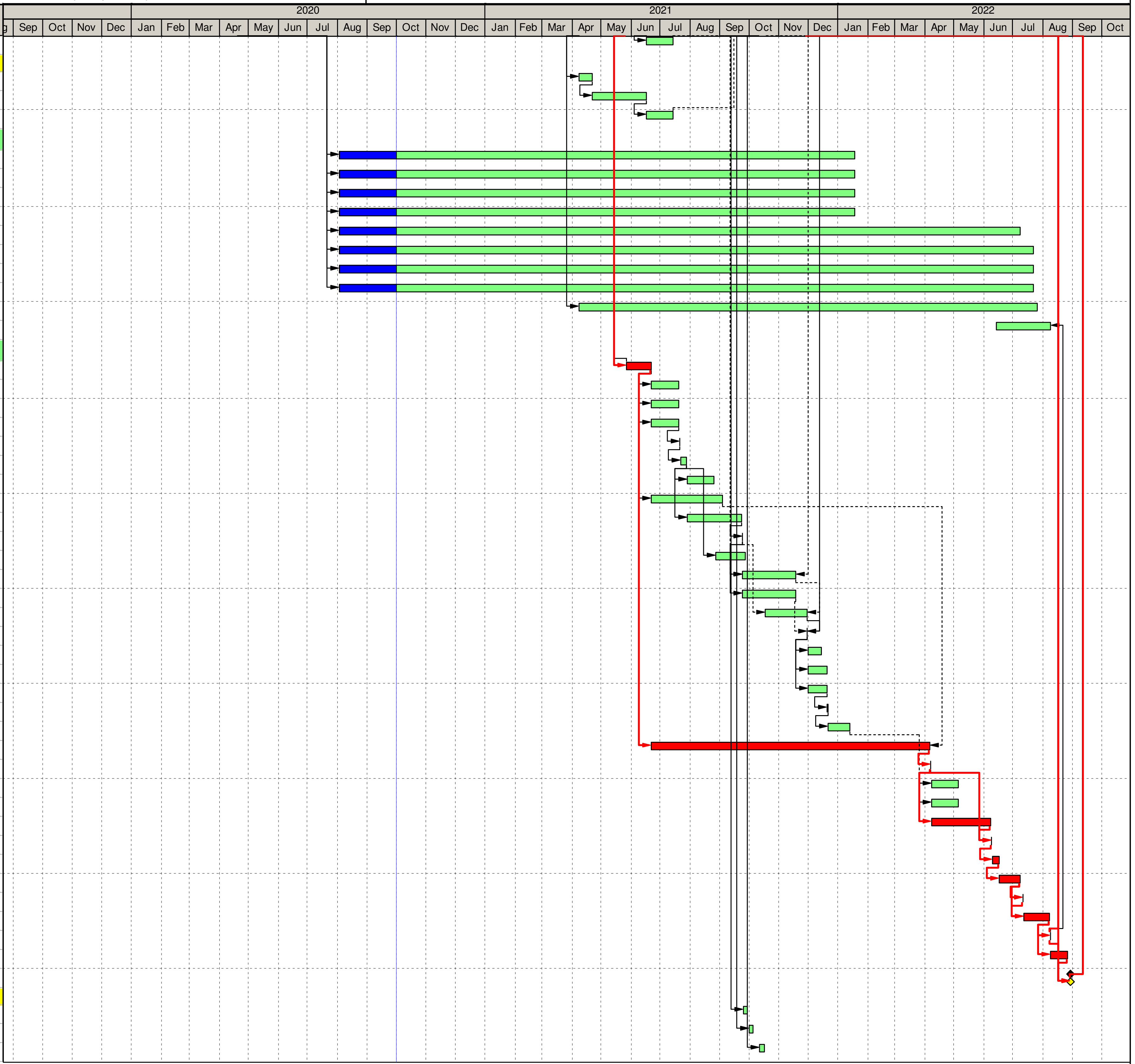
|---|---|
| 🟩 | Remaining Level of Effort ◆ |
| ◆ | Milestone |
| 🟦 | Actual Work |
| 🟩 | Remaining Work |
| 🟥 | Critical Remaining Work |
| ◇ | Baseline Milestone |

***Engineering, Procurement & Construction Schedule by WBS***

Sargent & Lundy

| WBS | Activity ID | Activity Name | Rem Duration | Activity % Complete | Start | Finish |
|---|---|---|---|---|---|---|
| | PFDV000000.99 | Pipes & Valves Procurement - Delivery | 20 | 0% | 17-Jun-21 | 14-Jul-21 |
| **CRD-BA0.71.7 Pumps** | | | 70 | | 08-Apr-21 | 14-Jul-21 |
| | PFDP000000.90 | Pumps Procurement - Ordering | 10 | 0% | 08-Apr-21 | 21-Apr-21 |
| | PFDP000000.95 | Pumps Procurement - Fabrication | 40 | 0% | 22-Apr-21 | 16-Jun-21 |
| | PFDP000000.99 | Pumps Procurement - Delivery | 20 | 0% | 17-Jun-21 | 14-Jul-21 |
| **CRD-BA0.66 Management and Administration** | | | 470 | | 03-Aug-20 A | 09-Aug-22 |
| | X010000000.00 | External Status Meetings - Summary | 326 | 0% | 03-Aug-20 A | 18-Jan-22 |
| | X020000001.00 | Project Status Meetings (Conference Calls) - Summary | 326 | 0% | 03-Aug-20 A | 18-Jan-22 |
| | X030000002.00 | Internal Team Meetings - Summary | 326 | 0% | 03-Aug-20 A | 18-Jan-22 |
| | X040000003.00 | Schedule Development and Maintenance - Summary | 326 | 0% | 03-Aug-20 A | 18-Jan-22 |
| | X050000004.00 | Monthly Progress reports - Summary | 448 | 0% | 03-Aug-20 A | 08-Jul-22 |
| | X060000005.00 | Project Adminstration Support & Document Control - Summary | 458 | 0% | 03-Aug-20 A | 22-Jul-22 |
| | X070000006.00 | Project Management (Lining) - Summary | 458 | 0% | 03-Aug-20 A | 22-Jul-22 |
| | X080000005.00 | Project Management (Closure) - Summary | 458 | 0% | 03-Aug-20 A | 22-Jul-22 |
| | CONSTR0100.00 | Home office support of construction - Summary | 330 | 0% | 08-Apr-21 | 26-Jul-22 |
| | CONSTR0200.00 | Incorporation of as-builts - Summary | 40 | 0% | 14-Jun-22 | 09-Aug-22 |
| **CRD-BA0.CON Construction, Startup, and Implementation** | | | 328 | | 27-May-21 | 29-Aug-22 |
| | A13770.1330 | 1A. Drawdown Waterlevel Within Ponds | 17 | 0% | 27-May-21 | 21-Jun-21 |
| | A13770.1340 | 1B. Install New Supply Pipe Through Dividing Berm | 20 | 0% | 22-Jun-21 | 20-Jul-21 |
| | A13770.1350 | 1C. Install Temporary Supply Pipe from Dividing Dike to Recirculation Pumphouse | 20 | 0% | 22-Jun-21 | 20-Jul-21 |
| | A13770.1360 | 1D. Install New Temporary Bulkheads In Recirculation Pumphouse | 20 | 0% | 22-Jun-21 | 20-Jul-21 |
| | A13770.1370 | 1E. Cease Flows to South Pond | 1 | 0% | 21-Jul-21 | 21-Jul-21 |
| | A13770.1380 | 2A. Dewater South Pond | 5 | 0% | 22-Jul-21 | 28-Jul-21 |
| | A13770.1400 | 2C. Remove Existing Water Treatment System and Associated Equipment | 20 | 0% | 29-Jul-21 | 25-Aug-21 |
| | A13770.1480 | 6B. Demolish or Relocate Metal Cleaning Waste Tank | 53 | 0% | 22-Jun-21 | 03-Sep-21 |
| | A13770.1410 | 2D. Remove CCR Material from within South Pond | 40 | 0% | 29-Jul-21 | 23-Sep-21 |
| | A13770.1415 | 2E. Certify All CCR Has Been Removed From South Pond | 0 | 0% | 24-Sep-21 | 24-Sep-21 |
| | A13770.1390 | 2B. Remove Existing Sheet Pile Wall | 20 | 0% | 27-Aug-21 | 27-Sep-21 |
| | A13770.1420 | 3A. Install EPA CCR Rule-Compliant Liner System in South Pond | 40 | 0% | 24-Sep-21 | 18-Nov-21 |
| | A13770.1450 | 3C. Extend BATW Pipes to South Pond | 40 | 0% | 24-Sep-21 | 18-Nov-21 |
| | A13770.1430 | 3B. Install New Dewatering and Staging Area | 30 | 0% | 18-Oct-21* | 30-Nov-21 |
| | A13770.1460 | 4A. Direct BATW to South Pond | 1 | 0% | 30-Nov-21 | 30-Nov-21 |
| | A13770.1495 | 4C. Allow South Pond to Refill to NWL | 10 | 0% | 01-Dec-21 | 14-Dec-21 |
| | A13770.1490 | 4B. Remove the Temporary Supply Pipe and Temporary Bulkheads | 14 | 0% | 01-Dec-21 | 20-Dec-21 |
| | A13770.1500 | 5A. Install Temporary LVW Impoundment In North Pond | 14 | 0% | 01-Dec-21 | 20-Dec-21 |
| | A13770.1510 | 5B. Isolate LVW Flows to the Temporary LVW Impoundment | 1 | 0% | 21-Dec-21 | 21-Dec-21 |
| | A13770.1530 | 6A. Dewater South Portion of North Pond | 14 | 0% | 22-Dec-21 | 13-Jan-22 |
| | A13770.1540 | 6C. Remove CCR Material from South Portion of North Pond | 200 | 0% | 22-Jun-21 | 06-Apr-22 |
| | A13770.1550 | 6D. Certify Clean Closure of South Portion of North Pond | 1 | 0% | 07-Apr-22 | 07-Apr-22 |
| | A13770.1440 | 7A. Reconfigure Outfall 023 and Install New Drain Pipe | 20 | 0% | 08-Apr-22 | 05-May-22 |
| | A13770.1570 | 7C. Reconfigure LVW Piping to North Pond | 20 | 0% | 08-Apr-22 | 05-May-22 |
| | A13770.1520 | 7B. Install OHIO EPA NPDES Compliant Liner in South Portion of North Pond | 44 | 0% | 08-Apr-22 | 08-Jun-22 |
| | A13770.1580 | 7D. Direct LVW Flows to South Portion of North Pond | 1 | 0% | 09-Jun-22 | 09-Jun-22 |
| | A13770.1590 | 8A. Dewater North Portion of North Pond | 5 | 0% | 10-Jun-22 | 16-Jun-22 |
| | A13770.1600 | 8B. Remove CCR Material from North Portion of North Pond | 15 | 0% | 17-Jun-22 | 08-Jul-22 |
| | A13770.1610 | 8C. Certify Clean Closure of the North Portion of North Pond | 1 | 0% | 11-Jul-22 | 11-Jul-22 |
| | A13770.1620 | 9A. Install Ohio EPA NPDES Compliant Liner in North Portion of North Pond | 20 | 0% | 12-Jul-22 | 08-Aug-22 |
| | A13770.1560 | 9C. Relabel Ponds | 1 | 0% | 09-Aug-22 | 09-Aug-22 |
| | A13770.1630 | 9B. Allow North Pond to Refill to NWL | 14 | 0% | 09-Aug-22 | 26-Aug-22 |
| | A13770.1300 | Ready for Operations | 0 | 0% | | 29-Aug-22 |
| **CRD-BA0.CON.OUT Outage Tie-Ins** | | | 22 | | 25-Sep-21 | 16-Oct-21 |
| | BAOUT.U3 | Unit 3 Bottom Ash Outage Tie-In | 5 | 0% | 25-Sep-21 | 29-Sep-21 |
| | BAOUT.U1 | Unit 1 Bottom Ash Outage Tie-In | 5 | 0% | 01-Oct-21 | 05-Oct-21 |
| | BAOUT.U2 | Unit 2 Bottom Ash Outage Tie-In | 5 | 0% | 12-Oct-21 | 16-Oct-21 |



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| 🟩 | Remaining Level of Effort ◆ |
| ◆ | Milestone |
| 🟦 | Actual Work |
| 🟩 | Remaining Work |
| 🟥 | Critical Remaining Work |
| ◇ | ◇ Baseline Milestone |

***Engineering, Procurement & Construction Schedule by WBS***

Sargent & Lundy

# 3.0 PROJECT SCHEDULE: NARRATIVE DISCUSSION

This section presents a narrative of the project steps and sequencing necessary to develop the alternative disposal capacity selected to replace the existing BAP Complex. This narrative follows and supplements the visual timeline representation of the project schedule provided in provided in Section 2.0.

Section 3.1 presents the steps Cardinal will take to retrofit the South Pond and repurpose the North Pond and the general sequence in which these steps will occur. This workflow is based on the steps necessary to execute the project and is considered to be the fastest feasible timeline in which the South Pond can be retrofitted with an EPA CCR Rule-compliant composite liner system and the North Pond can be repurposed as a non-CCR waste water basin. The subsequent sections discuss the steps that occur within each phase of the project (as shown in the visual timeline representation), including the tasks that occur during each of those steps.

See Section 4.0 for a narrative discussion of the progress the Cardinal Operating Company has made to date in developing this alternative disposal capacity for the BAP Complex.

## 3.1 INSTALLATION ACTIVITIES & PROJECTED WORKFLOW

As currently designed, the BAP Complex will be reconfigured by executing the following sequence of activities:

- Designing and permitting the retrofitted South Pond and repurposed North Pond;
- Procuring a general work contractor to perform the work;
- Retrofitting the South Pond:
  - Installing a temporary pipe system to supply the Recirculation Pumphouse from the North Pond during the South Pond retrofit work;
  - Dewatering the pond and excavating the CCR and CCR-impacted soils (if any) therein;
  - Performing leveling and grading;
  - Constructing a new dredge staging and CCR dewatering area;
  - Removing several existing pond features, including:
    - Transfer pumps, chemical treatment systems, and associated equipment,
    - A portion of the pond equalization pipe from North Pond discharge structure (sealing the pipe thereafter), and
    - The partition wall in the South Pond;
  - Installing the composite liner system:
    - Compacting and rolling smooth the exposed subgrade,
    - Placing and compacting a 2-foot-thick clay layer,
    - Installing a 60-mil HDPE geomembrane liner,
    - Placing a non-woven geotextile, and

        - Installing a protective layer of gravel, riprap, and/or concrete (varies within the South Pond);
    - Extending the existing BATW pipes to the retrofitted South Pond; and
    - Certifying and commissioning the retrofitted South Pond;
- Repurposing the southern portion of the North Pond:
    - Constructing a temporary impoundment in the northern portion of the pond,
    - Isolating LVW streams to the temporary impoundment,
    - Dewatering and excavating the CCR and CCR-impacted soils (if any) in the area,
    - Certifying the area as clean-closed,
    - Installing a new liner system:
        - Compacting and rolling smooth the exposed subgrade,
        - Installing a 60-mil HDPE geomembrane liner, and
        - Placing a non-woven geotextile; and
    - Diverting LVW streams to the repurposed portion of the North Pond.

## 3.2 ENGINEERING & DESIGN

Before construction can begin on the BAP Complex, detailed engineering and design work must be completed which includes preparing the design drawings and specifications required to execute the work. The engineering and design work began in April 2020 and is scheduled to be completed in April 2022. The timeline for the engineering and design work was based on experience from similar pond retrofit projects and on engineering judgement. The anticipated engineering work for this project is broken out into the following categories: General, Civil, Structural, Mechanical, Electrical, and Instrumentation and Controls (I&C).

### 3.2.1.1 GENERAL

The General engineering and design work encompasses tasks that do not fall under one specific discipline. This phase involves tasks that are required by the other disciplines prior to detailed design and is projected to span from April 2020 through December 2020. The work will include:

- Preparing a project design basis and criteria,
- Preparing general arrangement drawings of the project site,
- Updating the project cost estimate based on the more detailed engineering and design performed in this phase, and
- Conducting design reviews.

In addition to the preceding tasks, the Cardinal Operating Company will prepare the semi-annual progress reports on the development of this alternative disposal capacity for the BAP Complex in accordance with 40 CFR 257.103(f)(1)(x). Pursuant to 40 CFR 257.103(f)(1)(xi), these reports will be prepared by April 30 and October 31 of each year for the duration of the project. Based on having alternative disposal capacity available by the end of April 2022 for all of the CCR and non-CCR waste streams currently being managed in the BAP Complex, the Cardinal Operating Company anticipates submitting three of these progress reports to the EPA.

#### 3.2.1.2 CIVIL

The Civil engineering and design work began in July 2020 and is scheduled to be substantially completed by April 2021. This phase involves tasks like preparing drawings, various permitting support documents, and the required EPA CCR Rule compliance demonstrations:

- Drawings:
    - Civil general notes and details,
    - Temporary erosion control,
    - Pond lining,
    - Civil sitework demolition, and
    - Roads and paving.
- Permitting Documents:
    - Ohio EPA Storm Water Pollution Prevention Plan (SWPPP) for construction,
    - Ohio EPA permitting documents support, and
    - Ohio DNR dam modifications permitting support.
- EPA CCR Rule Compliance Demonstrations:
    - Location Restrictions (40 CFR 257.60 through 64),
    - Design Criteria (40 CFR 257.72 and 74),
    - Operating Criteria (40 CFR 257.80, 82, and 83),
    - Groundwater Monitoring (40 CFR 257.90 through 93), and
    - Closure and Post Closure Care (40 CFR 257.102 and 104).

In addition to the preceding tasks, the Civil engineering and design work included the procurement of a topographic and bathymetric survey of the BAP Complex to provide the necessary site inputs for design calculations and design drawings, including:

- Depth of bottom ash in the BAP Complex;
- Existing dike alignments, slopes, and elevations; and
- Locations of existing structures, equipment, and piping.

The process of procuring a topographic and bathymetric survey procurement began in April 2020, and the contract was awarded to a surveyor in late July 2020. This process included preparing a technical specification for the work, issuing a bid package, and performing technical and commercial evaluations in order to confirm the bidders evaluated every aspect of the specification. The surveying work began in July

2020 and was completed in September 2020. The total approximate area that was surveyed was over 60 acres.

#### 3.2.1.3 STRUCTURAL

The Structural engineering and design work began in September 2020 and is scheduled to be completed in April 2021. Within this subcategory, the following drawings and support documents will be prepared:

- Concrete general notes and details,
- Modifications to the existing Outfall 023 structure,
- Pipe road crossing trenches,
- Foundations for miscellaneous structural pads and pipe supports,
- Pumphouse bulkheads, and
- Structural steel for pipe supports and auxiliary steel.

To support the preceding tasks, site walkdowns will be performed to gather necessary structural engineering and design inputs for the project.

#### 3.2.1.4 MECHANICAL

The Mechanical engineering and design work began in May 2020 and is scheduled to be completed in April 2021. Within this subcategory, drawings and piping and instrumentation diagrams (P&IDs) will be prepared, including:

- Mechanical general notes and details;
- Demolition drawings for:
    - BATW piping,
    - LVW piping,
    - Metal cleaning waste tank facility, and
    - Chemical treatment system;
- P&IDs, isometric and composite drawings, and/or pipe supports for:
    - Blowdown to the Unit 3 FGD,
    - Existing system tie-ins for the recirculation system,
    - Existing system tie-ins for BATW from Units 1 and 2,
    - Existing system tie-ins for BATW from Unit 3,
    - Existing system tie-ins for LVW,
    - Temporary piping from the North Pond to the Recirculation Pumphouse
    - Unit 1 and 2 service water system tie-ins, and
    - Ash hopper piping;
- Control valve data sheets; and
- Lists for pipelines and valves.

To support the preceding tasks, site walkdowns will be performed to gather necessary mechanical engineering and design inputs for the project.

#### 3.2.1.5 ELECTRICAL

The Electrical engineering and design work began in July 2020 and is scheduled to be completed in April 2021. Within this subcategory, drawings and calculations will be prepared, including:

- Wiring drawings,
- Cable tabulations, and
- Electrical installation drawings.
- Electrical walkdown summary.

To support the preceding tasks, site walkdowns will be performed to gather necessary electrical engineering and design inputs for the project.

#### 3.2.1.6 INSTRUMENTATION & CONTROLS (I&C)

The I&C engineering and design work began in July 2020 and is scheduled to be completed in February 2021. Within this subcategory, drawings and calculations will be prepared, including:

- Logic control descriptions,
- I/O Database list, and
- Instrument list and details.

To support the preceding tasks, site walkdowns will be performed to gather necessary I&C engineering and design inputs for the project.

## 3.3 PROCUREMENT

### 3.3.1 CONTRACTOR SELECTION

#### 3.3.1.1 GENERAL WORK CONTRACTOR

The Cardinal Operating Company intends to hire one General Work Contractor to retrofit the South Pond and install the ancillary pond features. The General Work Contractor selection process is scheduled to begin in November 2020. The technical specification will take approximately two months to prepare and review, which will be performed concurrently with the corresponding engineering design drawings to be included with the specification in the bid package. This bid package is expected to be released to qualified contractors in early January 2021, and the subsequent bid period is expected to last approximately six weeks in order to give the bidders adequate time to assess, understand, price, and develop a plan for executing the scope of work.

Once all bids are obtained by mid-February 2021, the Cardinal Operating Company will assess the bids on a technical and commercial basis. The bid evaluation phase is expected to take six weeks in order to provide adequate time to thoroughly review each proposal, which may include asking bidders questions, ensuring each bid addresses all aspects of the scope of work, addressing any exceptions taken by the bidders in the technical and/or commercial terms, and ultimately selecting the winning bidder for the general work contract. Immediately after this bid evaluation phase, Cardinal will conform the commercial terms and technical specification with the winning bidder and subsequently award the contract. This last phase is expected to take about three weeks, which would have the general work contract awarded in early April 2021.

#### 3.3.1.2 CONSTRUCTION QUALITY ASSURANCE

The Cardinal Operating Company also intends to hire a Construction Quality Assurance (CQA) Contractor to inspect the General Work Contractor's work to ensure it meets the performance standards specified in the construction contract. The CQA Contractor selection process will commence after the bid package for the General Work Contractor is released in early January 2021 and will go through a similar procurement process. A technical specification will be prepared detailing the work required of the CQA, which is expected to take approximately one month to prepare and review. The CQA bid package will then be issued to qualified CQA contractors; this is expected to occur in early February 2021. Given the nature of this work, the bid period and subsequent evaluation phase are only expected to take three weeks each. Thus, the Cardinal Operating Company expects to have bids for the CQA work reviewed for technical and commercial conformance by mid-March 2021. Like the general work contract, it is expected that the specification will be conformed with and awarded to the selected CQA Contractor within two weeks of completing the bid evaluation. Thus, the CQA Contractor for the project is expected to be hired around the end of March 2021, which is around the same time the Cardinal Operating Company anticipates awarding the general work contract.

### 3.3.2 EQUIPMENT FABRICATION & DELIVERY

Immediately after executing the general work contract in early April 2021, the manufactured materials required for the project (*e.g.*, HDPE geomembrane, piping) will be ordered. Some of these materials are expected to be long lead-time components, so ordering them in early spring of 2021 reduces the risk of supply delay by the time these materials are installed in the fall of 2021. In particular, the HDPE geomembrane for the South Pond's composite liner system is expected to have a long lead time to procure given the anticipated surge in CCR pond work.

The following subsections discuss how the Cardinal Operating Company anticipates the various materials required to execute this project will be procured.

#### 3.3.2.1 CLAY, GRAVEL, & RIPRAP

Once the General Work Contractor has been awarded the construction contract, the contractor will work with the Cardinal Operating Company to find and select borrow sites for the clay, gravel, and riprap materials for the project. In particular, contractor will need to evaluate whether a clay borrow site has suitable material to meet the low hydraulic conductivity specified for the South Pond's composite liner system and whether it can be delivered to the project site on time.

It is expected that the borrow sites for clay, gravel, and riprap will be selected within a month after the construction contract is awarded. It is anticipated that the clay borrow site will be located within 20 miles of Cardinal, whereas the gravel and riprap are expected to come from borrow sites located between 30 and 60 miles away from the plant. A four-month delivery duration was scheduled for all three materials to provide an adequate window of time to ensure the materials are at the project site before the composite liner installation work begins in September of 2021.

#### 3.3.2.2 GEOMEMBRANE & GEOTEXTILE

Concurrent with identifying borrow sites for the soil materials, the General Work Contractor will order the geosynthetic materials required for the project. Once the panels are ordered, the vendor will begin the fabrication process. From prior projects, experience with geomembrane/geotextile vendors, and the anticipated demand for geosynthetic materials for EPA CCR Rule compliance work, the fabrication time is expected to be approximately 70 days. Potential vendors that supply geomembrane and/or geotextile are between 100 and 350 miles away from the station. Accordingly, a 20-day delivery duration was scheduled to provide an adequate window of time to ensure the materials are at the project site before the composite liner installation work begins in September of 2021.

#### 3.3.2.3 CONCRETE

Immediately after being awarded the contract to reconfigure the BAP Complex (beginning of April 2021), the General Work Contractor will begin contacting ready-mix concrete suppliers to furnish and deliver the concrete being installed over a portion of the composite liner system in the South Pond. Several potential ready-mix concrete suppliers are located within a 20-mile radius of the Cardinal site, including Brilliant and Steubenville, Ohio. Therefore, it is expected that the concrete for the retrofitted pond will be prepared at one of these plants and delivered to the site via ready-mix trucks. Given the proximity of these plants, ready-mix trucks should have adequate time to deliver and discharge the concrete in accordance with ASTM C94, "Standard Specification for Ready-Mixed Concrete," which requires concrete be discharged within 90 minutes after hydration commences.

#### 3.3.2.4 PUMPS, PIPES, & VALVES

The final materials required for the project are the new pumps, pipes, and valves required for modifications to the existing CCR and non-CCR pipelines and upstream equipment. Like the other materials, these items will also be ordered once the General Work Contractor is awarded the project. These materials are expected to be delivered by mid-July 2021 since the installation of the new pumps is one of the earliest tasks on the construction schedule. Thus, the General Work Contractor is expected to have these materials ordered within two weeks after starting the project.

From prior projects and experience with pump, HDPE pipe, and valve vendors, the fabrication time was scheduled for 40 days. Potential vendors that supply these items are located between 30 and 110 miles from the plant site. Accordingly, a 20-day delivery duration was scheduled to provide an adequate window of time to ensure the equipment arrives at to the Cardinal station in time for it to be installed.

## 3.4 CONSTRUCTION, STARTUP, & IMPLEMENTATION

After being awarded the contract in early April 2021, the General Work Contractor will start mobilizing to the site. As previously mentioned, the BAP Complex must continue operating until the station's new dry fly ash-handling system is operational and FAR II is no longer needed. Per the Cardinal Operating Company's corresponding workplan for replacing FAR II, the dry fly ash-handling system is expected to be operational by June 7, 2021. Thus, the General Work Contractor for this project is expected to be fully mobilized to the site by late May, early June 2021. Upon mobilizing to the site, construction is anticipated to follow a multi-phase approach to allow Cardinal to continue operating without major outages while the Bottom Ash Pond Complex is reconfigured.

The following construction schedule assumes that the General Work Contractor and its subcontractors (if any) will normally work five days per week at 10 hours per day.

### 3.4.1 PHASE 1: INITIATE DEWATERING & RE-ROUTE NORTH POND OUTFLOW

Before the water and ash in the South Pond can be removed, the pond needs to be isolated from the operations of the BAP Complex. This will be accomplished by installing a temporary supply pipe between the Recirculation Pumphouse and the North Pond. This work is scheduled to commence at the end of June 2021.

In order to install the temporary supply pipe in a dry condition, the water levels in the North and South Ponds will be lowered. This drawdown process is expected to start in May of 2021 after the contractor has partially mobilized to the site. The water level will be lowered by about seven feet in each pond, which will allow the Recirculation Pumphouse to continue supplying water to Cardinals' fly ash-handling system while the South Pond is being retrofitted. Approximately 390 million gallons of water in the South Pond and 1,100 million gallons of water in the North Pond are expected to be removed during the drawdown process. The removed water will be directed to the Ohio River through NPDES-permitted Outfall 023 using temporary pumps located along the perimeter dike. The effluent limitations of Cardinal's NPDES permit will be maintained during the discharge of BATW as required to perform the necessary improvement. Compliance will be monitored in strict accordance with the applicable permits.

Once the water levels in both ponds are drawn down, the temporary supply pipe will then be installed through the dividing berm by excavating, installing and backfilling the pipe on the north side of the dike. Once the northern portion of the pipe is installed, the North Pond will be refilled to its working water elevation. The contractor will then repeat the same process on the south side of the dike. The temporary supply pipe will ultimately run through the existing dike where it will then connect to the Recirculation Pumphouse. This pipe will be approximately 300 feet from the existing outlet structure in the North Pond to the connection to the Recirculation Pumphouse. At its connection to the pumphouse, the temporary pipe will feature a manifold attached to temporary bulkheads that will be installed at the entrance of each pump bay to prevent water remaining in the South Pond from entering the pumphouse.

Once the North and South Ponds are segregated and a new flow path is established for the North Pond, all waste water streams will cease entering the South Pond, which can then be fully dewatered. Based on the work required, it is currently anticipated that approximately two months will be necessary to complete this task. Therefore, it is expected that the General Work Contractor can begin dewatering and removing CCR material from the South Pond by the end of July 2021.

### 3.4.2 PHASE 2: CLEAN OUT SOUTH POND

After all waste water is diverted away from the South Pond, the General Work Contractor will continue dewatering the pond until all free water remaining from Phase 1 is removed. It is estimated that approximately six feet of free water, the equivalent of 270 million gallons, will need to be removed at this time. This water will be removed in the similar manner as the pond drawdown work in Phase 1 but may be sent to the North Pond in lieu of Outfall 023 if space is available.

Once the water in the South Pond is removed, the General Work Contractor will remove the pond's water treatment system and the existing sheet pile wall currently separating the South Pond into two areas. At this point the contractor can begin removing CCR material and any CCR-impacted soils from the pond. Based on the recently-completed bathymetric survey and historical design drawings, it is anticipated that approximately 44,000 cubic yards of CCR will be removed during this phase. All removed CCR and CCR-impacted soils will be transported to FAR I Landfill for final disposal. Appropriate fugitive dust control measures (*e.g.*, water spray) will be implemented to minimize airborne CCR particulates while the CCR is being handled.

Based on the amount of water and CCR to be removed, it is anticipated that the General Work Contractor will need approximately two months to complete this phase. Therefore, it is expected that the South Pond will be free of CCR and CCR-impacted soils by the end of September 2021.

### 3.4.3 PHASE 3: RETROFIT SOUTH POND

Once the CCR material and CCR-impacted soils are removed from the South Pond, the composite liner system can be installed. The General Work Contractor will first compact and roll smooth the pond floor as necessary to ensure the subgrade is firm, clean, and smooth. After the CQA Contractor verifies the condition of the subgrade, the General Work Contractor will proceed with installing the clay component of the composite liner system. The clay will be placed in lifts, with each lift compacted to provide a hydraulic conductivity not exceeding $1\times10^{-7}$ cm/sec in accordance with 40 CFR 257.70(b). Concurrent with the contractor placing and compacting the clay layer, the CQA Contractor will verify the lifts are indeed compacted to the specified performance criteria (*i.e.*, density, moisture content, and lift thickness).

Subsequent to placing and compacting the clay component of the composite liner system, panels of HDPE geomembrane will be deployed over the clay. Adjacent panels will be overlapped and thermally welded together. Like the clay component, the CQA Contractor will inspect the deployment of the geomembrane panels and the welds connecting them for conformance with the project specifications. Once the HDPE geomembrane liner is in place, the General Work Contractor will then begin placing the non-woven geotextile. The geotextile will be placed in panels and subsequently overlapped and sewn together at the seams.

The protective layer will be the final component of the composite system liner that is installed. As discussed in Section 1.4.1, this protective layer will vary across the South Pond due to different dredging frequencies expected in these areas during the pond’s operating life. The various thicknesses of riprap, gravel, and concrete will be placed once the geotextile has been installed. The gravel and riprap layers will require some light compaction, while the concrete layer will be placed once the gravel and riprap have been positioned.

As the composite liner system is being installed, the new dredge staging and CCR dewatering area will be constructed near the new BATW discharge point into the South Pond. This area will be built over the new composite liner system with an 8-in.-thick protective layer of gravel. Compacted bottom ash excavated from the North Pond will be used to raise this area approximately three feet above the retrofitted pond’s normal operating water level. Finally, the existing BATW discharge pipes will be extended south along the western berm of the BAP Complex to the South Pond.

This phase is currently scheduled to begin in the end of September 2021. The composite liner system is expected to require 26,000 cubic yards of clay; 33,000 square yards of geomembrane and geotextile; and over 6,000 cubic yards of aggregate (gravel and/or riprap) and concrete. Based on the work required, it is currently anticipated that approximately two months will be necessary to complete this task. Therefore, it is expected that the composite liner system will be fully installed in the South Pond by mid-November 2021.

### 3.4.4 PHASE 4: COMMISSION & CERTIFY RETROFITTED SOUTH POND

After the new composite liner system has been installed in the South Pond and once the BATW lines have been extended thereto, the retrofitted pond will be certified in accordance with 40 CFR 257.102(k)(4). At this point, Cardinal will have alternative bottom ash disposal capacity available and will immediately begin sluicing BATW to the South Pond to store and treat the station's bottom ash. Thus, per the project schedule, it is expected that Cardinal will have alternative disposal capacity for the CCR waste streams currently sent to the existing BAP Complex by November 30, 2021.

Once the retrofitted South Pond is operational, the four recirculation pumps in the pond will be taken out of service. Meanwhile the four recirculation pumps for the North Pond will remain in service in order to continue segregating the LVW streams in the North Pond from the BATW in the South Pond. Once the South Pond's recirculation pumps are shutdown, the temporary bulkheads installed during Phase 1 will be removed in order to allow water to begin entering the South Pond. At this point, the temporary supply pipe from the North Pond to the Recirculation Pumphouse will be removed.

In order to remove the temporary supply pipe, the valve at the north end of the pipe will be closed and the pipe will be drained of excess water from the branch pipe valves at the Recirculation Pumphouse. At this point, the temporary bulkheads can be removed from the four northernmost openings. The temporary supply pipe will then be removed. up until the upstream side of the dividing dike. The rest of the pipe will remain within the dike to mitigate the risk of otherwise compromising the South Pond's new composite liner system; accordingly, the pipe will be sealed and filled with grout. Supports for the temporary supply pipe will also remain in place with sleeves integrated into the composite liner system.

This phase is expected to take approximately three weeks to complete once the retrofitted South Pond is operational. Therefore, it is expected that the temporary supply pipe and bulkheads will be removed by the late December 2021.

### 3.4.5 PHASE 5: INSTALL TEMPORARY IMPOUNDMENT IN NORTH POND

Once the retrofitted South Pond is operational, the General Work Contractor will begin repurposing the North Pond into a non-CCR waste water basin. As previously stated, this conversion will be accomplished by repurposing the southern portion of the pond first, followed by the northern portion. In order to start dewatering the CCR in the southern end of the pond, the LVW streams entering the North Pond will need to be isolated from the area.

In order to prevent LVW streams from entering the southern portion of the North Pond, a temporary impoundment will be installed in the pond's northwest corner to contain the waste during construction. The temporary impoundment will be formed by excavating bottom ash stored in the area to form a bowl shape with side slopes of 3H:1V or shallower. The excavated material will then be used to contract a dike between the temporary LVW impoundment and the rest of the North Pond. Once the dike is constructed, approximately 3,300 square yards of geomembrane will be temporarily placed on top of impoundment floor and will be held in place with washed gravel for ballast (as needed). Finally, the LVW streams will then be directed to the temporary impoundment and thus isolated from the rest of the North Pond.

Based on the amount of work needed to install the temporary LVW impoundment, it is anticipated that the General Work Contractor will need approximately three weeks to complete this phase. However, this phase can and is expected to be performed concurrently with Phase 4. Therefore, it is expected that the temporary LVW impoundment will be installed by late December 2021.

### 3.4.6 PHASE 6: CLEAN CLOSE SOUTHERN PORTION OF NORTH POND

Once the LVW streams have been isolated to the temporary impoundment, the contractor can begin the process of clean closing the southern portion of the new LVW Pond. However, given that approximately 310,000 cubic yards of CCR are expected to be removed from this area of the pond, it is anticipated that the General Work Contractor will start removing material from this pond after the water level is drawn down in the pond during Phase 1. The station regularly dredges material from the North Pond from an elevated area within the pond limits, where the excavated ash is dewatered and then transported to FAR I Landfill for disposal. It is expected that the contractor will follow a similar process to remove material from the North Pond even while it continues operating during the South Pond retrofit work (Phases 1 through 3).

Following the diversion of LVW streams to the temporary impoundment, the CCR remaining in the North Pond from the initial excavation work during Phases 1 and 3 will be dewatered using temporary pumps located along the perimeter dikes. This water will be discharged to the Ohio River through Outfall 023 in strict accordance with Cardinal's NPDES permit.

Once the water in the area has been removed, the General Work Contractor can begin removing CCR material and any CCR-impacted soils (if any) from the southern portion of the North Pond. At this point, the equipment in the aforementioned elevated dredging area will also be removed, including a 70-foot diameter, 40-foot tall metal cleaning waste tank and over 30 tons of auxiliary piping. All removed CCR and CCR-impacted soils will be transported to FAR I Landfill for final disposal. Appropriate fugitive dust control measures (*e.g.*, water spray) will be implemented to minimize airborne CCR particulates while the CCR is being handled. Finally, once all CCR and CCR-impacted soils have been removed, the southern portion of the North Pond will be certified as clean-closed in accordance with 40 CFR 257.102(f)(3).

Based on the amount of water, CCR, and equipment to be removed, it is anticipated that the General Work Contractor will need about three months to complete this phase after the LVW impoundment is installed. Therefore, it is expected that the southern portion of the North Pond will be clean-closed by early April 2022.

### 3.4.7 PHASE 7: INSTALL LINER SYSTEM IN SOUTHERN PORTION OF NORTH POND

As soon as the southern portion of the North Pond is certified as clean-closed, Outfall 023 will be relocated and a new drainpipe will be installed to discharge LVW streams from the repurposed North Pond. About 160 linear feet of piping will be installed from the existing outfall structure through the eastern dike to create the reconfigured Outfall 023.

While Outfall 023 is being reconfigured, an Ohio EPA NPDES-compliant liner will be installed in the clean-closed, southern portion of the North Pond. This liner will consist of, from bottom to top, a 60-mil geomembrane and a non-woven geotextile. Approximately 110,000 square yards of each geosynthetic material is expected to be needed to line this area. As the liner is being installed, the LVW gravity piping will be temporarily extended to the southern portion of the North Pond, while the pressurized piping will be permanently rerouted to this area.

Once the LVW piping is reconfigured and the new liner is installed, the LVW streams will be directed to the southern portion of the North Pond, marking the completion of alternative disposal capacity for the LVW streams. Based on the amount of work required to install the liner system in the southern portion of the North Pond, it is anticipated that the General Work Contractor will need approximately two months to complete this phase. Thus, per the project schedule, it is expected that Cardinal will have alternative disposal capacity for the non-CCR waste streams currently being sent to the existing BAP Complex by June 9, 2022.

### 3.4.8 PHASES 8 & 9: COMPLETE LINER INSTALLATION IN NORTH POND

Once the LVW lines are diverted away from the temporary impoundment, the northern portion of the North Pond will be dewatered. All of the CCR material and CCR-impacted soils (if any) will be removed from this area and from underneath the temporary impoundment. Upon removing the CCR and CCR-impacted soils, the northern portion of the North Pond will be certified as clean closed per 40 CFR 257.102(f)(3). Afterwards, any necessary leveling and grading work can occur as specified in the construction drawings. Once the grading work is complete, an Ohio EPA NPDES-compliant liner system can be installed. Immediately thereafter, the entire North Pond will have been repurposed, can refill to its normal operating water level, and can begin operating exclusively as an LVW pond.

This phase of the project will begin after the southern portion of the North Pond starts receiving LVW streams on June 9, 2022. Given the amount of material to be removed and the area to be lined, it is expected that the entire LVW pond will be operational by the end of August 2022.

# 4.0 PROJECT SCHEDULE: PROGRESS TO DATE

This section presents a narrative of the progress the Cardinal Operating Company has made in retrofitting the South Pond and repurposing the North Pond for the BAP Complex's CCR and non-CCR waste streams, respectively. The project was authorized in April 2020, and the engineering and design work commenced shortly thereafter.

To date, the Cardinal Operating Company has finished preparing the project design basis, general arrangement drawings, and an updated cost estimate. In addition to these general engineering and design tasks, many of the discipline-specific activities are underway. Most of the P&IDs for the project have been prepared and issued for design, including the diagrams for the new FGD blowdown line, tie-ins to existing plant systems (bottom ash, recirculation, LVW, and service water). Finally, A 25% design review meeting was held to discuss the engineering and design work accomplished thus far in early September, and a follow-up meeting is scheduled for the end of November 2020 when the design work is expected to be about 60% complete. In addition, the Cardinal Operating Company is currently in the process of finalizing Ohio permitting requirements for the Engineering and Surface Water Controls, NPDES, and Dam modifications. These permit applications are expected to be submitted to the appropriate agencies prior to the end of 2020.

Finally, the Cardinal Operating Company has obtained a topographic and bathymetric survey of the BAP Complex area to provide the necessary design inputs for the engineering and design work to reconfigure the area. The initial survey was received at the end of August 2020 and was finalized a few weeks thereafter in late September 2020.

# 5.0 REFERENCES

1. 40 CFR Part 257 Subpart D, “Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments.”

2. United States Court of Appeals, District of Columbia Circuit, *Utility Solid Waste Activities Group et al. v. Environmental Protection Agency*, No. 15-1219, 08/21/2018.

3. Ohio Environmental Protection Agency, “Fact Sheet Regarding an NPDES Permit To Discharge to Waters of the State of Ohio for Cardinal Operating Company,” Public Notice No. 18-05-061, Ohio EPA Permit No. 0IB00009*WD, Application No. OH0012581, 05/21/2018.

4. Buckeye Power, “CCR Rule Compliance Data and Information,” https://ohioec.org/buckeye-power/ccr-rule-compliance-data-information/, Accessed 10/20/2020.

5. Environmental Protection Agency, “Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals from Electric Utilities, Part VI (Development of Final Rule – Technical Requirements),” 80 Fed. Reg. 74, p. 21423, 04/17/2015.

6. 55 Ohio Revised Code 5577, “Load Limits on Highways,” https://codes.ohio.gov/orc/5577, Accessed 10/20/2020.

7. Ohio Department of Transportation, “Transportation Data Management System, Location ID 541, LRS ID SJEFSR00007**C,” http://www.ms2soft.com/tcds/?loc=Odot&mod=tcds&local_id=541, Accessed 10/20/2020.

8. Environmental Protection Agency, “Steam Electric Reconsideration Rule,” 85 Fed. Reg. 198, pp. 64650–64723, 10/13/2020.

9. Environmental Protection Agency, “Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category,” 80 Fed. Reg. 212, pp. 67838– 67903, 11/03/2015.

10. Environmental Protection Agency, “Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals From Electric Utilities; A Holistic Approach to Closure Part A: Deadline to Initiate Closure,” 85 Fed. Reg. 168, pp. 53516–53566, 08/28/2020.

11. Ohio Administrative Code, 3745-29-19, “Operational Criteria for an Industrial Solid Waste Landfill Facility,” Effective 09/23/2014.

## 6.0 Certification of Compliance

To demonstrate that the criteria in 40 CFR § 257.103(f)(1)(iii) has been met, the following information is provided pursuant to 40 CFR § 257.103(f)(1)(iv)(B) to demonstrate that the Bottom Ash Pond is in compliance with the CCR Rule.

## 6.1 Owners Certification of Compliance

In accordance with 40 CFR § 257.103(f)(1)(iv)(B)(1), I hereby certify that, based on my inquiry of those persons who are immediately responsible for compliance with environmental regulations at Cardinal Power Plant, the Bottom Ash Pond is in compliance with all requirements contained in 40 CFR § 257 Subpart D.

TC M. Alban

NK CS PMJ

Thomas M. Alban
Vice President
October 30, 2020

## 6.2 Compliance Documents

In accordance with 40 CFR§ 257.103(f)(1)(iv)(B)(2) through (B)(8), the following documents are provided below:

**§257.103(f)(1)(iv)(B)(2)(i)-(iii)** – Maps of groundwater monitoring wells relative to CCR Unit, well construction and drilling logs, and seasonal groundwater flow maps.

**§257.103(f)(1)(iv)(B)(3)** – Groundwater monitoring results through first 2020 Semi-Annual monitoring period. In addition, the most recent Annual Groundwater Report (January 2020) is also provided for reference.

**§257.103(f)(1)(iv)(B)(4)** – Description of site geology and stratigraphic cross sections. Text is provided from the Groundwater Monitoring Network Report in accordance with §257.91.

**§257.103(f)(1)(iv)(B)(5)** – Corrective Measures Assessment – Not applicable, the Bottom Ash Pond is currently in Assessment Monitoring and does not exceed Groundwater Protection

Standards.

**§257.103(f)(1)(iv)(B)(6) –** Remedy Selection Report – Not applicable, as described above, the Bottom Ash Pond is currently in Assessment Monitoring and no remedy selection report is required.

**§257.103(f)(1)(iv)(B)(7) –** Structural Stability Assessment pursuant to §257.73(d) was completed in October 2016. The next Stability Assessment will be completed prior to October 2021.

**§257.103(f)(1)(iv)(B)(8) –** Safety Factor Assessment pursuant to §257.73(e) was completed in October 2016. The next Safety Factor Assessment will be completed prior to October 2021.

# 40 CFR 257.101 (f)(1)(iv)(B)(2)(i)

## Maps of Groundwater monitoring well locations in relation to CCR Unit

**Monitoring Well Network**

- ⊕ Compliance Sampling Location
- ⊕ Background Sampling Location
- ▭ Bottom Ash Pond

Notes
- Monitoring well coordinates provided by Buckeye Power.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Bottom Ash Pond (Geosyntec, 2016) provided by Buckeye Power.

250 125 0 250 Feet

Site Layout
Bottom Ash Complex

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec
consultants

Columbus, Ohio | 2018/01/25

Figure
**2**

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\BAP\AEP-Cardinal_BAP_Site_Layout.mxd. MMuenich. 1/25/2018. CHA8423/01/08.

# 40 CFR 257.101 (f)(1)(iv)(B)(2)(ii)

## Well construction diagrams and drilling logs for all groundwater monitoring wells

# EXPLANATION OF SYMBOLS AND TERMS USED ON BORING LOGS FOR SAMPLING AND DESCRIPTION OF SOIL

## SAMPLING DATA

▮ - Blocked-in "SAMPLES" column indicates sample was attempted and recovered within this depth interval.

▯ - Sample was attempted within this interval but not recovered.

2/5/9 - The number of blows required for each 6-inch increment of penetration of a "Standard" 2-inch O.D. split-barrel sampler, driven a distance of 18 inches by a 140-pound hammer freely falling 30 inches. Addition of one of the following symbols indicates the use of a split-barrel other than the 2" O.D. sampler:

$\boxed{\text{2S}}$ - 2½"O.D. split-barrel sampler

$\boxed{\text{3S}}$ - 3" O.D. split-barrel sampler

P - Shelby tube sampler, 3" O.D., hydraulically pushed.

R - Refusal of sampler in very-hard or dense soil, or on a resistant surface.

50-2" - Number of blows (50) to drive a split-barrel sampler a certain number of inches (2), other than the normal 6-inch increment.

S/D - Split-barrel sampler (S) advanced by weight of drill rods (D),

S/H - Split-barrel sampler (S) advanced by combined weight of rods and drive hammer (H).

## SOIL DESCRIPTIONS

All soils have been classified basically in accordance with the Unified Soil Classification System, but this system has been augmented by the use of special adjectives to designate the approximate percentages of minor components as follows:

| Adjective | Percent by Weight |
|---|---|
| trace | 1 to 10 |
| little | 11 to 20 |
| some | 21 to 35 |
| "and" | 36 to 50 |

The following terms are used to describe density and consistency of soils:

| Term (Granular Soils) | Blows per foot |
|---|---|
| Very-loose | Less than 5 |
| Loose | 5 to 10 |
| Medium-dense | 11 to 30 |
| Dense | 31 to 50 |
| Very-dense | Over 50 |

| Term (Cohesive Soils) | Qu (tsf) |
|---|---|
| Very-soft | Less than 0.25 |
| Soft | 0.25 to 0.5 |
| Medium-stiff | 0.5 to 1.0 |
| Stiff | 1.0 to 2.0 |
| Very-stiff | 2.0 to 4.0 |
| Hard | Over 4.0 |

Page 1 of 2

# LOG OF BORING NO. MW-BAP-1
# BOTTOM ASH POND MONITORING WELL INSTALLATION
# CARDINAL PLANT, BRILLIANT, OH

LOCATION: **N. 820,305, E. 2,513,927** ELEVATION: **669.8** DATE: **12/4/15 - 12/10/15**
DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **52.0'**
SAMPLER(S): **2" O.D. Split-barrel Sampler**

2010 NEW DEFAULT BORING LOG-W/ N60

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE EFFORT | $N_{60}$ | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT / PLASTIC LIMIT / LIQUID LIMIT (10 20 30 40) | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|
| 667.0 | 0 | 1 | 47/34/26 | 75 | 100 | AGGREGATE - 34 INCHES | | |
| 665.3 | | 2 | 4/21/30 | 64 | 100 | FILL: Hard brown silty clay, some fine to coarse sand, some fine to coarse gravel, cobbles, moist. | | H=3.0 |
| | 5 | 3 | 15/6/8 | 18 | 27 | FILL: Medium-dense gray fine to coarse grave, little to some fine to coarse sand, trace silt to some silty clay, cobbles, dry. | | |
| 662.8 | | 4 | 7/40/7 | 59 | 67 | | | |
| | | 5 | 7/4/5 | 11 | 87 | FILL: Stiff to very-stiff brown silty clay, some to "and" fine to coarse sand, some fine to coarse gravel, contains fine to coarse sand seams and sandstone fragments, damp. | | H=2.5 |
| | | 6 | 8/11/4 | 19 | 100 | | | H=3.0 |
| 658.3 | 10 | 7 | 6/8/5 | 16 | 100 | | | H=2.5-3.5 |
| | | 8 | 10/8/7 | 19 | 67 | FILL: Medium-dense fine to coarse gravel, some to "and" fine to coarse sand, some clayey silt, damp becoming moist. | | |
| | | 9 | 3/3/6 | 11 | 100 | - 3" pocket of sand at 14.5'. | | |
| 653.8 | 15 | 10 | 5/3/7 | 13 | 53 | | | H=1.25 |
| 652.3 | | 11 | 4/3/3 | 8 | 67 | Stiff gray clayey silt, "and" fine to coarse sand, little to some fine gravel, moist. | | H=1.25 |
| 650.6 | | 12 | 3/2/4 | 8 | 53 | Loose brown fine to coarse sand, "and" silty clay, some fine to coarse gravel, moist. | | H=1.0 |
| | 20 | 13 | 7/8/5 | 16 | 93 | Loose to medium-dense brown fine to coarse gravel, some to "and" fine to coarse sand, some silty clay, damp to moist. | | H=4.5 |
| | | 14 | 4/6/5 | 14 | 80 | | | |
| | | 15 | 5/8/4 | 15 | 67 | | | |
| 643.8 | 25 | 16 | 6/3/2 | 6 | 80 | | | |
| 641.0 | ▼ | 17 | 4/4/5 | 11 | 73 | Hard brown mottled with gray and dark-gray silty clay, little fine to coarse sand, trace fine to coarse gravel (shale fragments), slightly organic, damp. | | H=3.0-4.0 |
| | 30 | 18 | 2/2/ | 4 | 100 | Stiff dark-brown clayey silt, little to some fine to medium sand, slightly organic, damp. | | H=1.25-2.25 |

| | ▽ | ▼ |
|---|---|---|
| WATER LEVEL: | 31.0 | 27.5 |
| WATER NOTE: | Inside HSA | Inside Well |
| DATE: | 12/7/15 | 12/15/15 |

SYMBOLS USED TO INDICATE TEST RESULTS
G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves
H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.75
**Last Calibration Date :** 8/2/2013
**Drill Rig Number :** S&ME ATV 550-2

**JOB: 7217-15-007B**

-CONTINUED-

# LOG OF BORING NO. MW-BAP-1
# BOTTOM ASH POND MONITORING WELL INSTALLATION
# CARDINAL PLANT, BRILLIANT, OH

S&ME

LOCATION: **N. 820,305, E. 2,513,927** ELEVATION: **669.8** DATE: **12/4/15 - 12/10/15**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **52.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

2010 NEW DEFAULT BORING LOG-W/ N60

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | $N_{60}$ | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX<br>NATURAL MOISTURE CONTENT<br>PLASTIC LIMIT — LIQUID LIMIT | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|---|
| | 30 | | | | | | | 10 20 30 40 | |
| **638.8** | | ▽ | | | | | | | |
| | | 19 | | SH/SH/SH 1 | 0 | 100 | Very-soft to medium-stiff brown, gray and dark-gray organic clayey silt, little fine sand, contains silt seams and lenses, contains seams of fine to coarse sand, wet. | | H=0.0-0.25 |
| | | 20 | | SH/SH/SH | 0 | 100 | | | H=0.0-0.75 |
| | 35 | | | | | | | | |
| | | 21 | | SH/SH/SH | 0 | 100 | | | H=0.0-0.75 |
| **630.7** | | 22A<br>22B<br>22C | | SH/SH/1 | 0 | 100 | | | H=1.0-1.5 |
| | | | | | | | Very-loose gray fine to coarse sand, interbedded with silty clay seams, wet. | | |
| | 40 | | | | | | | | |
| **628.8** | | | | | | | | | |
| | | 23 | | 1/2/3 | 6 | 60 | Loose brown fine to coarse sand, trace fine gravel, trace silt, wet. | | |
| **626.8** | | | | | | | Dense brown fine to coarse gravel, some to "and" fine to coarse sand, trace silt. | | |
| | 45 | | | | | | | | |
| | | 24 | | 13/17/23 | 50 | 47 | | | G |
| | | 25 | | 19/14/18 | 40 | 67 | | | |
| | 50 | | | | | | | | |
| **618.8** | | | | | | | | | |
| | | 26 | | 9/7/8 | 19 | 47 | Medium-dense brown fine to coarse sand, trace fine gravel, trace clay. | | |
| **617.3** | | | | | | | | | |
| | 55 | | | | | | - Encountered water at 31.0'.<br>- Encountered cobbles at 4.4 and 18.2'.<br>- Borehole converted to monitoring well upon completions. See separate well completion diagram.<br>- Boring locations and elevation surveyed by AEP.<br>- Datum: Ohio State Plane South.<br>- NAD 27/NAVD 29 (Plant Grid). | | |
| | 60 | | | | | | | | |

| | ▽ | ▼ |
|---|---|---|
| WATER LEVEL: | **31.0** | **27.5** |
| WATER NOTE: | **Inside HSA** | **Inside Well** |
| DATE: | **12/7/15** | **12/15/15** |

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.75
**Last Calibration Date :** 8/2/2013
**Drill Rig Number :** S&ME ATV 550-2

**JOB: 7217-15-007B**

**PLATE 4**

Page 1 of 2

# LOG OF BORING NO. MW-BAP-2
# BOTTOM ASH POND MONITORING WELL INSTALLATION
# CARDINAL PLANT, BRILLIANT, OH

S&ME

LOCATION: **N. 819,792, E. 2,513,707** ELEVATION: **669.9** DATE: **12/2/15 - 12/4/15**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **45.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT / PLASTIC LIMIT / LIQUID LIMIT (10, 20, 30, 40) | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | | | | | | AGGREGATE - 23 INCHES | | |
| 668.0 | | 1 | | 19/11/25 | 45 | 87 | | | |
| | | | | | | | FILL: Dense to very-dense dark-gray fine to coarse sand, trace to little fine gravel, trace to little silt, moist. | | |
| 666.3 | | 2 | | 25/33/30 | 79 | 47 | | | |
| | | | | | | | FILL: Stiff to hard brown and dark-brown silty clay, some to "and" fine to coarse sand, little to some fine to coarse gravel, few pockets of gravel, dry becoming damp. | | |
| | 5 | 3 | | 33/11/8 | 24 | 60 | | | H=2.0 |
| | | 4 | | 11/9/15 | 30 | 67 | | | H=4.5 |
| | | 5 | | 8/9/13 | 28 | 80 | | | |
| | | 6 | | 4/6/9 | 19 | 60 | | | |
| | 10 | 7 | | 7/5/5 | 13 | 87 | | | |
| | | 8 | | 4/10/8 | 23 | 80 | | | H=2.0-4.5 |
| | | 9 | | 2/8/3 | 14 | 53 | | | H=2.5 |
| 655.4 | | | | | | | FILL: Medium-stiff to very-stiff brown mottled with gray silty clay, some fine to coarse sand, little fine to coarse gravel, moist. | | |
| | 15 | 10 | | 3/6/5 | 14 | 67 | | | H=3.5 |
| | | 11 | | 2/3/4 | 9 | 87 | | | H=1.0-2.25 |
| | | 12 | | 3/3/5 | 10 | 67 | | | H=0.75-1.5 |
| 650.3 | | | | | | | FILL: Very-loose to loose dark-gray fine to coarse sand, trace to little fine gravel, little silt, moist becoming wet.<br>- Contains sand seams at 20.0' to 20.3'. | | |
| | 20 | 13 | | 3/3/4 | 9 | 87 | | | H=2.0 |
| | | 14 | | 3/4/3 | 9 | 67 | | | |
| | | 15 | | SH/SH/1 | 0 | 100 | | | |
| | | 16 | | SH/1/1 | 3 | 100 | | | |
| 644.7 | 25 | 17 | | 1/1/1 | 3 | 100 | FILL: Very-loose dark-gray silt, trace fine to coarse sand, slightly organic, wet. | | H=0.5 |
| 643.9 | | | | | | | Stiff gray mottled with brown silty clay, some fine sand, trace medium to coarse sand, slightly organic, silt seams, damp. | | |
| | | 18 | | SH/SH/3 | 0 | 53 | | | H=2.0 |
| 641.9 | | | | | | | Medium-stiff dark-gray organic clayey silt, little fine sand, damp. | | |
| | ▽ | 19 | | SH/SH/ | 0 | 100 | | | H=1.0 |
| | 30 | | | | | | | | |

WATER LEVEL: ▽ 29.2 ▼

WATER NOTE: Inside Well

DATE: 12/15/15

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio : 0.75**

**Last Calibration Date : 8/2/2013**

**Drill Rig Number : S&ME ATV 550-2**

**JOB: 7217-15-007B**

-CONTINUED-

**PLATE 5**

2010 NEW DEFAULT BORING LOG-W/ N60

# LOG OF BORING NO. MW-BAP-2
# BOTTOM ASH POND MONITORING WELL INSTALLATION
# CARDINAL PLANT, BRILLIANT, OH

LOCATION: **N. 819,792, E. 2,513,707** ELEVATION: **669.9** DATE: **12/2/15 - 12/4/15**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **45.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

2010 NEW DEFAULT BORING LOG-W/ N60

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX<br>NATURAL MOISTURE CONTENT<br>PLASTIC LIMIT — LIQUID LIMIT<br>10 20 30 40 | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|---|
| 639.4 | 30 | | | | | | | | |
| | | 20 | | SH 1/2/2 | 5 | 100 | Stiff gray mottled with brown silty clay, little fine sand, trace medium to coarse sand, slightly organic, damp. | | H=1.5 |
| 636.2 | | | | | | | | | |
| | | 21 | | 1/3/3 | 8 | 100 | Loose fine to coarse sand, trace fine gravel, little to some silt, slightly organic, moist. | | H=1.5 |
| 634.4 | 35 | | | | | | | | |
| | | 22 | | 1/4/4 | 10 | 53 | Loose brown fine to coarse sand, trace fine gravel, trace to little silt. | | |
| | | 23 | | 2/2/2 | 5 | 67 | | | G |
| | 40 | | | | | | | | |
| | | 24 | | 2/2/3 | 6 | 100 | | | |
| | | 25 | | 2/2/2 | 5 | 100 | | | |
| 624.9 | 45 | | | | | | | | |
| | 50 | | | | | | | | |
| | 55 | | | | | | | | |
| | 60 | | | | | | | | |

- Encountered water at 14.5'. to 16.0'.
- Borehole converted to monitoring well upon completion - See separate well completion digram.
- Boring location and elevation surveyed by AEP.
- Datum: Ohio State Plane South
- NAD 27/NAVD 29 (Plant Grid).

| | ∇ | ▼ |
|---|---|---|
| WATER LEVEL: | 29.2 | |
| WATER NOTE: | Inside Well | |
| DATE: | 12/15/15 | |

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

Drill Rod Energy Ratio : **0.75**
Last Calibration Date : **8/2/2013**
Drill Rig Number : **S&ME ATV 550-2**

Page 1 of 3

# LOG OF BORING NO. MW-BAP-3
# BOTTOM ASH POND MONITORING WELL INSTALLATION
# CARDINAL PLANT, BRILLIANT, OH

S&ME

LOCATION: **N. 819,111, E. 2,513,519** ELEVATION: **669.9** DATE: **11/11/15 - 11/12/15**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **55.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

2010 NEW DEFAULT BORING LOG-W/ N60

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | $N_{60}$ | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX<br>NATURAL MOISTURE CONTENT<br>PLASTIC LIMIT / LIQUID LIMIT<br>10 20 30 40 | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | | | | | | AGGREGATE - 12 INCHES | | |
| 668.9 | | | | | | | | | |
| | | 1 | | 20/12/10 | 28 | 87 | FILL: Medium-dense to dense gray and brown fine to coarse gravel, some to "and" fine to coarse sand, little to some silt or silty clay (variers), contains pockets of fine to coarse sand, dry. | | H=3.5 |
| | | 2 | | 10/13/18 | 39 | 80 | | | H=4.0 |
| | 5 | 3 | | 10/14/20 | 43 | 67 | | | |
| | | 4 | | 3/22/13 | 44 | 100 | | | |
| | | 5 | | 9/11/9 | 25 | 67 | | | |
| 661.4 | | | | | | | | | |
| | | 6 | | 3/10/13 | 29 | 100 | FILL: Hard gray and brown silty clay, some fine to coarse and, little fine to coarse gravel, damp. | | H=4.5+ |
| 659.9 | 10 | | | | | | | | |
| | | 7 | | 11/27/30 | 71 | 67 | FILL: Very-dense fine to coarse black and gray sand, some fine to coarse gravel, damp. | | |
| 658.4 | | | | | | | | | |
| | | 8 | | 6/6/9 | 19 | 100 | FILL: Very-stiff brown silty clay, some to "and" fine to coarse sand, some fine to coarse gravel, damp. | | H=3.5 |
| | | 9 | | 6/14/14 | 35 | 87 | | | H=3.5-4.0 |
| 655.4 | | | | | | | | | |
| | 15 | 10 | | 4/5/6 | 14 | 80 | FILL: Loose to medium-dense brown fine to coarse gravel, some to "and" fine to coarse sand, some silty clay, damp to moist. | | |
| | | 11 | | 6/6/5 | 14 | 80 | - Contains zones of hard silty clay at 16.0'. | | H=4.5 |
| | | 12 | | 2/4/6 | 13 | 93 | | | |
| | 20 | 13 | | 1/4/2 | 8 | 67 | | | |
| 649.4 | | | | | | | | | |
| | | 14 | | 2/3/4 | 9 | 53 | Medium-stiff to stiff brown clayey silt, "and" fine to coarse sand, some fine to coarse gravel, wet. | | H=1.0-2.0 |
| 647.3 | | 15A | | 2/2/3 | 6 | 100 | | | H=0.5 |
| | | 15B | | | | | Loose gray fine to medium sand, trace coarse sand, trace fine gravel, little silt, wet. | | |
| | | 16 | | 1/3/1 | 5 | 100 | | | |
| 644.4 | 25 | | | | | | | | |
| | | 17 | | 1/1/SH | 0 | 100 | Very-loose gray silt, little fine to medium sand, wet. | | |
| 641.9 | ▽ | | | | | | | | |
| | | 18 | | 1/2/ | 8 | 100 | Soft to stiff dark-brown mottled with dark-gray slithly organic to organic clayey silt, little to some fine to medium sand, contains silt seams, fine | | H=1.0-1.5 |
| | 30 | | | | | | | | |

| | ▽ | ▼ |
|---|---|---|
| WATER LEVEL: | 28.2 | |
| WATER NOTE: | Inside Well | |
| DATE: | 12/11/15 | |

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio : 0.75**
**Last Calibration Date : 8/2/2013**
**Drill Rig Number : S&ME ATV 550-2**

**JOB: 7217-15-007B**

-CONTINUED-

**PLATE 7**

# LOG OF BORING NO. MW-BAP-3
# BOTTOM ASH POND MONITORING WELL INSTALLATION
# CARDINAL PLANT, BRILLIANT, OH

S&ME

LOCATION: **N. 819,111, E. 2,513,519** ELEVATION: **669.9** DATE: **11/11/15 - 11/12/15**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **55.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX<br>NATURAL MOISTURE CONTENT<br>PLASTIC LIMIT<br>LIQUID LIMIT | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|---|
| | 30 | | | | | | sand seams and roots, wet. | 10 20 30 40 | |
| | | | | | | | Soft to stiff dark-brown mottled with dark-gray slithly organic to organic clayey silt, little to some fine to medium sand, contains silt seams, fine sand seams and roots, wet. | | |
| | | 19 | | 1/2/2 4 | 5 | 100 | | | |
| | | 20 | | SH/2/1 | 4 | 100 | | | |
| 634.4 | 35 | | | | | | | | |
| | | | | | | | Soft to medium-stiff dark-brown mottled with gray slightly organic to organic clayey silt, some to "and" fine to medium sand, wet. | | |
| | | 21 | | SH/2/1 | 4 | 100 | | | |
| | | 22 | | SH/1/2 | 4 | 100 | | | |
| 629.4 | 40 | | | | | | | | |
| | | | | | | | Soft to medium-stiff gray mottled with brown silty clay, trace to some fine to coarse sand, slightly organic, contains fine sand seams, wet. | | |
| | | 23 | | SH/2/1 | 4 | 100 | | | |
| | | 24 | | SH/4/7 | 14 | 100 | | | |
| 624.9 | 45 | | | | | | | | |
| | | | | | | | Medium-dense to very-dense brown fine to coarse gravel, some to "and" fine to coarse sand, trace to little silt, wet.<br>- Contains zones of fine to coarse sand at 49.0'. | | |
| | | 25 | | 6/11/17 | 35 | 80 | | | |
| | | 26 | | 22/35/25 | 75 | 53 | | | G |
| | 50 | | | | | | | | |
| | | 27 | | 21/8/8 | 20 | 33 | | | |
| 614.9 | 55 | | | | | | | | |
| | | | | | | | - Encountered seepage at 16.0'.<br>- Encountered water at 20.5'.<br>- Borehole converted to monitoring well upon completion - See separate well completion diagram.<br>- Datum: Ohio State Plane South. NAD | | |
| | 60 | | | | | | | | |

| | ▽ | ▼ |
|---|---|---|
| WATER LEVEL: | 28.2 | |
| WATER NOTE: | Inside Well | |
| DATE: | 12/11/15 | |

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.75
**Last Calibration Date :** 8/2/2013
**Drill Rig Number :** S&ME ATV 550-2

2010 NEW DEFAULT BORING LOG-W/ N60

# LOG OF BORING NO. MW-BAP-3
# BOTTOM ASH POND MONITORING WELL INSTALLATION
# CARDINAL PLANT, BRILLIANT, OH

LOCATION: **N. 819,111, E. 2,513,519** ELEVATION: **669.9** DATE: **11/11/15 - 11/12/15**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **55.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | $N_{60}$ | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX<br>NATURAL MOISTURE CONTENT<br>PLASTIC LIMIT — LIQUID LIMIT<br>10 20 30 40 | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|---|
| | 60 | | | | | | 27/NAVD 29 (Plant Grid). | | |
| | 65 | | | | | | | | |
| | 70 | | | | | | | | |
| | 75 | | | | | | | | |
| | 80 | | | | | | | | |
| | 85 | | | | | | | | |
| | 90 | | | | | | | | |

2010 NEW DEFAULT BORING LOG-W/ N60

WATER LEVEL: ▽ 28.2 ▼

WATER NOTE: Inside Well

DATE: 12/11/15

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.75

**Last Calibration Date :** 8/2/2013

**Drill Rig Number :** S&ME ATV 550-2

# LOG OF BORING NO. MW-BAP-4
# BOTTOM ASH POND MONITORING WELL INSTALLATION
# CARDINAL PLANT, BRILLIANT, OH

S&ME

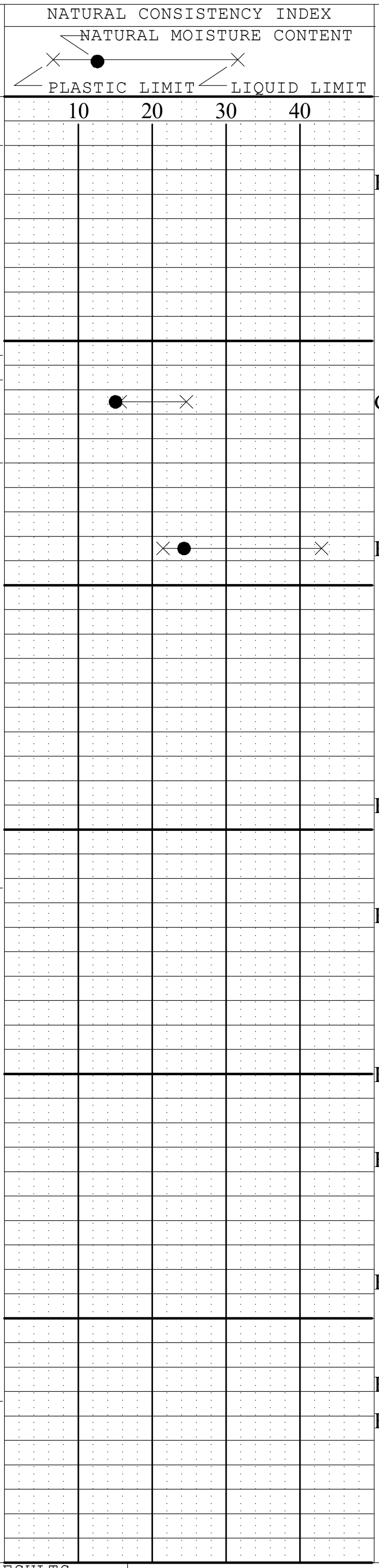
LOCATION: **N. 820,880, E. 2,513,617** ELEVATION: **661.1** DATE: **11/20/15 - 11/23/15**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **40.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

2010 NEW DEFAULT BORING LOG-W/ N60

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE EFFORT | $N_{60}$ | SAMPLE REC-% | DESCRIPTION | TEST RESULTS |
|---|---|---|---|---|---|---|---|
| | 0 | | | | | AGGREGATE - 12 INCHES | |
| **660.1** | | | | | | FILL: Medium-dense to dense gray and brown fine to coarse gravel, some to "and" fine to coarse sand, little to some silt, dry. | |
| | | 1 | 4/15/16 | 39 | 87 | | H=4.25-4.5 |
| | | 2 | 10/9/5 | 18 | 53 | | |
| | 5 | 3 | 6/9/7 | 20 | 67 | | |
| **655.8** | | | | | | FILL: Very-soft brown and gray silty clay, "and" fine to coarse sand, little fine to coarse gravel. | |
| **655.3** | | 4 | 35/13/12 | 31 | 87 | FILL: Dense brown fine to coarse sand, little fine to coarse gravel, "and" clayey silt, cobbles, moist. | G |
| | | 5 | 50-3"R | | 20 | | |
| **653.6** | | | | | | Stiff to very-stiff dark-brown mottled with dark-gray silty clay, little fine to coarse sand, trace fine gravel, slightly organic, damp. | |
| | | 6 | 2/3/4 | 9 | 87 | | H=2.0-3.0 |
| | 10 | | | | | | |
| | 15 | | P | | | | H=1.25-2.5 |
| **644.9** | | | | | | Very-stiff brown mottled with gray silty clay, little fine to medium sand, trace coarse sand, few cobbles, contains silt seams near top of stratum, damp. | |
| | | 7 | 3/5/6 | 14 | 87 | | H=2.0-3.5 |
| | 20 | 8<br>2S | 7/7/7/10 | 18 | 100 | | H=2.25-3.25 |
| | | 9 | 3/5/6 | 14 | 100 | | H=3.0 |
| | 25 | 10 | 3/5/6 | 14 | 100 | | H=3.25 |
| **634.4** | | 11A | 1/3/4 | 9 | 100 | | H=2.5 |
| | | 11B | | | | Medium-stiff to stiff brown clayey silt, "and" fine to medium sand, trace coarse sand, includes sand seams, moist. | H=0.5-1.5 |
| | 30 | 12 | 1/2/ | 4 | 100 | | |



WATER LEVEL: ▽ **18.7** ▼

WATER NOTE: **Inside Well**

DATE: **12/15/15**

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio : 0.75**
**Last Calibration Date : 8/2/2013**
**Drill Rig Number : S&ME ATV 550-2**

**JOB: 7217-15-007B**

-CONTINUED-

# LOG OF BORING NO. MW-BAP-4
# BOTTOM ASH POND MONITORING WELL INSTALLATION
# CARDINAL PLANT, BRILLIANT, OH

S&ME

LOCATION: **N. 820,880, E. 2,513,617** ELEVATION: **661.1** DATE: **11/20/15 - 11/23/15**
DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **40.0'**
SAMPLER(S): **2" O.D. Split-barrel Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX<br>NATURAL MOISTURE CONTENT<br>PLASTIC LIMIT — LIQUID LIMIT<br>10 20 30 40 | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|---|
| 630.6 | 30 | | | | | | Medium-stiff to stiff brown clayey silt, "and" fine to medium sand, trace coarse sand, includes sand seams, moist. | | |
| | | 13 | ■ | SH/SH/1 1 | 0 | 100 | Very-loose brown and gray fine to medium sand, little to "and" silt (percent varies), contains zones with a trace of coarse sand, wet. | | G |
| | | 14 | ■ | SH/SH/1 | 0 | 67 | | | |
| | 35 | | | | | | | | |
| | | 15 | ■ | SH/1/1 | 3 | 67 | | | |
| | | 16 | ■ | SH/SH/1 | 0 | 100 | | | G |
| 621.1 | 40 | | | | | | | | |
| | 45 | | | | | | | | |
| | 50 | | | | | | | | |
| | 55 | | | | | | | | |
| | 60 | | | | | | | | |

- Encountered water at 5.5'.
- Encountered cobbles at 18.5'.
- Borehole converted to monitoring well upon completion - See separate well completion diagram.
- Boring location and elevation surveyed by AEP.
- Datum: Ohio State Plane South, NAD 27/NAVD 29 (Plant Grid).

| | ▽ | ▼ |
|---|---|---|
| WATER LEVEL: | 18.7 | |
| WATER NOTE: | Inside Well | |
| DATE: | 12/15/15 | |

SYMBOLS USED TO INDICATE TEST RESULTS
G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves
H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio : 0.75**
**Last Calibration Date : 8/2/2013**
**Drill Rig Number : S&ME ATV 550-2**

# LOG OF BORING NO. MW-BAP-5
# BOTTOM ASH POND MONITORING WELL INSTALLATION
# CARDINAL PLANT, BRILLIANT, OH

S&ME

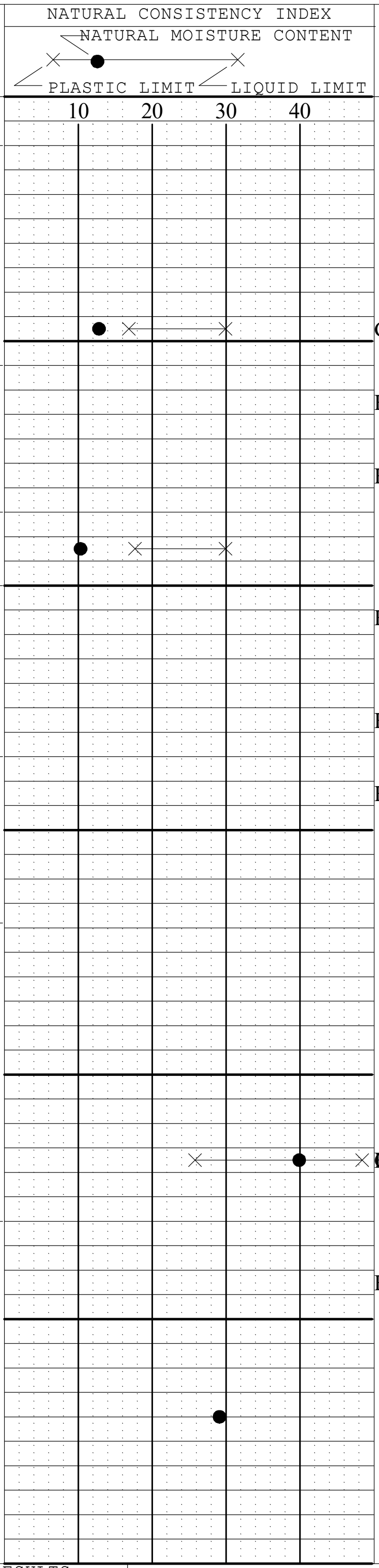
LOCATION: **N. 820,052, E. 2,513,277** ELEVATION: **669.2** DATE: **11/24/15 - 11/25/15**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **62.5'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

2010 NEW DEFAULT BORING LOG-W/ N60

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | TEST RESULTS |
|---|---|---|---|---|---|---|---|
| | 0 | | | | | AGGREGATE - 12 INCHES | |
| 668.2 | | | | | | FILL: Medium-dense brown fine to coarse sand, some fine to coarse gravel, some to "and" silty clay, dry. | |
| | | 1 | 6/8/11 | 24 | 60 | | |
| | | 2 | 16/5/5 | 13 | 60 | | |
| | 5 | 3 | 4/4/6 | 13 | 73 | | G |
| 663.7 | | | | | | FILL: Hard gray and brown silty clay, "and" fine to coarse sand, little to some fine to coarse gravel, damp. | |
| | | 4 | 5/9/32 | 51 | 87 | | H=4.5 |
| | | 5 | 16/15/16 | 39 | 80 | | H=4.5 |
| 660.7 | | | | | | FILL: Medium-dense brown and gray fine to coarse sand, little fine to coarse gravel, some silty clay, damp. | |
| | | 6 | 10/13/11 | 30 | 87 | | |
| 659.2 | 10 | | | | | FILL: Hard brown silty clay, some fine to coarse sand, some fine to coarse gravel (shale fragments), damp. | |
| | | | P | | | | H=4.5 |
| | | 7 | 3/5/10 | 19 | 80 | | H=4.5 |
| 655.7 | | | | | | FILL: Medium-dense to dense brown fine to coarse gravel, some fine to coarse sand, some silty clay becoming trace silt at bottom of stratum, damp. | |
| | | 8 | 10/11/25 | 45 | 80 | | H=3.0 |
| | 15 | | | | | | |
| | | 9 | 11/7/6 | 16 | | | |
| 652.3 | | 10A | 4/6/10 | 20 | 100 | Medium-stiff to stiff gray mottled with dark-gray and brown silty clay, trace fine to coarse sand, trace fine gravel, few roots, few silt seams, slightly organic, moist. | |
| | | 10B | | | | | |
| | | | P | | | | |
| | 20 | | | | | | |
| | | 11 | SH/1/3 | 5 | 100 | | G H=0.5-1.25 |
| 646.2 | | | | | | Medium-stiff to very-stiff brown mottled with gray silty clay, trace to little fine to coarse sand, damp. | |
| | | 12 | 2/2/4 | 8 | 100 | | H=3.5 |
| | 25 | | | | | | |
| | ▽ | | P | | | | |
| | | | P | | | | |
| | 30 | | | | | | |



WATER LEVEL: ▽ **27.1** ▼

WATER NOTE: **Inside Well**

DATE: **12/15/15**

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio : 0.75**
**Last Calibration Date : 8/2/2013**
**Drill Rig Number : S&ME ATV 550-2**

-CONTINUED-

# LOG OF BORING NO. MW-BAP-5
# BOTTOM ASH POND MONITORING WELL INSTALLATION
# CARDINAL PLANT, BRILLIANT, OH

LOCATION: **N. 820,052, E. 2,513,277** ELEVATION: **669.2** DATE: **11/24/15 - 11/25/15**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **62.5'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT ● / PLASTIC LIMIT × LIQUID LIMIT × (10 20 30 40) | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|
| | 30 | | | | | Medium-stiff to very-stiff brown mottled with gray silty clay, trace to little fine to coarse sand, damp. | | |
| | | 13 | 2/4/6 | 13 | 100 | | | H=2.0-3.5 |
| | | 14 | 3/4/5 | 11 | 100 | | | H=2.5-3.0 |
| | 35 | | | | | | | |
| | | 15 | 2/5/6 | 14 | 100 | | | H=2.5 |
| | | 16 | 2/3/5 | 10 | 100 | | | H=2.5 |
| | 40 | | | | | | | |
| | | 17 | SH/2/3 | 6 | 100 | | ● | H=1.25 |
| | | 18 | SH/SH/SH | 0 | 100 | | | H=1.25 |
| | 45 | | | | | | | |
| 623.7 | | | | | | Stiff gray mottled with brown and dark-gray silty clay, trace fine to coarse sand, slightly organic, damp. | | |
| | | 19 | SH/SH/1 | 0 | 100 | | | H=0.75 |
| 621.2 | | | | | | Medium-stiff to stiff gray and dark-gray organic clayey silt, trace fine to coarse sand, damp. | | |
| | | 20 | SH/SH/SH | 0 | 100 | | | H=0.75-1.25 |
| | 50 | | | | | | | |
| 618.7 | | | | | | Medium-dense to dense fine to coarse gravel, some to "and" fine to coarse sand, trace to little silt, wet. | | |
| | | 21 | 6/9/9 | 23 | 87 | | | G |
| | | 22 | 8/21/34 | 69 | 87 | | | |
| | 55 | | | | | | | |
| 613.8 | | | | | | Medium-dense to dense gray and brown fine to coarse sand, "and" fine to coarse gravel, little silt, wet. | | |
| | | 23 | 14/20/14 | 43 | 80 | | | |
| | | 24 | 7/12/ | 35 | 60 | | | G |
| | 60 | | | | | | | |

WATER LEVEL: ▽ 27.1 ▼

WATER NOTE: Inside Well

DATE: 12/15/15

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.75

**Last Calibration Date :** 8/2/2013

**Drill Rig Number :** S&ME ATV 550-2

-CONTINUED-

# LOG OF BORING NO. MW-BAP-5
# BOTTOM ASH POND MONITORING WELL INSTALLATION
# CARDINAL PLANT, BRILLIANT, OH

LOCATION: **N. 820,052, E. 2,513,277** ELEVATION: **669.2** DATE: **11/24/15 - 11/25/15**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **62.5'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | $N_{60}$ | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX<br>NATURAL MOISTURE CONTENT<br>PLASTIC LIMIT — LIQUID LIMIT<br>10 20 30 40 | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|---|
| | 60 | 25 | ■ | 8 16<br>/ 4 /<br>5 | 11 | 60 | Medium-dense to dense gray and brown fine to coarse sand, "and" fine to coarse gravel, little silt, wet. | | |
| **606.7** | | | | | | | - Encountered water at 17.0'.<br>- Borehole converted to monitoring well upon completion. See separate well completion diagram.<br>- Boring location and elevation surveyed by AEP.<br>- Datum: Ohio State Plane South NAD 27/NAVD 29 (Plant Grid). | | |
| | 65 | | | | | | | | |
| | 70 | | | | | | | | |
| | 75 | | | | | | | | |
| | 80 | | | | | | | | |
| | 85 | | | | | | | | |
| | 90 | | | | | | | | |

2010 NEW DEFAULT BORING LOG-W/ N60

| | ▽ | ▼ |
|---|---|---|
| WATER LEVEL: | 27.1 | |
| WATER NOTE: | Inside Well | |
| DATE: | 12/15/15 | |

SYMBOLS USED TO INDICATE TEST RESULTS

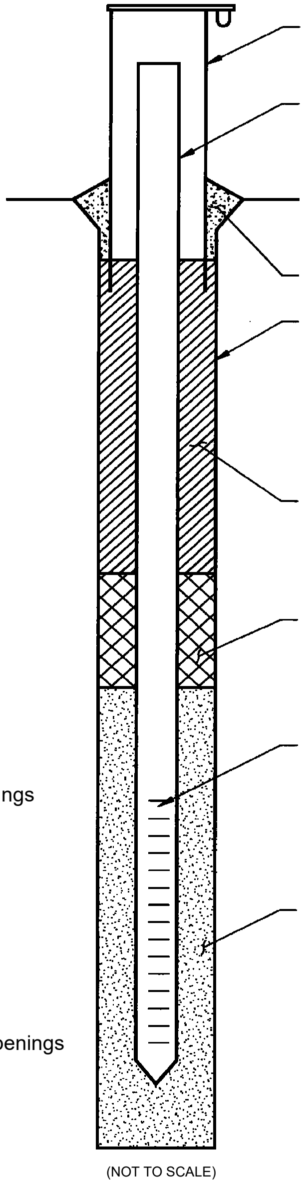
G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio : 0.75**
**Last Calibration Date : 8/2/2013**
**Drill Rig Number : S&ME ATV 550-2**

S&ME

| Elevation (Feet above MSL) | Depth Below Ground Surface (Feet) | |
|---|---|---|
| **672.65** | **-2.86** | Top of Cover |
| **672.29** | **-2.50** | Top of PVC |
| **669.79** | **0.0** | Ground Surface |
| **667.2** | **2.6** | Top of Grout |
| **638.9** | **30.9** | Top of Bentonite |
| **632.2** | **37.6** | Top of Filter Pack |
| **628.2** | **41.6** | Top of Screen Openings |
| **618.4** | **51.4** | Bottom of Screen Openings |
| **617.8** | **52.0** | Bottom of Well |
| **617.8** | **52.0** | Bottom of Boring |


(NOT TO SCALE)

**4** - Inch Diameter Protective Steel Casing

**2** - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)

**8** " **0.0** to **52.0**

" to

" to

Grout: **Portland & Quick Gel**

Bentonite Seal: **3 - 5 gallon buckets (15 gal.) bentonite pellets**

**10** - Slot Screen

Filter Pack: **4 - 50 lb bags (200 lb.) #5 quartz sand**

| | | | | | |
|---|---|---|---|---|---|
| Depth to Static Water: | 28.7 | 27.5 | | | |
| Static Water Elevation: | 638.6 | 639.8 | | | |
| Date: | **12/11/15** | **12/15/15** | | | |

Well Development:

12/10 - Bailed 175 gallons of water (approx. 41 well volumes) via submersible pump. Water level stayed steady during pumping. NTU = 7 at 155 gallons, but increased to NTU = 12 upon terminating pump. Bailed additional 20 gallons during which initial NTU readings were intially high but decreased to NTU = 25.4.
-Water level measurement on 12/15 was immediately before slug testing.
-Top cover set in 3'x3' concrete pad. Protective steel bollards placed around concrete pad.

Water Quality Readings (Horiba U-52)

| Cumulative Gallons | NTU | C | ms/cm | PH | ORPmV |
|---|---|---|---|---|---|
| 175 | 25.4 | 18.09 | 1.31 | 7.15 | -6 |

Location: N. 820,305.3' E. 2,513,927.4' Datum: NAD27/NGVD29 OH S

## WELL COMPLETION DIAGRAM

**Project Name:**
AEP CD Bottom Ash Pond Monitoring Wells

**Project Location:**
Cardinal Plant / Brilliant, Ohio

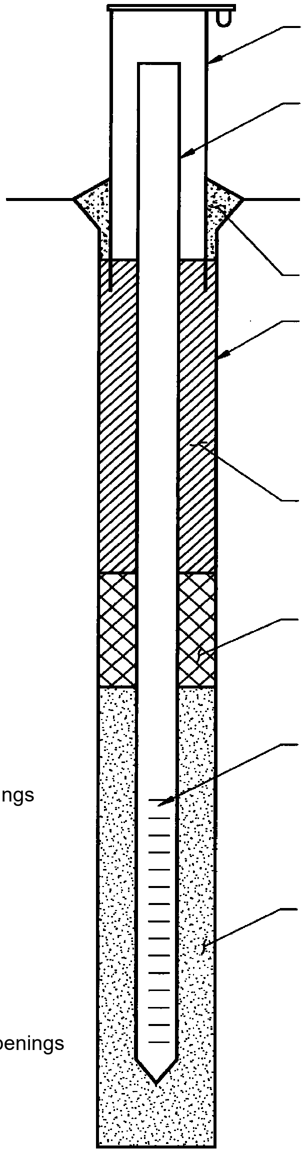
**Project Number:**
7217-15-007A

**Boring Number:**
MW-BAP-1

**Date Well Installed:**
12/10/2015

S&ME

| Elevation (Feet above MSL) | Depth Below Ground Surface (Feet) | |
|---|---|---|
| **673.47** | **-3.55** | Top of Cover |
| **673.24** | **-3.32** | Top of PVC |
| **669.92** | **0.0** | Ground Surface |
| **667.3** | **2.7** | Top of Grout |
| **644.2** | **25.7** | Top of Bentonite |
| **638.2** | **31.7** | Top of Filter Pack |
| **635.8** | **34.1** | Top of Screen Openings |
| **626.0** | **43.9** | Bottom of Screen Openings |
| **625.4** | **44.5** | Bottom of Well |
| **624.9** | **45.0** | Bottom of Boring |


(NOT TO SCALE)

**4** - Inch Diameter Protective Steel Casing

**2** - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)

| | | | | |
|---|---|---|---|---|
| **8** | " | **0.0** | to | **44.5** |
| | " | | to | |
| | " | | to | |

Grout: **Portland & Quick Gel**

Bentonite Seal: **3 - 5 gallon buckets (15 gal.) bentonite pellets**

**10** - Slot Screen

Filter Pack: **9 - 50 lb. bags (450 lb.) #5 quartz sand**

| | | | | | |
|---|---|---|---|---|---|
| Depth to Static Water: | 29.5 | 29.2 | | | |
| Static Water Elevation: | 637.2 | 637.4 | | | |
| Date: | **12/11/15** | **12/15/15** | | | |

Well Development:

12/10 - Bailed 60 gallons of water (approx. 20 well volumes) out of well via submersible pump, water level stayed steady.
-Water level measurement on 12/15 was immediately before slug testing.
-Top cover set in 3'x3' concrete pad. Protective steel bollards placed around concrete pad.

Water Quality Readings (Horiba U-52)

| Cumulative Gallons | NTU | C | ms/cm | PH | ORPmV |
|---|---|---|---|---|---|
| 60 | 0 | 17.25 | 0.99 | 6.97 | 47 |

*Note: NTU readings were variable, water appeared visibly clear

Location: N. 819,792.3' E. 2,513,707.1'
Datum: NAD27/NGVD29 OH S

## WELL COMPLETION DIAGRAM

**Project Name:**
AEP CD Bottom Ash Pond Monitoring Wells

**Project Location:**
Cardinal Plant / Brilliant, Ohio

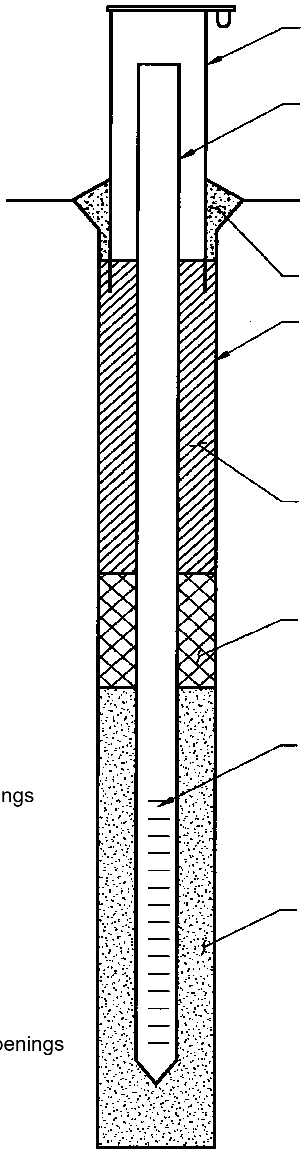
**Project Number:**
7217-15-007A

**Boring Number:**
MW-BAP-2

**Date Well Installed:**
12/2/2015

S&ME

| Elevation (Feet above MSL) | Depth Below Ground Surface (Feet) | |
|---|---|---|
| **673.26** | **-3.33** | Top of Cover |
| **672.84** | **-2.91** | Top of PVC |
| **669.93** | **0.0** | Ground Surface |
| **667.4** | **2.5** | Top of Grout |
| **632.5** | **37.4** | Top of Bentonite |
| **626.5** | **43.4** | Top of Filter Pack |
| **624.5** | **45.4** | Top of Screen Openings |
| **614.5** | **55.4** | Bottom of Screen Openings |
| **613.9** | **56.0** | Bottom of Well |
| **613.9** | **56.0** | Bottom of Boring |


(NOT TO SCALE)

**4** - Inch Diameter Protective Steel Casing

**2** - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)

**8** " **0.0** to **56.0**

" to

" to

Grout: **Portland & Quick Gel**

Bentonite Seal: **3 - 5 gallon buckets (15 gal.) bentonite pellets**

**10** - Slot Screen

Filter Pack: **5 - 50 lb. bags (250 lb.) #5 quartz sand**

| | | | | | |
|---|---|---|---|---|---|
| Depth to Static Water: | 28.2 | 28.0 | 28.2 | | |
| Static Water Elevation: | 638.8 | 639.1 | 638.8 | | |
| Date: | **11/29/15** | **12/8/15** | **12/11/15** | | |

Well Development:

11/17 - Bailed 62.5 gallons of water (approx. 15 well volumes) out of well via submersible pump, water level stayed steady.
-Water level measurement on 12/8 was immediately before slug testing.
-Top cover set in 3'x3' concrete pad. Protective steel bollards placed around concrete pad.

Water Quality Readings (Horiba U-52)

| Cumulative Gallons | NTU | C | ms/cm | PH | ORPmV |
|---|---|---|---|---|---|
| 62.5 | 4.7 | 18.09 | 0.7 | 6.92 | 50 |

Location: N. 819,112.0' E. 2,513,519.4'
Datum: NAD27/NGVD29 OH S

## WELL COMPLETION DIAGRAM

**Project Name:**
AEP CD Bottom Ash Pond Monitoring Wells

**Project Location:**
Cardinal Plant / Brilliant, Ohio

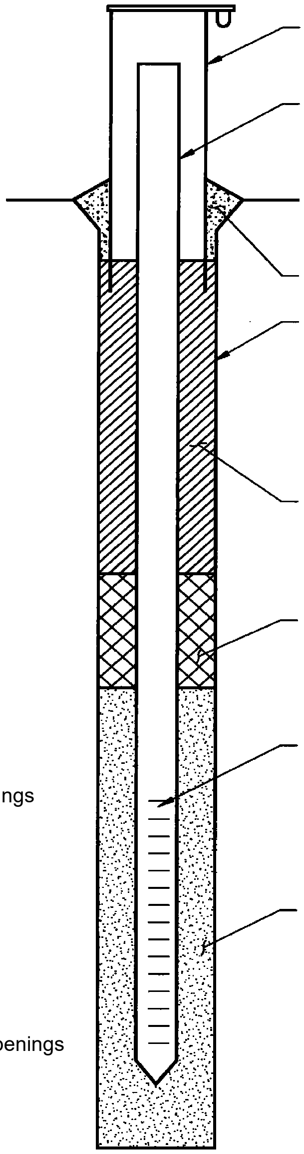
**Project Number:**
7217-15-007A

**Boring Number:**
MW-BAP-3

**Date Well Installed:**
11/13/2015

S&ME

| Elevation (Feet above MSL) | Depth Below Ground Surface (Feet) | |
|---|---|---|
| **663.80** | **-2.75** | Top of Cover |
| **663.54** | **-2.49** | Top of PVC |
| **661.05** | **0.0** | Ground Surface |
| **658.4** | **2.7** | Top of Grout |
| **639.5** | **21.6** | Top of Bentonite |
| **634.2** | **26.9** | Top of Filter Pack |
| **632.2** | **28.9** | Top of Screen Openings |
| **622.4** | **38.7** | Bottom of Screen Openings |
| **621.8** | **39.3** | Bottom of Well |
| **621.1** | **40.0** | Bottom of Boring |



(NOT TO SCALE)

**4** - Inch Diameter Protective Steel Casing

**2** - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)

**8** " **0.0** to **39.3**

" to

" to

Grout: **Portland & Quick Gel**

Bentonite Seal: **3 - 5 gallon buckets (15 gal.) bentonite pellets**

**10** - Slot Screen

Filter Pack: **7 - 50 lb. bags (350 lb.) #5 quartz sand**

| | | | | | |
|---|---|---|---|---|---|
| Depth to Static Water: | 18.8 | 18.7 | | | |
| Static Water Elevation: | 639.8 | 639.9 | | | |
| Date: | **12/11/15** | **12/15/15** | | | |

Well Development:

12/3 - Bailed 67.5 gallons of water (approx. 18 well volumes) out of well via submersible pump, water level stayed steady.
-Measurement on 12/15 was immediately before slug testing.
-Top cover set in 3'x3' concrete pad. Protective steel bollards placed around concrete pad.

Water Quality Readings (Horiba U-52)

| Cumulative Gallons | NTU | C | ms/cm | PH | ORPmV |
|---|---|---|---|---|---|
| 67.5 | 8.8 | 16.7 | 1.78 | 6.36 | -7 |

Location: N. 820,879.5' E. 2,513,616.9'
Datum: NAD27/NGVD29 OH S

## WELL COMPLETION DIAGRAM

**Project Name:**
AEP CD Bottom Ash Pond Monitoring Wells

**Project Location:**
Cardinal Plant / Brilliant, Ohio

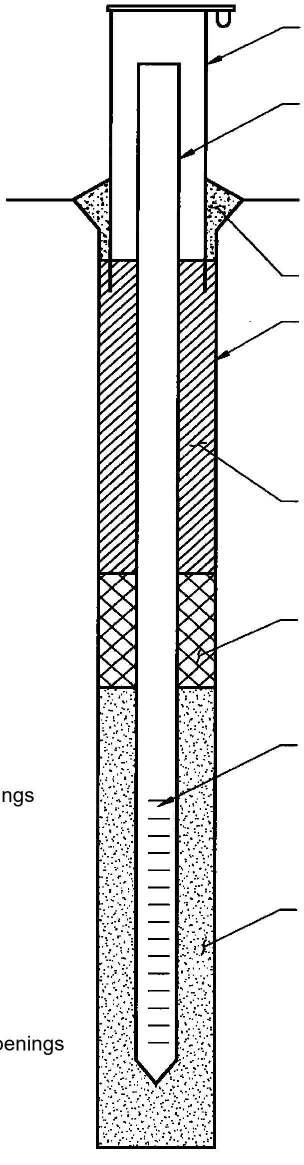
**Project Number:**
7217-15-007A

**Boring Number:**
MW-BAP-4

**Date Well Installed:**
11/23/2015

S&ME

| Elevation (Feet above MSL) | Depth Below Ground Surface (Feet) | |
|---|---|---|
| **672.28** | **-3.10** | Top of Cover |
| **672.00** | **-2.82** | Top of PVC |
| **669.18** | **0.0** | Ground Surface |
| **662.6** | **6.6** | Top of Grout |
| **625.0** | **44.2** | Top of Bentonite |
| **619.5** | **49.7** | Top of Filter Pack |
| **617.5** | **51.7** | Top of Screen Openings |
| **607.7** | **61.5** | Bottom of Screen Openings |
| **607.1** | **62.1** | Bottom of Well |
| **606.7** | **62.5** | Bottom of Boring |


(NOT TO SCALE)

**4** - Inch Diameter Protective Steel Casing

**2** - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)

| | | | |
|---|---|---|---|
| **8** " | **0.0** | to | **62.1** |
| " | | to | |
| " | | to | |

Grout: **Portland & Quick Gel**

Bentonite Seal: **3 - 5 gallon buckets (15 gal.) bentonite pellets**

**10** - Slot Screen

Filter Pack: **7 - 50 lb. bags (350 lb.) #5 quartz sand**

| | | | | | |
|---|---|---|---|---|---|
| Depth to Static Water: | 27.3 | 27.6 | 27.2 | 27.1 | |
| Static Water Elevation: | 639.1 | 638.8 | 639.2 | 639.2 | |
| Date: | **11/29/15** | **12/7/15** | **12/11/15** | **12/15/15** | |

Well Development:

12/10 - Bailed 61.5 gallons of water (approx. 13 well volumes) out of well via submersible pump, water level stayed steady.
-Measurement on 12/15 was immediately before slug testing.
-Top cover set in 3'x3' concrete pad. Protective steel bollards placed around concrete pad.

Water Quality Readings (Horiba U-52)

| Cumulative Gallons | NTU | C | ms/cm | PH | ORPmV |
|---|---|---|---|---|---|
| 61.5 | 24.3 | 15.08 | 1.46 | 6.86 | -56 |

Location: N. 820,052.1' E. 2,513,277.5'
Datum: NAD27/NGVD29 OH S

## WELL COMPLETION DIAGRAM

**Project Name:**
AEP CD Bottom Ash Pond Monitoring Wells

**Project Location:**
Cardinal Plant / Brilliant, Ohio

**Project Number:**
7217-15-007A

**Boring Number:**
MW-BAP-5

**Date Well Installed:**
11/25/2015

# 40 CFR 257.101 (f)(1)(iv)(B)(2)(iii)

## Maps that characterize the direction of groundwater flow accounting for seasonal variations

Legend

- ⯐ Groundwater Monitoring Well
- ➞ Approximate Groundwater Flow Direction
- — Groundwater Elevation Contour

Notes

- Monitoring well coordinates and water level data (collected from June 21 to June 22, 2016) provided by AEP.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Bottom Ash Pond (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.

250 125 0 250 Feet

Potentiometric Surface Map - Uppermost Aquifer
Bottom Ash Complex
June 2016

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec
consultants

Figure
1

Columbus, Ohio
2017/08/16

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Legend

- ⊕ Groundwater Monitoring Well
- → Approximate Groundwater Flow Direction
- — Groundwater Elevation Contour

Notes

- Monitoring well coordinates and water level data (collected from October 3 to October 4, 2016) provided by AEP.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Bottom Ash Pond (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.

250 125 0 250
Feet

Potentiometric Surface Map - Uppermost Aquifer
Bottom Ash Complex
October 2016

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec
consultants

Columbus, Ohio
2017/08/16

Figure
3

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Legend

- ⯐ Groundwater Monitoring Well
- ➞ Approximate Groundwater Flow Direction
- — Groundwater Elevation Contour

Notes

- Monitoring well coordinates and water level data (collected on November 14, 2016) provided by AEP.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Bottom Ash Pond (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.

### Potentiometric Surface Map - Uppermost Aquifer
### Bottom Ash Complex
### November 2016

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec
consultants

Columbus, Ohio | 2017/08/16

Figure
4

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Legend

⊕ Groundwater Monitoring Well

→ Approximate Groundwater Flow Direction

— Groundwater Elevation Contour

Notes

- Monitoring well coordinates and water level data (collected on January 9, 2016) provided by AEP.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Bottom Ash Pond (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.

250 125 0 250 Feet

Potentiometric Surface Map - Uppermost Aquifer
Bottom Ash Complex
January 2017

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio

2017/08/16

Figure

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Legend

- ⯐ Groundwater Monitoring Well
- ➔ Approximate Groundwater Flow Direction
- — Groundwater Elevation Contour

Notes

- Monitoring well coordinates and water level data (collected on February 8, 2017) provided by AEP.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Bottom Ash Pond (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.

250 125 0 250 Feet

## Potentiometric Surface Map - Uppermost Aquifer
## Bottom Ash Complex
## February 2017

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec
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Columbus, Ohio
2017/08/16

Figure
7

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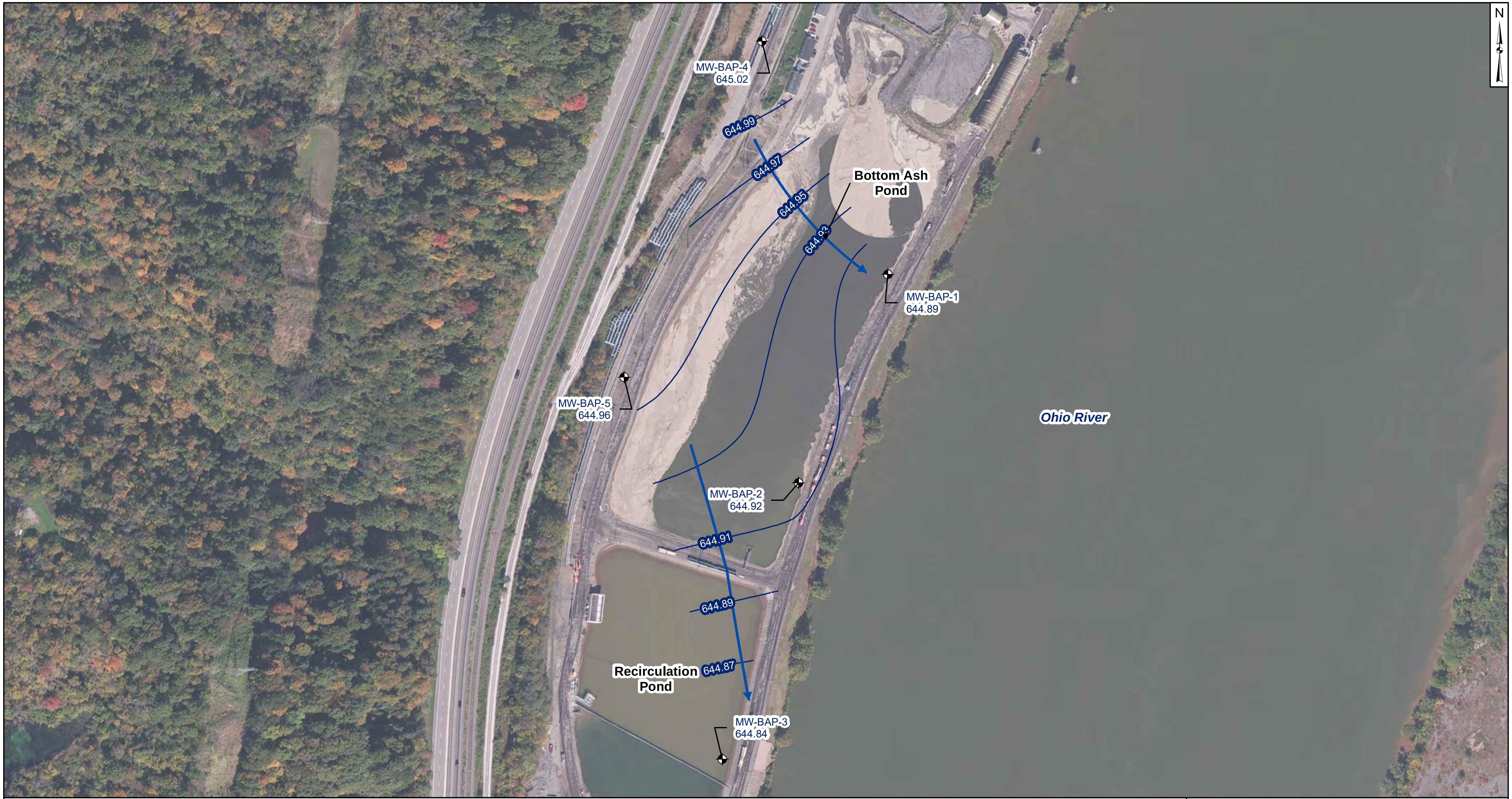

Legend

⊕ Groundwater Monitoring Well

→ Approximate Groundwater Flow Direction

— Groundwater Elevation Contour

Notes

- Monitoring well coordinates and water level data (collected on April 10, 2017) provided by AEP.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Bottom Ash Pond (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.

250 125 0 250
Feet

# Potentiometric Surface Map - Uppermost Aquifer
Bottom Ash Complex
April 2017

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec
consultants

Figure
8

| | |
|---|---|
| Columbus, Ohio | 2017/08/23 |

Legend

- ⊕ Groundwater Monitoring Well
- → Approximate Groundwater Flow Direction
- — Groundwater Elevation Contour

Notes
- Monitoring well coordinates and water level data (collected on May 23, 2017) provided by AEP.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Bottom Ash Pond (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.

250 125 0 250 Feet

Potentiometric Surface Map - Uppermost Aquifer
Bottom Ash Complex
May 2017

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio

2017/08/23

Figure

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Legend
- ⯐ Groundwater Monitoring Well
- — Groundwater Elevation Contour
- → Approximate Groundwater Flow Direction

Notes
- Monitoring well coordinates and water level data (collected on July 25, 2017) provided by AEP.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Bottom Ash Pond (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.

## Potentiometric Surface Map - Uppermost Aquifer
Bottom Ash Complex
July 2017

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec
consultants

Columbus, Ohio
2017/08/16

Figure
11

# 40 CFR 257.101 (f)(1)(iv)(B)(3)

Constituent concentrations, summarized in table form, at each groundwater monitoring well monitored during each sampling event

# Table 1: Groundwater Data Summary
## Cardinal Plant - Bottom Ash Pond

| Parameter | Unit | MW-BAP-1 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1/12/2017 | 10/20/2016 | 5/3/2017 | 5/31/2017 | 6/20/2017 | 6/28/2016 | 8/1/2017 | 8/10/2016 | 9/26/2017 |
| | | Background | | | | | | | | Detection |
| Antimony | µg/L | 0.06 | 0.08 | 0.07 | 0.04J | 0.04J | 0.07 | 0.03J | 0.08 | - |
| Arsenic | µg/L | 1.13 | 1.6 | 1.56 | 0.78 | 0.53 | 1.45 | 0.4 | 1.05 | - |
| Barium | µg/L | 86.5 | 107 | 85.3 | 72.6 | 63.6 | 93.6 | 61.5 | 107 | - |
| Beryllium | µg/L | 0.043 | 0.06 | 0.061 | 0.03 | 0.01J | 0.072 | 0.01J | 0.037 | - |
| Boron | mg/L | 1.95 | 1.73 | 2.27 | 2.11 | 2.4 | 1.71 | 2.69 | 1.83 | 2.7 |
| Cadmium | µg/L | 0.13 | 0.11 | 0.15 | 0.12 | 0.1 | 0.12 | 0.09 | 0.11 | - |
| Calcium | mg/L | 157 | 166 | 159 | 148 | 153 | 167 | 170 | 162 | 175 |
| Chloride | mg/L | 96.1 | 94.5 | 95.2 | 94.3 | 95.4 | 98.4 | 100 | 93.4 | 93.7 |
| Chromium | µg/L | 1.45 | 2 | 2.1 | 0.811 | 0.355 | 1.8 | 0.185 | 1.3 | - |
| Cobalt | µg/L | 1.1 | 1.29 | 1.3 | 0.951 | 0.74 | 1.49 | 0.665 | 1.2 | - |
| Combined Radium | pCi/L | 1.093 | 1.238 | 0.301 | 1.174 | 0.602 | 0.343 | 0.452 | 0.21 | - |
| Fluoride | mg/L | 0.34 | 0.35 | 0.33 | 0.3 | 0.3 | 0.38 | 0.41 | 0.33 | 0.33 |
| Lead | µg/L | 1.24 | 1.69 | 1.72 | 0.786 | 0.314 | 2.09 | 0.073 | 1.03 | - |
| Lithium | mg/L | 0.021 | 0.015 | 0.02 | 0.017 | 0.029 | 0.035 | 0.022 | 0.019 | - |
| Mercury | µg/L | 0.005U | 0.007 | 0.006 | 0.004J | 0.005U | 0.01 | 0.003J | 0.005U | - |
| Molybdenum | µg/L | 26.4 | 28.6 | 26.8 | 27.4 | 29 | 19.6 | 29.2 | 27.5 | - |
| Selenium | µg/L | 0.2 | 0.4 | 0.3 | 0.1 | 0.06J | 0.2 | 0.04J | 0.2 | - |
| Total Dissolved Solids | mg/L | 918 | 942 | 948 | 952 | 957 | 953 | 926 | 916 | 977 |
| Sulfate | mg/L | 405 | 407 | 411 | 419 | 458 | 402 | 471 | 397 | 469 |
| Thallium | µg/L | 0.071 | 0.226 | 0.058 | 0.059 | 0.05J | 0.05 | 0.05J | 0.122 | - |
| pH | SU | 7.06 | 7.08 | 6.98 | 7.62 | 7.28 | 7.06 | 6.94 | 7.17 | 6.76 |

Notes:

mg/L: milligrams per liter

µg/L: micrograms per liter

pCi/L: picocuries per liter

SU: standard unit

U: Component was not present in concentrations above method detection limit and is reported as the reporting limit

J: Estimated value. Component was detected in concentrations below the reporting limit

-: Not sampled

# Table 1: Groundwater Data Summary
## Cardinal Plant - Bottom Ash Pond

| Parameter | Unit | MW-BAP-2 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1/12/2017 | 10/20/2016 | 5/3/2017 | 5/31/2017 | 6/20/2017 | 6/28/2016 | 8/1/2017 | 8/10/2016 | 9/5/2017 | 9/26/2017 |
| | | Background | | | | | | | | | Detection |
| Antimony | µg/L | 0.03J | 0.1 | 0.05J | 0.03J | 0.03J | 0.07 | 0.03J | 0.04J | 0.03J | - |
| Arsenic | µg/L | 26 | 29.6 | 10.6 | 13.1 | 11.1 | 11.3 | 17.1 | 11.1 | 9.08 | - |
| Barium | µg/L | 104 | 123 | 104 | 106 | 91.5 | 94.3 | 93.8 | 89.5 | 78.4 | - |
| Beryllium | µg/L | 0.035 | 0.083 | 0.032 | 0.02J | 0.01J | 0.02J | 0.02J | 0.02J | 0.01J | - |
| Boron | mg/L | 2.08 | 1.79 | 2.2 | 2.09 | 2.16 | 2.28 | 1.95 | 2.04 | 1.75 | 1.73 |
| Cadmium | µg/L | 0.05 | 0.09 | 0.04 | 0.04 | 0.02J | 0.04 | 0.02 | 0.03 | 0.03 | - |
| Calcium | mg/L | 86.4 | 92.3 | 82.4 | 87.6 | 84.6 | 98.7 | 86 | 89.5 | 81.6 | 86.8 |
| Chloride | mg/L | 72.9 | 79.6 | 72 | 70.7 | 71.9 | 74.1 | 71.4 | 75.9 | 69.1 | 68.2 |
| Chromium | µg/L | 0.65 | 1.8 | 0.704 | 0.292 | 0.213 | 0.5 | 0.371 | 0.3 | 0.217 | - |
| Cobalt | µg/L | 1.59 | 2.17 | 1.61 | 1.37 | 1.21 | 1.52 | 1.2 | 1.36 | 1.06 | - |
| Combined Radium | pCi/L | 0.776 | 0.849 | 0.376 | 1.206 | 0.993 | 0.749 | 1.086 | 0.588 | 0.731 | - |
| Fluoride | mg/L | 0.62 | 0.79 | 0.42 | 0.33 | 0.34 | 0.35 | 0.46 | 0.33 | 0.35 | 0.33 |
| Lead | µg/L | 0.965 | 2.16 | 0.77 | 0.325 | 0.234 | 0.439 | 0.33 | 0.307 | 0.197 | - |
| Lithium | mg/L | 0.016 | 0.006 | 0.013 | 0.009 | 0.02 | 0.011 | 0.01 | 0.01 | 0.013 | - |
| Mercury | µg/L | 0.002J | 0.004J | 0.005U | 0.005U | 0.005U | 0.005U | 0.005U | 0.005U | 0.005U | - |
| Molybdenum | µg/L | 26.2 | 31.9 | 42.1 | 46.6 | 49 | 37.6 | 46.1 | 38.4 | 42.7 | - |
| Selenium | µg/L | 0.1 | 0.4 | 0.2 | 0.09J | 0.07J | 0.09J | 0.08J | 0.08J | 0.09J | - |
| Total Dissolved Solids | mg/L | 583 | 628 | 557 | 562 | 563 | 612 | 560 | 544 | 538 | 552 |
| Sulfate | mg/L | 176 | 190 | 213 | 222 | 234 | 239 | 218 | 228 | 226 | 230 |
| Thallium | µg/L | 0.03J | 0.075 | 0.03J | 0.02J | 0.02J | 0.03J | 0.02J | 0.03J | 0.03J | - |
| pH | SU | 6.73 | 6.76 | 6.85 | 7.15 | 7.1 | 6.75 | 6.74 | 6.31 | - | 6.94 |

Notes:

mg/L: milligrams per liter

µg/L: micrograms per liter

pCi/L: picocuries per liter

SU: standard unit

U: Component was not present in concentrations above method detection limit and is reported as the reporting limit

J: Estimated value. Component was detected in concentrations below the reporting limit

-: Not sampled

## Table 1: Groundwater Data Summary
## Cardinal Plant - Bottom Ash Pond

| Parameter | Unit | MW-BAP-3 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1/12/2017 | 10/20/2016 | 5/3/2017 | 5/31/2017 | 6/20/2017 | 6/28/2016 | 8/1/2017 | 8/11/2016 | 9/5/2017 | 9/26/2017 |
| | | Background | | | | | | | | | Detection |
| Antimony | µg/L | 0.03J | 0.02J | 0.02J | 0.02J | 0.02J | 0.03J | 0.02J | 0.04J | 0.04J | - |
| Arsenic | µg/L | 0.99 | 0.69 | 0.39 | 0.36 | 0.32 | 0.42 | 0.31 | 0.75 | 0.74 | - |
| Barium | µg/L | 52.2 | 55.8 | 47.7 | 51.7 | 46.7 | 49.1 | 47.4 | 65.3 | 66.4 | - |
| Beryllium | µg/L | 0.009J | 0.009J | 0.006J | 0.005J | 0.02U | 0.008J | 0.005J | 0.022 | 0.036 | - |
| Boron | mg/L | 1.77 | 1.8 | 1.87 | 1.91 | 2.05 | 1.92 | 2.12 | 2.03 | 1.99 | 2.03 |
| Cadmium | µg/L | 0.07 | 0.05 | 0.06 | 0.1 | 0.09 | 0.04 | 0.08 | 0.05 | 0.17 | - |
| Calcium | mg/L | 62.6 | 65.7 | 60.6 | 60.3 | 62.1 | 64.1 | 67 | 63 | 65.6 | 69.1 |
| Chloride | mg/L | 60.7 | 60.1 | 61.9 | 61.8 | 62.8 | 59.8 | 63.4 | 58.8 | 63.5 | 63.8 |
| Chromium | µg/L | 0.427 | 0.4 | 0.257 | 0.128 | 0.111 | 0.5 | 0.126 | 0.8 | 1.05 | - |
| Cobalt | µg/L | 0.779 | 0.759 | 0.721 | 0.675 | 0.591 | 0.759 | 0.579 | 0.962 | 0.92 | - |
| Combined Radium | pCi/L | 0.546 | 1.738 | 0.853 | 0.506 | 0.373 | 0.358 | 0.00513 | 0.76 | 0.767 | - |
| Fluoride | mg/L | 0.16 | 0.1J | 0.16 | 0.1J | 0.1J | 0.17 | 0.1J | 0.1J | 0.1J | 0.1 |
| Lead | µg/L | 0.216 | 0.184 | 0.091 | 0.088 | 0.065 | 0.164 | 0.066 | 0.487 | 0.814 | - |
| Lithium | mg/L | 0.012 | 0.001U | 0.003 | 0.001U | 0.013 | 0.018 | 0.005 | 0.005 | 0.007 | - |
| Mercury | µg/L | 0.003J | 0.002J | 0.005U | 0.005U | 0.007 | 0.002J | 0.005U | 0.003J | 0.004J | - |
| Molybdenum | µg/L | 2.7 | 2.45 | 3.57 | 2.51 | 2.21 | 2.13 | 1.87 | 5.63 | 1.8 | - |
| Selenium | µg/L | 0.03J | 0.07J | 0.06J | 0.1U | 0.1U | 0.05J | 0.1U | 0.09J | 0.1 | - |
| Total Dissolved Solids | mg/L | 390 | 396 | 402 | 410 | 421 | 418 | 424 | 400 | 417 | 421 |
| Sulfate | mg/L | 119 | 129 | 131 | 135 | 145 | 130 | 148 | 134 | 142 | 146 |
| Thallium | µg/L | 0.05J | 0.059 | 0.04J | 0.05J | 0.05J | 0.05J | 0.05J | 0.061 | 0.052 | - |
| pH | SU | 6.67 | 6.7 | 6.74 | 7.22 | 6.95 | 6.65 | 6.52 | 6.7 | - | 6.53 |

Notes:
mg/L: milligrams per liter
µg/L: micrograms per liter
pCi/L: picocuries per liter
SU: standard unit
U: Component was not present in concentrations above method detection limit
and is reported as the reporting limit
J: Estimated value. Component was detected in concentrations below the reporting limit
-: Not sampled

## Table 1: Groundwater Data Summary
## Cardinal Plant - Bottom Ash Pond

| Parameter | Unit | MW-BAP-4 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **1/12/2017** | **10/20/2016** | **5/2/2017** | **5/31/2017** | **6/20/2017** | **6/30/2016** | **8/1/2017** | **8/10/2016** | **9/26/2017** |
| | | **Background** | | | | | | | | **Detection** |
| Antimony | µg/L | 0.09 | 0.1 | 0.05J | 0.04J | 0.03J | 0.06 | 0.05 | 0.07 | - |
| Arsenic | µg/L | 44.8 | 42.4 | 41.9 | 35.9 | 42.7 | 36.3 | 43.7 | 42.2 | - |
| Barium | µg/L | 59.9 | 69.8 | 44.9 | 51.7 | 41.9 | 54.9 | 49.9 | 54.7 | - |
| Beryllium | µg/L | 0.176 | 0.227 | 0.071 | 0.111 | 0.046 | 0.119 | 0.092 | 0.117 | - |
| Boron | mg/L | 0.02 | 0.064 | 0.16 | 0.024 | 0.038 | 0.115 | 0.034 | 0.062 | 0.033 |
| Cadmium | µg/L | 0.14 | 0.18 | 0.05 | 0.1 | 0.03 | 0.11 | 0.06 | 0.1 | - |
| Calcium | mg/L | 197 | 214 | 197 | 181 | 190 | 233 | 202 | 220 | 203 |
| Chloride | mg/L | 27.5 | 28.6 | 27.5 | 27.6 | 27.5 | 30 | 27.6 | 30.6 | 27.1 |
| Chromium | µg/L | 4.16 | 4.4 | 1.48 | 1.96 | 0.834 | 1.7 | 1.89 | 2.4 | - |
| Cobalt | µg/L | 20.3 | 19.8 | 19.2 | 20.2 | 18 | 18.7 | 19.9 | 18.2 | - |
| Combined Radium | pCi/L | 0.703 | 1.17 | 0.377 | 0.599 | 0.645 | 0.535 | 1.069 | 0.722 | - |
| Fluoride | mg/L | 0.1J | 0.1J | 0.1J | 0.1J | 0.1J | 0.15 | 0.1J | 0.16 | 0.1 |
| Lead | µg/L | 4.63 | 5.67 | 1.66 | 2.94 | 0.955 | 3.2 | 2.06 | 2.78 | - |
| Lithium | mg/L | 0.012 | 0.006 | 0.009 | 0.005 | 0.02 | 0.015 | 0.013 | 0.012 | - |
| Mercury | µg/L | 0.005 | 0.007 | 0.005U | 0.004J | 0.005U | 0.005U | 0.005U | 0.004J | - |
| Molybdenum | µg/L | 1.76 | 1.87 | 1.56 | 1 | 2.15 | 1.35 | 1.52 | 4.51 | - |
| Selenium | µg/L | 0.7 | 0.9 | 0.3 | 0.4 | 0.2 | 0.5 | 0.4 | 0.5 | - |
| Total Dissolved Solids | mg/L | 1200 | 1300 | 1250 | 1270 | 1280 | 1400 | 1330 | 1320 | 1250 |
| Sulfate | mg/L | 620 | 617 | 584 | 590 | 655 | 661 | 631 | 629 | 618 |
| Thallium | µg/L | 0.102 | 0.106 | 0.03J | 0.03J | 0.02J | 0.03J | 0.04J | 0.063 | - |
| pH | SU | 6.37 | 6.72 | 6.45 | 6.63 | 6.81 | 6.37 | 6.27 | 6.28 | 6.36 |

Notes:
mg/L: milligrams per liter
µg/L: micrograms per liter
pCi/L: picocuries per liter
SU: standard unit
U: Component was not present in concentrations above method detection limit and is reported as the reporting limit
J: Estimated value. Component was detected in concentrations below the reporting limit
-: Not sampled

# Table 1: Groundwater Data Summary
## Cardinal Plant - Bottom Ash Pond

| **Parameter** | **Unit** | **MW-BAP-5** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **1/12/2017** | **10/20/2016** | **5/2/2017** | **5/31/2017** | **6/20/2017** | **6/28/2016** | **8/1/2017** | **8/10/2016** | **9/26/2017** |
| | | **Background** | | | | | | | | **Detection** |
| Antimony | µg/L | 0.06 | 0.12 | 0.07 | 0.05 | 0.03J | 0.07 | 0.03J | 0.09 | - |
| Arsenic | µg/L | 8.78 | 16.1 | 11.5 | 11.7 | 9.1 | 11.3 | 10.6 | 12.1 | - |
| Barium | µg/L | 87.9 | 118 | 88.2 | 95.3 | 77.7 | 92.7 | 83.1 | 102 | - |
| Beryllium | µg/L | 0.061 | 0.157 | 0.095 | 0.075 | 0.045 | 0.068 | 0.039 | 0.112 | - |
| Boron | mg/L | 0.043 | 0.058 | 0.116 | 0.073 | 0.05 | 0.072 | 0.043 | 0.043 | 0.059 |
| Cadmium | µg/L | 0.02 | 0.06 | 0.04 | 0.03 | 0.02J | 0.03 | 0.01J | 0.05 | - |
| Calcium | mg/L | 207 | 226 | 201 | 176 | 200 | 228 | 206 | 209 | 209 |
| Chloride | mg/L | 15.3 | 14.3 | 14.8 | 13.3 | 15.7 | 13.4 | 14.7 | 13.5 | 15.3 |
| Chromium | µg/L | 2.35 | 5.7 | 2.83 | 2.1 | 1.33 | 2 | 1.16 | 3.4 | - |
| Cobalt | µg/L | 1.34 | 3.06 | 1.92 | 1.47 | 0.966 | 1.28 | 0.855 | 2.03 | - |
| Combined Radium | pCi/L | 1.411 | 1.497 | 0.364 | 0.894 | 0.788 | 0.6516 | 0.686 | 1.026 | - |
| Fluoride | mg/L | 0.09J | 0.08 | 0.1J | 0.06J | 0.08J | 0.1J | 0.08J | 0.09J | 0.09 |
| Lead | µg/L | 1.72 | 4.6 | 2.77 | 1.95 | 1.18 | 1.92 | 1.04 | 3.08 | - |
| Lithium | mg/L | 0.008 | 0.007 | 0.01 | 0.012 | 0.016 | 0.02 | 0.012 | 0.01 | - |
| Mercury | µg/L | 0.005U | 0.003J | 0.005U | 0.005U | 0.005U | 0.005U | 0.005U | 0.003J | - |
| Molybdenum | µg/L | 0.74 | 1.15 | 0.62 | 0.94 | 0.52 | 0.8 | 0.52 | 1.22 | - |
| Selenium | µg/L | 0.2 | 0.7 | 0.4 | 0.3 | 0.2 | 0.2 | 0.1 | 0.4 | - |
| Total Dissolved Solids | mg/L | 1050 | 1010 | 1010 | 955 | 1080 | 1050 | 1050 | 1060 | 1050 |
| Sulfate | mg/L | 474 | 433 | 418 | 404 | 472 | 449 | 448 | 456 | 442 |
| Thallium | µg/L | 0.058 | 0.114 | 0.059 | 0.04J | 0.03J | 0.03J | 0.02J | 0.059 | - |
| pH | SU | 6.6 | 6.59 | 6.6 | 7.07 | 6.94 | 6.6 | 6.55 | 6.7 | 6.72 |

Notes:

mg/L: milligrams per liter

µg/L: micrograms per liter

pCi/L: picocuries per liter

SU: standard unit

U: Component was not present in concentrations above method detection limit and is reported as the reporting limit

J: Estimated value. Component was detected in concentrations below the reporting limit

-: Not sampled

## Table 1: Groundwater Data Summary
## Cardinal Plant - Bottom Ash Pond

| Parameter | Unit | BAP-1 | | | BAP-2 | | | BAP-3 | | | BAP-4 | | BAP-5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1/23/2018 | 5/17/2018 | 8/29/2018 | 1/23/2018 | 5/17/2018 | 8/29/2018 | 1/23/2018 | 5/17/2018 | 8/29/2018 | 5/21/2018 | 8/29/2018 | 5/21/2018 | 8/29/2018 |
| | | Detection | Assessment | | Detection | Assessment | | Detection | Assessment | | Assessment | | Assessment | |
| Antimony | µg/L | - | 0.0400 J | 0.5 U | - | 0.0300 J | 0.5 U | - | 0.0200 J | 0.5 U | 0.0300 J | 0.5 U | 0.0400 J | 0.5 U |
| Arsenic | µg/L | - | 0.430 | 0.5 U | - | 12.4 | 122 | - | 0.270 | 0.5 U | 34.1 | 44.2 | 7.78 | 6.20 |
| Barium | µg/L | - | 56.0 | 57.6 | - | 92.3 | 135 | - | 48.1 | 46.8 | 38.8 | 49.7 | 72.1 | 78.7 |
| Beryllium | µg/L | - | 0.0100 J | 0.1 U | - | 0.0200 J | 0.1 U | - | 0.00800 J | 0.1 U | 0.0360 | 0.100 | 0.0500 | 0.1 U |
| Boron | mg/L | 2.91 | 2.70 | 3.44 | 1.97 | 1.57 | 1.92 | 1.91 | 1.97 | 2.45 | 0.137 | 0.0217 | 0.112 | 0.0956 |
| Cadmium | µg/L | - | 0.100 | 0.140 | - | 0.0200 | 0.1 U | - | 0.110 | 0.1 U | 0.0200 | 0.1 U | 0.0200 J | 0.1 U |
| Calcium | mg/L | - | 159 | 153 | - | 82.0 | 79.5 | - | 66.8 | 69.4 | 202 | 216 | 203 | 222 |
| Chloride | mg/L | 86.2 | 76.9 | 74.4 | 61.1 | 60.0 | 70.0 | 64.1 | 67.2 | 67.2 | 27.7 | 28.5 | 17.0 | 19.2 |
| Chromium | µg/L | - | 0.598 | 1 U | - | 0.345 | 1 U | - | 0.270 | 1 U | 0.715 | 2.10 | 1.45 | 1 U |
| Cobalt | µg/L | - | 0.649 | 0.790 | - | 1.16 | 1.30 | - | 0.521 | 0.5 U | 19.1 | 20.1 | 0.950 | 0.770 |
| Combined Radium | pCi/L | - | 0.227 | 0.686 | - | 0.643 | 0.225 | - | 0.385 | 0.312 | 0.987 | 1.06 | 0.865 | 1.01 |
| Fluoride | mg/L | 0.370 | 0.380 | 0.360 | 0.390 | 0.490 | 0.620 | - | 0.130 | 0.110 | 0.160 | 0.140 | 0.0900 | 0.0930 |
| Lead | µg/L | - | 0.246 | 0.5 U | - | 0.217 | 0.5 U | - | 0.0720 | 0.5 U | 0.601 | 1.70 | 1.19 | 0.540 |
| Lithium | mg/L | - | 0.0100 | 0.0166 | - | 0.00400 | 10 U | - | 0.001 U | 10 U | 0.00600 | 10 U | 0.00300 | 10 U |
| Mercury | µg/L | - | 0.00300 J | 0.00126 | - | 0.005 U | 0.000930 | - | 0.005 U | 0.5 U | 0.005 U | 0.00266 | 0.005 U | 0.00123 |
| Molybdenum | µg/L | - | 27.4 | 30.6 | - | 37.4 | 36.3 | - | 1.73 | 1.50 | 1.31 | 1.50 | 0.460 | 0.510 |
| pH | SU | 7.09 | 7.04 | 6.96 | 6.90 | 6.81 | 6.86 | 6.71 | 6.48 | 6.59 | 6.26 | 6.32 | 6.48 | 6.56 |
| Selenium | µg/L | - | 0.100 | 0.5 U | - | 0.100 J | 0.5 U | - | 0.0400 J | 0.5 U | 0.200 | 0.5 U | 0.200 | 0.5 U |
| Total Dissolved Solids | mg/L | - | 924 | 927 | - | 518 | 519 | - | 416 | 415 | 1260 | 1240 | 1030 | 974 |
| Sulfate | mg/L | - | 446 | 494 | - | 228 | 217 | - | 157 | 159 | 590 | 628 | 433 | 464 |
| Thallium | µg/L | - | 0.0610 | 0.5 U | - | 0.0300 J | 0.5 U | - | 0.0680 | 0.5 U | 0.0500 J | 0.5 U | 0.0300 J | 0.5 U |

Notes:
mg/L: milligrams per liter
µg/L: micrograms per liter
SU: standard unit
pCi/L: picocuries per liter
U: Parameter was not present in concentrations above method detection limit and is reported as the reporting limit
J: Estimated value. Parameter was detected in concentrations below the reporting limit
-: Not sampled

# Table 1 - Groundwater Data Summary
## Cardinal Plant - Bottom Ash Pond

| **Parameter** | **Unit** | **BAP-1** | | **BAP-2** | | **BAP-3** | | **BAP-4** | | **BAP-5** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **4/8/2019** | **10/9/2019** | **4/8/2019** | **10/9/2019** | **4/8/2019** | **10/10/2019** | **4/8/2019** | **10/10/2019** | **4/8/2019** | **10/10/2019** |
| Antimony | µg/L | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| Arsenic | µg/L | 0.500 U | 0.500 U | 122 | 34.9 | 0.500 U | 0.500 U | 39.0 | 54.8 | 5.20 | 5.80 |
| Barium | µg/L | 52.3 | 50.0 | 225 | 121 | 44.4 | 44.3 | 42.4 | 47.1 | 77.4 | 83.4 |
| Beryllium | µg/L | 0.100 U | 0.100 U | 0.260 | 0.100 U | 0.100 U | 0.100 U | 0.100 U | 0.100 U | 0.100 U | 0.100 U |
| Boron | µg/L | 2,680 | 3,050 | 1,960 | 1,560 | 2,020 | 2,100 | 19.8 | 19.5 | 92.0 | 118 |
| Cadmium | µg/L | 0.130 | 0.120 | 0.230 | 0.100 U | 0.100 U | 0.100 | 0.100 U | 0.100 U | 0.100 U | 0.100 U |
| Calcium | µg/L | 167,000 | 158,000 | 91,100 | 82,800 | 76,000 | 71,900 | 209,000 | 184,000 | 224,000 | 213,000 |
| Chloride | mg/L | 64.7 | 68.9 | 59.4 | 64.5 | 64.6 | 68.4 | 20.9 | 25.3 | 14.9 | 16.7 |
| Chromium | µg/L | 1.00 U | 1.00 U | 5.50 | 1.00 U | 1.00 U | 1.00 U | 1.20 | 1.70 | 1.00 U | 2.20 |
| Cobalt | µg/L | 1.00 | 0.700 | 4.60 | 1.20 | 0.570 | 0.500 U | 17.8 | 19.1 | 1.00 | 1.10 |
| Combined Radium | pCi/L | 1.10 | 6.52 | 0.617 | 1.06 | 0.552 | 0.371 | 0.564 | 1.48 | 0.765 | 1.27 |
| Fluoride | mg/L | 0.380 | 0.370 | 0.800 | 0.560 | 0.140 | 0.110 | 0.150 | 0.140 | 0.0990 | 0.0680 |
| Lead | µg/L | 0.500 U | 0.500 U | 5.30 | 0.500 U | 0.500 U | 0.500 U | 1.20 | 1.40 | 1.10 | 1.20 |
| Lithium | µg/L | 17.1 | 19.8 | 10.0 U | 10.0 U | 10.0 U | 10.0 U | 10.0 U | 10.0 U | 10.0 U | 10.0 U |
| Mercury | µg/L | 0.000500 U | 0.000500 U | 0.00965 | 0.000670 | 0.000500 U | 0.000500 U | 0.00186 | 0.00117 | 0.00123 | 0.000785 |
| Molybdenum | µg/L | 30.4 | 32.3 | 36.3 | 40.0 | 1.30 | 1.60 | 1.30 | 1.40 | 0.500 U | 0.500 U |
| Selenium | µg/L | 0.500 U | 0.500 U | 0.570 | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| Sulfate | mg/L | 419 | 416 | 167 | 202 | 149 | 164 | 471 | 560 | 404 | 433 |
| Thallium | µg/L | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| Total Dissolved Solids | mg/L | 905 | 874 | 563 | 484 | 415 | 425 | 1,260 | 1,210 | 1,050 | 983 |
| pH | SU | 6.82 | 7.10 | 7.12 | 6.95 | 6.53 | 6.05 | 6.35 | 6.26 | 6.65 | 6.43 |

Notes:
mg/L: milligrams per liter
µg/L: micrograms per liter
SU: standard unit
pCi/L: picocuries per liter
U: Parameter was not present in concentrations above method detection limit and is reported as the reporting limit
J: Estimated value. Parameter was detected in concentrations below the reporting limit
All samples were collected as part of the assessment monitoring program in accordance with 40 CFR 257.90(e)(3).

## Spring 2020 App III & IV Parameters
## Cardinal Plant - Bottom Ash Pond

| Parameter | Unit | BAP-1 | BAP-2 | BAP-3 | BAP-4 | BAP-5 |
|---|---|---|---|---|---|---|
| | | 4/08/2020 | 4/08/2020 | 4/08/2020 | 4/08/2020 | 4/08/2020 |
| Antimony | µg/L | *0.50 U* | *0.50 U* | *0.50 U* | *0.50 U* | *0.50 U* |
| Arsenic | µg/L | 2.4 | 24.2 | 1.1 | 45.1 | 2.3 |
| Barium | µg/L | 89.1 | 160 | 83.6 | 42.8 | 80.1 |
| Beryllium | µg/L | 0.15 | *0.10 U* | *0.10 U* | *0.10 U* | *0.10 U* |
| Boron | µg/L | 2770 | 1860 | 1940 | 20.7 | 138 |
| Cadmium | µg/L | 0.15 | *0.10 U* | 0.15 | *0.10 U* | *0.10 U* |
| Calcium | µg/L | 147000 | 88000 | 69700 | 186000 | 234000 |
| Chloride | mg/L | 73.9 | 83.7 | 77.3 | 29 | 22.1 |
| Chromium | µg/L | 4.6 | 1.5 | 3.5 | 1.4 | *1.0 U* |
| Cobalt | µg/L | 2.3 | 1.8 | 1.9 | 19.6 | 0.99 |
| Combined Radium | pCi/L | 1.63 | 0.736 | 0.641 | 0.552 | 0.794 |
| Fluoride | mg/L | 0.38 | 0.58 | 0.12 | 0.11 | 0.08 |
| Lead | µg/L | 3.3 | 1.1 | 1.5 | 1.1 | *0.50 U* |
| Lithium | µg/L | 27.5 | 12.1 | *10.0 U* | 12.9 | 11.4 |
| Mercury | µg/L | 0.0137 | 0.00249 | 0.0084 | 0.00223 | 0.000734 |
| Molybdenum | µg/L | 29.9 | 35.2 | 2.7 | 1.4 | *0.50 U* |
| pH | SU | 6.82 | 6.67 | 6.36 | 6.31 | 6.47 |
| Selenium | µg/L | *0.50 U* | *0.50 U* | *0.50 U* | *0.50 U* | *0.50 U* |
| Total Dissolved Solids | mg/L | 825 | 527 | 430 | 1170 | 1080 |
| Sulfate | mg/L | 389 | 208 | 158 | 637 | 511 |
| Thallium | µg/L | *0.50 U* | *0.50 U* | *0.50 U* | *0.50 U* | *0.50 U* |

Notes:

mg/L: milligrams per liter

µg/L: micrograms per liter pCi/L: picocuries per liter SU: standard unit

*U: Component was not present in concentrations above method detection limit and is reported as the reporting limit*

J: Estimated value. Component was detected in concentrations below the reporting limit

# 2019 ANNUAL GROUNDWATER MONITORING REPORT

# FEDERAL CCR RULE

## CARDINAL PLANT – BOTTOM ASH POND
## BRILLIANT, OHIO

*Submitted to*

**Cardinal Operating Company**
306 County Road 7E
Brilliant, Ohio 43913

*Submitted by*

Geosyntec consultants
engineers | scientists | innovators

941 Chatham Lane, Suite 103
Columbus, Ohio 43221

January 10, 2020

CHA8468

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# LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| BAP | Bottom Ash Pond |
| CCR | Coal Combustion Residuals |
| CFR | Code of Federal Regulations |
| ESP | Electrostatic Precipitator |
| FGD | Flue Gas Desulfurization |
| GWPS | Groundwater Protection Standards |
| MCL | Maximum Contaminant Level |
| MW | Megawatt |
| RSW | Residual Solid Waste |
| SCR | Selective Catalytic Reduction |
| SSI | Statistically Significant Increase |
| SSL | Statistically Significant Level |
| USEPA | United States Environmental Protection Agency |

# 1. INTRODUCTION

The Federal Coal Combustion Residuals (CCR) Rule (40 Code of Federal Regulations [CFR] Part 257.90(e)) (USEPA, 2015) requires owners and or operators of existing CCR landfills and surface impoundments to prepare a Groundwater Monitoring and Corrective Action Report (Report) no later than January 31 annually. Geosyntec Consultants (Geosyntec) has prepared this Report for the Bottom Ash Pond (BAP), an existing CCR unit at the Cardinal Plant in Brilliant, Ohio (Site). This Report summarizes the groundwater monitoring activities conducted pursuant to the CCR Rule through December 31, 2019.

# 2. SITE DESCRIPTION

## 2.1 Site Description

The Site is located one-mile south of Brilliant, Ohio in Jefferson County (**Figure 1**) and is operated by Buckeye Power, Inc. (Buckeye Power). Located along the Ohio River, the generating station consists of three coal-powered units with an 1,800 megawatt (MW) capacity and annual coal use of 5.2 million tons (Geosyntec, 2016). Units 1 and 2 began operation in 1967 and Unit 3 began operation in 1977. As of 2012, all three units were equipped with an electrostatic precipitator (ESP), a selective catalytic reduction (SCR) system, and a flue gas desulfurization (FGD) system.

The BAP is situated along the Ohio River south of Cardinal Plant Unit 3. The BAP perimeter dikes enclosing the facility are approximately 6,500 feet (ft) in length with a 20-foot average height. The dikes were originally constructed in the 1960s, with major reconstruction in 1974 as part of the Unit 3 addition. The BAP receives bottom ash, pyrite, and other wastes from the coal burning process in addition to stormwater drainage and wastewater flows from the property. Site features and locations are outlined in **Figure 2**.

## 2.2 Regional Physiographic Setting

The Site is underlain by horizontal sequences of lower Permian and upper Pennsylvanian sedimentary rock. The Conemaugh Group, 500 ft thick in Jefferson County, consists of shale, sandstone, limestone, claystone, and coal. This group includes the Morgantown Sandstone underlain by the Elk Lick Limestone, the Skelly Limestone and Shale, the Ames Limestone, and the Cow Run Sandstone (Geosyntec, 2016). Above the current grade of the Residual Solid Waste (RSW) Landfill lies the Monongahela Group consisting of shale, sandstone, limestone, coal, claystone, and siltstone. Overlying the Monongahela Group, at approximately 1,250 feet in elevation, is the Permian-age Dunkard Group.

The uppermost aquifer at the Site consists of fine to coarse sand and gravel below a silty clay, interbedded organic clay and silt. The uppermost aquifer is hydraulically connected to the Ohio River. Groundwater in the uppermost aquifer generally flows southeast towards the Ohio River with hydraulic conductivity ranging from $1 \times 10^{-1}$ to $1 \times 10^{-4}$ centimeters per second (cm/s) (Geosyntec, 2016).

# 3. GROUNDWATER MONITORING SYSTEM

The BAP's groundwater monitoring network was designed to comply with 40 CFR 257.91. The groundwater monitoring network utilizes monitoring wells initially installed as part of a separate site-wide hydrogeologic investigation and is used to monitor groundwater quality in the uppermost aquifer at the Site. Monitoring well construction and soil boring logs were provided in the *Groundwater Monitoring Network Design Report* (Geosyntec, 2016).

The BAP groundwater monitoring well network consists of five monitoring wells, as shown in **Figure 2**. Two upgradient monitoring wells (MW-BAP-4 and MW-BAP-5) are used to measure background conditions and three downgradient monitoring wells (MW-BAP-1, MW-BAP-2, and MW-BAP-3) are used as compliance wells.

# 4. CCR RULE GROUNDWATER KEY ACTIVITIES COMPLETED

## 4.1 2018 Statistical Evaluation Activities

A Groundwater Protection Standard (GWPS) was established for each Appendix IV parameter in accordance with the United States Environmental Protection Agency (USEPA's) *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance* (Unified Guidance; USEPA, 2009) and the Site's Statistical Analysis Plan (Geosyntec, 2017). The established GWPSs were determined to be the greater value of the background concentration and the maximum contaminant level (MCL) or risk-based screening level for each Appendix IV parameter. GWPSs determined in 2018 are provided in the *2018 Annual Groundwater Monitoring Report* (Geosyntec, 2019a).

A statistical evaluation of the 2018 assessment monitoring data compared against the GWPSs was completed in January 2019 and is described in the *Statistical Analysis Summary – Bottom Ash Pond* (Geosyntec, 2019b). The statistical analysis report included an evaluation of significant levels (SSLs) for Appendix IV parameters and an evaluation of statistically significant increases (SSIs) for Appendix III parameters. Additionally, prediction limits for interwell tests were recalculated using data collected during the 2018 assessment monitoring events. No SSLs were identified at the BAP. SSIs for boron and chloride were identified at MW-BAP-1, MW-BAP-2, and MW-BAP-3 and SSIs for fluoride were identified at MW-BAP-1 and MW-BAP-2 (Geosyntec, 2019b). Based on these results, the CCR unit remained in assessment monitoring.

## 4.2 2019 Sampling and Data Evaluation Activities

### *4.2.1 Assessment Monitoring Program*

The BAP remained in assessment monitoring throughout 2019. Assessment monitoring sampling events were conducted in April and October 2019 in accordance with 40 CFR 257.95(b) and 40 CFR 257.95(d)(1), respectively. Samples from both events were analyzed for all Appendix III and Appendix IV parameters; results are shown in **Table 1**. A revision of the GWPS and statistical evaluation of the 2019 assessment monitoring data is ongoing and will be completed outside of the timeframe of this report.

### *4.2.2 Groundwater Elevation and Flow Velocities*

Prior to sampling, a synoptic round of groundwater level measurements was collected from compliance and background monitoring wells. Potentiometric surface maps based on groundwater elevations measured during the April and October 2019 assessment monitoring events are presented in **Figure 3** and **Figure 4**, respectively. The potentiometric maps show that groundwater near the BAP flows southeast towards the Ohio River. The groundwater residence time (inverse of velocity) at the BAP ranged from 1.4 days at well MW-BAP-3 to 6.5 days at MW-BAP-2 and MW-BAP-3. A summary of hydraulic gradients and groundwater residence times at the BAP is provided in **Table 2**.

### *4.2.3 Data Usability*

Upon receipt of laboratory analytical reports, the data were evaluated for usability. Analytical data were checked for the following:

- Samples were analyzed within the method specified hold times;
- Samples were received within holding temperature;
- The chain of custody form was complete;
- Precision was within control limits using relative percent differences of blind duplicate samples;
- Matrix spike and matrix spike duplicate recoveries and laboratory control samples were within the control limits; and
- Potential for positive bias was evaluated using method blanks.

All data received during 2019 were considered complete and usable.

## 5. PROBLEMS ENCOUNTERED AND RESOLUTIONS

No problems were encountered during 2019 that were related to assessment monitoring activities at the BAP. No monitoring wells were gauged dry, abandoned, or added to the well network during 2019. All analytical data received were deemed to be of acceptable quality.

## 6. STATUS OF MONITORING PROGRAM

During the time period of this report, the Site has remained in assessment monitoring. Assessment monitoring events were conducted in April and October 2019. The BAP's status will be re-evaluated after completion of the ongoing statistical evaluation.

## 7. PLANNED KEY ACTIVITIES FOR 2020

The following activities are planned for 2020 at the BAP:

- The 2019 Annual Groundwater Monitoring Report will be entered into the facility's operating record and posted to the public internet site;
- A statistical evaluation of the 2019 assessment monitoring event will be completed in January 2020, which will evaluate potential SSIs against revised GWPSs. The BAP's monitoring well status will be confirmed following the evaluation;
- Assuming the unit remains in assessment monitoring, two semi-annual groundwater assessment monitoring program events will be conducted and tested for potential SSLs and SSIs; and
- The 2020 Annual Groundwater Monitoring will be prepared for submittal in January 2021.

## 8. REFERENCES

Geosyntec Consultants, Inc. 2016. Groundwater Monitoring Network Evaluation, Cardinal Site – Bottom Ash Pond, July.

Geosyntec Consultants, Inc. 2017. Statistical Analysis Plan. January.

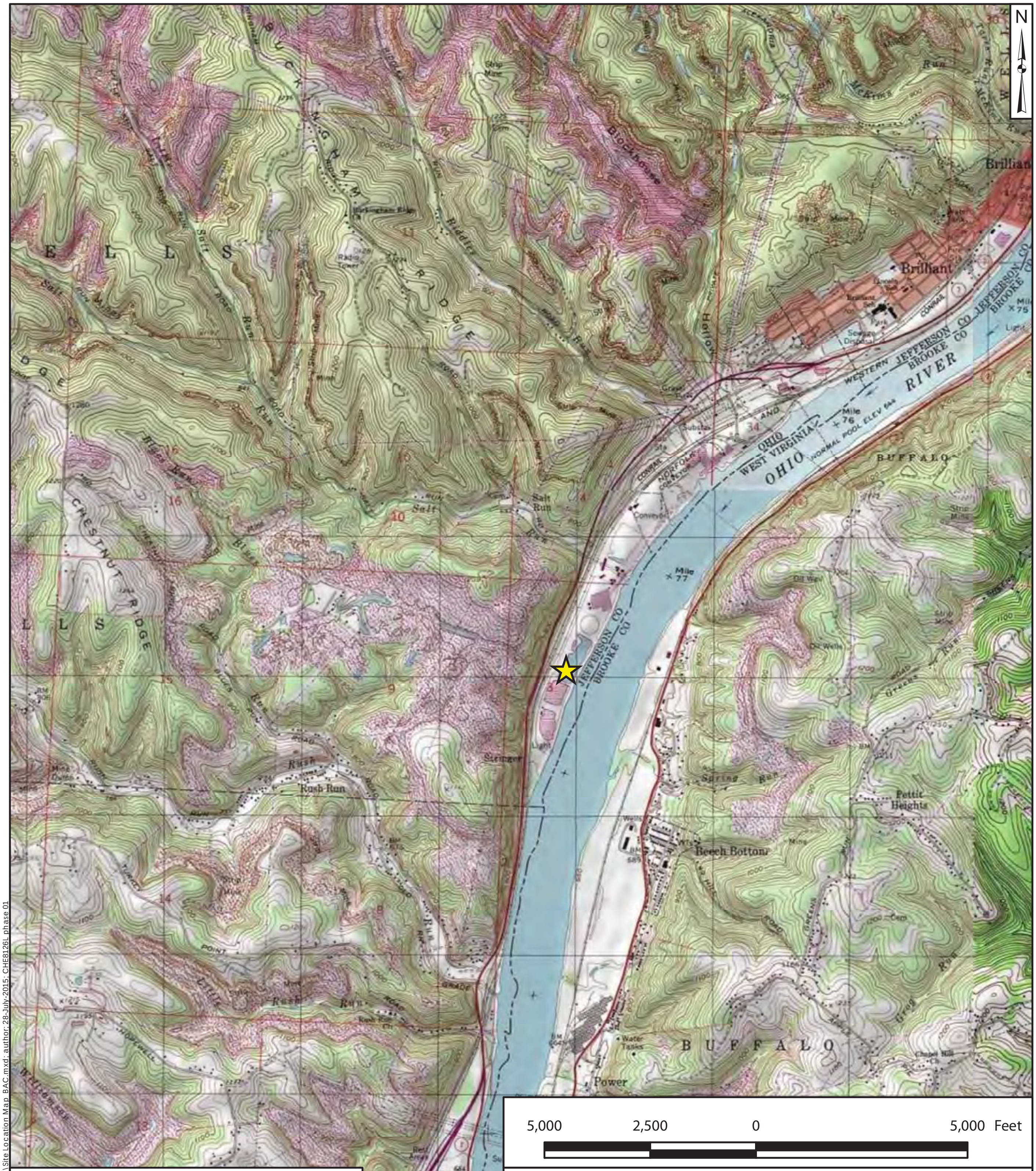
Geosyntec Consultants, Inc. 2019a. 2018 Annual Groundwater Monitoring Report, Federal CCR Rule, Cardinal Plant – Bottom Ash Pond. January.

Geosyntec Consultants, Inc. 2019b. Statistical Analysis Summary – Bottom Ash Pond, Cardinal Plant. 2019.

United States Environmental Protection Agency (USEPA). 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities - Unified Guidance. EPA 530/R-09-007. March.

United States Environmental Protection Agency (USEPA). 2015. Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities (Final Rule). Fed. Reg. 80 FR 21301, pp. 21301-21501, 40 CFR Parts 257 and 261, April.

# FIGURES



5,000 2,500 0 5,000 Feet

**Legend**

★ Site Location

**Notes**
- All locations are approximate.
- Topographic maps courtesy of National Geographic Society.

**Site Location Map**
**Bottom Ash Complex**

Cardinal Power Plant
Brilliant, Ohio

Geosyntec consultants

Ann Arbor, Michigan

28-July-2015

Figure

1

P:\Projects\AEP\Cardinal\CCR Compliance Document\Figures\Site Location Map BAC.mxd; author; 28-July-2015; CHE8126L phase 01

**Monitoring Well Network**

⊕ Compliance Sampling Location

⊕ Background Sampling Location

▭ Bottom Ash Pond

Notes
- Monitoring well coordinates provided by Buckeye Power.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Bottom Ash Pond (Geosyntec, 2016) provided by Buckeye Power.

250 125 0 250
Feet

Site Layout
Bottom Ash Complex

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec
consultants

Columbus, Ohio

2018/01/25

Figure
**2**

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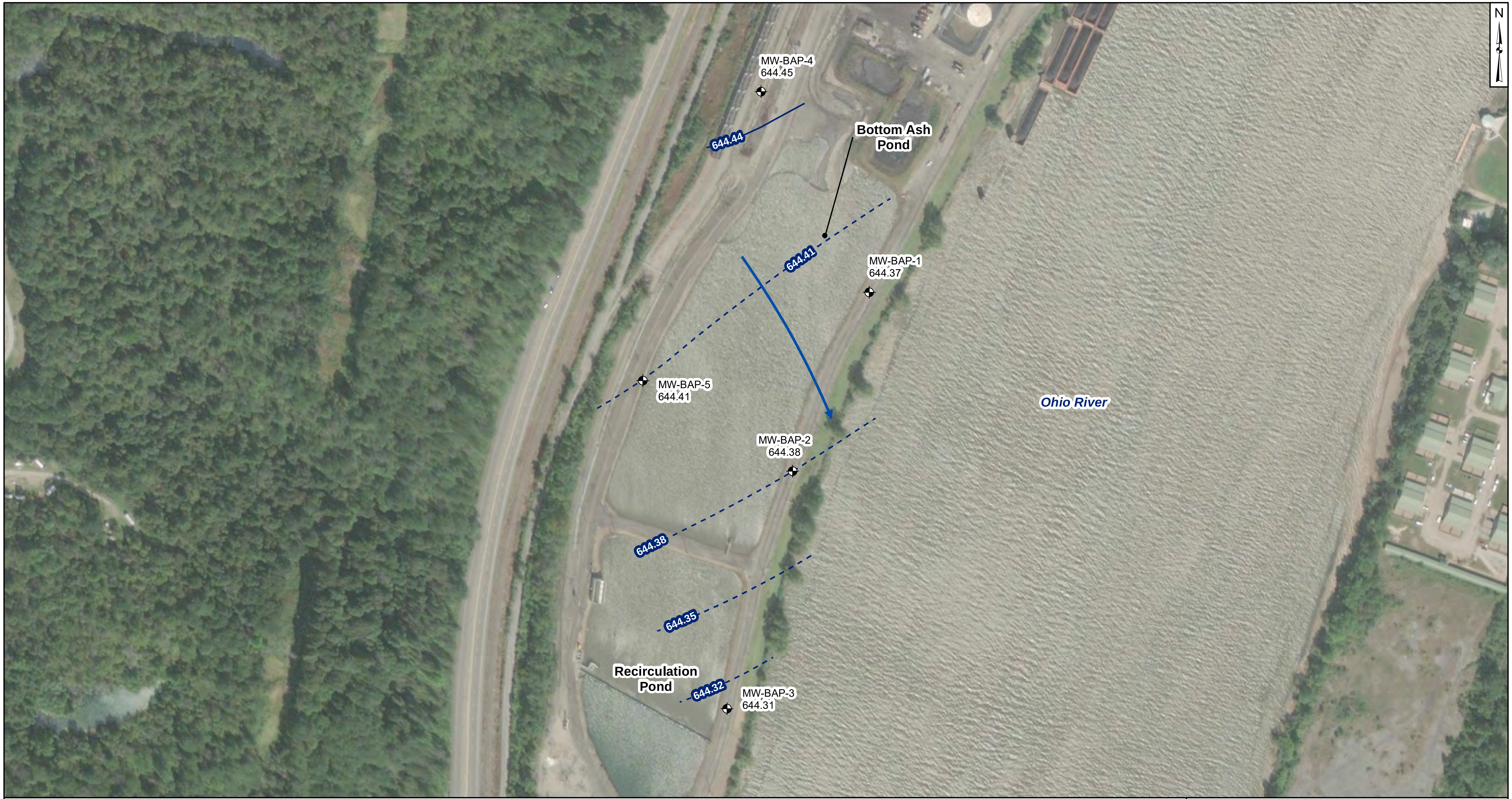


Legend

⊕ Groundwater Monitoring Well

→ Approximate Groundwater Flow Direction

— Groundwater Elevation Contour

- - - Groundwater Elevation Contour (Inferred)

Notes

- Monitoring well coordinates and water level data (collected on March 21, 2019) provided by Buckeye Power.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Bottom Ash Pond (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.

250 125 0 250 Feet

## Potentiometric Surface Map - Uppermost Aquifer
## Bottom Ash Complex
## March 2019

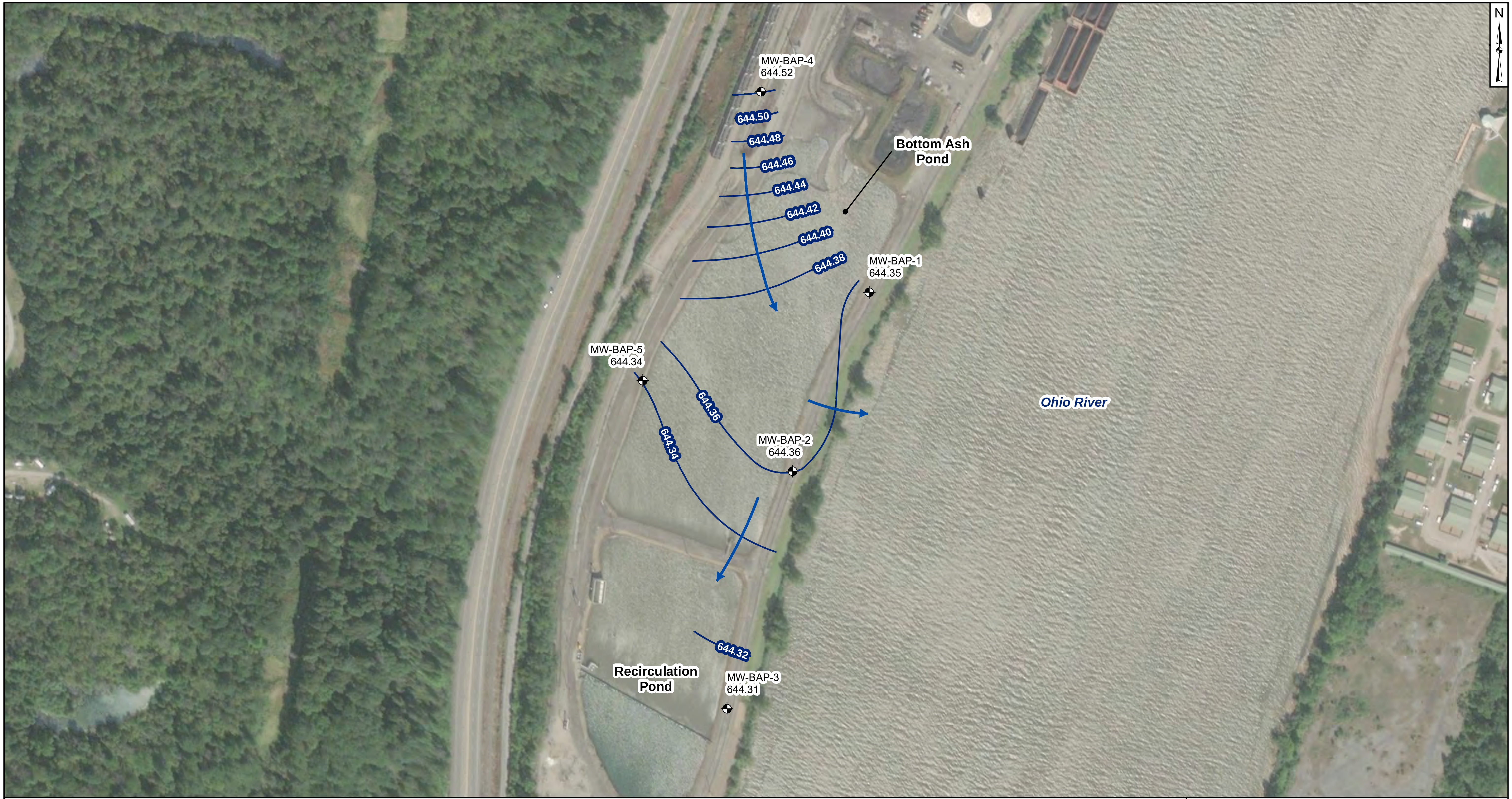
Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio

2020/01/03

Figure
3



Legend

- ⯐ Groundwater Monitoring Well
- ➡ Approximate Groundwater Flow Direction
- — Groundwater Elevation Contour

Notes

- Monitoring well coordinates and water level data (collected on October 26, 2019) provided by Buckeye Power.
- Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Bottom Ash Pond (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.

250 125 0 250 Feet

Potentiometric Surface Map - Uppermost Aquifer
Bottom Ash Complex
October 2019

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio

2019/12/31

Figure
4

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# TABLES

# Table 1 - Groundwater Data Summary
# Cardinal Plant - Bottom Ash Pond

| Parameter | Unit | BAP-1 | | BAP-2 | | BAP-3 | | BAP-4 | | BAP-5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **4/8/2019** | **10/9/2019** | **4/8/2019** | **10/9/2019** | **4/8/2019** | **10/10/2019** | **4/8/2019** | **10/10/2019** | **4/8/2019** | **10/10/2019** |
| Antimony | µg/L | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| Arsenic | µg/L | 0.500 U | 0.500 U | 122 | 34.9 | 0.500 U | 0.500 U | 39.0 | 54.8 | 5.20 | 5.80 |
| Barium | µg/L | 52.3 | 50.0 | 225 | 121 | 44.4 | 44.3 | 42.4 | 47.1 | 77.4 | 83.4 |
| Beryllium | µg/L | 0.100 U | 0.100 U | 0.260 | 0.100 U | 0.100 U | 0.100 U | 0.100 U | 0.100 U | 0.100 U | 0.100 U |
| Boron | µg/L | 2,680 | 3,050 | 1,960 | 1,560 | 2,020 | 2,100 | 19.8 | 19.5 | 92.0 | 118 |
| Cadmium | µg/L | 0.130 | 0.120 | 0.230 | 0.100 U | 0.100 U | 0.100 | 0.100 U | 0.100 U | 0.100 U | 0.100 U |
| Calcium | µg/L | 167,000 | 158,000 | 91,100 | 82,800 | 76,000 | 71,900 | 209,000 | 184,000 | 224,000 | 213,000 |
| Chloride | mg/L | 64.7 | 68.9 | 59.4 | 64.5 | 64.6 | 68.4 | 20.9 | 25.3 | 14.9 | 16.7 |
| Chromium | µg/L | 1.00 U | 1.00 U | 5.50 | 1.00 U | 1.00 U | 1.00 U | 1.20 | 1.70 | 1.00 U | 2.20 |
| Cobalt | µg/L | 1.00 | 0.700 | 4.60 | 1.20 | 0.570 | 0.500 U | 17.8 | 19.1 | 1.00 | 1.10 |
| Combined Radium | pCi/L | 1.10 | 6.52 | 0.617 | 1.06 | 0.552 | 0.371 | 0.564 | 1.48 | 0.765 | 1.27 |
| Fluoride | mg/L | 0.380 | 0.370 | 0.800 | 0.560 | 0.140 | 0.110 | 0.150 | 0.140 | 0.0990 | 0.0680 |
| Lead | µg/L | 0.500 U | 0.500 U | 5.30 | 0.500 U | 0.500 U | 0.500 U | 1.20 | 1.40 | 1.10 | 1.20 |
| Lithium | µg/L | 17.1 | 19.8 | 10.0 U | 10.0 U | 10.0 U | 10.0 U | 10.0 U | 10.0 U | 10.0 U | 10.0 U |
| Mercury | µg/L | 0.000500 U | 0.000500 U | 0.00965 | 0.000670 | 0.000500 U | 0.000500 U | 0.00186 | 0.00117 | 0.00123 | 0.000785 |
| Molybdenum | µg/L | 30.4 | 32.3 | 36.3 | 40.0 | 1.30 | 1.60 | 1.30 | 1.40 | 0.500 U | 0.500 U |
| Selenium | µg/L | 0.500 U | 0.500 U | 0.570 | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| Sulfate | mg/L | 419 | 416 | 167 | 202 | 149 | 164 | 471 | 560 | 404 | 433 |
| Thallium | µg/L | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| Total Dissolved Solids | mg/L | 905 | 874 | 563 | 484 | 415 | 425 | 1,260 | 1,210 | 1,050 | 983 |
| pH | SU | 6.82 | 7.10 | 7.12 | 6.95 | 6.53 | 6.05 | 6.35 | 6.26 | 6.65 | 6.43 |

Notes:
mg/L: milligrams per liter
µg/L: micrograms per liter
SU: standard unit
pCi/L: picocuries per liter
U: Parameter was not present in concentrations above method detection limit and is reported as the reporting limit
J: Estimated value. Parameter was detected in concentrations below the reporting limit
All samples were collected as part of the assessment monitoring program in accordance with 40 CFR 257.90(e)(3).

# Table 2: Residence Time Calculation Summary
## Cardinal Plant - Bottom Ash Pond

| | | | 2019-03 | | 2019-10 | |
|---|---|---|---|---|---|---|
| CCR Management Unit | Monitoring Well | Well Diameter (inches) | Groundwater Velocity (ft/year) | Groundwater Residence Time (days) | Groundwater Velocity (ft/year) | Groundwater Residence Time (days) |
| Bottom Ash Pond | MW-BAP-1 [2] | 2.0 | 30.6 | 2.0 | 32.4 | 1.9 |
| | MW-BAP-2 [2] | 2.0 | 9.4 | 6.5 | 12.4 | 4.9 |
| | MW-BAP-3 [2] | 2.0 | 20.8 | 2.9 | 9.3 | 6.5 |
| | MW-BAP-4 [1] | 2.0 | 16.6 | 3.7 | 42.8 | 1.4 |
| | MW-BAP-5 [1] | 2.0 | 10.1 | 6.0 | 20.1 | 3.0 |

Notes:
[1] - Upgradient Well
[2] - Compliance Well

# 40 CFR 257.101 (f)(1)(iv)(B)(4)

A decryption of site hydrogeology including stratigraphic cross-sections

### 2.4.2 Regional and Local Geologic Setting

The BAP is located in an area of Ohio which was unglaciated during the last ice age. The surficial geology at the BAP consists of alluvial silt, clay, and sand deposited by the Ohio River floodwaters, underlain by glacial outwash deposits of sand and gravel. The glacial outwash deposits extend to the bedrock surface, which occurs at approximately 60 feet below the natural ground surface at the pond. Bedrock consists of interbedded shale, sandstone, coal, and limestone of the Pennsylvanian-aged Conemaugh Formation (BBC&M, 2009; CHA, 2009).

### 2.4.3 Surface Water and Surface Water-Groundwater Interactions

The BAP is located immediately west of the Ohio River. According to United States Army Corps of Engineers records, the Ohio River elevation at this location is controlled by the Pike Island Dam, with a regular pool elevation of 644.0 ft above msl (USACE, 2003). Notes on an AEP plan drawing provide 50-year and 100-year flood elevations for the Ohio River of 664.0 ft and 666.0 ft above msl, respectively.

Surface water near the BAP enters a tributary to the Ohio River. According to USACE maps, the nearest tributary entering the Ohio River is Salt Run, located approximately 0.5 miles to the north (USACE, 2003). Riddles Run and Blockhouse Run are located approximately 1.25 and 1.5 miles to the north, respectively. Groundwater also flows towards and recharges the Ohio River. Seasonal fluctuations in the Ohio River pool stage near the BAP are expected to reflect seasonal precipitation values for Brilliant, Ohio with the highest pool elevations in the spring and summer months. The BAP is separated from the lower aquifer by a confining silt and clay layer of at least 5 feet in thickness. However, limited seepage may occur from the BAP to the near-surface zone of saturation, which drains towards the Ohio River.

### 2.4.4 Water Users

Based on water well records obtained from the Ohio Department of Natural Resources (ODNR, 2016) online search tools, the nearest domestic water supply wells are located approximately one mile west of the BAP. The well records indicate well depths ranging from 30 to 110 feet below ground surface within shale and sandstone aquifers. According to the Jefferson County Water and Sewer District, there are no surface water intakes supplying water to the town of Brilliant, Ohio. Brilliant's water source comes from two groundwater wells located at a water treatment plant approximately three miles northeast of the BAP.

# 3. MONITORING NETWORK EVALUATION

## 3.1 Hydrostratigraphic Units

### 3.1.1 Horizontal and Vertical Position relative to CCR Unit

The principal regional aquifer is comprised of the alluvial sediments along the Ohio River, located below and east of the BAP. The identified uppermost aquifer in the vicinity of the BAP is the Sand and Gravel aquifer, which is hydraulically connected to the Ohio River. The BAP is lies above and is separated from the uppermost aquifer by a lower conductivity layer of silty clay and silt which thickens toward the west away from the Ohio River. The five (5) groundwater monitoring wells that make up the groundwater monitoring network around the BAP are screened to target the Sand and Gravel beneath the lower conductivity separation layer. Cross-sections illustrating the horizontal and vertical position of BAP relative to the uppermost aquifer are provided in Appendix B.

### 3.1.2 Overall Flow Conditions

Regionally, the most productive aquifer is the surficial aquifer, comprised of sand and gravel alluvial deposits along the Ohio River. Water supply wells within this aquifer can sustain yields of up to several hundred gallons per minute (gpm). This surficial aquifer is likely recharged through direct precipitation, infiltration from the Ohio River, and to a smaller extent, discharge from the surrounding bedrock (Geosyntec, 2006). Seasonal variation in the groundwater table beneath the BAP is expected to reflect the seasonal variation in precipitation with the highest groundwater elevations in the spring and summer months as well as the season fluctuation in the pool stage of the Ohio River.

Based on ODNR water well logs, the surficial aquifer of alluvial sediments along the Ohio River near the BAP can generally sustain yields of up to several hundred gpm.

## 3.2 Uppermost Aquifer

### 3.2.1 CCR Rule Definition

According to the 2015 CCR rule, the term "uppermost aquifer" has the same provisions as in §257.40: "The geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within the facility's property boundary. This definition includes a shallow, deep, perched, confined, or unconfined aquifer, provided that it yields usable water" (40 CFR 257.60).

For purposes of this report, it is assumed that the uppermost useable aquifer has the following characteristics: (1) groundwater production rate over a 24-hour period of at least 0.1 gallons per minute (gpm); and (2) groundwater quality with total dissolved solids (TDS) less than 10,000 milligrams per liter (mg/L).

### 3.2.2 Identified Onsite Hydrostratigraphic Unit

Based on boring log and monitoring well data around the BAP, the uppermost aquifer system is comprised of fine to coarse sand and gravel associated with the alluvial sediments of the Ohio River valley. The sand and gravel of the uppermost aquifer has an estimated range of hydraulic conductivity from 1 x 10-1 to 1 x 10-4 centimeters per second (cm/sec). in the area of the BAP. The direction of flow is generally to the east and southeast toward the Ohio River. Contours depicting the groundwater elevations and general direction of flow in the uppermost aquifer are shown in Figure 3-1. The uppermost aquifer is separated from an upper zone of saturation and the bottom of the BAP unit by a layer of silty clay, organic clay and silt that varies in thickness from 9.5 ft to 33.6 ft. The thicker portions of the layer are typically found along the west side of the BAP farthest from the Ohio River. Boring logs also suggest that the top of top of the uppermost aquifer ranges in elevation from approximately 619 ft to 635 ft. above mea sea level (amsl).

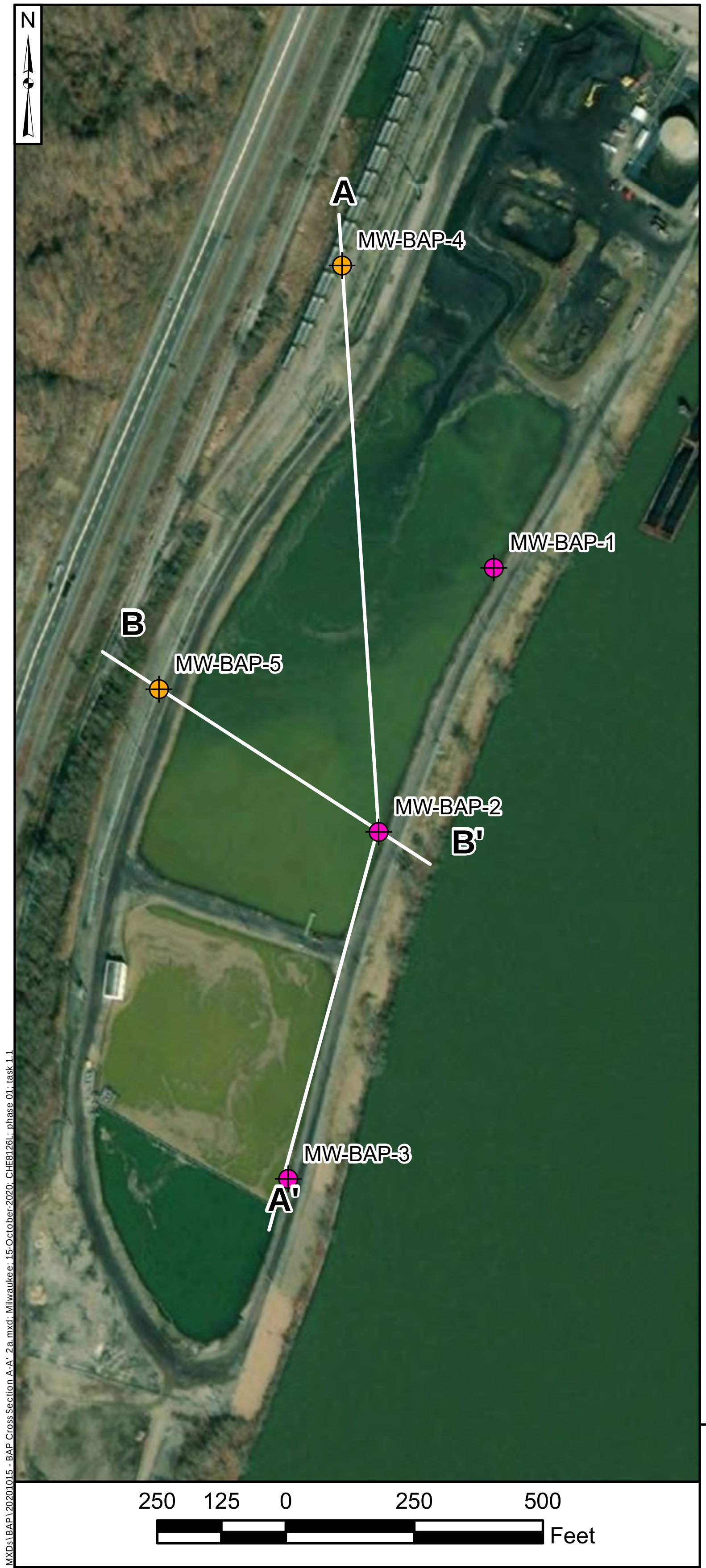
## 3.3 <u>Review of Existing Monitoring Network</u>

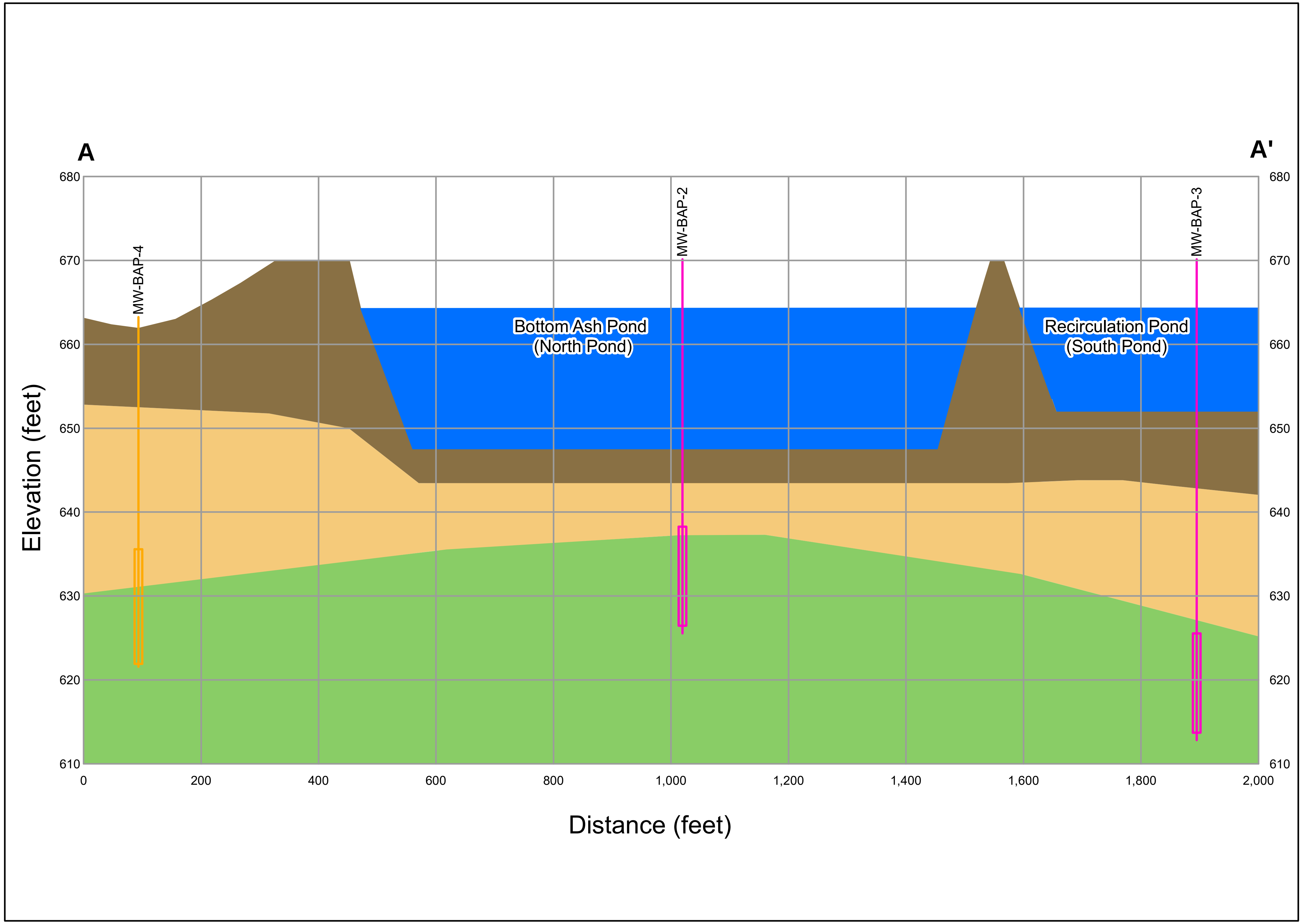
### 3.3.1 Overview

The groundwater monitoring network is shown on Figure 3-2 and consists of two (2) wells located upgradient (MW-BAP-4 and MW-BAP-5) and three (3) monitoring wells located downgradient (MW-BAP-1, MW-BAP-2 and MW-BAP-3) of the BAP and provide detection monitoring for the uppermost aquifer (Sand and Gravel Aquifer). The number, spacing, and depth of groundwater monitoring wells included in the groundwater monitoring network are based on site-specific geochemical, geologic and hydrogeologic information of the uppermost aquifer. Well construction details are summarized in Table 3-1. Boring and well construction logs for the groundwater monitoring well network wells are provided in Appendix C.

### 3.3.2 Compliance Assessment

Review of the existing groundwater monitoring well network in relation to the geologic and hydrogeologic conditions in the area of the BAP indicates that the monitoring well network consists of a sufficient number of wells installed at the appropriate depths to collect groundwater samples from the uppermost aquifer that accurately represent the groundwater quality upgradient and downgradient of the BAP. The groundwater monitoring well network is also capable of providing upgradient background groundwater quality and downgradient detection monitoring for a potential contaminant release to the uppermost aquifer (Sand and Gravel Aquifer) nearest the waste boundary. Based on the above review, the groundwater monitoring network around the Cardinal BAP meets the requirements of 40 CFR 257.91.





**Notes**
- Aerial imagery courtesy of ESRI.
- All boundaries are approximate.

**Legend**

⊕ Monitoring Well, Background

⊕ Monitoring Well, Compliance

🟦 Surface Water

🟫 Fill

🟧 Alluvium (Silt/Clay)

🟩 Glacial Outwash

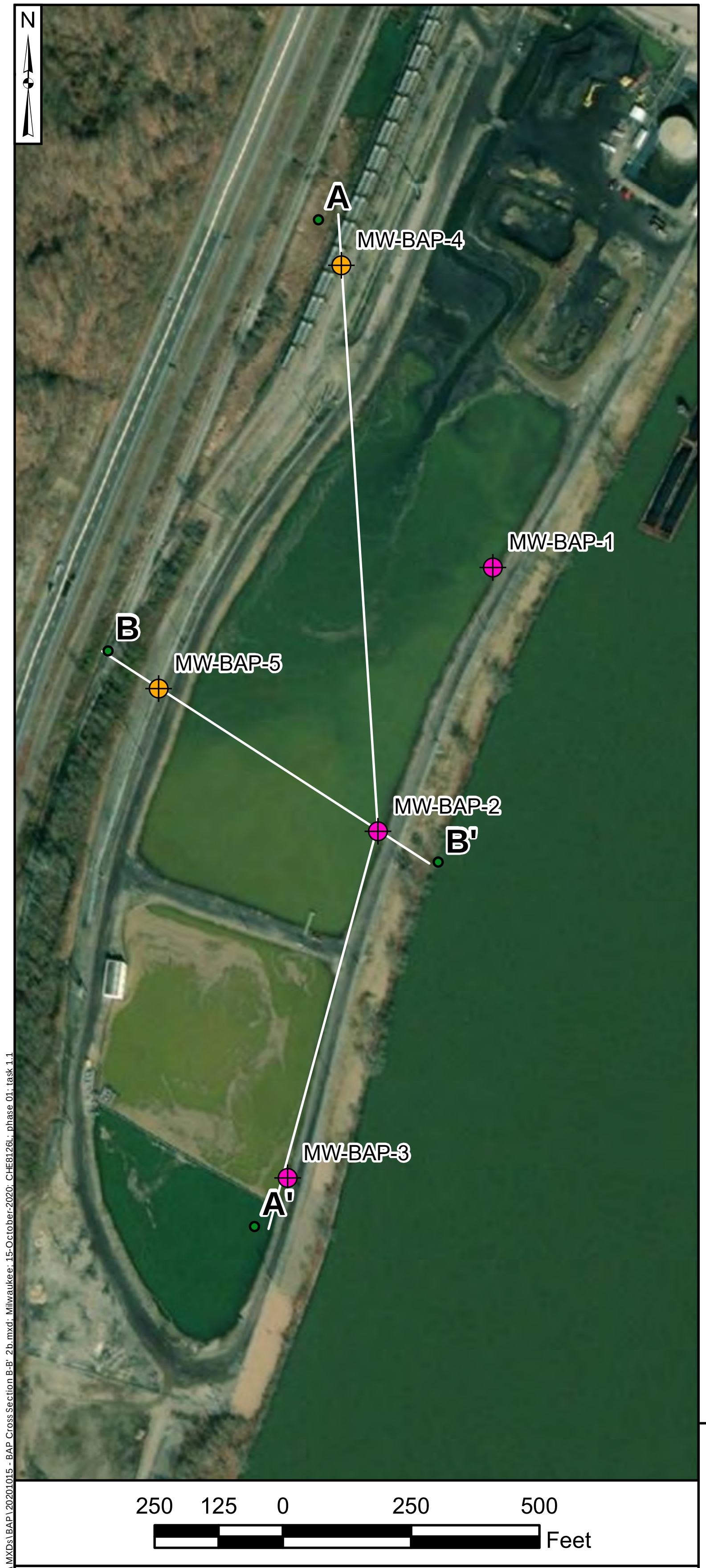
**Cardinal BAP**
**Geologic Cross Section A - A'**
**Current Conditions**
Cardinal Power Plant
Brilliant, Ohio

Geosyntec
consultants

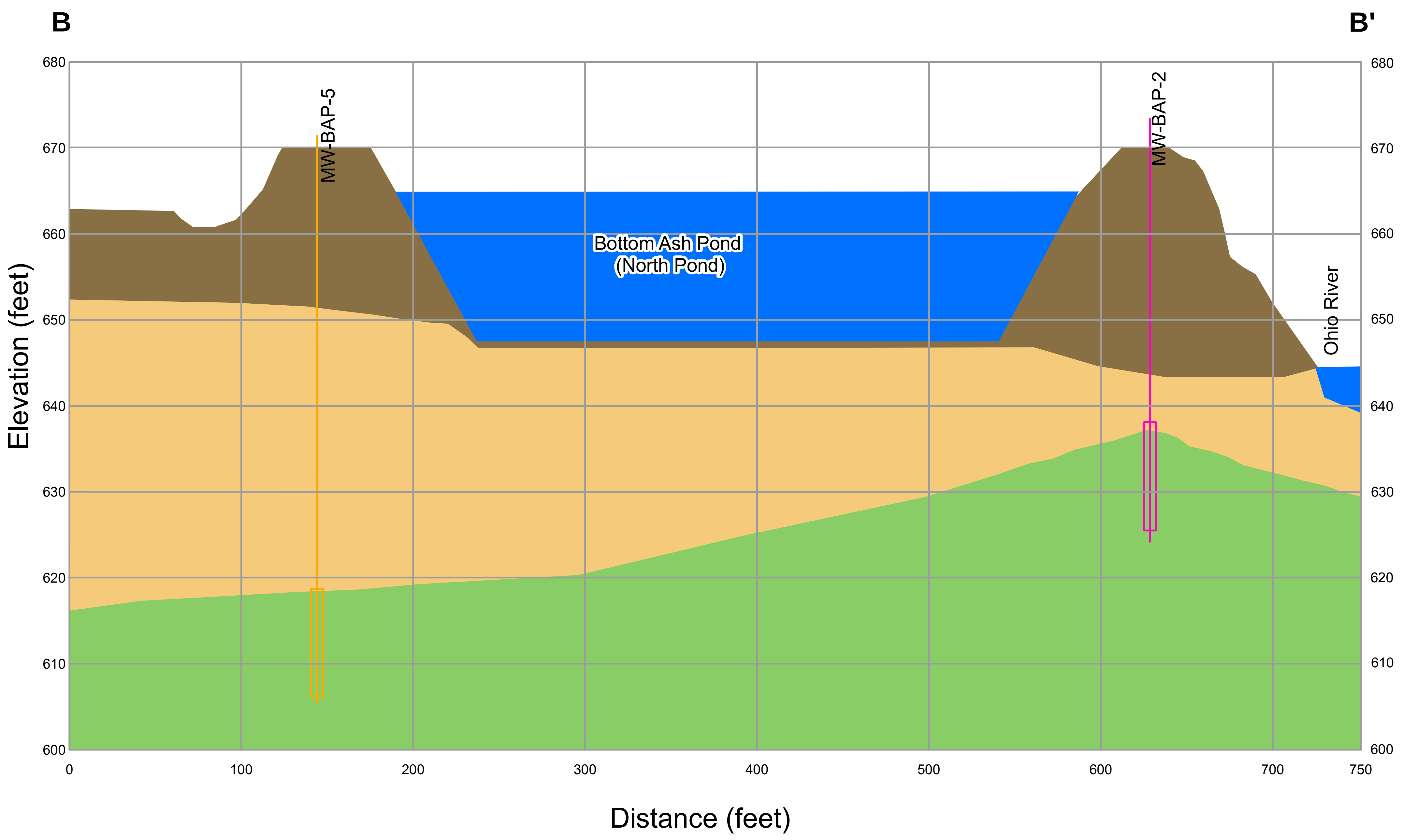
Columbus, Ohio
August 2020

Figure
**Xa**

C:\Users\cchristenson\Desktop\MXDs\BAP\20201015 - BAP Cross Section A-A' 2a.mxd; Milwaukee; 15-October-2020; CHE8126L; phase 01; task 1.1



**Notes**
- Aerial imagery courtesy of ESRI.
- All boundaries are approximate.



**Legend**

⊕ Monitoring Well, Background
⊕ Monitoring Well, Compliance

🟦 Surface Water
🟫 Fill
🟧 Alluvium (Silt/Clay)
🟩 Glacial Outwash

**Cardinal BAP**
**Geologic Cross Section B - B'**
**Current Conditions**
Cardinal Power Plant
Brilliant, Ohio

Geosyntec
consultants

Columbus, Ohio
August 2020

Figure
**Xb**

# 40 CFR 257.101 (f)(1)(iv)(B)(5)

Any corrective measures assessment conducted as required at 40 CFR 257.96

Not applicable. The Bottom Ash Pond is currently in Assessment Monitoring.

# 40 CFR 257.101 (f)(1)(iv)(B)(6)

Any progress reports on corrective action remedy selection and design and the report of final remedy selection required at 40 CFR 257.97(a)

Not applicable. The Bottom Ash Pond is currently in Assessment Monitoring.

# 40 CFR 257.101 (f)(1)(iv)(B)(7)

The most recent structural stability assessment required at 40 CFR 257.73(d)

# STRUCTURAL STABILITY ASSESSMENT

## CFR 257.73(d)

Bottom Ash Pond Complex
Cardinal Plant
Brilliant, Ohio

October, 2016

Prepared for: Cardinal Operating Company - Cardinal Plant

Brilliant, Ohio

Prepared by: Geotechnical Engineering Services

American Electric Power Service Corporation

1 Riverside Plaza

Columbus, OH 43215

GERS-16-135

# STRUCTURAL STABILITY ASSESSMENT
# CFR 257.73(d)
# BOTTOM ASH COMPLEX
# CARDINAL PLANT

GERS-16-135

**PREPARED BY** Mohammad A. Ajlouni, Ph.D.,P.E. **DATE** 10/4/2016

**REVIEWED BY** JT Massey-Norton
John T. Massey-Norton **DATE** 10/4/2016

**APPROVED BY** Gary F. Zych
Gary F. Zych, P.E.
Manager – AEP Geotechnical Engineering **DATE** 10/5/2016

STATE OF OHIO
MOHAMMAD
A
AJLOUNI
67074
REGISTERED
PROFESSIONAL ENGINEER

I certify to the best of my knowledge, information and belief that the information contained in this structural stability assessment meets the requirements of 40 CFR 257.73(d)

# TABLE OF CONTENTS

## 1.0 OBJECTIVE 257.73(d)

This report was prepared by AEP- Geotechnical Engineering Services (GES) section to fulfill requirements of CFR 257.73(d) and document whether the design, construction, operations, and maintenance of the CCR unit is consistent with recognized and generally accepted good engineering practices. This is the initial assessment as per the Rule.

## 2.0 NAME AND DESCRIPTION OF CCR SURFACE IMPOUNDMENT

The Cardinal Power Plant in Wells Township, Jefferson County, near the town of Brilliant in eastern Ohio. The Cardinal Power Plant is owned by Buckeye Power and AEP Generation Resources (GENCO) a unit of American Electric Power. is operated by Cardinal Operating Company. The facility operates two surface impoundments for storing CCR; the Bottom Ash Pond (BAP) Complex and Cardinal Fly Ash Reservoir II (FAR II) Dam. The focus of this report is the Bottom Ash Pond Complex.

The BAP complex is comprised of diked embankments on the east and west sides while the north and south sides of the BAP are incised. The complex consists of two separate ponds, the larger bottom ash pond and the smaller recirculation pond. The entire crest length is just over a mile, and the nominal crest width is 20 feet. The north end of the pond has been partially filled in with ash and the exact limits of the pond are poorly defined.

The pond complex was originally developed as part of the construction of Units 1 and 2 in the 1960s. The crest of the dikes forming the original pond was at El. 658.0. However, the pond complex was raised to a crest elevation of 970.0 and extensively modified in 1974 as part of the construction of Unit 3.

## 3.0 STABLE FOUNDATION AND ABUTMENTS 257.73(d)(1)(i)

***[Was the facility designed for and constructed on stable foundations and abutments? Describe any foundation improvements required as part of construction.]***

Based on the historical cross-sections extending through both the Bottom Ash Pond and the Recirculation Pond from the vertical expansion, the original ash pond embankments along the Ohio River ranged in height from 4 to 6 feet above the bottom of the ash pond.

A subsurface investigation was conducted in 2009 and the strength parameters of the foundation as well as the embankment were defined based on laboratory tests or correlations to known strengths based on blow counts. Table 1 lists the material properties for the foundation material.

The original ground surface at the site is generally located between El. 645 and 655. Near surface soils generally consist of a layer of alluvium silt, clay and fine sand (organic in some locations) over glacial outwash deposits of variable thickness overlying the bedrock surface. The alluvium clays and silts were deposited in the backwater of the Ohio River, while the outwash materials typically consist of sand, gravel and silt deposits deposited during the last ice age. Based on geological literature, the glacial outwash extends to the bedrock surface, estimated to be roughly 50 to 60 feet below the natural ground surface at the pond. The upper most bedrock consists of shale and/or sandstone belonging to the Conemaugh Group of Pennsylvanian Age. The soils were screened for liquefaction potential and found to be non-liquefiable.

Table 1 Strength Parameters for main Natural/constructed zones.

| Layer | $\gamma_m$ | c' | φ' |
|---|---|---|---|
| | pcf | psf | degrees |
| Newer Embankment Fill | 125 | 0 | 31 |
| Original Embankment Fill | 125 | 100 | 30 |
| Alluvium Silt/Clay | 125 | 0 | 30 |
| Organic Clayey Silt | 125 | 0 | 30 |
| Loose Glacial Outwash Sand/Gravel | 115 | 0 | 29 |
| MDe Glacial Outwash Sand/Gravel | 120 | 0 | 34 |

## 4.0 SLOPE PROTECTION 257.73(d)(1)(ii)

***[Describe the slope protection measures on the upstream and downstream slopes.]***

The Bottom Ash Complex was designed and constructed with soil embankment covered with a layer of bottom ash built up along the inboard slopes providing further protection. The outboard slopes primarily consist of grass vegetation with portions of the outboard slope protected by coarse riprap.

Operation and maintenance of the aggregate primarily includes periodic spraying for vegetation control. Grassed slopes are mowed regularly. Any erosion or slips that may occur is repaired within a timely period.

## 5.0 EMBANKMENT CONSTRUCTION 257.73 (d)(1)(iii)

***[Describe the specifications for compaction and/or recent boring to give a relative comparison of density.]***

The BAP complex embankments have maximum height of approximately 25 feet and are constructed of compacted clay on a slope ranging from 2.5:1 (2.5 feet horizontal, 1 foot vertical). The elevation at the top of the embankment around the perimeter of the BAP is approximately 670 feet msl, and the normal operating level is approximately 665 feet msl. The embankment fill materials dike ranged from hard silty Clay to fine and coarse gravel, overlying native material. The interior bottom elevation of the BAP Complex is approximately 645 feet msl.

The pond complex was originally developed as part of the construction of Units 1 and 2 in the 1960s. The crest of the dikes forming the original pond was at El. 658.0. However, the pond complex was raised to a crest elevation of 970.0 and extensively modified in 1974 as part of the construction of Unit 3.

No construction specifications are available for the Bottom Ash Pond. Recent borings through the embankment indicate that the embankment material is a medium stiff to very stiff sandy lean clay and representative of a compacted earthen material. A stability analysis of the diking system was also conducted which demonstrates that the facility has a factor of safety great than minimum values required by the CCR rule.

## 6.0 VEGETATION CONTROL 257.73 (d)(1)(iv)

***[Describe the maintenance plan for vegetative cover.]***

The vegetative areas are mowed to facilitate inspections and maintain the growth of the vegetative layer; and prevent the growth of woody vegetation.

## 7.0 SPILLWAY SYSTEM 257.73(d)(1)(v)

***[Describe the spillway system and its capacity to pass the Inflow Design Flood as per its Hazard Classification.]***

The Bottom Ash Complex has been determined to be a Significant Hazard potential CCR impoundment. Based on this hazard classification the design flood is determined by section 257.82(a)(3) to be the 1000-year storm. An analysis was performed for the 50% Probable Maximum Flood (PMF), which looks at 50% of the runoff from PMP storm of 33 inches in 24 hours. This produces significantly more runoff than the 1000-year storm and therefore exceeds the requirements of section 257.82(a)(3).

The Cardinal Bottom Ash Complex is comprised of diked embankments on three sides which directs storm water away from the impoundment and limits runoff to that which falls directly on the pond surface. The area of the pond is approximately 24.3 acres. The pond also receives pumped inflow from plant facilities and stormwater collection areas.

Discharge to the Ohio River is through a principal spillway located at the south end of the recirculation pond (a drop outlet and a 36"-pipe). During normal operation, there is no discharge to the river; rather all flows are re-circulated into the plant via the pump station located on the west side of the re-circulation pond.

Based on the flood routing, the calculated peak discharge from the dam is 67.7 cfs at a maximum pool elevation of 668.1 feet NGVD.

## 8.0 BURIED HYDRAULIC STRUCTURES 257.73 (d)(1)(vi)

***[Describe the condition of the sections of any hydraulic structure that in buried beneath and/or in the embankment.]***

The discharge pipe does not show any sign of corrosion or deterioration based on an exterior visual inspection.

## 9.0 SUDDEN DRAWDOWN 257.73 (d)(1)(vii)

***[If the downstream slope is susceptible to inundation, discuss the stability due to a sudden drawdown.]***

The downstream slope of the Bottom Ash Complex is not expected to be inundated from any adjacent water bodies.

# 40 CFR 257.101 (f)(1)(iv)(B)(8)

The most recent safety factor assessment required at 40 CFR 257.73(e)

# Bottom Ash Pond
# Initial Safety Factor Assessment
# Cardinal Power Plant
# Brilliant, Ohio
# S&ME Project No. 7217-15-007A

Prepared for:
**American Electric Power**
**1 Riverside Plaza, 22nd Floor**
**Columbus, Ohio  43215**

Prepared by:
**S&ME, Inc.**
**6190 Enterprise Court**
**Dublin, OH 43016**

**December 30, 2015**

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# Appendices

# 1.0 Introduction

## 1.1 Background

In April of 2015, the US EPA formally published national regulations for disposal of coal combustion residuals (CCR) from electric facilities. As part of the rule, the owner or operator of the CCR unit must obtain a certification from a qualified professional engineer stating that aspects of the CCR impoundments are in accordance with the rules. Based on our understanding of the Request for Fee Estimate received from AEP on April 29, 2015, AEP specifically requested P.E. certification to fulfill the requirements of 40 CFR § 257.73(e), *Periodic Safety Factor Assessments*. In the employment of BBC&M Engineering, Inc., the undersigned engineers conducted site investigations at the bottom ash pond in 2009 and 2010. Due to our familiarity with the site, S&ME was selected to perform the Safety Factor Assessment for this facility. S&ME understands that certification and/or documentation for other structural integrity criteria will be performed by AEP or other consultants.

## 1.2 Location and Geologic Conditions

The Cardinal Generating Plant is located along the Ohio River between Brilliant, Ohio and Tiltonsville, Ohio. The Bottom Ash Pond Complex is located along the west bank of the river just to the south of the Unit 3 area. The Bottom Ash Complex consists of two components: the Bottom Ash Pond and the Recirculation Pond. The Bottom Ash Pond is located north of the Recirculation Pond and they are separated by an earthen embankment. The crest elevation for all of the embankments has a minimum Elevation of 670 feet. The total length of the exterior embankment along the Ohio River is approximately 2,000 feet. Based on the current topography around the bottom ash complex, there is no discernable embankment on the north and south ends, thus the areas of the pond embankments are typically identified by referencing the eastern or western embankments. The bottom ash pond is operated at a constant Elevation of 664.5 feet. For comparison, the normal pool for this stretch of the Ohio River is EL. 644, as controlled by the Pike Island Dam Both ponds are isolated from exterior surface water inflow and during normal operation, all water that enters the pond is pumped back to the plant via the pump station located within the Recirculation Pond. The exception is during high rainfall events where the principal spillway may activate releasing water into the Ohio River through an NPDES outfall. The discharge is controlled by a 4-foot wide weir surveyed at Elevation 666.2. A review of the historical plans available for the bottom ash pond facility is included in Appendix V.

The original ground surface at the site is generally located between El. 645 and 655. Near surface soils generally consist of a layer of alluvium silt, clay and fine sand (organic in some locations) over glacial outwash deposits of variable thickness overlying the bedrock surface. The alluvium clays and silts were deposited in the backwater of the Ohio River, while the outwash materials typically consist of sand, gravel and silt deposits deposited during the last ice age. Based on geological literature, the glacial outwash extends to the bedrock surface, estimated to be roughly 50 to 60 feet below the natural ground surface at the pond. The upper most bedrock most likely consists of shale and/or sandstone belonging to the Conemaugh Group of Pennsylvanian Age.

Figure 1-1 – Cardinal Plant

## 1.3 Previous Investigations

In 2009, the undersigned engineers, when in the employment of BBC&M Engineering, Inc., completed a subsurface investigation and geotechnical assessment of the bottom ash pond embankments. The assessment, dated August 4, 2009, concluded that the embankment exhibited adequate factors of safety against slope failure under steady-state seepage and seismic loading conditions relative to typical US Army Corps of Engineers requirements. In 2010, BBC&M Engineering, Inc. performed additional geotechnical analyses and an hydrology and hydraulic evaluation of the pond. As part of this work, additional slope stability failure modes were examined, including the maximum surcharge pool and rapid drawdown load cases. A report documenting the additional geotechnical analysis, dated December 17, 2010, was submitted as an addendum to the 2009 report. The text from the 2009 report and an excerpt from the 2010 follow-up report is Appendices V and VI.

## 2.0 Scope of Work

In accordance with AEP's request, the following work items were performed by S&ME:

1. S&ME completed a cursory review of previously conducted assessment work performed by the undersigned engineers, as well as a limited number of construction documents made available by AEP.

2. S&ME visited the site along with personnel from AEP. The site visit was not a formal inspection, but rather served to document any significant modifications or changed conditions that may have taken place since the time of the previous investigations.

3. Upon completing Tasks 1 and 2, S&ME determined that there was insufficient information to certify the structural integrity of the surface impoundment in accordance with the requirements of 40 CFR § 257.73(e). To this end, S&ME was authorized to perform a supplemental investigation to support the safety factor assessment. Details regarding the investigation are described in the following sections of this report.

## 3.0 Information Review and Site Visit

S&ME conducted a cursory review of previous documents relating to the bottom ash pond and conducted a site visit at the facility. AEP provided S&ME with the following documents:

- Site Development Plan 1973 (Dwg. 3-3017-5 and 3-3027-3)
- Assessment of Dam Safety Final Report, Clough Harbour, & Assoc., December, 2009
- Bottom Ash Pond Subsurface Investigation & Analysis, BBC&M Engineering, Inc., August, 2009
- Addendum to Bottom Ash Pond Investigation, BBC&M Engineering, Inc., December, 2010

On August 18, 2015, the undersigned S&ME personnel met with Dr. Mohammad Ajlouni (AEP Civil Engineering) and Mr. Randy Sims (Landfill Operations) at the Cardinal Plant and conducted a site visit at the bottom ash pond. The participants discussed and observed the operations of the bottom ash and recirculation ponds, including the hydraulic structures within the ponds. During our visit, two localized possible seepage areas were observed on the outboard slope of the eastern embankment of the recirculation pond. Based on discussions with the group, it was believed that the seepage areas were relatively new.

One apparent seepage area was located immediately north of the existing riprap and the other was approximately 300 feet north of the riprap. The limits of the possible seepage areas were delineated with a handheld GPS unit. The apparent seepage areas range from 35 to 50 feet wide by 6 to 8 feet high. The seepage areas were observed to be wetter than the surrounding area and were muddy in some areas, which may be a result of mowing operations. While the ground surface has been softened as a result of seepage, there was no indication of flowing water emanating at either of the areas at the time of our visit. Additionally there was no indication of piping of soil. S&ME understands the riprap on the outboard slope of the recirculation pond to the south of the new seepage area was constructed as an inverted filter; similar seepage conditions were observed in this area resulting in construction of the filter. Based on the historical drawings, the embankments do not contain any internal drains to intercept/control the phreatic surface within the embankment. Despite this, S&ME understands the embankments have otherwise performed well, particularly in regard to shallow sloughs along the outboard slope of the 41 years that they have been in service in the current configuration.

While no other visual observations suggested dam safety concerns, S&ME noted the following modifications to the bottom ash pond complex since the 2009 and 2010 assessments:

- The northern section of the western bottom ash pond embankment was widened on the outboard side to create additional space for construction staging.
- Crest improvements were made to raise low areas and establish a consistent top of dam Elevation of 670 feet.
- The 2009 investigation focused only on the river side embankment. Although the river side embankment is significantly taller than the west embankment, investigation of the west embankment was believed to be warranted.

## 4.0 Field and Laboratory Work

As part of the 2009 investigation, 7 soil borings were performed along the eastern embankment of the bottom ash pond and recirculation pond. For the 2015 supplemental investigation, S&ME performed 4 soil borings along the western embankments, as well as two additional shallow borings through the eastern embankment crest upstream from the identified seepage areas. The borings are designated as CD-BAP-1501 through B-1505 and MW-BAP-4 through MW-BAP-5. Boring CD-BAP-1503, originally planned to be located at the toe of the west embankment could not be accessed and was not performed. Boring numbers with 'MW' indicate a monitoring well was installed at this location, which were performed as part of a separate hydrogeology study. Additionally, S&ME installed three other monitoring wells, designated MW-BAP-1 through MW-BAP-3, and advanced one soil boring designated CD-BAP-1506 as part of the separate hydrogeology study at the bottom ash pond facility. Although not performed as part of this factor of safety assessment, the results from these explorations were considered in developing our understanding of the embankments and foundation soils. Locations of all explorations are shown on the Plan of Borings included as Drawing No. 1 in Appendix I.

Laboratory testing was performed on selected representative soil samples obtained during the field investigations to determine natural moisture content (ASTM D2216), liquid and plastic limits (S&ME adjustment to ASTM D4318), and grain size analyses (ASTM D422). The results of these and other tests permit an evaluation of the strength, compressibility and permeability characteristics of the soils encountered at this site.

The results of the moisture content testing and of the liquid and plastic limits are graphically displayed on the individual boring logs presented in Appendix I. All laboratory test results, including a summary of laboratory test results and grain size analyses are presented in Appendix II.

# 5.0 Subsurface Conditions

## 5.1 Stratigraphy

Borings CD-BAP-1501,CD-BAP-1502, and MW-BAP-5 were performed from the crest of the western embankment, while Boring MW-BAP-4 was performed from the toe of the western embankment. Based on the descriptions of the samples recovered in the borings and laboratory testing, the subsurface stratigraphy for each section can generally be described in descending order from the top of the western embankment as follows:

- Borings CD-BAP-1502 and MW-BAP-5 were performed from the crest of the embankment encountered 15 inches of aggregate at the ground surface overlying 10 to 13 feet of embankment fill consisting of medium-dense to dense fine to coarse sand and gravel and hard clayey silt. SPT N-values (corrected for 60% energy) ranged from 13 to 60 while hand penetrometer measurements on samples exhibiting cohesion ranged from __ to 4.5+ tons per square foot (tsf).
- Boring CD-BAP-1501 was performed from the widened crest area. The boring encountered 15 inches aggregate underlain by 11.5 feet of embankment fill consisting of a thin stratum of medium-stiff clayey silt over of loose to medium dense fine to coarse sand.
- Underlying the embankments, the borings encountered alluvial soils consisting of

Borings CD-BAP-1504 and CD-BAP-1505 were performed from the crest of the eastern embankment adjacent to the observed seepage areas. The main purpose of these boring was to identify potential anomalies within the embankments that would suggest a unique circumstance which could be contributing to the observed seepage. Both borings were advanced to a depth of 16 feet within the embankment fill. For reference, the seepage areas were observed to begin approximately 6 to 8 feet below the crest. These borings, along with results from the sampling from monitoring wells MW-BAP-1, MW-BAP-2 and MW-BAP-3 did not reveal any appreciable differences from the crest borings performed during the 2009 investigation, such as a layer or zone of clean sand, as the embankment fill was already known to contain soils of a varying degree.

The stratigraphy of the eastern embankments is summarized in the text from the 2009 Investigation included as Appendix V.

## 5.2 Groundwater Conditions

Groundwater observations were made as each boring was being advanced and measurements were made at the completion of drilling. The groundwater observations are graphically displayed on the boring logs and also noted at the bottom of the log, and are referenced from the ground surface. Groundwater was encountered within the crest borings at a depth of approximately 15 feet. Groundwater in Boring MW-BAP-4 was encountered at a depth of 5.5 feet. The groundwater readings correlate to an approximate Elevation of 655 feet.

Temporary open standpipe piezometers were installed in Borings CD-BAP-1504 and CD-BAP-1505 to obtain groundwater information in relation to the observed seepage area. Unfortunately, owing to the presence of overhead electric along the outboard side of the crest, the borings had to be performed near the inboard side of the crest. Several longer term groundwater readings were taken during the course of the field work. The readings are summarized on the individual well logs, and generally range between Elevation 661 and Elevation 663. The readings indicate a small decrease in water level from the recirculation pond operating pool. It should be noted that all of the wells positioned within the crest are located on the inboard side to avoid blocking the road as well as the overhead power lines.

### 5.3 Shear Strength and Permeability

The laboratory testing results for the 2015 investigation were compared to laboratory testing completed as part of the 2009 investigation. The comparison of the index testing was performed to determine if there was any justification for developing different shear strength and permeability values for the subsurface materials encountered in the western side of the complex than had been previously been estimated for cross-sections on the eastern side in 2009. As the results of the 2009 laboratory index testing are very similar to the new index testing results, S&ME is of the opinion that the strength parameters used to characterize the eastern embankment and foundation soils in 2009 are applicable to the supplemental investigation of the western embankment and foundation soils.

The shear strength parameters used in the slope stability analysis are shown in Table 5-1.

**Table 5-1 – Shear Strength Parameters**

| *Material Description* | $\gamma_{wet}$ *(pcf)* | *Effective* | | *Reference* |
|---|---|---|---|---|
| | | φ′ | c′ (psf) | |
| Newer Embankment Fill | 125 | 31° | 0 | SPT and Index Testing Correlations |
| Original Embankment Fill | 125 | 30° | 100 | Index Testing Correlations |
| Alluvium Silt and Clay | 125 | $30^{o}$ | 0 | Index Testing Correlations |
| Organic Clayey Silt | 125 | $30^{o}$ | 0 | Index Testing Correlations and CU Triaxial Test (BBCM 2009) |
| Very Loose to Loose Glacial Outwash Sand and Gravel | 115 | 29° | 0 | SPT and Grain Size Correlations |
| Medium Dense Glacial Outwash Sand and Gravel | 120 | 34° | 0 | SPT and Grain Size Correlations |
| Granular Embankment Fill(1) | 115 | $30^{o}$ | 0 | SPT and Grain Size Correlations |

(1)Applies only to widened crest area on the northwestern side of bottom ash pond

## 6.0 Safety Factor Assessment

As part of the safety factor assessment, S&ME completed Parts 1 and 2 of Section 257.73(e) of the Final Rules for the Disposal of Coal Combustion Residuals from Electric Utilities published on April 17, 2015 in the Federal Register. In accordance with the Rule, the analysis was performed for the critical cross-sections(s) that are anticipated to be most susceptible of all cross-sections to structural failure based on appropriate engineering considerations. The Rule specified the following loading conditions for analysis:

i. Static Factor of Safety under the long-term, maximum storage pool loading condition must equal or exceed 1.50.
ii. Calculated static factor of safety under the maximum surcharge pool loading condition must equal or exceed 1.50.
iii. The calculated seismic factor of safety must equal or exceed 1.00.
iv. For dikes constructed of soils susceptible to liquefaction, the calculated liquefaction factor of safety must equal or exceed 1.20.

## 6.1 Limit Equilibrium Analyses

The 2009 Investigation Report and the 2010 Addendum discuss in detail the subsurface investigation, laboratory testing, parameter justification, seepage analyses and limit equilibrium slope stability analyses that were performed to develop safety factors for the bottom ash pond embankments. As mentioned previously, engineering parameters developed as part of the 2009 and 2010 investigations were utilized for the new analyses associated with the western embankment as the laboratory testing and subsurface investigation did not encounter soil properties that differed greatly from the soils encountered in the previous investigations.

In summary, four sections along the eastern (river-side) embankment and two sections along the western embankment were studied. Both cross-sections through the western embankment are located within the bottom ash pond as the embankment adjacent to the recirculation pond is only 4 to 6 feet high and access to the toe was not readily available. Subsurface information for each section was obtained by performing borings through the crest and toe of the embankment. Based on a review of all six sections explored, three were selected for detailed limit equilibrium stability analysis (two on the eastern embankment and one on the western embankment).

Prior to performing the limit equilibrium stability analyses as part of the 2009 assessment, seepage analyses were performed to develop a better understanding of the likely phreatic surface within the embankment and foundation. The models were calibrated by adding additional total head boundary conditions within the subsurface to best model the groundwater table as observed in the observation wells. Although a classically shaped phreatic surface extending from the ash pond level to the Ohio River was generated by the seepage analyses, much of the seepage emanating from the ponds appears to be moving downward through the newer embankment fill and thin stratum of alluvium soils and into the glacial outwash sand and gravel stratum which essentially serves as a drain.

Results of the slope stability analysis indicate that the critical cross-section occurs through the eastern embankment of the bottom ash pond (referred to as Section D in the 2009 and 2010 assessments). The design cross-section does not vary along the eastern embankment, but Section D yielded the lowest factors of safety due to slight variations in the outboard slope. All load cases performed for the Safety Factor Assessment as well as additional load cases evaluated for typical US Army Corps of Engineer's requirements met the minimum factor of safety for global stability.

One observed seepage area is located just north of Section B and the other is located approximately 200 feet south. Comparison of boring logs for CD-BAP-1504 and CD-BAP-1505 with the log for boring CD-PZ-BAP-0902 located at Section B do not reveal any key differences in the embankment fill. In fact, Boring CD-PZ-BAP-0902 exhibited a larger zone of granular embankment fill located within the observed elevation of seepage on the outboard slope, but no seepage was observed adjacent to this boring. The fill soils are believed to vary laterally through the embankment as much as it was observed to vary vertically at the boring locations, suggesting that the granular layers observed in the borings are unlikely to extend all the way through the embankment. Considering this, it is the opinion of S&ME that at this time, the seepage areas are representative of localized pockets of more permeable soils within the overall embankment matrix. As such, it is not believed that the phreatic surface intercepts the outboard face, but rather that there are narrow zones of seepage with unsaturated soils beneath. Nonetheless, these areas should be addressed, as further discussed below.

As noted, the seepage observed during our August, 2015 site visit appeared to occur in two isolated areas. With time, the outboard slope at these locations may weaken due to the presence of groundwater within close proximity to the ground surface resulting in reduced shear strength and shallow slope failures. Though such a failure would typically be minor in extent, S&ME recommends these areas be addressed in the near future before they lead to more significant issues over time. Construction of an inverted filter may be suitable given the performance of the existing inverted filter on the south end. S&ME also recommends continued monitoring of these areas to ensure soils particles are not being carried from inside the embankment.

## 6.2 Liquefaction Potential of Embankment Soils

S&ME evaluated the potential of the embankment soils to liquefy during a seismic event. The embankment material is classified as a fined grained material and the recovered samples with gradation testing were evaluated following guidelines presented in the 2003 NEHRP (National Earthquake Hazards Reduction Program) Recommended Provisions for Seismic Regulations for New Buildings and Other Structures. The provisions in Chapter 7 indicate that liquefaction potential in fine grained soils should be assessed provided the following criteria are met (Seed and Idriss 1982; Seed et al., 1983): the weight of the soil particles finer than 0.005 mm is less than 15 percent of the dry unit weight of a specimen of the soil; the liquid limit of soil is less than 35 percent; and the moisture content of the in-place soil is greater than 0.9 times the liquid limit. If all of these criteria are not met, the soils may be considered non-liquefiable.

Laboratory testing results from 16 fine grained samples that were available from the 2009 and 2015 investigations for evaluation of the screening criteria. Of the 16 samples, 8 samples contained data to check all three screening criteria, and 7 samples contained data to check two screening criterion. Based on the results of the screening, no sample met all 3 criteria; therefore, these fine grained embankment fill can be considered non-liquefiable. A table depicting this evaluation is included in Appendix IV.

The potential for the coarse grained embankment soils to resist liquefaction was evaluated. The fine grained (cohesive) and coarse grained (granular) embankment soils appear to be from the same borrow source as there are no well-defined layers and often only minor variations in the percent by weight of the recovered sample change the main description from fine grained to coarse grained. Although construction records were not available, the density of the coarse grained samples and consistency of the fine grained samples within the embankment fill suggest they were well compacted. Based on the controlled manner in which the fill was placed, the coarse grained embankment soils can be considered non-liquefiable.

### 6.3 Summary of Results

A summary of the computed safety factors for the critical cross-section is provided in Table 5-2. Also included in the table are the minimum values defined in 40 CFR § 257.73(e)(1) subparts (i) through (iv). Graphical output corresponding to the analysis cases are presented in Appendix IV along with additional slope stability load cases evaluated during the course of the bottom ash pond assessments.

**Table 6-1 – Safety Factor Summary**

| Analysis Case | Minimum Safety Factor | Computed Safety Factor |
|---|---|---|
| Long-term, maximum storage pool | 1.50 | 1.52 |
| Maximum surcharge pool | 1.40 | 1.52 |
| Pseudo-static seismic loading | 1.00 | 1.09 |
| Embankment Liquefaction | 1.20 | Non-liquefiable |

## 7.0 Certification

Based on our previous investigations and current assessment of the Bottom Ash Pond facility, S&ME certifies that this assessment meets the requirements of paragraphs (e)(1) and (e)(2) of Part 257.73 for the critical cross-section of the embankment.

We appreciate having been given the opportunity to be of service on this project. If you have any questions, please do not hesitate to contact this office.

Sincerely,

**S&ME, Inc.**

MICHAEL T. ROMANELLO
E-74384

12-30-15

Michael T. Romanello, P.E.
Project Engineer
Registration No. 74384

Michael G. Rowland, P.E.
Senior Engineer
Registration No. 65559

# Appendices

# Appendix I – 2009 & 2015 Site Investigation Figures

| BORING | NORTHING | EASTING | ELEVATION |
|---|---|---|---|
| CD-BAP-0901 | 819021.73 | 2513493.10 | 668.68 |
| CD-PZ-BAP-0902 | 819364.85 | 2513568.73 | 668.04 |
| CD-BAP-0903 | 819345.90 | 2513647.44 | 650.07 |
| CD-PZ-BAP-0904 | 819708.29 | 2513666.53 | 668.05 |
| CD-PZ-BAP-0905 | 819681.02 | 2513742.24 | 650.11 |
| CD-BAP-0906 | 820058.00 | 2513791.36 | 668.64 |
| CD-BAP-0907 | 820022.70 | 2513886.71 | 650.34 |
| CD-BAP-1501 | 820853.00 | 2513678.00 | 671 |
| CD-BAP-1502 | 820838.80 | 2513713.00 | 671 |
| CD-BAP-1504 | 819154.10 | 2513525.00 | 670 |
| CD-BAP-1505 | 819447.60 | 2513591.00 | 670 |
| CD-BAP-1506 | 818752.90 | 2513205.00 | 671 |
| MW-BAP-1 | 820309.50 | 2513925.00 | 670 |
| MW-BAP-2 | 819797.40 | 2513705.00 | 670 |
| MW-BAP-3 | 819116.30 | 2513518.00 | 670 |
| MW-BAP-4 | 820884.30 | 2513614.00 | 660 |
| MW-BAP-5 | 820057.10 | 2513275.00 | 670 |

DATUM: NAD 27/NGVD 29 OHIO SOUTH

SCALE IN FEET
0 100 200

REFERENCE: AEP CARDINAL DRAWING 94151038

LEGEND

EXISTING GROUND CONTOUR (1 FT. INTERVAL)
EXISTING WATER SURFACE (AT TIME OF SURVEY)
FENCE LINE
EXISTING VEGETATION
CV-PZ-BAP-0901 BORING NUMBER AND LOCATION 2009 INVESTIGATION
CD-BAP-1501 BORING NUMBER AND LOCATION 2015 INVESTIGATION
MW-BAP-1 ● MONITORING WELL NUMBER AND LOCATION 2015 INVESTIGATION

| | | | |
|---|---|---|---|
| PROJECT NUMBER: | 7217-15-007B | DRAWN BY: | MRM |
| DRAWING DATE: | 12-30-2015 | ENGINEER: | MTR |
| LAST UPDATED: | 12-30-2015 | APPROVED BY: | MGR |
| | | SCALE: | 1" = 100' |

S&ME
WWW.SMEINC.COM
6190 ENTERPRISE COURT
DUBLIN, OH 43015
(614) 793-2226
ENGINEERING FIRM LICENSE NUMBER: F-0176

| DATE | NO. | DESCRIPTION | APPD. |
|---|---|---|---|
| | | REVISIONS | |

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A.E.P.
CARDINAL PLANT
BRILLIANT OHIO

BOTTOM ASH POND
INVESTIGATION
PLAN OF BORINGS

DWG. NO. PLATE 1

SCALE: CIVIL ENGINEERING
DR:
CH:
ENGR:
PROJ ENGR:
DATE:
APPROVED BY

AMERICAN ELECTRIC POWER
AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

SYSTEM DATE- DD-MMM-YYYY
SYSTEM TIME- HOUR:MINUTE

IGS0694

# EXPLANATION OF SYMBOLS AND TERMS USED ON BORING LOGS FOR SAMPLING AND DESCRIPTION OF SOIL

## SAMPLING DATA

▮ - Blocked-in "SAMPLES" column indicates sample was attempted and recovered within this depth interval.

▯ - Sample was attempted within this interval but not recovered.

2/5/9 - The number of blows required for each 6-inch increment of penetration of a "Standard" 2-inch O.D. split-barrel sampler, driven a distance of 18 inches by a 140-pound hammer freely falling 30 inches. Addition of one of the following symbols indicates the use of a split-barrel other than the 2" O.D. sampler:

- 2S - 2½"O.D. split-barrel sampler
- 3S - 3" O.D. split-barrel sampler

P - Shelby tube sampler, 3" O.D., hydraulically pushed.

R - Refusal of sampler in very-hard or dense soil, or on a resistant surface.

50-2" - Number of blows (50) to drive a split-barrel sampler a certain number of inches (2), other than the normal 6-inch increment.

S/D - Split-barrel sampler (S) advanced by weight of drill rods (D),

S/H - Split-barrel sampler (S) advanced by combined weight of rods and drive hammer (H).

## SOIL DESCRIPTIONS

All soils have been classified basically in accordance with the Unified Soil Classification System, but this system has been augmented by the use of special adjectives to designate the approximate percentages of minor components as follows:

| Adjective | Percent by Weight |
|---|---|
| trace | 1 to 10 |
| little | 11 to 20 |
| some | 21 to 35 |
| "and" | 36 to 50 |

The following terms are used to describe density and consistency of soils:

| Term (Granular Soils) | Blows per foot |
|---|---|
| Very-loose | Less than 5 |
| Loose | 5 to 10 |
| Medium-dense | 11 to 30 |
| Dense | 31 to 50 |
| Very-dense | Over 50 |

| Term (Cohesive Soils) | Qu (tsf) |
|---|---|
| Very-soft | Less than 0.25 |
| Soft | 0.25 to 0.5 |
| Medium-stiff | 0.5 to 1.0 |
| Stiff | 1.0 to 2.0 |
| Very-stiff | 2.0 to 4.0 |
| Hard | Over 4.0 |

# LOG OF BORING NO. CD-BAP-1501
# BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
# CARDINAL PLANT, BRILLIANT, OH

S&ME

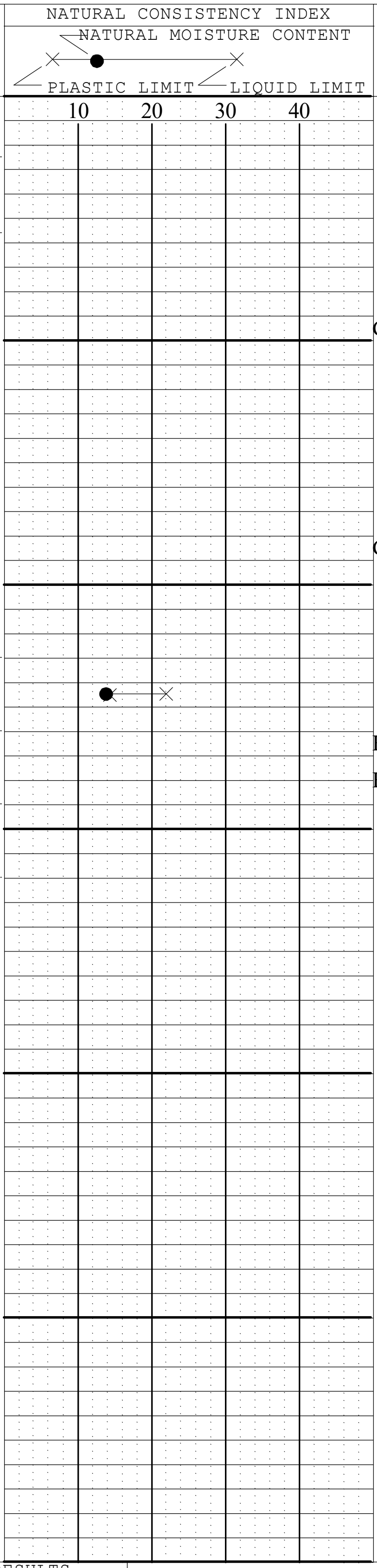
LOCATION: **N. 820,853, E. 2,513,678** ELEVATION: **671** DATE: **11/17/15 - 11/18/15**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **16.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|
| | 0 | | | | | | AGGREGATE - 15 INCHES | |
| 669.8 | | 1 | | 12/15/21 | 45 | 87 | FILL: Medium-stiff gray clayey silt, "and" fine to coarse sand, little fine gravel, intermixed with silty clay, damp. | |
| 668.2 | | 2 | | 5/6/4 | 13 | 67 | FILL: Loose to medium-dense brown and gray fine to coarse sand, little to some silty fine to coarse gravel, little to some silt, damp. | |
| | 5 | 3 | | 3/3/3 | 8 | 53 | | G |
| | | 4 | | 3/2/3 | 6 | 53 | | |
| | | 5 | | 1/3/5 | 10 | 80 | | |
| | | 6 | | 31/6/8 | 18 | 80 | | G |
| | 10 | 7 | | 50-1"R | | 0 | | |
| 659.5 | | 8 | | 8/19/13 | 40 | 73 | FILL: Dense brown fine to coarse sand, trace fine gravel, some to "and" clayey silt, damp. | |
| 658.0 | | 9A | | 10/15/19 | 43 | 100 | FILL: Stiff to very-stiff gray silty clay, some to "and" fine to coarse sand, little fine to coarse gravel, damp. | H=1.75-2.25 |
| | | 9B | | | | | | H=3.0-4.0 |
| 656.5 | 15 | 10 | | 8/8/19 | 34 | 67 | FILL: Dense brown and gray fine to coarse sand, little fine to coarse gravel, some silt, damp. | |
| 655.0 | | | | | | | | |
| | 20 | | | | | | | |
| | 25 | | | | | | | |
| | 30 | | | | | | | |

- Boring backfilled with cement bentonite grout.
- Boring location recorded with a hand-held GPS unit. Elevation estimated from March, 2015 plant survey.
- Datum: Ohio State Plane South NAD 27/ NAVD 29 (Plant Grid).



2010 NEW DEFAULT BORING LOG-W/ N60

WATER LEVEL: ▽ ▼

WATER NOTE:

DATE:

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.75
**Last Calibration Date :** 2/20/2013
**Drill Rig Number :** S&ME ATV 550-2

**JOB: 7217-15-007A**

# LOG OF BORING NO. CD-BAP-1502
# BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
# CARDINAL PLANT, BRILLIANT, OH

S&ME

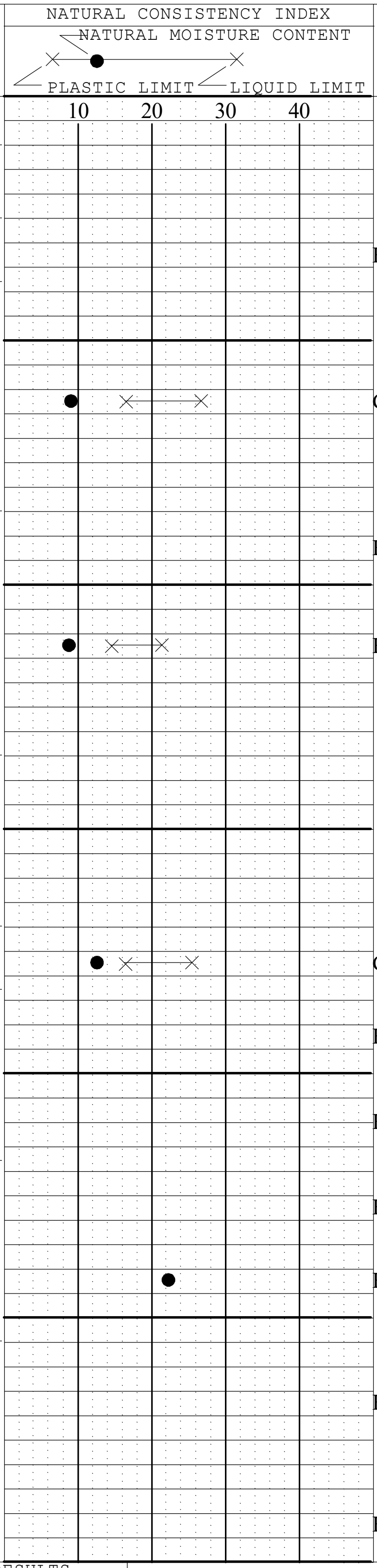
LOCATION: **N. 820,839, E. 2,513,713** ELEVATION: **671** DATE: **11/18/15**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **41.5'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

2010 NEW DEFAULT BORING LOG-W/ N60

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | TEST RESULTS |
|---|---|---|---|---|---|---|---|
| | 0 | | | | | AGGREGATE - 12 INCHES | |
| 670.0 | | | | | | | |
| | | 1 | 3/12/18 | 38 | 53 | FILL: Dense brown and gray fine to coarse gravel, some fine to coarse sand, little silt, damp. | |
| 668.5 | | | | | | | |
| | | 2 | 15/18/30 | 60 | 80 | FILL: Hard brown and gray clayey silt, "and" fine to coarse sand, little fine gravel, damp. | H=4.5 |
| 667.2 | | | | | | | |
| | 5 | 3 | 32/23/18 | 51 | 80 | FILL: Medium-dense to very-dense brown and gray fine to coarse sand, little to some fine to coarse gravel, little to some silt, silty clay, or clayey silt (varies), damp. | |
| | | 4 | 10/12/13 | 31 | 80 | | G |
| | | 5 | 8/10/11 | 26 | 93 | | |
| 662.5 | | | | | | | |
| | | 6 | 9/11/15 | 33 | 87 | FILL: Hard gray and brown clayey silt, some to "and" fine to coarse sand, little fine to coarse gravel, damp. | H=4.5 |
| | 10 | | | | | | |
| | | 7 | 11/15/18 | 41 | 53 | | H=4.5 |
| | | | P | | | | |
| 657.5 | | | | | | | |
| | | 8 | 3/4/7 | 14 | 67 | FILL: Medium-dense gray and brown fine to coarse sand, some fine to coarse gravel, some silty clay, moist becoming wet. | |
| | 15 | | | | | | |
| | | | P | | | | |
| 654.0 | | | | | | | |
| | | 9 | 7/7/8 | 19 | 87 | FILL: Medium-dense gray fine to coarse sand, some fine to coarse gravel, some clayey silt, wet. | G |
| 652.7 | | | | | | | |
| | | 10 | 7/6/3 | 11 | 100 | Stiff gray clayey silt, some fine to coarse sand, some fine gravel, moist. | H=1.25 |
| | 20 | | | | | | |
| | | | P | | | | H=1.25 |
| 649.2 | | | | | | | |
| | | 11 | 4/5/5 | 13 | 73 | Stiff brown silty clay, some fine to coarse sand, little to some fine to coarse gravel, moist. | H=2.5 |
| | | 12 | SH/SH/SH | 0 | 33 | | H=1.25 |
| | 25 | | | | | | |
| 645.5 | | | | | | | |
| | | 13 | SH/5/8 | 16 | 93 | Very-stiff red-brown mottled with gray silty clay, trace to little fine to coarse sand, contains silt seams, damp. | H=3.0-3.75 |
| | | 14 | 2/4/ | 13 | 93 | | H=3.5 |
| | 30 | | | | | | |



WATER LEVEL: ▽ ▼

WATER NOTE:

DATE:

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves
H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.75
**Last Calibration Date :** 2/20/2013
**Drill Rig Number :** S&ME ATV 550-2

-CONTINUED-

# LOG OF BORING NO. CD-BAP-1502
# BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
# CARDINAL PLANT, BRILLIANT, OH

S&ME

LOCATION: **N. 820,839, E. 2,513,713** ELEVATION: **671** DATE: **11/18/15**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **41.5'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT / PLASTIC LIMIT / LIQUID LIMIT (10 20 30 40) | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|
| 638.5 | 30 | 15 | 3 6 / 5 / 7 | 15 | 87 | Very-stiff red-brown mottled with gray silty clay, trace to little fine to coarse sand, contains silt seams, damp. | | H=3.5 |
| 636.5 | | | P | | | Stiff to very-stiff brown mottled with gray silty clay, some to "and" from to medium sand, trace coarse sand, damp. | | H=1.5-2.25 |
| 634.0 | 35 | 16 | 1 / 3 / 3 | 8 | 100 | Loose red-brown from to medium sand, trace coarse sand, "and" silt, damp. | | |
| 632.7 | | 17 | 3 / 2 / 3 | 6 | 100 | Stiff red-brown silty clay, "and" fine to medium sand, trace coarse sand, trace fine gravel, damp. | | H=1.75 |
| 629.5 | 40 | 18 | 2 / 2 / 2 | 5 | 67 | Very-loose brown fine to medium sand, "and" silt, damp. | | G |
| | 45 | | | | | | | |
| | 50 | | | | | | | |
| | 55 | | | | | | | |
| | 60 | | | | | | | |

- Encountered water at 15.0'.
- Boring backfilled with cement bentonite grout.
- Boring location surveyed with a hand-held GPS unit. Elevation estimated from March 2015 plant survey.
- Datum: Ohio State Plane South NAD 27/NAVD 29 (Plant Grid).

WATER LEVEL: ▽ ▼
WATER NOTE:
DATE:

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.75
**Last Calibration Date :** 2/20/2013
**Drill Rig Number :** S&ME ATV 550-2

2010 NEW DEFAULT BORING LOG-W/ N60

# LOG OF BORING NO. CD-BAP-1504
# BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
# CARDINAL PLANT, BRILLIANT, OH

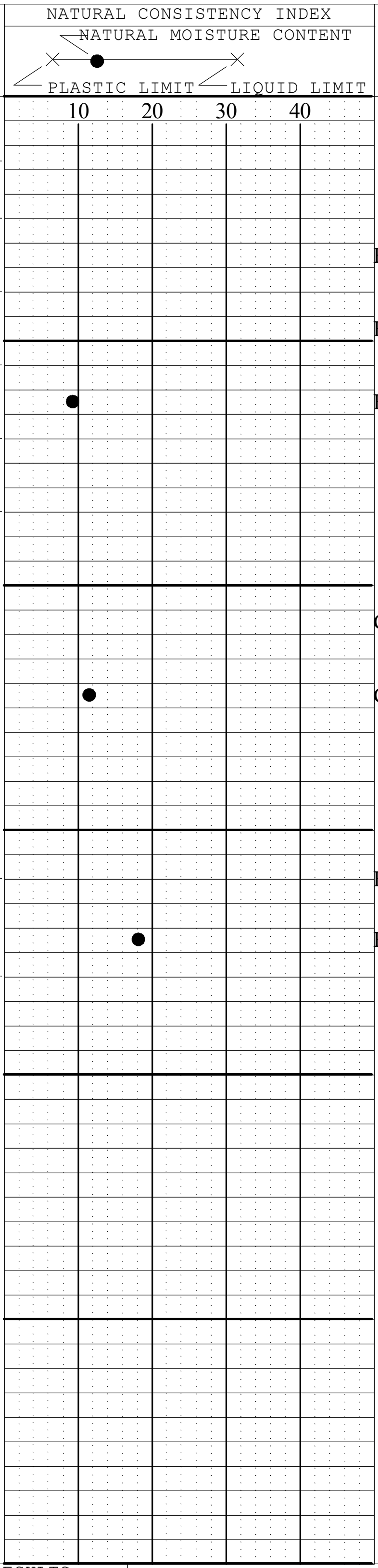
S&ME

LOCATION: **N. 819,154, E. 2,513,525** ELEVATION: **670** DATE: **11/16/15**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **18.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|
| | 0 | | | | | | AGGREGATE - 16 INCHES | |
| 668.7 | | 1 | | 27/18/14 | 40 | 87 | FILL: Hard gray and brown silty clay, some fine to coarse sand, brown fine gravel, dry. | |
| 667.5 | | 2 | | 18/10/9 | 24 | 80 | FILL: Medium-dense dark-brown fine to coarse sand, trace fine gravel, trace silt, dry. | H=4.0 |
| 666.0 | 5 | 3 | | 4/20/19 | 49 | 93 | FILL: Hard gray and brown silty clay, "and" fine to coarse sand, little fine gravel, dry. | H=4.0 |
| 664.5 | | 4 | | 11/18/24 | 53 | 100 | FILL: Dense dark-gray and brown fine to coarse sand, little to some fine to coarse gravel, some silty clay, dry. | H=4.0 |
| 663.0 | | ▽ 5 | | 24/17/14 | 39 | 67 | FILL: Hard brown silty clay, some fine to coarse sand, little fine gravel, dry. | |
| 661.5 | | 6 | | 11/14/21 | 44 | 33 | FILL: Medium-dense to dense brown and dark-gray fine to coarse sand, little to some fine to coarse gravel (sandstone fragments), little to "and" silty clay, dry. | |
| | 10 | 7 | | 7/11/16 | 34 | 67 | | G |
| | | 8 | | 11/8/10 | 23 | 27 | | G |
| | | 9 | | 8/27/16 | 54 | 47 | | |
| | 15 | 10 | | 2/4/7 | 14 | 0 | | |
| 654.0 | | 11<br>2S | | 11 | | 100 | FILL: Medium-stiff to stiff brown and gray silty clay, some fine to coarse sand, little fine to coarse gravel, damp becoming wet. | H=1.5-2.0 |
| | | 12 | | 1/4/4 | 10 | | | H=0.75-1.5 |
| 652.0 | | | | | | | | |
| | 20 | | | | | | - No seepage encountered.<br>- Encountered water at 16.5'.<br>- Borehole converted to temporary piezometer upon completion - See Separate Well Log.<br>- Boring backfilled with cement bentonite grout.<br>- Boring location surveyed with a hand-held GPS unit. Elevation estimated from March 2015 plant survey.<br>- Datum: Ohio State Plane South NAD 27/NAVD 29 (Plant Grid). | |
| | 25 | | | | | | | |
| | 30 | | | | | | | |



WATER LEVEL: ▽ 7.9 ▼

WATER NOTE: In Well

DATE: 12/10/15

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.75
**Last Calibration Date :** 2/20/2013
**Drill Rig Number :** S&ME ATV 550-2

Page 1 of 1

# LOG OF BORING NO. CD-BAP-1505
## BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
## CARDINAL PLANT, BRILLIANT, OH

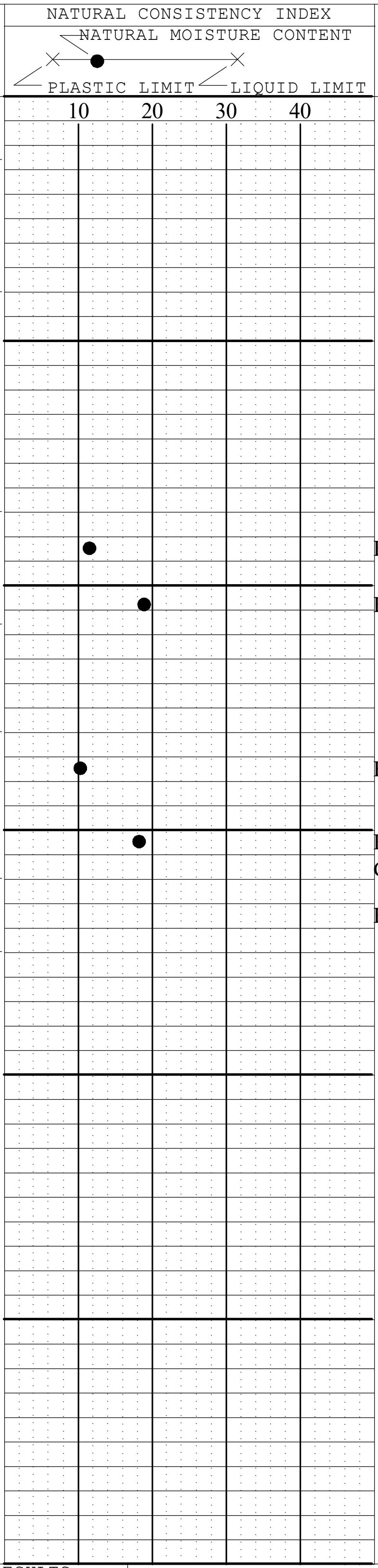
S&ME

LOCATION: **N. 819,448, E. 2,513,591** ELEVATION: **670** DATE: **11/17/15**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **17.5'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | $N_{60}$ | SAMPLE REC-% | DESCRIPTION | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|
| | 0 | | | | | | AGGREGATE - 16 INCHES | |
| 668.7 | | 1 | | 9/12/13 | 31 | 60 | FILL: Medium-dense to dense brown and gray fine to coarse sand, some fine to coarse gravel, little silt, dry. | |
| | | 2 | | 9/12/40 | 65 | 53 | | |
| 666.0 | 5 | 3 | | 10/10/9 | 24 | 53 | FILL: Medium-dense brown fine to coarse gravel, some fine to coarse sand, little to some silt, dry. | |
| | | 4 | | 6/9/14 | 29 | 13 | | |
| | | 5 | | 8/9/13 | 28 | 80 | | |
| 661.5 | ▽ | 6 | | 5/7/5 | 15 | 53 | FILL: Very-stiff to hard brown clayey silt, "and" fine to coarse sand, little to some fine to coarse gravel, damp to moist. | H=3.5 |
| | 10 | 7A | | 4/7/11 | 23 | 100 | | H=1.5 |
| 659.2 | | 7B | | | | | FILL: Medium-dense brown and gray fine to coarse sand, some fine to coarse gravel, little silty clay, dry. | |
| | | 8 | | 7/5/9 | 18 | 73 | | |
| 657.0 | | 9 | | 4/8/5 | 16 | 67 | FILL: Hard brown and gray silty clay, some fine to coarse sand, little fine to coarse gravel, moist. | H=4.5 |
| | 15 | 10 | | 3/5/8 | 16 | 87 | | H=4.5<br>G |
| 654.0 | | 11 | | 4/3/6 | 11 | 53 | FILL: Medium-stiff brown and gray silty clay, some fine to coarse sand, little fine to coarse gravel, moist. | H=0.5-1.0 |
| 652.5 | | | | | | | | |
| | 20 | | | | | | | |
| | 25 | | | | | | | |
| | 30 | | | | | | | |



- No seepage encountered.
- Encountered water at 14.5'.
- Borehole converted to temporary piezometer well upon completion - See Separate Well Log.
- Boring backfilled with cement bentonite grout.
- Boring location surveyed with a hand-held GPS unit. Elevation estimated from March 2015 plant survey.
- Datum: Ohio State Plane South NAD 27/NAVD 29 (Plant Grid).

| | ▽ | ▼ |
|---|---|---|
| WATER LEVEL: | 8.8 | |
| WATER NOTE: | In Well | |
| DATE: | 12/10/15 | |

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.75
**Last Calibration Date :** 2/20/2013
**Drill Rig Number :** S&ME ATV 550-2

**JOB: 7217-15-007A**

**PLATE 7**

Page 1 of 2

# LOG OF BORING NO. MW-BAP-4
# BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
# CARDINAL PLANT, BRILLIANT, OH

S&ME

LOCATION: **N. 820,884, E. 2,513,614** ELEVATION: **660** DATE: **11/20/15 - 11/23/15**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **40.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | $N_{60}$ | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT / PLASTIC LIMIT / LIQUID LIMIT<br>10 20 30 40 | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | | | | | | AGGREGATE - 12 INCHES | | |
| 659.0 | | | | | | | | | |
| | | 1 | | 4 / 15 / 16 | 39 | 87 | FILL: Medium-dense to dense gray and brown fine to coarse gravel, some to "and" fine to coarse sand, little to some silt, dry. | | H=4.25-4.5 |
| | | 2 | | 10 / 9 / 5 | 18 | 53 | | | |
| | | 3 | | 6 / 9 / 7 | 20 | 67 | | | |
| 654.7 | 5 | | | | | | | | |
| 654.2 | | | | | | | FILL: Very-soft brown and gray silty clay, "and" fine to coarse sand, little fine to coarse gravel. | | |
| | | 4 | | 35 / 13 / 12 | 31 | 87 | FILL: Dense bown fine to coarse sand, little fine to coarse gravel, "and" clayey silt, cobbles, moist. | | |
| | | 5 | | 50-3"R | | 20 | | | |
| 652.5 | | | | | | | Stiff to very-stiff dark-brown mottled with dark-gray silty clay, little fine to coarse sand, trace fine gravel, slightly organic, damp. | | |
| | | 6 | | 2 / 3 / 4 | 9 | 87 | | | H=2.0-3.0 |
| | 10 | | | | | | | | |
| | | | | P | | | | | H=1.25-2.5 |
| | 15 | | | | | | | | |
| 643.8 | | | | | | | Very-stiff brown mottled with gray silty clay, little fine to medium sand, trace coarse sand, few cobbles, contains silt seams near top of stratum, damp. | | |
| | | 7 | | 3 / 5 / 6 | 14 | 87 | | | H=2.0-3.5 |
| | | 8 | | 7 / 7 / 7 | 18 | | | | |
| | 20 | 2S | | 10 | | 100 | | | H=2.25-3.25 |
| | | 9 | | 3 / 5 / 6 | 14 | 100 | | | H=3.0 |
| | | 10 | | 3 / 5 / 6 | 14 | 100 | | | H=3.25 |
| | 25 | | | | | | | | |

2010 NEW DEFAULT BORING LOG-W/ N60

WATER LEVEL: ▽ ▼

WATER NOTE:

DATE:

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.75
**Last Calibration Date :** 8/2/2013
**Drill Rig Number :** S&ME ATV 550-2

-CONTINUED-

# LOG OF BORING NO. MW-BAP-4
# BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
# CARDINAL PLANT, BRILLIANT, OH

S&ME

LOCATION: **N. 820,884, E. 2,513,614** ELEVATION: **660** DATE: **11/20/15 - 11/23/15**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **40.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

2010 NEW DEFAULT BORING LOG-W/ N60

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | $N_{60}$ | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT / PLASTIC LIMIT / LIQUID LIMIT (10, 20, 30, 40) | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|---|
| | 25 | | | | | | Very-stiff brown mottled with gray silty clay, little fine to medium sand, trace coarse sand, few cobbles, contains silt seamsnear top of stratum, damp. | | |
| 633.3 | | 11A | ■ | 1/3/4 | 9 | 100 | | | H=2.5 |
| | | 11B | ■ | | | | Medium-stiff to stiff brown clayey silt, "and" fine to medium sand, trace coarse sand, includes sand seams, moist. | | H=0.5-1.5 |
| | | 12 | ■ | 1/2/1 | 4 | 100 | | | |
| 629.5 | 30 | | | | | | Very-loose brown and gray fine to medium sand, little to "and" silt (percent varies), contains zones with a trace of coarse sand, wet. | | |
| | | 13 | ■ | SH/SH/1 | 0 | 100 | | | |
| | | 14 | ■ | SH/SH/1 | 0 | 67 | | | |
| | 35 | | | | | | | | |
| | | 15 | ■ | SH/1/1 | 3 | 67 | | | |
| | | 16 | ■ | SH/SH/1 | 0 | 100 | | | |
| 620.0 | 40 | | | | | | | | |
| | | | | | | | - Encountered water at 5.5'.<br>- Encountered cobbles at 18.5'.<br>- Borehole converted to monitoring well upon completion - See separate well log.<br>- Boring elevation recorded with a hand held GPS unit. Elevation estimated from March 2015 survey.<br>- Datum: Ohio State Plane South, NAD 27/NAVD 29 (Plant Grid). | | |
| | 45 | | | | | | | | |
| | 50 | | | | | | | | |

WATER LEVEL: ▽ ▼

WATER NOTE:

DATE:

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.75

**Last Calibration Date :** 8/2/2013

**Drill Rig Number :** S&ME ATV 550-2

Page 1 of 3

# LOG OF BORING NO. MW-BAP-5
# BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
# CARDINAL PLANT, BRILLIANT, OH

S&ME

LOCATION: **N. 820,057, E. 2,513,275** ELEVATION: **670** DATE: **11/24/15 - 11/25/15**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **62.5'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | $N_{60}$ | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT / PLASTIC LIMIT / LIQUID LIMIT (10 20 30 40) | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | | | | | | AGGREGATE - 12 INCHES | | |
| 669.0 | | 1 | | 6/8/11 | 24 | 60 | FILL: Medium-dense brown fine to coarse sand, some fine to coarse gravel, some to "and" silty clay, dry. | | |
| | | 2 | | 16/5/5 | 13 | 60 | | | |
| | 5 | 3 | | 4/4/6 | 13 | 73 | | | |
| 664.5 | | 4 | | 5/9/32 | 51 | 87 | FILL: Hard gray and brown silty clay, "and" fine to coarse sand, little to some fine to coarse gravel, damp. | | H=4.5 |
| | | 5 | | 16/15/16 | 39 | 80 | | | H=4.5 |
| 661.5 | | 6 | | 10/13/11 | 30 | 87 | FILL: Medium-dense brown and gray fine to coarse sand, little fine to coarse gravel, some silty clay, damp. | | |
| 660.0 | 10 | | | P | | | FILL: Hard brown silty clay, some fine to coarse sand, some fine to coarse gravel (shale fragments), damp. | | H=4.5 |
| | | 7 | | 3/5/10 | 19 | 80 | | | H=4.5 |
| 656.5 | | 8 | | 10/11/25 | 45 | 80 | FILL: Medium-dense to dense brown fine to coarse gravel, some fine to coarse sand, some silty clay becoming trace silt at bottom of stratum, damp. | | H=3.0 |
| | 15 | 9 | | 11/7/6 | 16 | | | | |
| 653.1 | | 10A<br>10B | | 4/6/10 | 20 | 100 | Medium-stiff to stiff gray mottled with dark-gray and brown silty clay, trace fine to coarse sand, trace fine gravel, few roots, few silt seams, slightly organic, moist. | | |
| | | | | P | | | | | |
| | 20 | 11 | | SH/1/3 | 5 | 100 | | | H=0.5-1.25 |
| 647.0 | | 12 | | 2/2/4 | 8 | 100 | Medium-stiff to very-stiff brown mottled with gray silty clay, trace to little fine to coarse sand, damp. | | H=3.5 |
| | 25 | | | | | | | | |

WATER LEVEL: ▽ ▼

WATER NOTE:

DATE:

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.75
**Last Calibration Date :** 8/2/2013
**Drill Rig Number :** S&ME ATV 550-2

-CONTINUED-

Page 2 of 3

# LOG OF BORING NO. MW-BAP-5
# BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
# CARDINAL PLANT, BRILLIANT, OH

LOCATION: **N. 820,057, E. 2,513,275** ELEVATION: **670** DATE: **11/24/15 - 11/25/15**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **62.5'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

2010 NEW DEFAULT BORING LOG-W/ N60

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | $N_{60}$ | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX<br>NATURAL MOISTURE CONTENT<br>PLASTIC LIMIT — LIQUID LIMIT | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|---|
| | 25 | | | | | | Medium-stiff to very-stiff brown mottled with gray silty clay, trace to little fine to coarse sand, damp. | 10 20 30 40 | |
| | | | | P | | | | | |
| | | | | P | | | | | |
| | 30 | | | | | | | | |
| | | 13 | | 2/4/6 | 13 | 100 | | | H=2.0-3.5 |
| | | 14 | | 3/4/5 | 11 | 100 | | | H=2.5-3.0 |
| | 35 | | | | | | | | |
| | | 15 | | 2/5/6 | 14 | 100 | | | H=2.5 |
| | | 16 | | 2/3/5 | 10 | 100 | | | H=2.5 |
| | 40 | | | | | | | | |
| | | 17 | | SH/2/3 | 6 | 100 | | | H=1.25 |
| | | 18 | | SH/SH/SH | 0 | 100 | | | H=1.25 |
| | 45 | | | | | | | | |
| **624.5** | | | | | | | Stiff gray mottled with brown and dark-gray silty clay, trace fine to coarse sand, slightly organic, damp. | | |
| | | 19 | | SH/SH/1 | 0 | 100 | | | H=0.75 |
| **622.0** | | | | | | | Medium-stiff to stiff gray and dark-gray organic clayey silt, trace fine to coarse sand, damp. | | |
| | | 20 | | SH/SH/SH | 0 | 100 | | | H=0.75-1.25 |
| | 50 | | | | | | | | |

WATER LEVEL: ▽ ▼
WATER NOTE:
DATE:

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation, Q - Uncon Comp, T - Triax Comp, C - Consol. — See Separate Curves
H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.75
**Last Calibration Date :** 8/2/2013
**Drill Rig Number :** S&ME ATV 550-2

-CONTINUED-

# LOG OF BORING NO. MW-BAP-5
# BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
# CARDINAL PLANT, BRILLIANT, OH

S&ME

LOCATION: **N. 820,057, E. 2,513,275** ELEVATION: **670** DATE: **11/24/15 - 11/25/15**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **62.5'**

SAMPLER(S): **2" O.D. Split-barrel Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT / PLASTIC LIMIT / LIQUID LIMIT (10 20 30 40) | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|---|
| 619.5 | 50 | | | | | | Medium-stiff to stiff gray and dark-gray organic clayey silt, trace fine to coarse sand, damp. | | |
| | | 21 | ■ | 6/9/9 | 23 | 87 | Medium-dense to dense fine to coarse gravel, some to "and" fine to coarse sand, trace to little silt, wet. | | |
| | | 22 | ■ | 8/21/34 | 69 | 87 | | | |
| 614.6 | 55 | | | | | | Medium-dense to dense gray and brown fine to coarse sand, "and" fine to coarse gravel, little silt, wet. | | |
| | | 23 | ■ | 14/20/14 | 43 | 80 | | | |
| | | 24 | ■ | 7/12/16 | 35 | 60 | | | |
| | 60 | | | | | | | | |
| | | 25 | ■ | 8/4/5 | 11 | 60 | | | |
| 607.5 | | | | | | | | | |
| | | | | | | | - Encountered water at 17.0'.<br>- Borehole converted to monitoring well upon completion. See separate well log.<br>- Boring location recorded with a hand-held GPS unit. Elevation estimated from March 2015 plant survey.<br>- Datum: Ohio State Plane South NAD 27/NAVD 29 (Plant Grid). | | |
| | 65 | | | | | | | | |
| | 70 | | | | | | | | |
| | 75 | | | | | | | | |

2010 NEW DEFAULT BORING LOG-W/ N60

WATER LEVEL: ▽ ▼

WATER NOTE:

DATE:

SYMBOLS USED TO INDICATE TEST RESULTS

| | | |
|---|---|---|
| G - Gradation<br>Q - Uncon Comp<br>T - Triax Comp<br>C - Consol. | See Separate Curves | H - Penetrometer (tsf)<br>W - Unit Dry Wt (pcf)<br>D - Relative Dens (%) |

**Drill Rod Energy Ratio :** 0.75

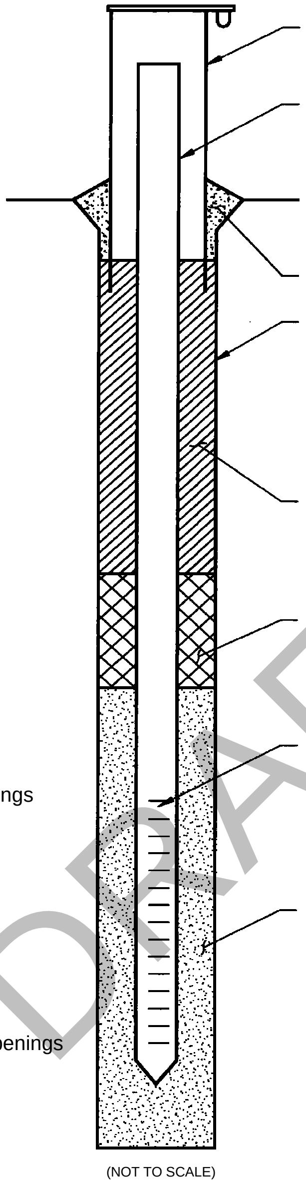
**Last Calibration Date :** 8/2/2013

**Drill Rig Number :** S&ME ATV 550-2

NOTE: This is a DRAFT well log.  Ground Elevation is approximate.

S&ME

| Elevation (Feet above MSL) | Depth Below Ground Surface (Feet) | |
|---|---|---|
| | | Top of Cover |
| **664.35** | **3.35** | Top of PVC |
| **661.0** | **0.0** | Ground Surface |
| **658.3** | **2.7** | Top of Grout |
| **639.4** | **21.6** | Top of Bentonite |
| **634.1** | **26.9** | Top of Filter Pack |
| | | Top of Aquifer |
| **632.1** | **28.9** | Top of Screen Openings |
| **622.3** | **38.7** | Bottom of Screen Openings |
| **621.7** | **39.3** | Bottom of Well |
| | | Bottom of Aquifer |
| **621.0** | **40.0** | Bottom of Boring |



**4** - Inch Diameter Protective Steel Casing

**2** - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)

**8** " **0.0** to **39.3**

" to

" to

Grout: **Portland & Quick Gel**

Bentonite Seal: **Bentonite pellets**

**10** - Slot Screen

Filter Pack: **#5 quartz sand**

| | | | | | |
|---|---|---|---|---|---|
| Depth to Static Water: | 18.79 | 18.71 | | | |
| Static Water Elevation: | 645.56 | 645.64 | | | |
| Date: | **12/11/15** | **12/15/15** | | | |

Well Development:

12/3 - Bailed 67.5 gallons of water (approx. 18 well volumes) out of well, water level stayed steady.
-Measurement on 12/15 was immediately before slug testing.
-Top cover set in 3'x3' concrete pad.  Protective steel bollards placed around concrete pad.

Water Quality Readings (Horiba U-52)

| Bucket | NTU | C | ms/cm | PH | ORPmV |
|---|---|---|---|---|---|
| 15.5 | 8.8 | 16.7 | 1.78 | 6.36 | -7 |

Well Location:       N. 820,884'  E. 2,513,614'
Datum: NAD27/NGVD29 OH S

## WELL COMPLETION DIAGRAM

**Project Name:**
AEP CD Bottom Ash Pond Monitoring Wells

**Project Location:**
Cardinal Plant / Brilliant, Ohio

**Project Number:**
7217-15-007A

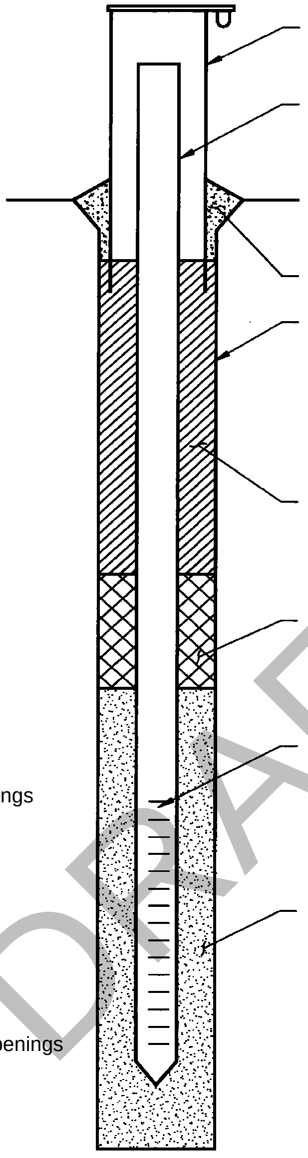
**Boring Number:**
MW-BAP-4

**Date Well Installed:**
11/23/2015

NOTE: This is a DRAFT well log. Ground Elevation is approximate.

**S&ME**

| Elevation (Feet above MSL) | Depth Below Ground Surface (Feet) | |
|---|---|---|
| | | Top of Cover |
| **672.88** | **2.88** | Top of PVC |
| **670.0** | **0.0** | Ground Surface |
| **663.4** | **6.6** | Top of Grout |
| **625.8** | **44.2** | Top of Bentonite |
| **620.3** | **49.7** | Top of Filter Pack |
| | | Top of Aquifer |
| **618.3** | **51.7** | Top of Screen Openings |
| **608.5** | **61.5** | Bottom of Screen Openings |
| **607.9** | **62.1** | Bottom of Well |
| | | Bottom of Aquifer |
| **607.5** | **62.5** | Bottom of Boring |


(NOT TO SCALE)

**4** - Inch Diameter Protective Steel Casing

**2** - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)

**8** " **0.0** to **62.1**

" to

" to

Grout: **Portland & Quick Gel**

Bentonite Seal: **Bentonite pellets**

**10** - Slot Screen

Filter Pack: **#5 quartz sand**

| | | | | | |
|---|---|---|---|---|---|
| Depth to Static Water: | 27.3 | 27.55 | 27.15 | 27.13 | |
| Static Water Elevation: | 645.58 | 645.33 | 645.73 | 645.75 | |
| Date: | **11/29/15** | **12/7/15** | **12/11/15** | **12/15/15** | |

Well Development:

12/10 - Bailed 61.5 gallons of water (approx. 13 well volumes) out of well, water level stayed steady.
-Measurement on 12/15 was immediately before slug testing.
-Top cover set in 3'x3' concrete pad. Protective steel bollards placed around concrete pad.

Water Quality Readings (Horiba U-52)

| Bucket | NTU | C | ms/cm | PH | ORPmV |
|---|---|---|---|---|---|
| 16 | 24.3 | 15.08 | 1.46 | 6.86 | -56 |

Note: For several buckets the NTU was leveled out in the 20's.

Well Location: N. 820,057' E. 2,513,274'
Datum: NAD27/NGVD29 OH S

## WELL COMPLETION DIAGRAM

**Project Name:**
AEP CD Bottom Ash Pond Monitoring Wells

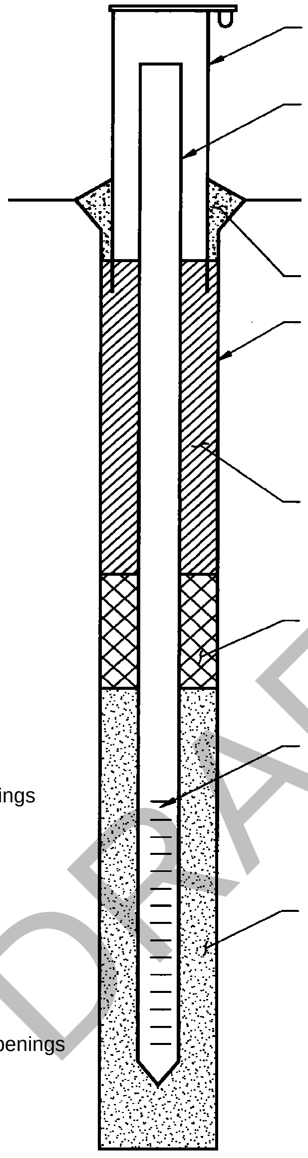
**Project Location:**
Cardinal Plant / Brilliant, Ohio

**Project Number:**
7217-15-007A

**Boring Number:**
MW-BAP-5

**Date Well Installed:**
11/25/2015

| Elevation (Feet above MSL) | Depth Below Ground Surface (Feet) | |
|---|---|---|
| | | Top of Cover |
| **672.45** | **2.45** | Top of PVC |
| **670.0** | **0.0** | Top of Bentonite |
| | | |
| | | |
| **657.7** | **12.3** | Top of Filter Pack |
| | | Top of Aquifer |
| **655.7** | **14.3** | Top of Screen Openings |
| **653.5** | **16.5** | Bottom of Screen Openings |
| **653.2** | **16.8** | Bottom of Well |
| | | Bottom of Aquifer |
| **652.0** | **18.0** | Bottom of Boring |



(NOT TO SCALE)

**No cover installed, well abandoned on 12/15/15**

**2** - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Hole Plug

Boring Diameter (in inches)
**8** " **0.0** to **18.0**
" to
" to

Grout: **no grout**

Bentonite Seal: **Bentonite Chips (hole plug)**

**10** - Slot Screen

Filter Pack: **#5 quartz sand**

| | | | | | |
|---|---|---|---|---|---|
| Depth to Static Water: | 9.2 | 9.75 | 9.69 | | |
| Static Water Elevation: | 663.25 | 662.70 | 662.76 | | |
| Date: | **11/29/15** | **12/11/15** | **12/15/15** | | |

Well Location: N. 819,154' E. 2,513,525'
Datum: NAD27/NGVD29 OH S

## WELL COMPLETION DIAGRAM

**Project Name:**
AEP CD Bottom Ash Pond Monitoring Wells

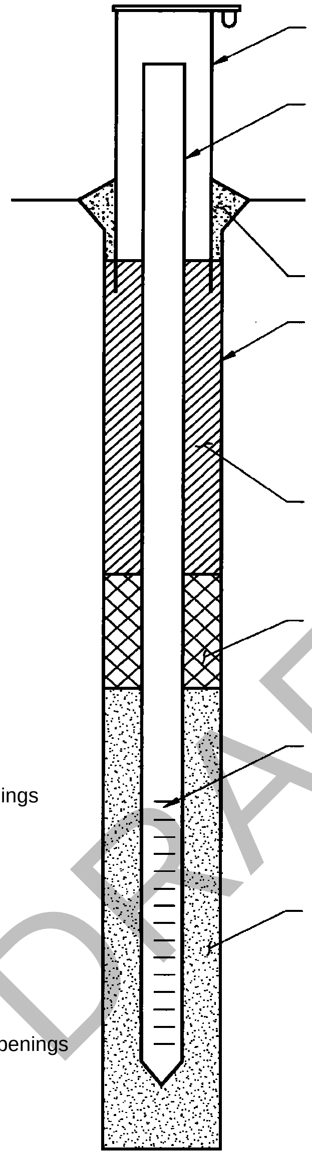
**Project Location:**
Cardinal Plant / Brilliant, Ohio

**Project Number:**
7217-15-007A

**Boring Number:**
CD-BAP-1504

**Date Well Installed:**
11/25/2015

| Elevation (Feet above MSL) | Depth Below Ground Surface (Feet) | |
|---|---|---|
| | | Top of Cover |
| **673.33** | **3.33** | Top of PVC |
| **670.0** | **0.0** | Ground Surface |
| **669.5** | **0.5** | Top of Grout |
| **659.6** | **10.4** | Top of Bentonite |
| **657.2** | **12.8** | Top of Filter Pack |
| | | Top of Aquifer |
| **658.0** | **12.0** | Top of Screen Openings |
| **653.2** | **16.8** | Bottom of Screen Openings |
| **652.5** | **17.5** | Bottom of Well |
| | | Bottom of Aquifer |
| **652.5** | **17.5** | Bottom of Boring |



(NOT TO SCALE)

**No cover installed, well abandoned on 12/15/15**

**2** - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Hole Plug

Boring Diameter (in inches)

| | | | |
|---|---|---|---|
| **8** " | **0.0** | to | **17.5** |
| " | | to | |
| " | | to | |

Grout: **Portland & Quick Gel**

Bentonite Seal: **Bentonite Chips (hole plug)**

**10** - Slot Screen

Filter Pack: **#5 quartz sand**

| | | | | | |
|---|---|---|---|---|---|
| Depth to Static Water: | 11.4 | 12.15 | 11.54 | | |
| Static Water Elevation: | 661.93 | 661.18 | 661.79 | | |
| Date: | **11/29/15** | **12/11/15** | **12/15/15** | | |

Well Location: N. 819,448' E. 2,513,591'
Datum: NAD27/NGVD29 OH S

## WELL COMPLETION DIAGRAM

**Project Name:**
AEP CD Bottom Ash Pond Monitoring Wells

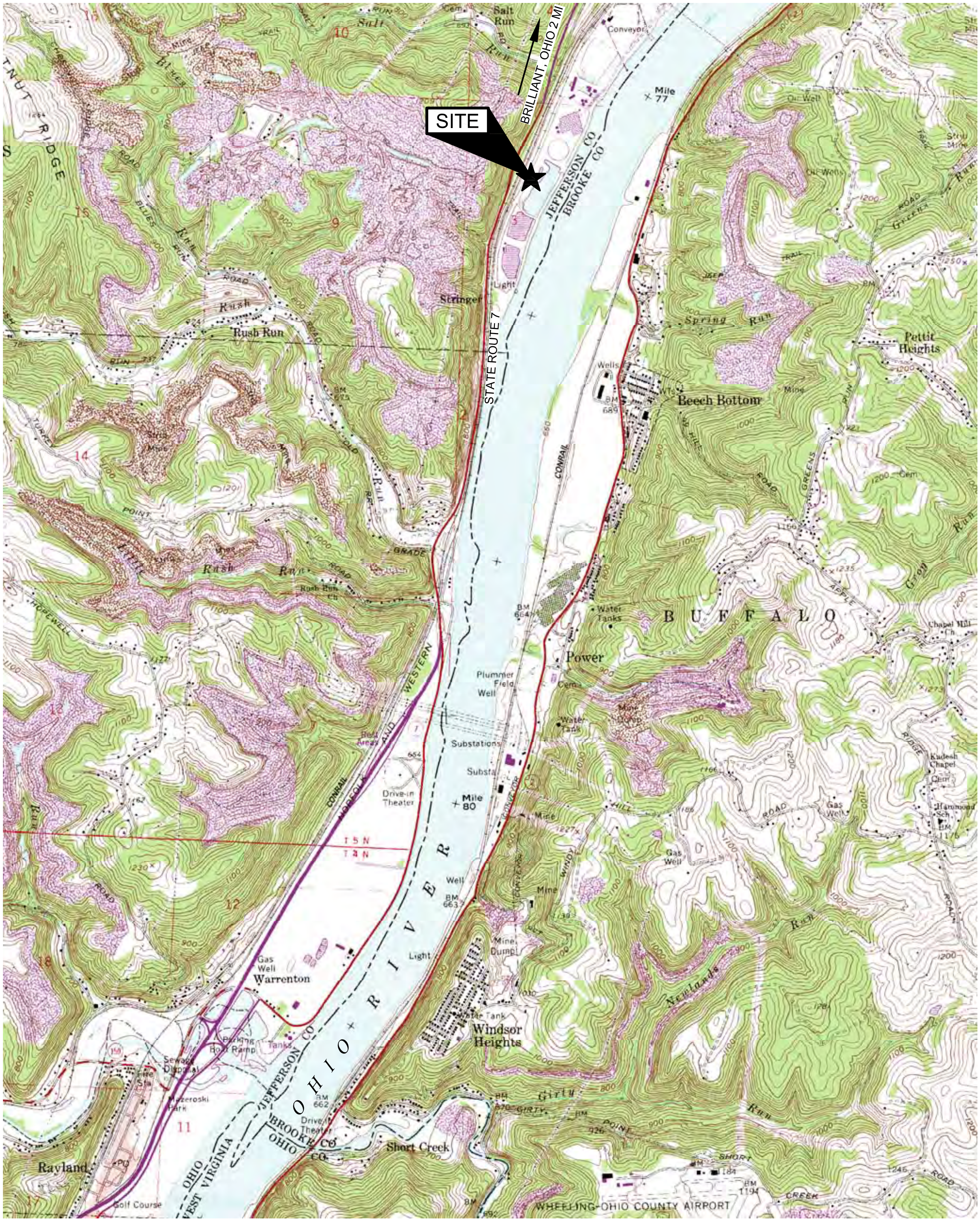
**Project Location:**
Cardinal Plant / Brilliant, Ohio

**Project Number:**
7217-15-007A

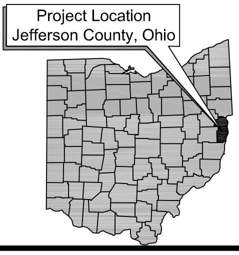
**Boring Number:**
CD-BAP-1505

**Date Well Installed:**
11/25/2015

# 2009 SITE INVESTIGATION



TILTONSVILLE



Tiltonsville Quadrangle

# VICINITY MAP

Cardinal Generating Plant
Ash Pond Investigation
Brilliant, Ohio

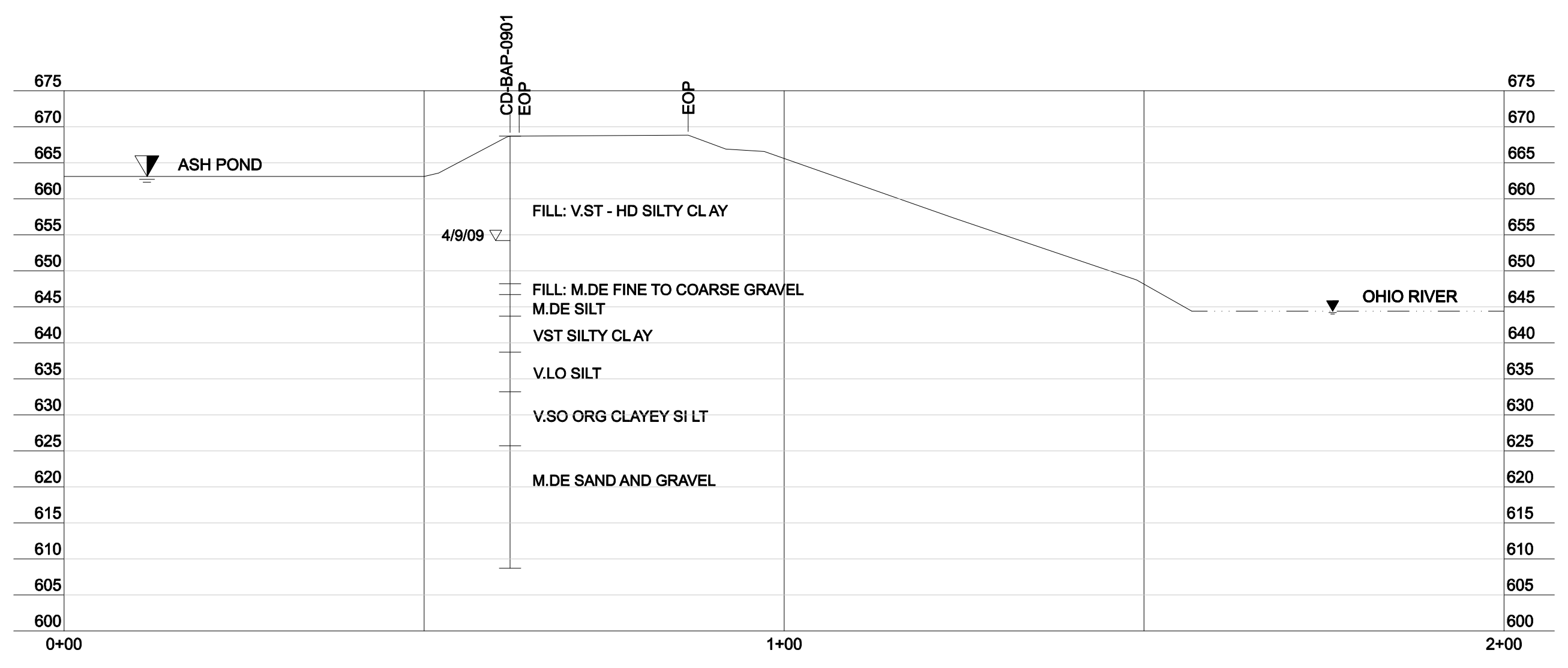
Project: 011-11497-013
Drawn By: MTR
Drawing Date: 7-2-09
Approved By: MGR
Last Updated: 7-6-2009
Scale: 1" = 3000' 1:1

BBCM
SOLUTIONS TO BUILD ON
Columbus (614) 793-2226
Cleveland (216) 901-1000
Cincinnati (513) 771-8471
Dayton (937) 424-1011

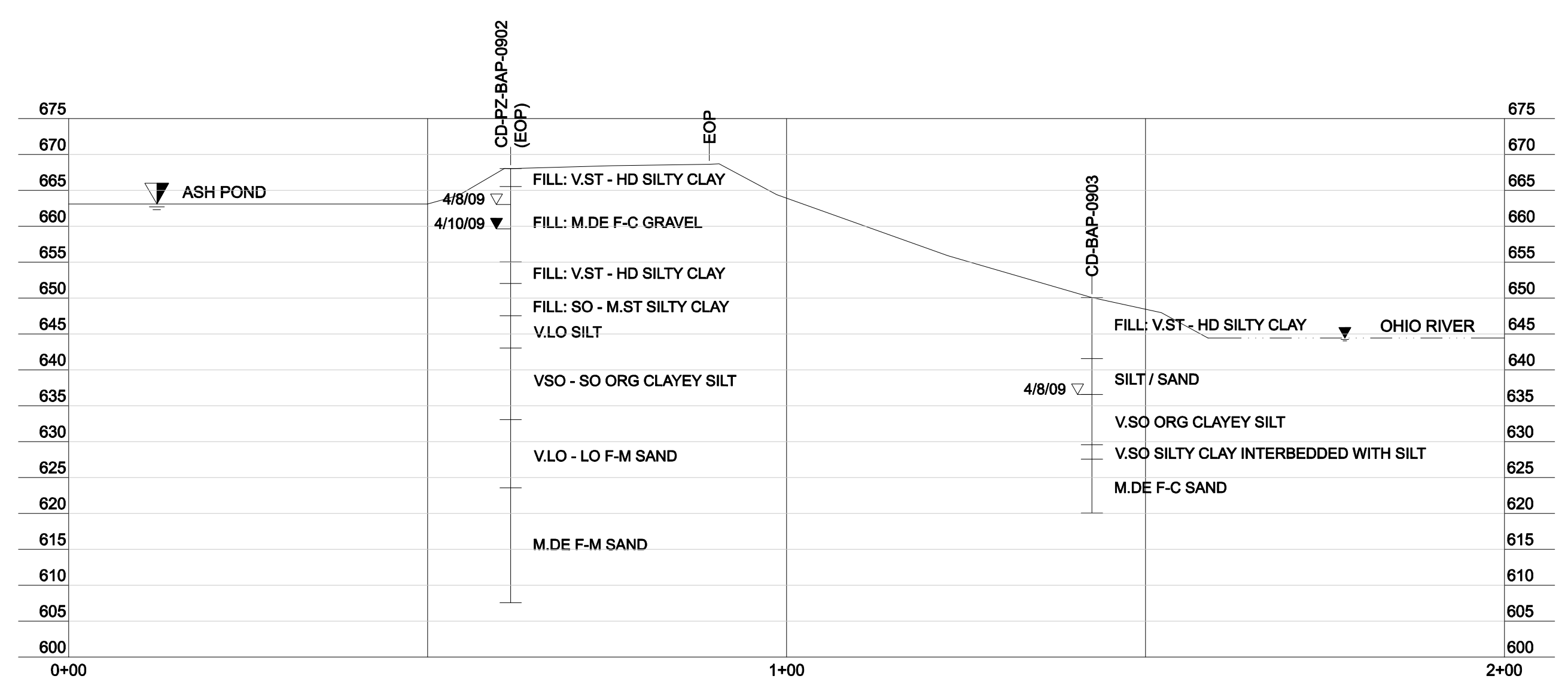
PLATE 1

Images: ~Tiltonsville Ohio Quad Map.tif
Xrefs:
File Last Updated: Jul 06, 2009
Plot Info: 7-22-2009 @ 3:23pm By: MRomanello
BBC&M Filename: I:\DEPTS\CADD\Drawings\Projects\011-11497-013\VMap.dwg Layout: 8.5x11P

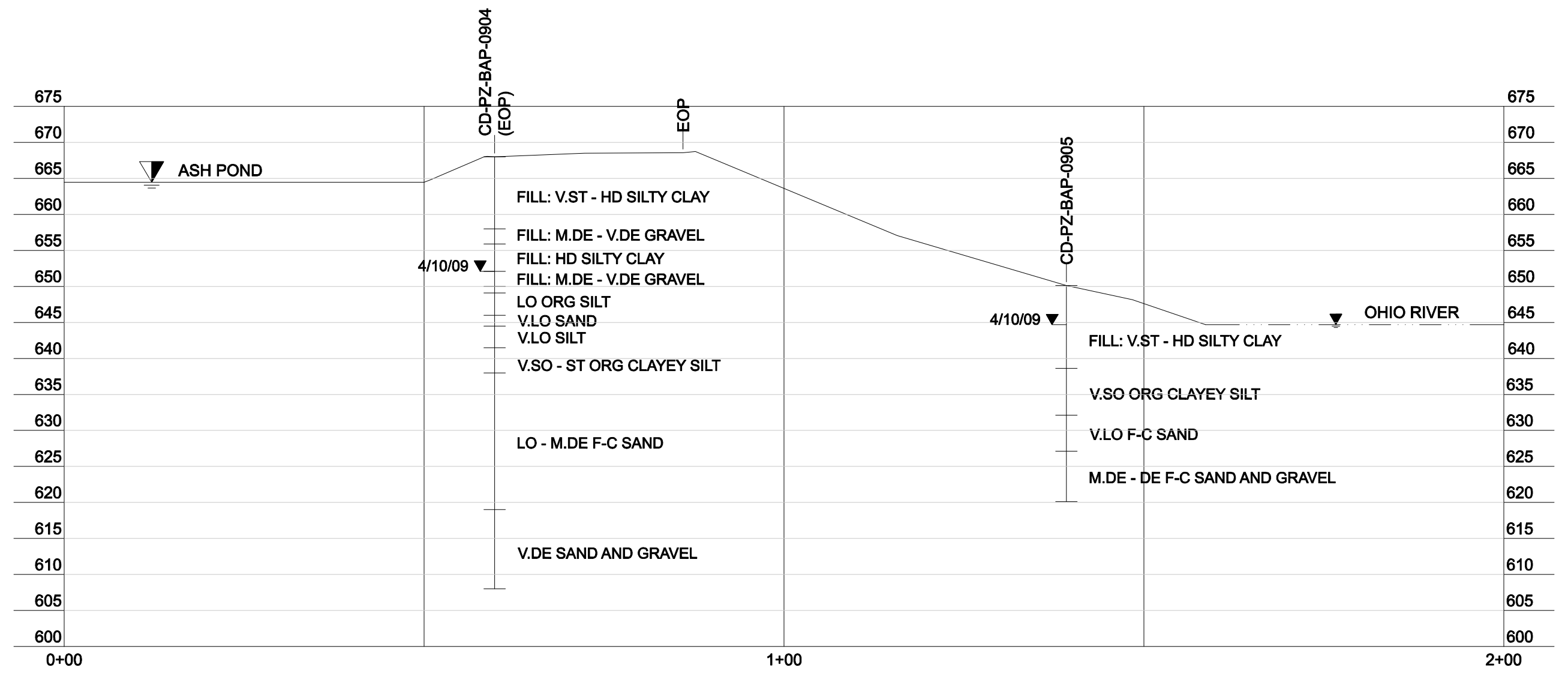
DWG. NO. PLATE 3



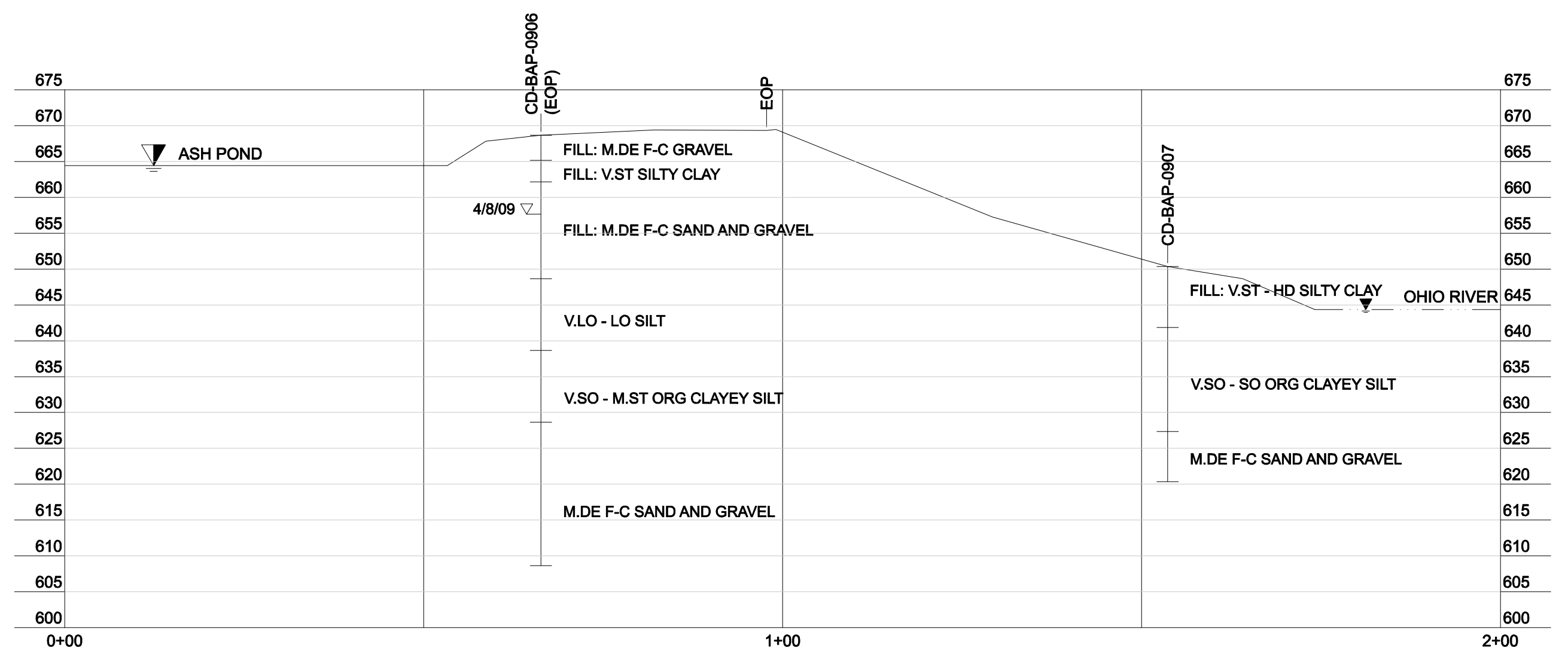
SECTION 'A'
Boring BAP-0901



SECTION 'B'
Borings BAP-0902 & BAP-0903



SECTION 'C'
Borings BAP-0904 & BAP-0905



SECTION 'D'
Borings BAP-0906 & BAP-0907

## LEGEND

| | |
|---|---|
| 4/20/09 ▼ | OBSERVATION WELL READING: ELEVATION AND DATE |
| 4/3/09 ▽ | SEEPAGE ENCOUNTERED DURING DRILLING |
| V.SO / SO | SOFT / VERY SOFT |
| M.ST | M. STIFF |
| ST / V.ST | STIFF / VERY STIFF |
| HD | HARD |
| V.LO / LO | VERY LOOSE / LOOSE |
| M.DE | MEDIUM DENSE |
| DE / V.DE | DENSE / VERY DENSE |
| ORG | ORGANIC |
| — — — | EXISTING WATER SURFACE (AT TIME OF INVESTIGATION) |

SCALE IN FEET
0 20 40

REFERENCE: AEP CARDINAL DRAWING 94151038
DATUM: NAD 27/NGVD 29 OHIO SOUTH

| | | | |
|---|---|---|---|
| PROJECT NUMBER: | 011-11497-013 | DRAWN BY: | RSH |
| DRAWING DATE: | 7-1-09 | ENGINEER: | MTR |
| LAST UPDATED: | 7-23-09 | APPROVED BY: | MGR |
| | | SCALE: | 1" = 20' |

BBCM
SOLUTIONS TO BUILD ON
Columbus (614) 793-2226
Cleveland (216) 901-1000
Cincinnati (513) 771-8471
Dayton (937) 424-1011

| DATE | NO. | DESCRIPTION | APPD. |
|---|---|---|---|
| | | REVISIONS | |

A.E.P.
CARDINAL PLANT
BRILLIANT OHIO

BOTTOM ASH POND
INVESTIGATION
SECTIONS

DWG. NO. PLATE 3

SCALE: CIVIL ENGINEERING
DR:
CH:
ENGR:
PROJ ENGR:
DATE:
APPROVED BY

AEP AMERICAN ELECTRIC POWER
AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

IS50694

SYSTEM DATE- DD-MMM-YYYY
SYSTEM TIME- HOUR:MINUTE

# EXPLANATION OF SYMBOLS AND TERMS USED ON BORING LOGS FOR SAMPLING AND DESCRIPTION OF SOIL

## SAMPLING DATA

▮ - Blocked-in "SAMPLES" column indicates sample was attempted and recovered within this depth interval.

▯ - Sample was attempted within this interval but not recovered.

2/5/9 - The number of blows required for each 6-inch increment of penetration of a "Standard" 2-inch O.D. split-barrel sampler, driven a distance of 18 inches by a 140-pound hammer freely falling 30 inches. Addition of one of the following symbols indicates the use of a split-barrel other than the 2" O.D. sampler:

  2S - 2½"O.D. split-barrel sampler

  3S - 3" O.D. split-barrel sampler

P - Shelby tube sampler, 3" O.D., hydraulically pushed.

R - Refusal of sampler in very-hard or dense soil, or on a resistant surface.

50-2" - Number of blows (50) to drive a split-barrel sampler a certain number of inches (2), other than the normal 6-inch increment.

S/D - Split-barrel sampler (S) advanced by weight of drill rods (D),

S/H - Split-barrel sampler (S) advanced by combined weight of rods and drive hammer (H).

## SOIL DESCRIPTIONS

All soils have been classified basically in accordance with the Unified Soil Classification System, but this system has been augmented by the use of special adjectives to designate the approximate percentages of minor components as follows:

| Adjective | Percent by Weight |
|---|---|
| trace | 1 to 10 |
| little | 11 to 20 |
| some | 21 to 35 |
| "and" | 36 to 50 |

The following terms are used to describe density and consistency of soils:

| Term (Granular Soils) | Blows per foot |
|---|---|
| Very-loose | Less than 5 |
| Loose | 5 to 10 |
| Medium-dense | 11 to 30 |
| Dense | 31 to 50 |
| Very-dense | Over 50 |

| Term (Cohesive Soils) | Qu (tsf) |
|---|---|
| Very-soft | Less than 0.25 |
| Soft | 0.25 to 0.5 |
| Medium-stiff | 0.5 to 1.0 |
| Stiff | 1.0 to 2.0 |
| Very-stiff | 2.0 to 4.0 |
| Hard | Over 4.0 |

Page 1 of 3

# LOG OF BORING NO. CD-BAP-0901
# CARDINAL PLANT ASH POND INVESTIGATION
# BRILLIANT, OHIO

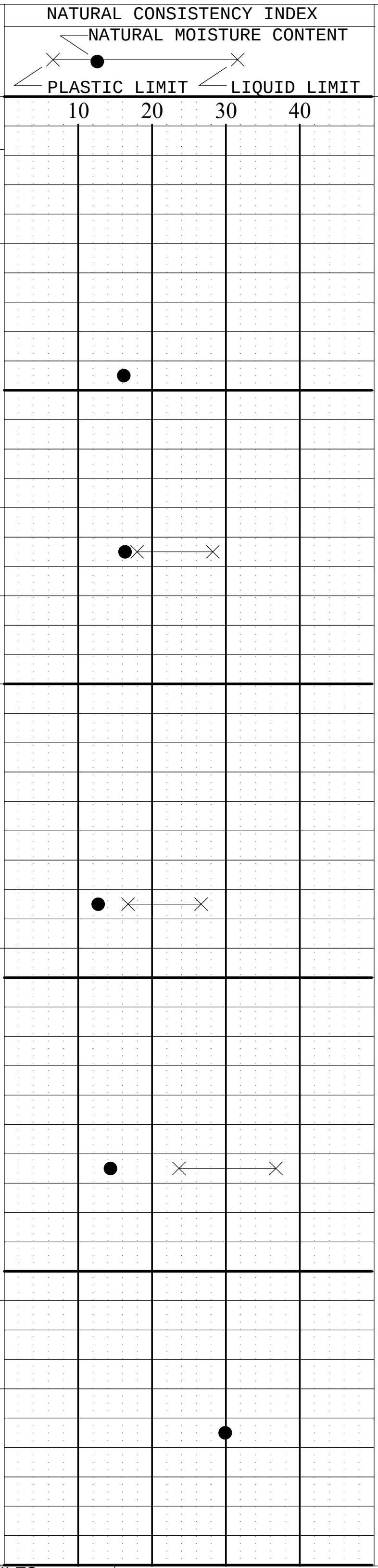
BBCM

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **668.7** DATE: **4/8/09 - 4/9/09**

DRILLING METHOD: **3-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **60.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|
| 667.8 | 0 | | | | | | GRAVEL FILL - 0.9 FEET | |
| 666.2 | | 1 | | 8/13/8 | 30 | 80 | FILL: Hard gray and brown silty clay, some fine to coarse sand, some fine to coarse gravel (sandstone, siltstone, and shale fragments), dry. | H=4.5+ |
| | | 2 | | 6/4/7 | 16 | 67 | FILL: Medium-dense to dense brown and gray fine to coarse gravel (sandstone, siltstone, and shale fragments), some fine to coarse sand, "and" silty clay, dry. | H=2.5-3.5 |
| | 5 | 3 | | 12/12/30 | 60 | 100 | | H=2.5 |
| 661.7 | | 4 | | 13/22/20 | 60 | 80 | | H=4.5+ |
| 660.2 | | 5 | | 5/10/16 | 37 | 93 | FILL: Hard gray clayey silt, some fine to coarse sand, some fine to coarse gravel (sandstone, siltstone and shale fragments), dry. | H=4.5+ |
| 658.7 | 10 | 6 | | 6/8/16 | 34 | 87 | FILL: Very-stiff brown and gray silty clay, some fine to coarse sand, some fine to coarse gravel (sandstone, siltstone, and shale fragments), dry. | H=3.0-4.0 |
| | | 7 | | 24/25/24 | 70 | 100 | FILL: Medium-dense to dense gray and brown fine to coarse gravel (sandstone, siltstone, and shale fragments), some fine to coarse sand, some silty clay becoming "and" clayey silt with depth, dry. | H=4.5+ |
| | | 8 | | 10/7/7 | 20 | 67 | | |
| 654.2 | ▽ | 9 | | 8/6/14 | 29 | 73 | | H=4.5+ |
| | 15 | 10 | | 5/8/14 | 32 | 80 | FILL: Very-stiff to hard brown and gray silty clay, some fine to coarse sand, some fine to coarse gravel (sandstone, siltstone, and shale fragments), medium-dense gray and brown fine to coarse gravel (shale fragments) seam from 17.5' to 18.3', moist to wet. | H=4.0-4.5+ |
| | | 11 | | 3/5/9 | 20 | 67 | | H=3.8-4.5+ |
| | | 12 | | 3/5/10 | 22 | 53 | | G |
| 648.2 | 20 | 13 | | 3/9/9 | 26 | 53 | | H=4.5 |
| 646.7 | | 14 | | 7/9/13 | 32 | 67 | FILL: Medium-dense gray fine to coarse gravel (shale fragments), little fine to coarse sand, little silty clay, moist to wet. | H=4.5 |
| | | 15 | | 6/9/10 | 27 | 80 | Medium-dense gray silt, trace clay, trace fine to medium sand, moist to wet. | G |
| 643.7 | 25 | 16A | | P | | | | |



WATER LEVEL: ▽ 13.8 ▼

WATER NOTE: Inside HSA

DATE: 4/9/09

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.86

**Last Calibration Date :** 02/17/09

**Drill Rig Number :** TRUCK 55

2008 NEW DEFAULT BORING LOG-W/ N60 11497013.GPJ BBCM.GDT 8/4/09

# LOG OF BORING NO. CD-BAP-0901
# CARDINAL PLANT ASH POND INVESTIGATION
# BRILLIANT, OHIO

BBCM

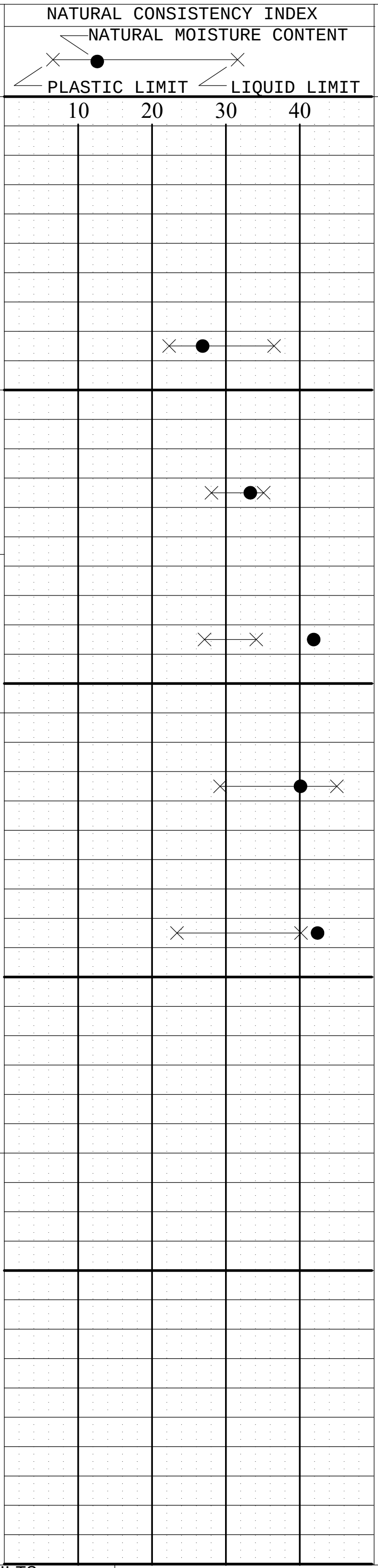
LOCATION: **See Plate 2 of Appendix A** ELEVATION: **668.7** DATE: **4/8/09 - 4/9/09**

DRILLING METHOD: **3-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **60.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

2008 NEW DEFAULT BORING LOG-W/ N60 111497013.GPJ BBCM.GDT 8/4/09

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE EFFORT | $N_{60}$ | SAMPLE REC-% | DESCRIPTION | TEST RESULTS |
|---|---|---|---|---|---|---|---|
| | 25 | 16B | | | | Very-stiff brown mottled with gray silty clay, trace fine sand, damp. | |
| | | 17 | 3/6/9 | 22 | 67 | | H=2.5-3.5 |
| | | 18 | 3/3/4 | 10 | 100 | | H=1.6-2.5<br>G |
| 638.7 | 30 | | | | | Gray mottled with dark-gray and brown clayey silt, some fine sand, trace medium to coarse sand, few seams and lenses of silty clay and fine sand, damp. | |
| | | 19 | P | | | | H=1.0-1.5<br>G |
| 635.9 | | | | | | Very-loose dark-brown and gray organic silt, some fine sand, moist to wet. | |
| | | 20 | 1/2/2 | 6 | 100 | | H=0.7<br>G |
| 633.2 | 35 | | | | | Soft to medium-stiff gray mottled with dark-gray organic clayey silt, little to some fine sand, trace medium to coarse sand, few lenses of fine sand interbedded with organic silt near top of stratum, moist to wet. | |
| | | 21 | 2/2/2 | 6 | 100 | | H=0.4<br>G |
| | | 22 | 2/3/3 | 9 | 100 | | H=0.5-0.8<br>G |
| | 40 | | | | | | |
| | | 23 | 2/2/3 | 7 | 67 | | H=0.3-0.7 |
| 625.7 | | | | | | Medium-dense to dense brown and gray fine to coarse gravel, some fine to coarse sand, trace silt, wet. | |
| | | 24 | 9/11/13 | 34 | 53 | | |
| | 45 | | | | | | |
| | | 25 | 9/12/16 | 40 | 53 | | |
| | | 26 | 11/19/20 | 56 | 53 | | |
| | 50 | | | | | | |



WATER LEVEL: ▽ 13.8 ▼

WATER NOTE: Inside HSA

DATE: 4/9/09

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.86
**Last Calibration Date :** 02/17/09
**Drill Rig Number :** TRUCK 55

# LOG OF BORING NO. CD-BAP-0901
# CARDINAL PLANT ASH POND INVESTIGATION
# BRILLIANT, OHIO

BBCM

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **668.7** DATE: **4/8/09 - 4/9/09**

DRILLING METHOD: **3-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **60.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT / PLASTIC LIMIT / LIQUID LIMIT (10 20 30 40) | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|
| | 50 | | | | | Medium-dense to dense brown and gray fine to coarse gravel, some fine to coarse sand, trace silt, wet. | | |
| | | 27 | 10/16/21 | 53 | 33 | | | |
| | | 28 | 6/10/10 | 29 | 33 | | | |
| | 55 | | | | | | | |
| | | 29 | 6/11/10 | 30 | 40 | | | |
| 610.7 | | | | | | Medium-dense brown fine to medium sand, trace coarse sand, trace fine gravel, trace silt, wet. | | |
| | | 30 | 7/10/10 | 29 | 40 | | | |
| 608.7 | 60 | | | | | | | |
| | | | | | | - Seepage encountered at 14.5'.<br>- Borehole grouted upon completion.<br>- Boring location and elevation surveyed by AEP. | | |
| | 65 | | | | | | | |
| | 70 | | | | | | | |
| | 75 | | | | | | | |

| | ▽ | ▼ |
|---|---|---|
| WATER LEVEL: | 13.8 | |
| WATER NOTE: | Inside HSA | |
| DATE: | 4/9/09 | |

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.86
**Last Calibration Date :** 02/17/09
**Drill Rig Number :** TRUCK 55

2008 NEW DEFAULT BORING LOG-W/ N60 111497013.GPJ BBCM.GDT 8/4/09

# LOG OF BORING NO. CD-PZ-BAP-0902
# CARDINAL PLANT ASH POND INVESTIGATION
# BRILLIANT, OHIO

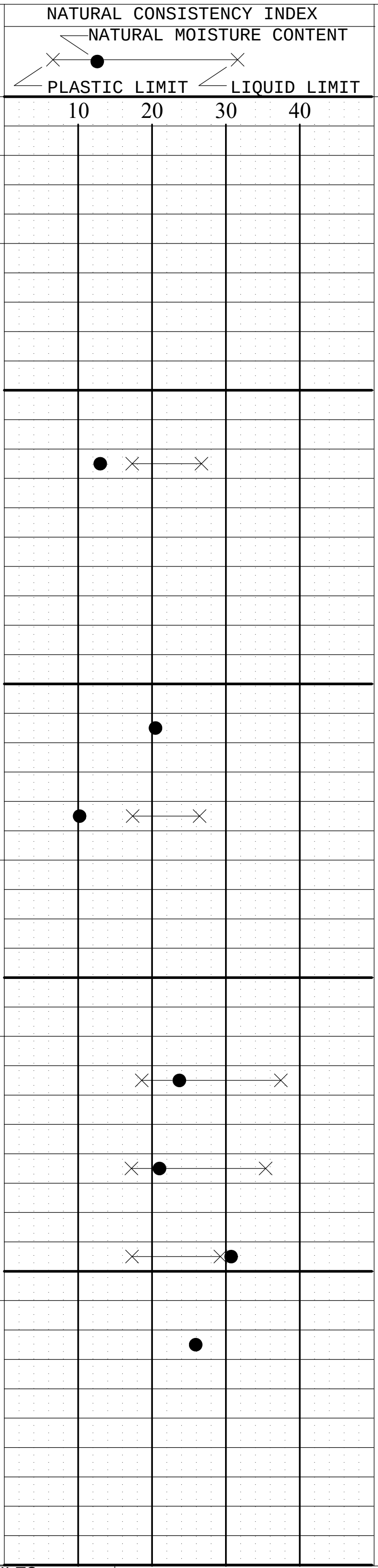
BBCM

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **668.0** DATE: **4/8/09**
DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **60.5'**
SAMPLER(S): **2" O.D. Split-barrel Sampler**

2008 NEW DEFAULT BORING LOG-W/ N60 111497013.GPJ BBCM.GDT 8/4/09

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | $N_{60}$ | SAMPLE REC-% | DESCRIPTION | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|
| 667.0 | 0 | | | | | | GRAVEL FILL - 1.0 FEET | |
| 665.5 | | 1 | | 5/5/7 | 17 | 87 | FILL: Very-stiff to hard brown silty clay, some fine to coarse sand, some fine to coarse gravel (sandstone, siltstone, and shale fragments), dry. | H=3.5-4.0 |
| | | 2 | | 6/6/8 | 20 | 80 | FILL: Medium-dense brown and gray fine to coarse gravel (sandstone, siltstone, and shale fragments), some fine to coarse sand, some silty clay, cobbles near top of stratum, dry. | H=3.75-4.25 |
| | 5 | 3 | | 6/9/10 | 27 | 73 | | H=4.0-4.5+ |
| | | 4 | | 8/5/7 | 17 | 73 | | H=3.0-4.25<br>G |
| | ▼ | 5 | | 9/9/7 | 23 | 53 | | H=3.5-4.0 |
| | | 6 | | 12/6/5 | 16 | 27 | | H=3.75-4.0 |
| | 10 ▽ | 7 | | 10/9/11 | 29 | 60 | | H=4.0-4.5+ |
| 655.0 | | 8 | | 3/5/7 | 17 | 73 | | H=3.0-3.75<br>G |
| | | 9 | | 3/3/4 | 10 | 33 | FILL: Very-stiff to hard brown and gray silty clay, some fine to coarse sand, trace to some fine gravel (siltstone and shale fragments), damp to wet. | H=3.75-4.5+ |
| 652.0 | 15 | 10 | | 2/2/3 | 7 | 40 | | H=2.5-2.75 |
| | | 11 | | 3/4/5 | 13 | 67 | FILL: Soft to medium-stiff brown and gray silty clay, some fine to coarse sand, trace to some fine gravel (siltstone and shale fragments), brown and gray fine to coarse gravel, some near middle of stratum, wet. | H=1.0-2.0 |
| | | 12 | | 1/2/2 | 6 | 40 | | H=1.5-2.25<br>G |
| 647.5 | 20 | 13 | | 1/SH/1 | 1 | 20 | | H=0.0-0.25<br>G |
| | | 14 | | 2/2/1 | 4 | 100 | Very-loose gray and dark-gray silt, little to some clay, trace becoming some with depth fine sand, wet. | G |
| | | 15 | | 2/1/1 | 3 | 53 | | G |
| 643.0 | 25 | 16 | | SH/SH/1 | 1 | 53 | | |

NATURAL CONSISTENCY INDEX
NATURAL MOISTURE CONTENT
PLASTIC LIMIT LIQUID LIMIT



| WATER LEVEL: | ▽ 10.7 | ▼ 8.4 |
|---|---|---|
| WATER NOTE: | Inside HSA | Inside Well |
| DATE: | 4/8/09 | 4/10/09 |

SYMBOLS USED TO INDICATE TEST RESULTS
G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves
H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

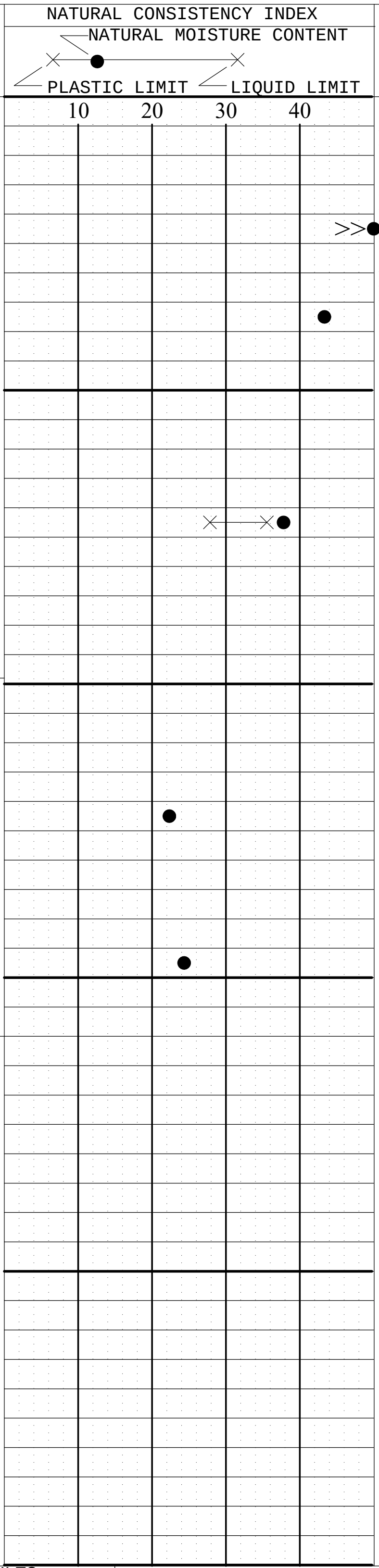
**Drill Rod Energy Ratio :** 0.86
**Last Calibration Date :** 02/17/09
**Drill Rig Number :** TRUCK 55

# LOG OF BORING NO. CD-PZ-BAP-0902
# CARDINAL PLANT ASH POND INVESTIGATION
# BRILLIANT, OHIO

BBCM

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **668.0** DATE: **4/8/09**
DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **60.5'**
SAMPLER(S): **2" O.D. Split-barrel Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | TEST RESULTS |
|---|---|---|---|---|---|---|---|
| | 25 | 17 | 1/1/2 | 4 | 80 | Very-soft to soft gray mottled with dark-gray organic clayey silt, trace fine sand, few lenses of organic silt near bottom of stratum, wet. | H=0.3 |
| | | 18 | SH/1/2 | 4 | 80 | | LOI=10.4%<br>>>H=0.0-0.1<br>G |
| | | 19 | SH/1/2 | 4 | 100 | | MC=54<br>H=0.0<br>G |
| | 30 | | | | | | |
| | | 20 | SH/1/1 | 3 | 73 | | G |
| | | 21A | 2/3/3 | 9 | | | |
| 633.1 | 35 | 21B | | | | Very-loose to loose brown and gray fine to medium sand, trace coarse sand, trace to little silt interbedded with organic clayey silt, wet. | |
| | | 22 | 2/2/3 | 7 | 73 | | G |
| | 40 | 23 | SH/1/2 | 4 | 80 | | G |
| 627.0 | | | | | | Medium-dense brown fine to medium sand, trace coarse sand, trace silt, trace to some fine gravel, trace coarse gravel, trace silt, wet. | |
| | | 24 | 2/3/10 | 19 | 100 | | G |
| | | 25A | 5/7/11 | 26 | | | |
| | 45 | 25B | | | | | |
| | | 26 | 6/10/13 | 33 | 67 | | |
| | | 27 | 10/15/13 | 40 | 33 | | |
| | 50 | | | | | | |



WATER LEVEL: ▽ 10.7 ▼ 8.4
WATER NOTE: Inside HSA Inside Well
DATE: 4/8/09 4/10/09

SYMBOLS USED TO INDICATE TEST RESULTS
G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves
H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.86
**Last Calibration Date :** 02/17/09
**Drill Rig Number :** TRUCK 55

# LOG OF BORING NO. CD-PZ-BAP-0902
# CARDINAL PLANT ASH POND INVESTIGATION
# BRILLIANT, OHIO

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **668.0** DATE: **4/8/09**
DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **60.5'**
SAMPLER(S): **2" O.D. Split-barrel Sampler**

2008 NEW DEFAULT BORING LOG-W/ N60 11497013.GPJ BBCM.GDT 8/4/09

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX<br>NATURAL MOISTURE CONTENT<br>PLASTIC LIMIT — LIQUID LIMIT<br>10 20 30 40 | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|---|
| | 50 | | | | | | Medium-dense brown fine to medium sand, trace coarse sand, trace silt, trace to some fine gravel, trace coarse gravel, trace silt, wet. | | |
| | | 28 | ■ | 1/8/10 | 26 | 80 | | | |
| | 55 | 29 | ■ | 1/2/9 | 16 | 67 | | | |
| | | 30 | ■ | 3/3/7 | 14 | 67 | | | |
| | | 31 | ■ | 4/3/7 | 14 | | | | |
| 607.9 | 60 | | | | | | | | |
| | | | | | | | - Cobbles encountered from 4.0' to 7.0'.<br>- Seepage encountered at 5.5'.<br>- Groundwater encountered at 13.0'.<br>- Borehole converted to observation well upon completion. See separate well log.<br>- Boring location and elevation surveyed by AEP. | | |
| | 65 | | | | | | | | |
| | 70 | | | | | | | | |
| | 75 | | | | | | | | |

| | ▽ | ▼ |
|---|---|---|
| WATER LEVEL: | 10.7 | 8.4 |
| WATER NOTE: | Inside HSA | Inside Well |
| DATE: | 4/8/09 | 4/10/09 |

SYMBOLS USED TO INDICATE TEST RESULTS
G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves
H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.86
**Last Calibration Date :** 02/17/09
**Drill Rig Number :** TRUCK 55

Page 1 of 2

# LOG OF BORING NO. CD-BAP-0903
# CARDINAL PLANT ASH POND INVESTIGATION
# BRILLIANT, OHIO

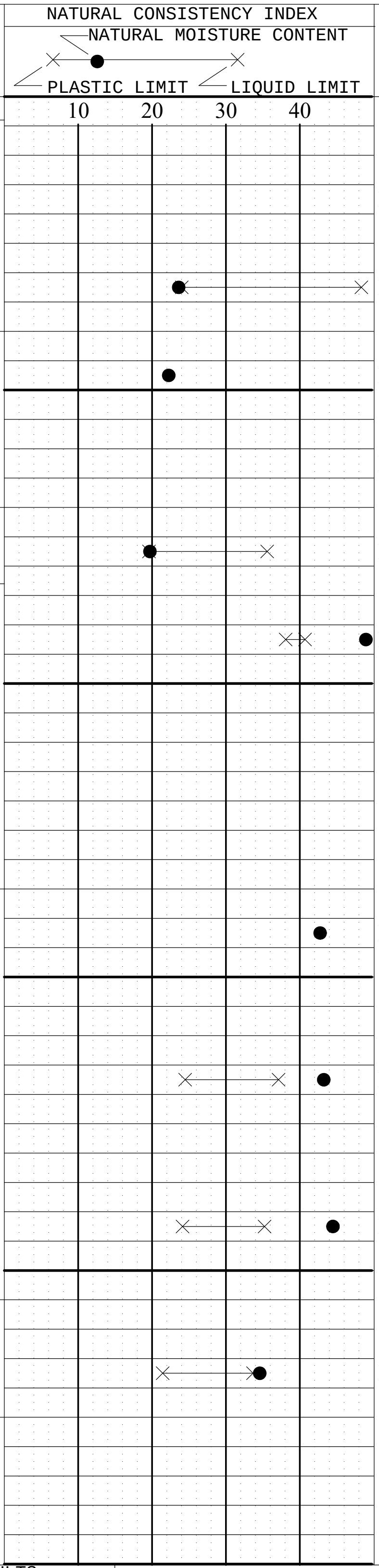
BBCM

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **650.1** DATE: **4/8/09**

DRILLING METHOD: **3-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **30.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | N₆₀ | SAMPLE REC-% | DESCRIPTION | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|
| 649.7 | 0 | | | | | | TOPSOIL - 0.4 FEET | |
| | | 1 | | 2/5/6 | 15 | 67 | FILL: Very-stiff to hard brown mottled with gray and dark-brown silty clay, trace fine to medium sand, few roots, damp. | H=3.6-3.8 |
| 646.1 | | 2 | | 4/6/6 | 16 | 53 | | H=3.3-4.5<br>G |
| | 5 | 3 | | 2/5/6 | 15 | 80 | FILL: Very-stiff to hard brown mottled with gray silty clay, trace fine sand, damp. | H=2.6-4.1 |
| 643.1 | | 4 | | 8/11/13 | 33 | 80 | | H=4.5 |
| 641.8 | | 5 | | 6/6/6 | 16 | 67 | FILL: Very-stiff to hard brown mottled with dark-gray and gray silty clay, little fine to coarse sand, trace fine gravel, few lenses of dark-gray silt, damp. | H=3.5-4.5<br>G |
| | | 6 | | 5/6/6 | 16 | 67 | Medium-stiff dark-gray organic clayey silt, trace fine sand, many lenses of fine sand, few decayed roots, damp to moist. | H=0.6<br>G |
| | 10 | | P | | | | | |
| 636.6 | | 7 | | SH/1/1 | 3 | 67 | Very-soft gray mottled with dark-gray organic clayey silt interbedded with organic silt, little fine sand, few seams and lenses of silt and fine sand, moist to wet. | H=0.0<br>G |
| | 15 | | | | | | | |
| | ▽ | 8 | | SH/1/1 | 3 | 67 | | H=0.0<br>G |
| | | 9 | | SH/1/1 | 3 | 73 | | H=0.0<br>G |
| 629.6 | 20 | | | | | | | |
| 627.6 | | 10 | | 1/2/4 | 8 | 60 | Very-soft gray silty clay interbedded with silt, trace fine sand, few seams of fine sand, few roots, moist to wet. | H=0.2<br>G |
| | | 11 | | 2/4/7 | 15 | 47 | Medium-dense brown and gray fine to coarse sand, trace medium to coarse sand, trace fine to coarse gravel, little silt, few seams of silty clay, wet. | G |
| | 25 | | | | | | | |



| | | |
|---|---|---|
| WATER LEVEL: | ▽ 16.5 | ▼ |
| WATER NOTE: | Inside HSA | |
| DATE: | 4/8/09 | |

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.82
**Last Calibration Date :** 11/19/07
**Drill Rig Number :** D50

**JOB: 011-11497-013** -CONTINUED- **PLATE 11**

# LOG OF BORING NO. CD-BAP-0903
# CARDINAL PLANT ASH POND INVESTIGATION
# BRILLIANT, OHIO

BBCM

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **650.1** DATE: **4/8/09**

DRILLING METHOD: **3-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **30.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | $N_{60}$ | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT / PLASTIC LIMIT / LIQUID LIMIT (10 20 30 40) | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|---|
| 624.6 | 25 | | | | | | Medium-dense brown and gray fine to coarse gravel, some fine to coarse sand, trace silt, wet. | | |
| | | 12 | | 6/10/12 | 30 | 33 | | | |
| | | 13 | | 7/7/7 | 19 | 47 | | | |
| 620.1 | 30 | | | | | | - Seepage encountered at 13.5'.<br>- Groundwater encountered at 22.5'.<br>- At 26.0', 1.8' heave, shook augers to sample.<br>- Borehole grouted upon completion.<br>- Boring location and elevation surveyed by AEP. | | |
| | 35 | | | | | | | | |
| | 40 | | | | | | | | |
| | 45 | | | | | | | | |
| | 50 | | | | | | | | |

| | ▽ | ▼ |
|---|---|---|
| WATER LEVEL: | 16.5 | |
| WATER NOTE: | Inside HSA | |
| DATE: | 4/8/09 | |

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.82
**Last Calibration Date :** 11/19/07
**Drill Rig Number :** D50

2008 NEW DEFAULT BORING LOG-W/ N60 11497013.GPJ BBCM.GDT 8/4/09

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# LOG OF BORING NO. CD-PZ-BAP-0904
# CARDINAL PLANT ASH POND INVESTIGATION
# BRILLIANT, OHIO

BBCM

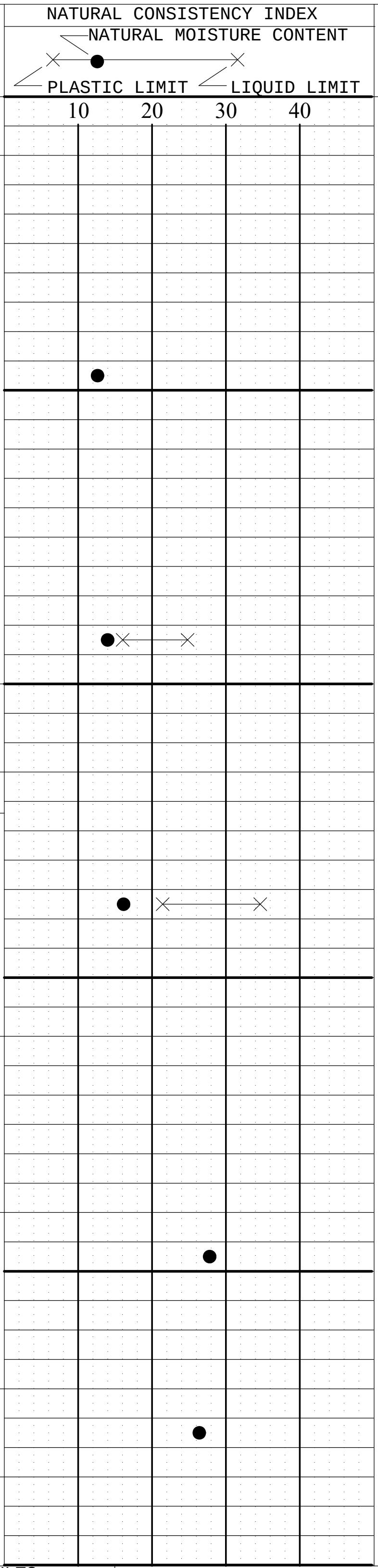
LOCATION: **See Plate 2 of Appendix A** ELEVATION: **668.1** DATE: **4/7/09**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **60.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

2008 NEW DEFAULT BORING LOG-W/ N60 111497013.GPJ BBCM.GDT 8/4/09

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE EFFORT | $N_{60}$ | SAMPLE REC-% | DESCRIPTION | TEST RESULTS |
|---|---|---|---|---|---|---|---|
| 667.1 | 0 | | | | | GRAVEL FILL - 1.0 FEET | |
| | | 1 | 6/6/8 | 20 | 100 | FILL: Very-stiff to hard brown and gray silty clay, some fine to coarse sand, some fine to coarse gravel (sandstone, siltstone, and shale fragments), fine to coarse gravel seams near middle of stratum, dry. | H=4.25-4.5+ |
| | | 2 | 6/8/11 | 27 | 53 | | H=4.5+ |
| | 5 | 3 | 9/11/12 | 33 | 93 | | H=3.5-4.0 |
| | | 4 | 12/15/17 | 46 | 7 | | |
| | | 5 | 12/8/8 | 23 | 13 | | |
| 658.1 | | 6 | 2/8/17 | 36 | 80 | | H=2.75-3.5<br>G |
| 656.6 | 10 | 7 | 20/50-3"R | | 33 | FILL: Very-dense brown and gray fine to coarse gravel (sandstone, siltstone, and shale fragments), little fine sand, trace silt, dry. | |
| 655.9 | | 8A | 13/14/17 | 44 | | FILL: Dense brown and gray fine to coarse gravel (sandstone fragments), cobbles, "and" fine to medium sand, trace coarse sand, trace silt, dry. | |
| | | 8B | | | | | H=4.5+ |
| | | 9 | 3/5/9 | 20 | 73 | FILL: Hard brown with gray silty clay, little to some fine to coarse sand, trace fine gravel, dry. | H=2.5-40 |
| 652.1 | 15 ▼ ▽ | 10 | 5/6/7 | 19 | 80 | | H=3.0-4.25 |
| | | 11 | 4/6/12 | 26 | 60 | FILL: Medium-dense brown and gray fine to coarse gravel (very-soft shale fragments), some fine to coarse sand, some silty clay, cobbles, damp. | G |
| | | 12A | 4/6/8 | 20 | | | |
| 649.1 | | 12B | | | | | |
| | 20 | 13 | 2/2/2 | 6 | 87 | Loose gray and dark-gray organic silt, little clay, little to some fine to medium sand, wet. | G |
| 646.1 | | 14 | 2/3/4 | 10 | 47 | | |
| 644.6 | | 15 | SH/1/2 | 4 | 47 | Very-loose gray and dark-gray fine to medium sand, trace coarse sand, little fine gravel, some organic silt, wet. | G |
| | 25 | 16 | SH/SH/SH | 0 | 53 | Very-loose gray silt, little clay, little fine sand, wet. | |



| | | |
|---|---|---|
| WATER LEVEL: | ▽ 16.0 | ▼ 15.9 |
| WATER NOTE: | Inside HSA | Inside Well |
| DATE: | 4/7/09 | 4/10/09 |

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.86
**Last Calibration Date :** 02/17/09
**Drill Rig Number :** TRUCK 55

**JOB: 011-11497-013** -CONTINUED- **PLATE 13**

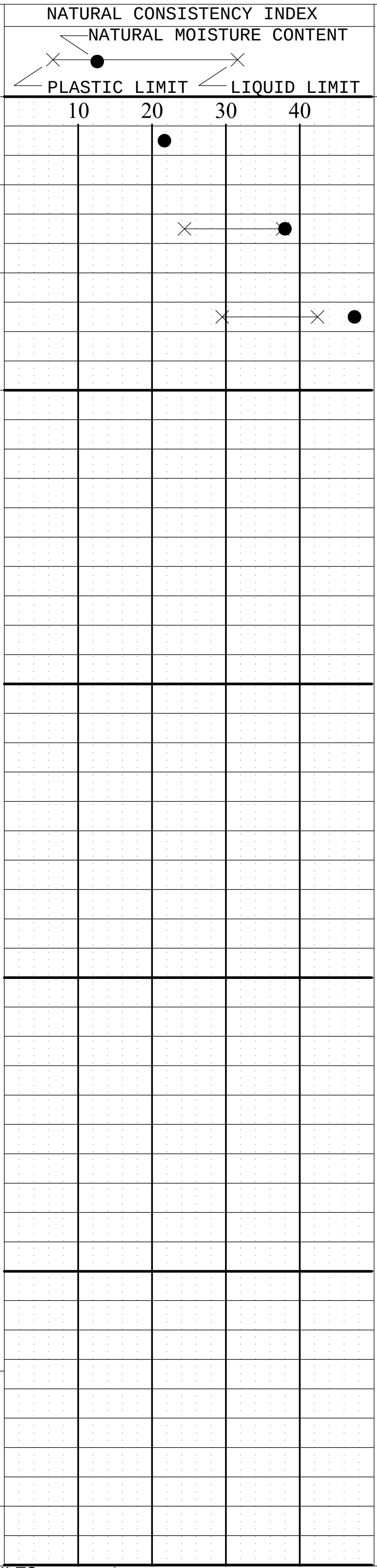
# LOG OF BORING NO. CD-PZ-BAP-0904
# CARDINAL PLANT ASH POND INVESTIGATION
# BRILLIANT, OHIO

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **668.1** DATE: **4/7/09**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **60.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | TEST RESULTS |
|---|---|---|---|---|---|---|---|
|  | 25 | 17 | SR/SH/3 | 4 | 53 | Very-loose gray silt, little clay, little fine sand, wet. | G |
| 641.6 |  |  |  |  |  |  |  |
|  |  | 18 | SH/1/3 | 6 | 100 | Medium-stiff to stiff gray mottled with dark-gray organic clayey silt, interbedded with organic silt, little fine to coarse sand, trace fine gravel, wet. | H=0.75-1.25<br>G |
| 640.1 |  |  |  |  |  |  |  |
|  |  | 19 | 1/1/3 | 6 | 87 | Very-soft to soft gray mottled with dark-gray organic clayey silt, trace fine sand, wet. | H=0.0-0.5<br>G |
| 638.1 | 30 |  |  |  |  |  |  |
|  |  |  | P |  |  | Loose to medium-dense brown and gray fine to medium sand, trace coarse sand, trace to some silt, few seams of gray mottled with dark-gray silty clay near bottom of stratum, contains zones interbedded with silt, wet. |  |
|  |  | 20A<br>20B | 5/5/7 | 17 |  |  |  |
|  | 35 |  |  |  |  |  |  |
|  |  | 21 | 2/3/5 | 11 | 93 |  | G |
|  |  | 22 | 2/2/5 | 10 | 100 |  |  |
|  | 40 |  |  |  |  |  |  |
|  |  | 23 | 2/2/5 | 10 | 100 |  |  |
|  |  | 24 | 2/8/12 | 29 | 100 |  |  |
|  | 45 |  |  |  |  |  |  |
|  |  | 25A<br>25B | 4/11/17 | 40 |  |  |  |
| 621.4 |  |  |  |  |  | Medium-dense brown and gray fine to coarse gravel, "and" fine to coarse sand, trace silt, wet. |  |
| 619.1 |  |  |  |  |  |  |  |
|  |  | 26 | 12/29/50-5"R |  | 93 | See description on the following page. |  |
|  | 50 |  |  |  |  |  |  |



| | | |
|---|---|---|
| WATER LEVEL: | ▽ 16.0 | ▼ 15.9 |
| WATER NOTE: | Inside HSA | Inside Well |
| DATE: | 4/7/09 | 4/10/09 |

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.86
**Last Calibration Date :** 02/17/09
**Drill Rig Number :** TRUCK 55

# LOG OF BORING NO. CD-PZ-BAP-0904
# CARDINAL PLANT ASH POND INVESTIGATION
# BRILLIANT, OHIO

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **668.1** DATE: **4/7/09**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **60.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX — NATURAL MOISTURE CONTENT, PLASTIC LIMIT, LIQUID LIMIT (10 20 30 40) | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|
| | 50 | | | | | Very-dense brown and gray fine to coarse sand, some fine to coarse sand, trace silt, zones of fine to coarse gravel, wet. | | |
| | | 27 | 8/40/50-4"R | | 87 | | | |
| | | 28 | 10/50-5"R | | 33 | | | |
| | 55 | | | | | | | |
| | | 29 | 9/28/50-3"R | | 67 | | | |
| | | 30 | 16/50-5"R | | 67 | | | |
| 608.1 | 60 | | | | | | | |
| | | | | | | - Cobbles encountered at 10.0', 11.5' and 13.0'.<br>- Groundwater encountered at 16.0'.<br>- Borehole converted to observation well upon completion. See separate well log.<br>- Boring location and elevation surveyed by AEP. | | |
| | 65 | | | | | | | |
| | 70 | | | | | | | |
| | 75 | | | | | | | |

| | ▽ | ▼ |
|---|---|---|
| WATER LEVEL: | 16.0 | 15.9 |
| WATER NOTE: | Inside HSA | Inside Well |
| DATE: | 4/7/09 | 4/10/09 |

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.86
**Last Calibration Date :** 02/17/09
**Drill Rig Number :** TRUCK 55

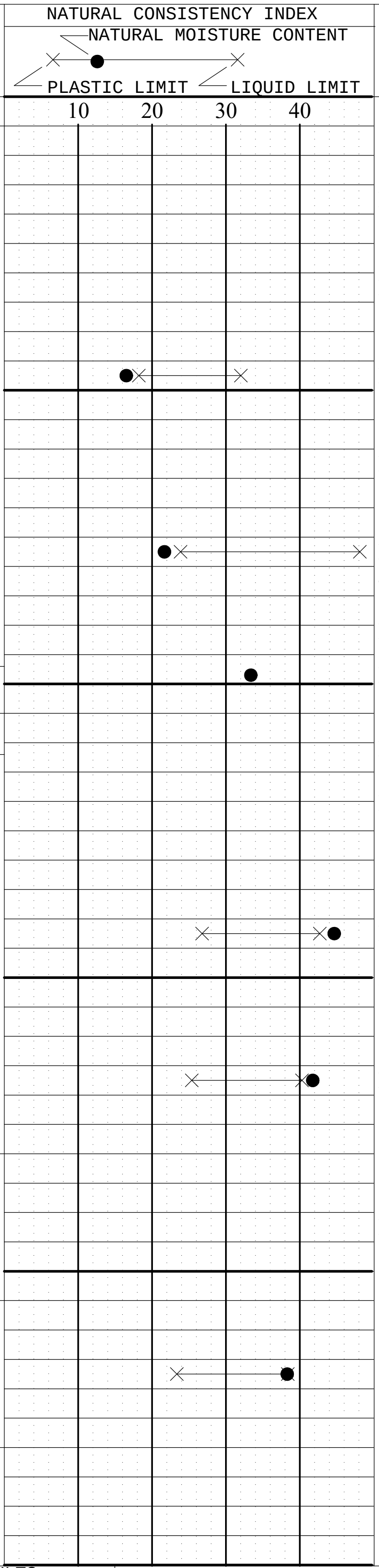
# LOG OF BORING NO. CD-PZ-BAP-0905
# CARDINAL PLANT ASH POND INVESTIGATION
# BRILLIANT, OHIO

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **650.1** DATE: **4/6/09**

DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **30.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | TEST RESULTS |
|---|---|---|---|---|---|---|---|
| 649.6 | 0 | | | | | ROOTMAT - 0.5 FEET | |
| | | 1 | 3/3/5 | 11 | 67 | FILL: Very-stiff to hard brown mottled with gray silty clay, trace fine sand, few lenses of dark-gray silt and fine sand near bottom of stratum, moist. | H=4.0-4.5 |
| | | 2 | 3/6/8 | 19 | 100 | | H=4.0-4.5 |
| | 5 | 3 ▼ | 6/7/10 | 23 | 100 | | H=3.0-4.5<br>G |
| | | 4 | 12/13/22 | 48 | 100 | | H=4.5+ |
| | | ▽ 5 | 9/11/14 | 34 | 100 | | H=4.0-4.5+ |
| 640.4 | | 6A | 6/5/10 | 21 | | | H=3.5-4.5 |
| 639.6 | 10 | 6B | | | | FILL: Stiff to very-stiff brown mottled with gray silty clay interbedded with dark-gray organic silt, little fine to coarse sand, trace fine gravel, moist. | H=1.5-3.0<br>G |
| 638.9 | | 7A | 2/2/2 | 5 | | FILL: Very-stiff brown mottled with gray silty clay, trace fine to coarse sand, trace fine gravel, moist. | H=3.5-3.75 |
| | | 7B | | | | | H=0.0 |
| | | | | | | Very-soft gray mottled with dark-gray organic clayey silt, trace fine to coarse sand, trace fine gravel, moist becoming wet. | |
| | | 8 | SH/SH/SH | 0 | 100 | | H=0.0<br>G |
| | 15 | | | | | | LOI=8.4% |
| | | 9 | SH/SH/SH | 0 | 100 | | H=0.0<br>G |
| 632.1 | | | | | | Very-loose brown and gray fine to coarse gravel, some fine to coarse sand, little silt, contains decayed wood, wet. | |
| | | 10 | SH/SH/2 | 3 | 33 | | H=0.5 |
| 629.6 | 20 | | | | | Very-soft gray mottled with brown silty clay, little fine to medium sand, few seams of fine to medium sand, wet. | |
| | | 11 | 6/7/5 | 16 | 27 | | G |
| 627.1 | | | | | | Medium-dense to dense brown and gray fine to coarse sand, trace to little fine to coarse gravel, trace silt, contains roots near top of stratum, contains zones of fine to coarse gravel, wet. | |
| | | 12 | 6/10/12 | 30 | 53 | | |
| | 25 | | | | | | |



| | ▽ | ▼ |
|---|---|---|
| WATER LEVEL: | 8.0 | 5.4 |
| WATER NOTE: | Inside Well | Inside Well |
| DATE: | 4/7/09 | 4/10/09 |

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.82
**Last Calibration Date :** 11/19/07
**Drill Rig Number :** D50

# LOG OF BORING NO. CD-PZ-BAP-0905
## CARDINAL PLANT ASH POND INVESTIGATION
## BRILLIANT, OHIO

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **650.1** DATE: **4/6/09**
DRILLING METHOD: **4-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **30.0'**
SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

2008 NEW DEFAULT BORING LOG-W/ N60 111497013.GPJ BBCM.GDT 8/4/09

NATURAL CONSISTENCY INDEX
NATURAL MOISTURE CONTENT
PLASTIC LIMIT — LIQUID LIMIT
10 20 30 40

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | $N_{60}$ | SAMPLE REC-% | DESCRIPTION | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|
| | 25 | | | | | | Medium-dense to dense brown and gray fine to coarse sand, trace to little fine to coarse gravel, trace silt, contains roots near top of stratum, contains zones of fine to coarse gravel, wet. | |
| | | 13 | ■ | 7/12/23 | 48 | 67 | | G |
| | | 14 | ■ | 9/12/25 | 51 | 73 | | |
| 620.1 | 30 | | | | | | | |
| | | | | | | | - Groundwater encountered at 18.0'.<br>- Encountered decayed wood at 18.5'.<br>- Borehole converted to observation well upon completion. See separate well log.<br>- Boring location and elevation surveyed by AEP. | |
| | 35 | | | | | | | |
| | 40 | | | | | | | |
| | 45 | | | | | | | |
| | 50 | | | | | | | |

| | ▽ | ▼ |
|---|---|---|
| WATER LEVEL: | 8.0 | 5.4 |
| WATER NOTE: | Inside Well | Inside Well |
| DATE: | 4/7/09 | 4/10/09 |

SYMBOLS USED TO INDICATE TEST RESULTS
G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
(G, Q, T, C:) See Separate Curves
H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.82
**Last Calibration Date :** 11/19/07
**Drill Rig Number :** D50

# LOG OF BORING NO. CD-BAP-0906
# CARDINAL PLANT ASH POND INVESTIGATION
# BRILLIANT, OHIO

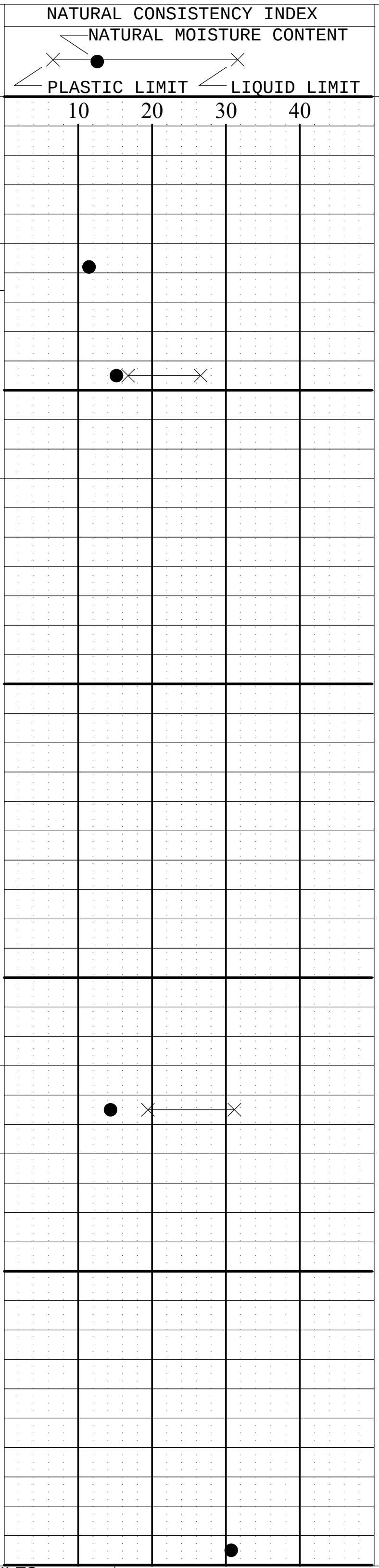
LOCATION: **See Plate 2 of Appendix A** ELEVATION: **668.6** DATE: **4/9/09 - 4/10/09**

DRILLING METHOD: **3-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **60.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

2008 NEW DEFAULT BORING LOG-W/ N60 111497013.GPJ BBCM.GDT 8/4/09

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE EFFORT | $N_{60}$ | SAMPLE REC-% | DESCRIPTION | TEST RESULTS |
|---|---|---|---|---|---|---|---|
| | 0 | | | | | FILL: Medium-dense brown and gray fine to coarse gravel (shale and siltstone fragments), some fine to coarse sand, some silty clay, dry. | |
| 666.1 | | 1 | 8/12/17 | 42 | 20 | | |
| 665.3 | | 2A | 16/8/8 | 23 | | FILL: Medium-dense dark-gray fine to medium sand, trace coarse sand, little fine gravel, some clayey silt, dry to damp. | |
| | | 2B | | | | | H=2.5-3.5 |
| | 5 | 3 | 6/4/5 | 13 | 33 | FILL: Very-stiff brown and gray silty clay and clayey silt, some fine to coarse sand, little fine gravel (sandstone, siltstone, and shale fragments), damp. | H=2.3 |
| 662.1 | | 4 | 6/8/9 | 24 | 40 | | H=2.3-3.3 |
| | | 5 | 6/7/7 | 20 | 67 | FILL: Medium-dense brown and gray fine to coarse gravel "and" fine to coarse sand, some silty clay (sandstone and siltstone fragments), stiff brown silty clay seam at 13.5', damp. | |
| | | 6A | P | | | | |
| | 10 ▽ | 6B | | | | | |
| | | 7 | 11/11/12 | 33 | 60 | | |
| | | 8 | 9/13/10 | 33 | 67 | | G |
| | | 9 | 9/16/19 | 50 | 60 | | H=2.2 |
| 652.1 | 15 | 10 | 10/11/11 | 32 | 40 | | |
| 650.6 | | 11 | 7/7/6 | 19 | 53 | FILL: Very-stiff brown silty clay, some fine to coarse sand, some fine to coarse gravel, damp to moist. | H=2.2<br>G |
| | | 12A | P | | | Very-loose to loose gray silt, trace to some fine sand, trace to little fine to medium sand, trace fine gravel, few seams of gray fine to medium sand, damp becoming wet at 20'. | |
| | | 12B | | | | | |
| | 20 | 13 | 1/1/3 | 6 | | | 80 |
| | | | SR/SR/SR | 0 | 0 | | |
| | | 14 | SH/SH/1 | 1 | 67 | | |
| | 25 | 15 | 1/1/1 | 3 | 100 | | |



| | | | |
|---|---|---|---|
| WATER LEVEL: | ▽ 10.3 | ▼ | |
| WATER NOTE: | Inside HSA | | |
| DATE: | 4/10/09 | | |

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

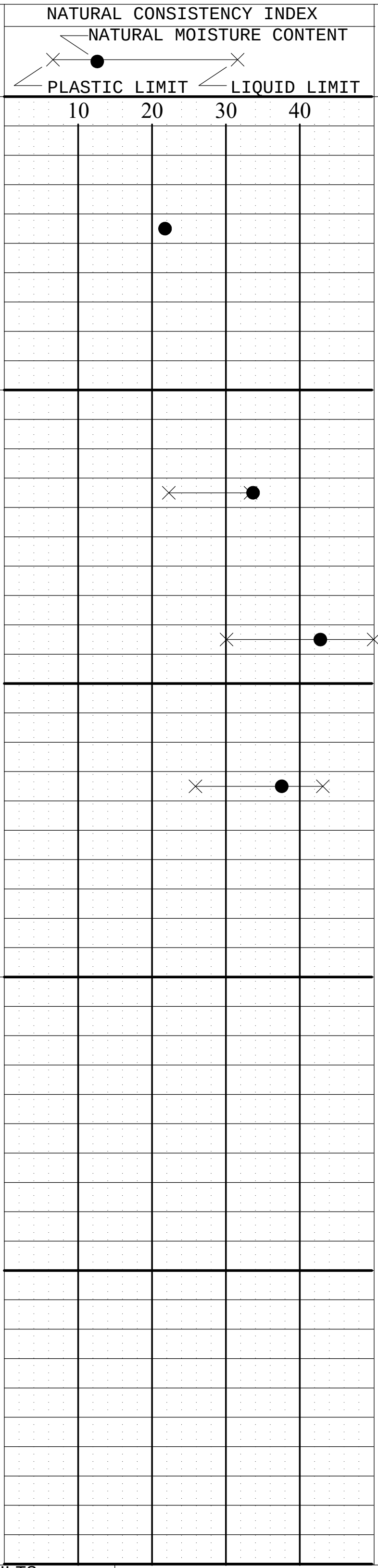
H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.86
**Last Calibration Date :** 02/17/09
**Drill Rig Number :** TRUCK 55

# LOG OF BORING NO. CD-BAP-0906
# CARDINAL PLANT ASH POND INVESTIGATION
## BRILLIANT, OHIO

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **668.6** DATE: **4/9/09 - 4/10/09**
DRILLING METHOD: **3-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **60.0'**
SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|
| | 25 | | | | | | Very-loose to loose gray silt, trace to some fine sand, trace to little fine to medium sand, trace fine gravel, few seams of gray fine to medium sand, damp becoming wet at 20'. | G |
| | | 16 | ■ | 3/4/5 | 13 | 67 | | G |
| | | 17 | ■ | 3/1/2 | 4 | 80 | | G |
| | | 18 | ■ | 2/2/2 | 6 | 67 | | |
| 638.6 | 30 | | | | | | Very-soft to medium-stiff gray organic clayey silt, trace fine to coarse sand, trace fine gravel, contains seams of silty clay, silt and fine to medium sand, wet. | |
| | | 19 | ■ | 1/1/3 | 6 | 67 | | H=0.9<br>G |
| | | 20 | ■ | 2/2/3 | 7 | 60 | | H=0.0-0.25<br>G<br>LOI=7.9% |
| | 35 | | | | | | | |
| | | 21 | ■ | 2/2/3 | 7 | 47 | | H=0.0<br>G |
| | | 22 | ■ | 3/5/9 | 20 | 53 | | H=0.9 |
| 628.6 | 40 | | | | | | Medium-dense brown and gray fine to coarse gravel, some fine to coarse sand, trace to little silt, contains zones of fine to coarse sand, wet. | |
| | | 23 | ■ | 5/6/7 | 19 | 40 | | |
| | | 24 | ■ | 6/7/9 | 23 | 47 | | G |
| | 45 | | | | | | | |
| | | 25 | ■ | 10/13/15 | 40 | 70 | | |
| | | 26 | ■ | 6/10/14 | 34 | 67 | | |
| | 50 | | | | | | | |



2008 NEW DEFAULT BORING LOG-W/ N60 111497013.GPJ BBCM.GDT 8/4/09

WATER LEVEL: ▽ 10.3 ▼
WATER NOTE: Inside HSA
DATE: 4/10/09

SYMBOLS USED TO INDICATE TEST RESULTS
G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves
H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.86
**Last Calibration Date :** 02/17/09
**Drill Rig Number :** TRUCK 55

-CONTINUED-

# LOG OF BORING NO. CD-BAP-0906
# CARDINAL PLANT ASH POND INVESTIGATION
# BRILLIANT, OHIO

BBCM

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **668.6** DATE: **4/9/09 - 4/10/09**

DRILLING METHOD: **3-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **60.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT / PLASTIC LIMIT / LIQUID LIMIT (10 20 30 40) | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|---|
| | 50 | | | | | | Medium-dense brown and gray fine to coarse gravel, some fine to coarse sand, trace to little silt, contains zones of fine to coarse sand, wet. | | |
| | | 27 | | 10/10/16 | 37 | 47 | | | |
| | | 28 | | 9/10/12 | 32 | 60 | | | |
| | 55 | | | | | | | | |
| | | 29 | | 10/15/33 | 69 | 33 | | | |
| | | | | 3/5/11 | 23 | | | | |
| 608.6 | 60 | | | | | | | | |
| | | | | | | | - Groundwater encountered at 20.0'.<br>- Cobbles encountered throughout the borehole.<br>- Borehole grouted upon completion.<br>- Boring location and elevation surveyed by AEP. | | |
| | 65 | | | | | | | | |
| | 70 | | | | | | | | |
| | 75 | | | | | | | | |

WATER LEVEL: ▽ 10.3 ▼

WATER NOTE: Inside HSA

DATE: 4/10/09

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.86
**Last Calibration Date :** 02/17/09
**Drill Rig Number :** TRUCK 55

2008 NEW DEFAULT BORING LOG-W/ N60 111497013.GPJ BBCM.GDT 8/4/09

Page 1 of 2

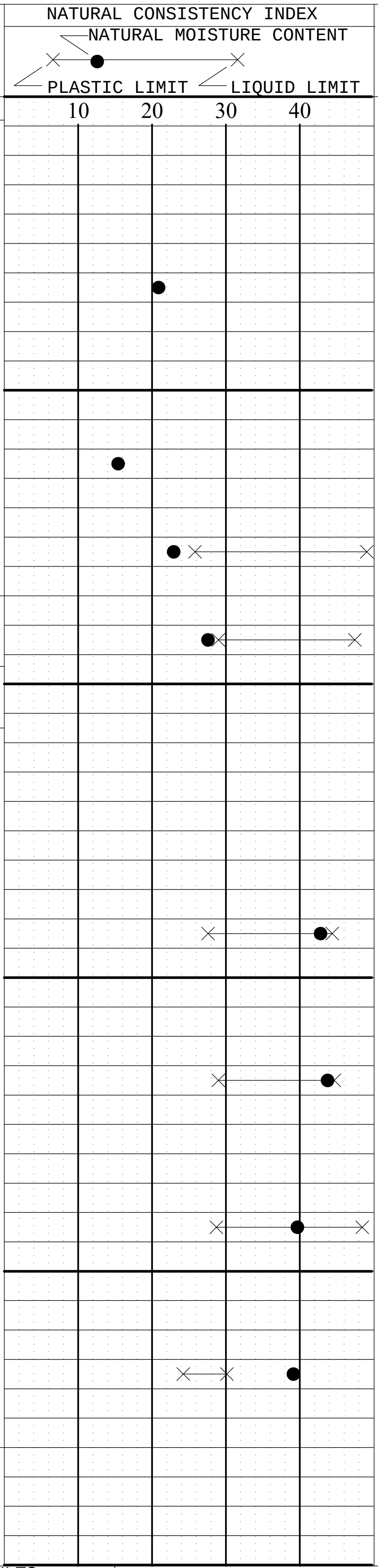
# LOG OF BORING NO. CD-BAP-0907
# CARDINAL PLANT ASH POND INVESTIGATION
# BRILLIANT, OHIO

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **650.3** DATE: **4/8/09**

DRILLING METHOD: **3-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **30.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | TEST RESULTS |
|---|---|---|---|---|---|---|---|
| 649.9 | 0 | | | | | TOPSOIL - 0.4 FEET | |
| | | 1 | 4/5/5 | 14 | 47 | FILL: Very-stiff to hard brown mottled with gray silty clay, trace to little fine to coarse sand, trace fine gravel, few roots near top of stratum, contains fine to medium sand lenses and seams near middle of stratum, damp. | H=2.2-2.4 |
| | | 2 | 4/5/10 | 21 | 73 | | H=3.9-4.2 |
| | 5 | 3 | 4/6/7 | 18 | 80 | | H=4.5 |
| | | 4 | 9/11/15 | 36 | 100 | | H=4.5 |
| | | 5 | 5/7/8 | 21 | 67 | | H=4.1-4.5 |
| 641.8 | | 6A | P | | | FILL: Hard brown, gray and dark-gray silty clay intermixed with organic silt, little fine to coarse sand, trace fine gravel, damp. | H=4.5<br>G |
| 640.6 | 10 | 6B | | | | Stiff gray organic silt, little fine to medium sand, few lenses of fine sand, damp to moist. | H=2.2 |
| 639.6 | | 7 | SH/SH/SH | 0 | 67 | Very-soft to soft gray organic clayey silt, little fine to medium sand, trace fine gravel, damp to moist. | H=0.0<br>G |
| | 15 | 8 | SH/SH/SH | 0 | 73 | | H=0.0<br>G |
| | ▽ | 9 | SH/SH/SH | 0 | 67 | | H=0.0-0.25<br>G |
| | 20 | 10 | SH/SH/SH | 0 | 73 | | H=0.0-0.25<br>G |
| | | 11 | SH/SH/3 | 4 | 67 | | H=0.0-0.50<br>G |
| 627.3 | | 12 | 2/6/8 | 19 | 33 | Medium-dense gray-brown and gray fine to coarse gravel, "and" fine to coarse sand, trace to little silt, wet. | |
| | 25 | | | | | | |



| | | |
|---|---|---|
| WATER LEVEL: | ▽ 16.3 | ▼ |
| WATER NOTE: | Inside HSA | |
| DATE: | 4/8/09 | |

SYMBOLS USED TO INDICATE TEST RESULTS

G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves

H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.82
**Last Calibration Date :** 11/19/07
**Drill Rig Number :** D50

**JOB: 011-11497-013** -CONTINUED- **PLATE 21**

2008 NEW DEFAULT BORING LOG-W/ N60 111497013.GPJ BBCM.GDT 8/4/09

# LOG OF BORING NO. CD-BAP-0907
# CARDINAL PLANT ASH POND INVESTIGATION
# BRILLIANT, OHIO

LOCATION: **See Plate 2 of Appendix A** ELEVATION: **650.3** DATE: **4/8/09**

DRILLING METHOD: **3-1/4" I.D. Hollow-stem Auger** COMPLETION DEPTH: **30.0'**

SAMPLER(S): **2" O.D. Split-barrel Sampler 3" O.D. Shelby Tube Sampler**

| ELEV. | DEPTH, FEET | SAMPLE NUMBER | SAMPLE | SAMPLE EFFORT | N60 | SAMPLE REC-% | DESCRIPTION | NATURAL CONSISTENCY INDEX — NATURAL MOISTURE CONTENT — PLASTIC LIMIT — LIQUID LIMIT<br>10 20 30 40 | TEST RESULTS |
|---|---|---|---|---|---|---|---|---|---|
| | 25 | | | | | | Medium-dense gray-brown and gray fine to coarse gravel, "and" fine to coarse sand, trace to little silt, wet. | | |
| | | 13 | ■ | 8/12/13 | 34 | 40 | | | G |
| | | 14 | ■ | 6/7/9 | 22 | 47 | | | |
| 620.3 | 30 | | | | | | | | |
| | | | | | | | - Seepage encountered at 11.0'.<br>- Groundwater encountered at 23.0'.<br>- Borehole grouted upon completion.<br>- Boring location and elevation surveyed by AEP. | | |
| | 35 | | | | | | | | |
| | 40 | | | | | | | | |
| | 45 | | | | | | | | |
| | 50 | | | | | | | | |

WATER LEVEL: ▽ **16.3** ▼
WATER NOTE: **Inside HSA**
DATE: **4/8/09**

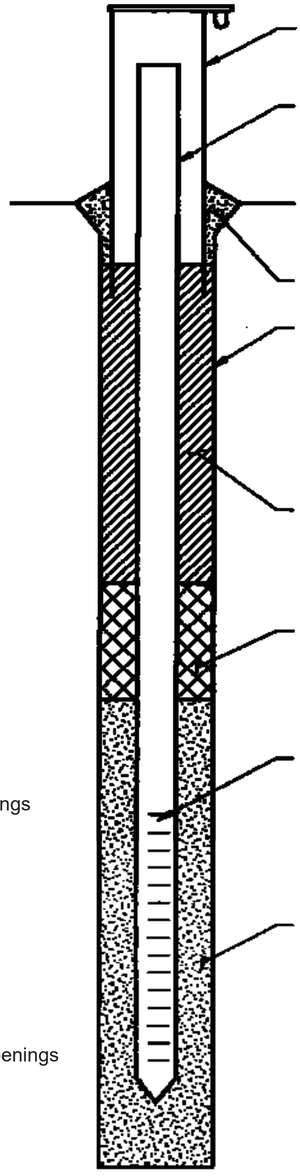
SYMBOLS USED TO INDICATE TEST RESULTS
G - Gradation
Q - Uncon Comp
T - Triax Comp
C - Consol.
See Separate Curves
H - Penetrometer (tsf)
W - Unit Dry Wt (pcf)
D - Relative Dens (%)

**Drill Rod Energy Ratio :** 0.82
**Last Calibration Date :** 11/19/07
**Drill Rig Number :** D50

2008 NEW DEFAULT BORING LOG-W/ N60 111497013.GPJ BBCM.GDT 8/4/09

BBCM
SOLUTIONS TO BUILD ON

| Elevation (Feet above MSL) | Depth Below Ground Surface (Feet) | |
|---|---|---|
| | | Top of Cover |
| | | Top of PVC |
| **668.0** | **0.0** | Ground Surface |
| **N/A** | **N/A** | Top of Grout |
| **666.5** | **1.5** | Top of Bentonite |
| **659.8** | **8.2** | Top of Filter Pack |
| **N/A** | **N/A** | Top of Aquifer |
| **658.0** | **10.0** | Top of Screen Openings |
| **608.0** | **60.0** | Bottom of Screen Openings |
| **608.0** | **60.0** | Bottom of Well |
| **N/A** | **N/A** | Bottom of Aquifer |
| **607.5** | **60.5** | Bottom of Boring |


(NOT TO SCALE)

**4** - Inch Diameter Protective Steel Casing

**2** - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)
**7** " **0.0** to **60.5**
" to
" to

Grout: **N/A**

Bentonite Seal: **Hole Plug**

**10** - Slot Screen

Filter Pack: **No. 4 Quartz Sand8.2' - 24.9'**
**Natural Sand 24.9' - 60.5'**

| | | | | | |
|---|---|---|---|---|---|
| Static Water Level: | **657.30** | **659.60** | | | |
| Date: | **4/8/09** | **4/10/09** | | | |

Well Development:
Removed approximately 10 well volumes during development and well remained silty. Additional well development performed and well remained slightly silty at completion of bailing. Set steel casing in 3'x3' concrete pad. Placed steel bollards around concrete pad.

## WELL COMPLETION DIAGRAM

**Project Name:**
Cardinal Plant Ash Pond Investigation

**Project Location:**
Brilliant, Ohio

**Project Number:**
011-11497-013

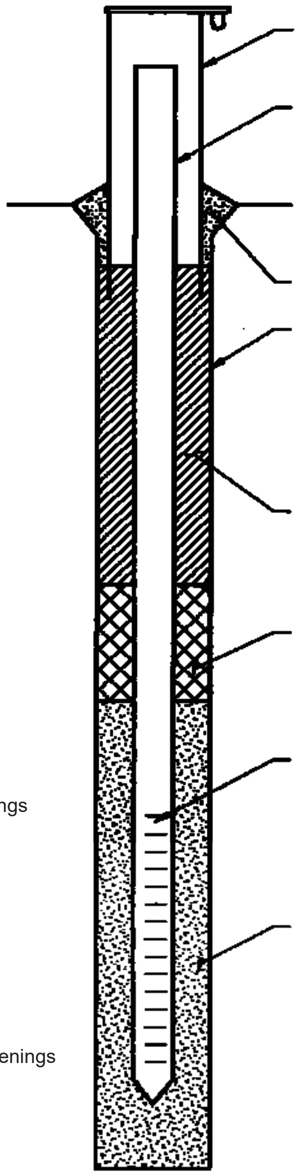
**Boring Number:**
CD-PZ-BAP-0902

**Date Well Installed:**
4/8/2009

**PLATE 23**

BBCM
SOLUTIONS TO BUILD ON

| Elevation (Feet above MSL) | Depth Below Ground Surface (Feet) | |
|---|---|---|
| | | Top of Cover |
| | | Top of PVC |
| **668.1** | **0.0** | Ground Surface |
| **N/A** | **N/A** | Top of Grout |
| **665.1** | **3.0** | Top of Bentonite |
| **660.1** | **8.0** | Top of Filter Pack |
| **N/A** | **N/A** | Top of Aquifer |
| **658.6** | **9.5** | Top of Screen Openings |
| **608.6** | **59.5** | Bottom of Screen Openings |
| **608.6** | **59.5** | Bottom of Well |
| **N/A** | **N/A** | Bottom of Aquifer |
| **608.1** | **60.0** | Bottom of Boring |


(NOT TO SCALE)

**4** - Inch Diameter Protective Steel Casing

**2** - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)
**7** " **0.0** to **60.0**
" to
" to

Grout: **N/A**

Bentonite Seal: **Hole Plug**

**10** - Slot Screen

Filter Pack: **No. 4 Quartz Sand 8.0' - 32.5'**
**Natural Sand 32.5' - 60.0'**

| | | | | | |
|---|---|---|---|---|---|
| Static Water Level: | **652.20** | | | | |
| Date: | **4/10/09** | | | | |

Well Development:
Removed approximately 10 well volumes during development and well remained silty. Additional well development performed and well remained slightly silty at completion of bailing. Set steel casing in 3'x3' concrete pad. Placed steel bollards around concrete pad.

## WELL COMPLETION DIAGRAM

**Project Name:**
Cardinal Plant Ash Pond Investigation

**Project Location:**
Brilliant, Ohio

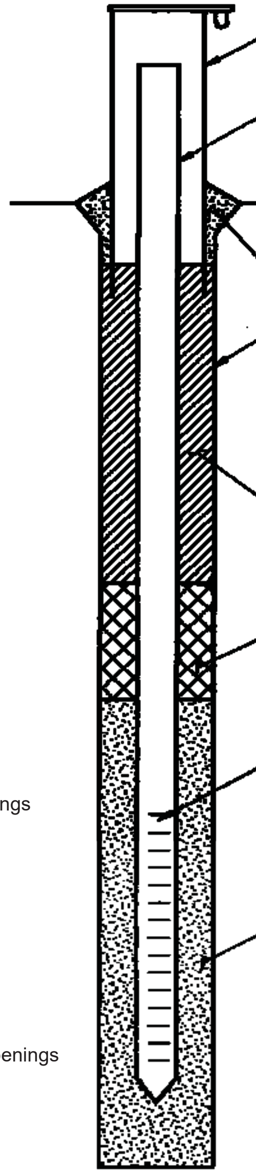
**Project Number:**
011-11497-013

**Boring Number:**
CD-PZ-BAP-0904

**Date Well Installed:**
4/7/2009

**PLATE 24**

| Elevation (Feet above MSL) | Depth Below Ground Surface (Feet) | |
|---|---|---|
| | | Top of Cover |
| | | Top of PVC |
| **650.1** | **0.0** | Ground Surface |
| **N/A** | **N/A** | Top of Grout |
| **647.6** | **2.5** | Top of Bentonite |
| **642.1** | **8.0** | Top of Filter Pack |
| **N/A** | **N/A** | Top of Aquifer |
| **641.6** | **8.5** | Top of Screen Openings |
| **621.6** | **28.5** | Bottom of Screen Openings |
| **621.6** | **28.5** | Bottom of Well |
| **N/A** | **N/A** | Bottom of Aquifer |
| **620.1** | **30.0** | Bottom of Boring |



(NOT TO SCALE)

**4** - Inch Diameter Protective Steel Casing

**2** - Inch Diameter Flush-Thread PVC Casing

Ground Surface

Concrete

Boring Diameter (in inches)

| | | | | |
|---|---|---|---|---|
| **7** | " | **0.0** | to | **30.0** |
| | " | | to | |
| | " | | to | |

Grout: **N/A**

Bentonite Seal: **Hole Plug**

**10** - Slot Screen

Filter Pack: **No. 4 Quartz Sand 8.0' - 32.5'**
**Natural Sand 18.0' - 30.0'**

| | | | | | |
|---|---|---|---|---|---|
| Static Water Level: | **642.10** | **644.70** | | | |
| Date: | **4/7/09** | **4/10/09** | | | |

Well Development:
Removed approximately 10 well volumes during development. Well remained silty at completion of bailing. Set steel casing in 3'x3' concrete pad. Placed steel bollards around concrete pad.

## WELL COMPLETION DIAGRAM

**Project Name:**
Cardinal Plant Ash Pond Investigation

**Project Location:**
Brilliant, Ohio

**Project Number:**
011-11497-013

**Boring Number:**
CD-PZ-BAP-0905

**Date Well Installed:**
4/6/2009

**PLATE 25**

# Appendix II – 2009 & 2015 Laboratory Testing Results

# SUMMARY OF LABORATORY TEST RESULTS

| BORING | G'int Id. | MC | LL | PL | PI | GRADATION | | | COMPACTION | | TRIAXIAL | | | DIRECT SHEAR | | | UNCONFIN COMPRESS | CONSOLID. | SPECIFIC GRAVITY | UNIT DRY WEIGHT | REMOLDED | PERMEABILITY | | | | RELATIVE DENSITY | LOI | ROCK CORE | SHELBY TUBE | Slake Index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Hydrometer | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | sieve | short | long | standard | modified | uncons. undrain | consolid undrain w/pores | drained | drained | undrain | residual | | | | | | cohesive | non/cohes | rigid wall | flexible wall | | | | | |
| | | % | % | % | % | * SEE INDIVIDUAL TEST CURVES | | | | | | | | | | | | | | PCF | | | | | | % | % | | | |
| CD-BAP-1501 | 4.75 | | | | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| CD-BAP-1501 | 9.25 | | | | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| CD-BAP-1501 | 12.25 | 13.9 | 22 | 14 | 8 | | | | | | | | | | | | | | | | | | | | | | | | | |
| CD-BAP-1502 | 6.25 | 9.1 | 27 | 16 | 11 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| CD-BAP-1502 | 11.25 | 8.9 | 21 | 14 | 7 | | | | | | | | | | | | | | | | | | | | | | | | | |
| CD-BAP-1502 | 17.75 | 12.7 | 26 | 16 | 10 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| CD-BAP-1502 | 20.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | * | |
| CD-BAP-1502 | 24.25 | 22.4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CD-BAP-1502 | 32.50 | | | | | | | | | | | | | | | | | | | | | | | | | | | | * | |
| CD-BAP-1502 | 40.75 | | | | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| CD-BAP-1504 | 6.25 | 9.4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CD-BAP-1504 | 10.75 | | | | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| CD-BAP-1504 | 12.25 | 11.6 | | | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| CD-BAP-1504 | 17.25 | 18.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CD-BAP-1505 | 9.25 | 11.6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CD-BAP-1505 | 10.40 | 19.0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CD-BAP-1505 | 13.75 | 10.4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CD-BAP-1505 | 15.25 | 18.3 | | | | * | | | | | | | | | | | | | | | | | | | | | | | | |

SUM REG

TESTING SUMMARY - STANDARD

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A DATE 12/30/15

# SUMMARY OF LABORATORY TEST RESULTS

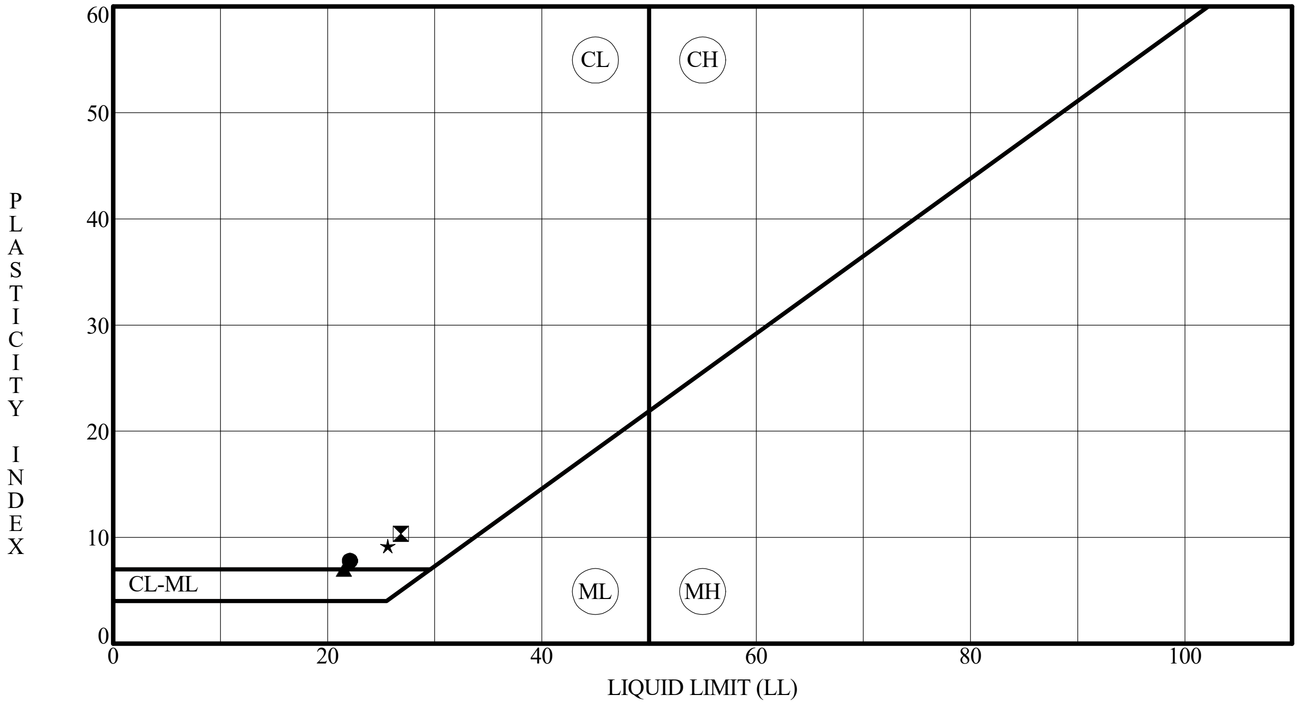
| BORING | G'int Id. | MC | LL | PL | PI | GRADATION | | | COMPACTION | | TRIAXIAL | | | DIRECT SHEAR | | | UNCONFIN COMPRESS | CONSOLID. | SPECIFIC GRAVITY | UNIT DRY WEIGHT | REMOLDED | PERMEABILITY | | | | RELATIVE DENSITY | LOI | ROCK CORE | SHELBY TUBE | Slake Index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | sieve | Hydrometer | | standard | modified | uncons. undrain | consolid undrain w/pores | drained | drained | undrain | residual | | | | | | cohesive | non/cohes | rigid wall | flexible wall | | | | | |
| | | | | | | | short | long | | | | | | | | | | | | | | | | | | | | | | |
| | | % | % | % | % | * SEE INDIVIDUAL TEST CURVES | | | | | | | | | | | | | | PCF | | | | | | % | % | | | |
| MW-BAP-4 | 6.25 | 15.0 | 25 | 16 | 9 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| MW-BAP-4 | 9.25 | 24.3 | 43 | 21 | 22 | | | | | | | | | | | | | | | | | | | | | | | | | |
| MW-BAP-4 | 14.50 | | | | | | | | | | | | | | | | | | | | | | | | | | | | * | |
| MW-BAP-4 | 32.25 | | | | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| MW-BAP-4 | 39.25 | | | | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| MW-BAP-5 | 4.75 | 12.8 | 30 | 17 | 13 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| MW-BAP-5 | 9.25 | 10.3 | 30 | 18 | 12 | | | | | | | | | | | | | | | | | | | | | | | | | |
| MW-BAP-5 | 11.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | * | |
| MW-BAP-5 | 21.75 | 39.9 | 48 | 26 | 22 | * | | * | | | | | | | | | | | | | | | | | | | 5.9 | | | |
| MW-BAP-5 | 27.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | * | |
| MW-BAP-5 | 29.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | * | |
| MW-BAP-5 | 41.75 | 29.7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| MW-BAP-5 | 51.75 | | | | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| MW-BAP-5 | 59.25 | | | | | * | | | | | | | | | | | | | | | | | | | | | | | | |

**S&ME**

TESTING SUMMARY - STANDARD

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A DATE 12/30/15

# ATTERBERG LIMITS' RESULTS - ASTM D4318

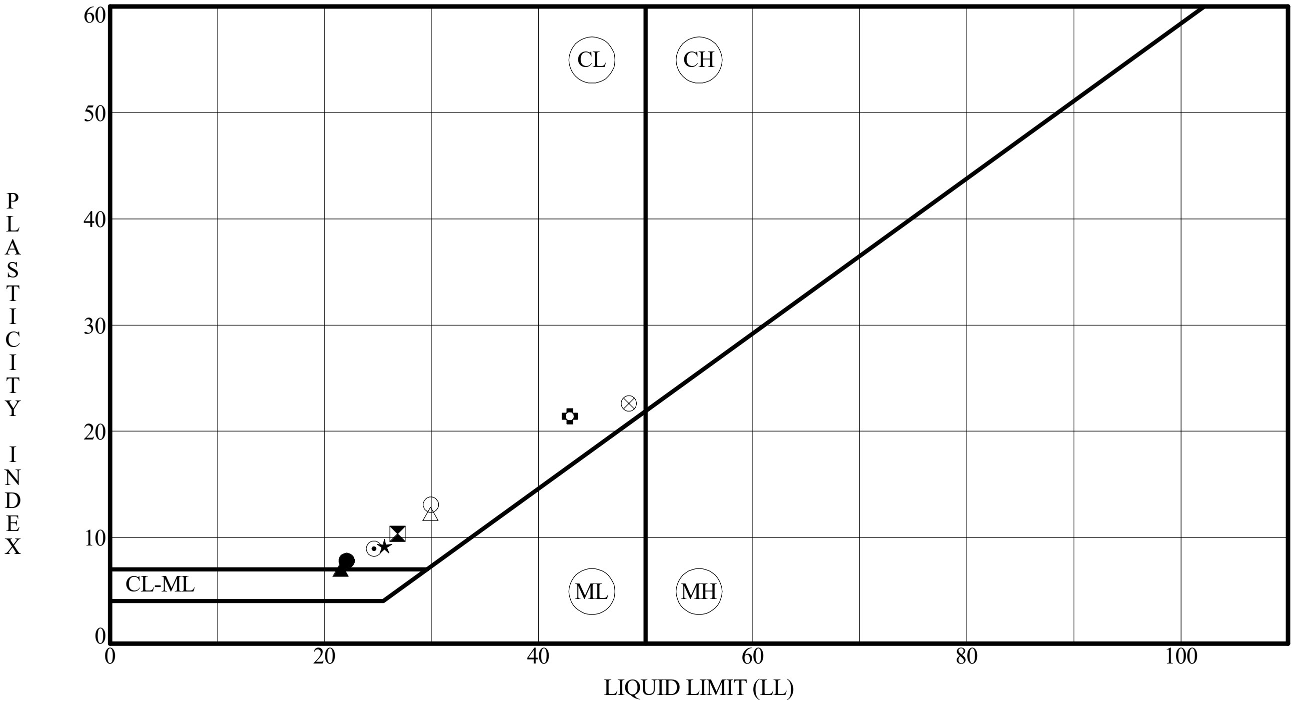


| Specimen Id. | Depth | MC | LL | PL | PI | Fines | ASTM Classification |
|---|---|---|---|---|---|---|---|
| ● CD-BAP-1501 | 12.25 | 14 | 22 | 14 | 8 | | |
| ⧗ CD-BAP-1502 | 6.25 | 9 | 27 | 16 | 11 | 28.6 | CLAYEY SAND with GRAVEL SC |
| ▲ CD-BAP-1502 | 11.25 | 9 | 21 | 14 | 7 | | |
| ★ CD-BAP-1502 | 17.75 | 13 | 26 | 16 | 10 | 27.9 | CLAYEY SAND with GRAVEL SC |

ALPI-REG

**PROJECT** BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
**LOCATION** CARDINAL PLANT, BRILLIANT, OH
**JOB NO.** 7217-15-007A **DATE** 12/30/15

# ATTERBERG LIMITS' RESULTS - ASTM D4318

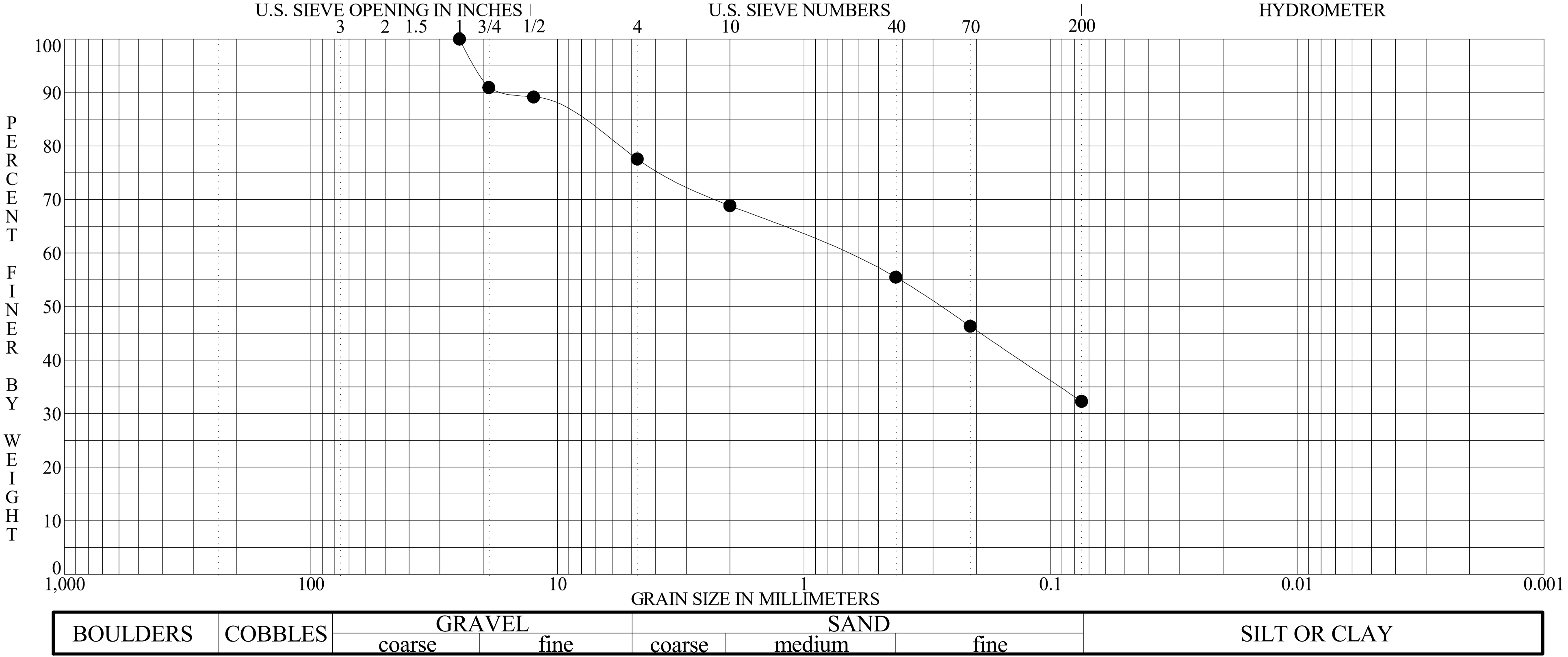


ALPI-REG

| Specimen Id. | Depth | MC | LL | PL | PI | Fines | ASTM Classification |
|---|---|---|---|---|---|---|---|
| ● CD-BAP-1501 | 12.25 | 14 | 22 | 14 | 8 | | |
| ⧗ CD-BAP-1502 | 6.25 | 9 | 27 | 16 | 11 | 28.6 | CLAYEY SAND with GRAVEL SC |
| ▲ CD-BAP-1502 | 11.25 | 9 | 21 | 14 | 7 | | |
| ★ CD-BAP-1502 | 17.75 | 13 | 26 | 16 | 10 | 27.9 | CLAYEY SAND with GRAVEL SC |
| ⊙ MW-BAP-4 | 6.25 | 15 | 25 | 16 | 9 | 41.2 | CLAYEY SAND SC |
| ✤ MW-BAP-4 | 9.25 | 24 | 43 | 21 | 22 | | |
| ○ MW-BAP-5 | 4.75 | 13 | 30 | 17 | 13 | 38.8 | CLAYEY SAND with GRAVEL SC |
| △ MW-BAP-5 | 9.25 | 10 | 30 | 18 | 12 | | |
| ⊗ MW-BAP-5 | 21.75 | 40 | 48 | 26 | 22 | 94.9 | LEAN CLAY CL |

**PROJECT** BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
**LOCATION** CARDINAL PLANT, BRILLIANT, OH
**JOB NO.** 7217-15-007A **DATE** 12/30/15

GRN-REG W/ASTM DESC.



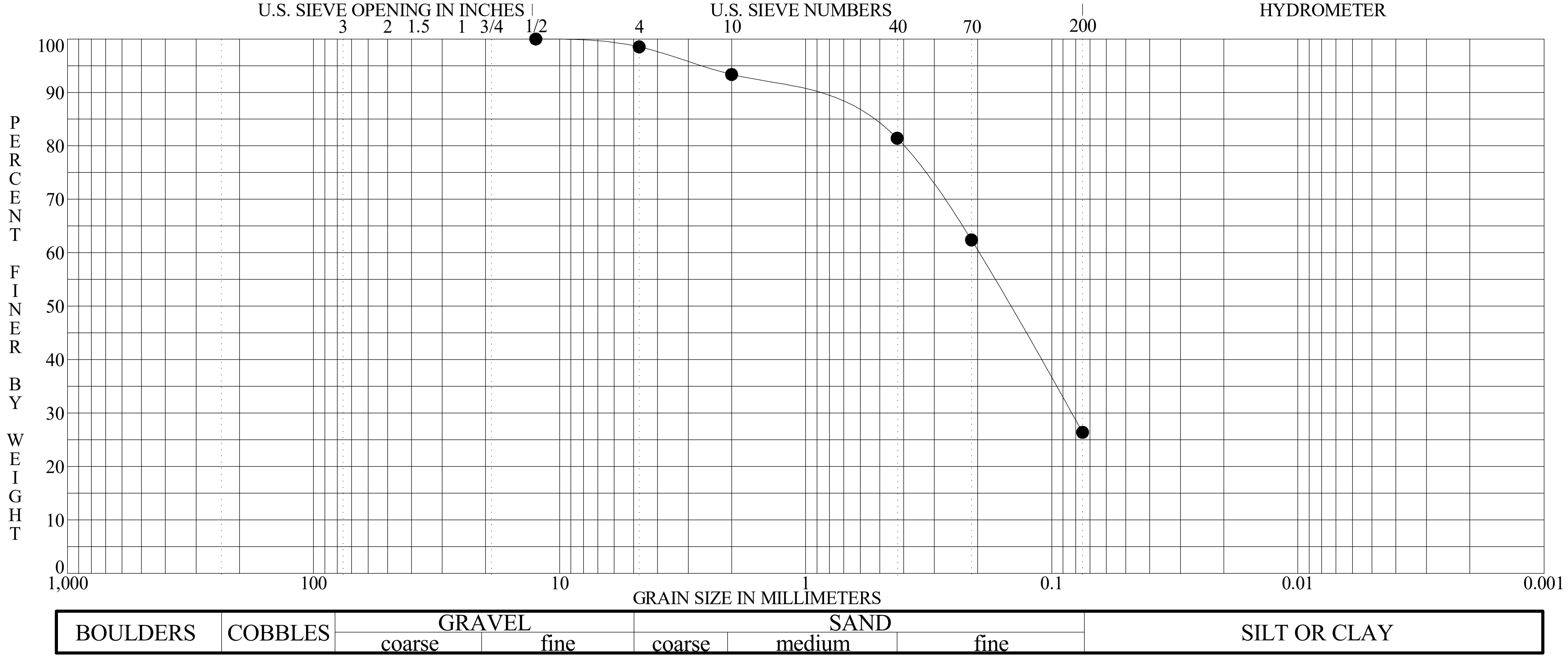
| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | CD-BAP-1501 S-3 4.0' to 4.8' | Gray and brown fine to coarse sand, some fine to coarse gravel, some silt. | | | | | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | CD-BAP-1501 S-3 4.0' to 4.8' | 25.0000 | 21.4832 | 0.7155 | 0.2797 | | 22.4 | 45.3 | 32.3 | |

**ASTM D422**

**GRADATION CURVE**

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A DATE 12/30/15



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● CD-BAP-1501 S-6 8.5' to 9.7' | **Red-brown and gray fine to coarse sand, trace fine gravel, some silt.** | | | | | | |

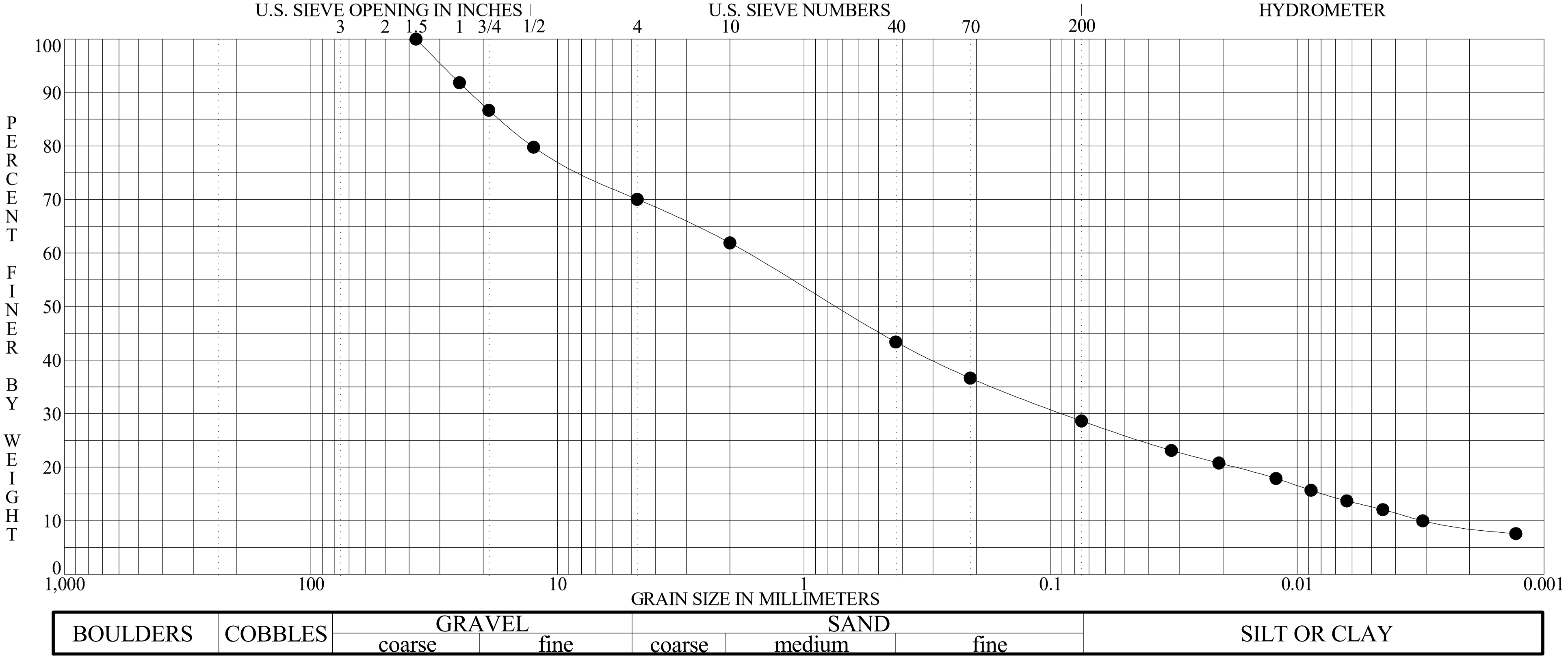
| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● CD-BAP-1501 S-6 8.5' to 9.7' | 12.5000 | 2.6291 | 0.1978 | 0.1482 | | 1.5 | 72.1 | 26.4 | |

**ASTM D422**

**GRADATION CURVE**

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A DATE 12/30/15

GRN-REG W/ASTM DESC.



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● CD-BAP-1502 S-4 5.5' to 6.7' | **Gray and brown fine to coarse sand, some fine to coarse gravel, some silty clay.**<br>**CLAYEY SAND with GRAVEL SC** | **9** | **27** | **16** | **11** | **1.508** | **547.388** |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● CD-BAP-1502 S-4 5.5' to 6.7' | **37.5000** | **29.2411** | **1.7048** | **0.7385** | **0.0031** | **29.9** | **41.4** | **16.1** | **12.6** |

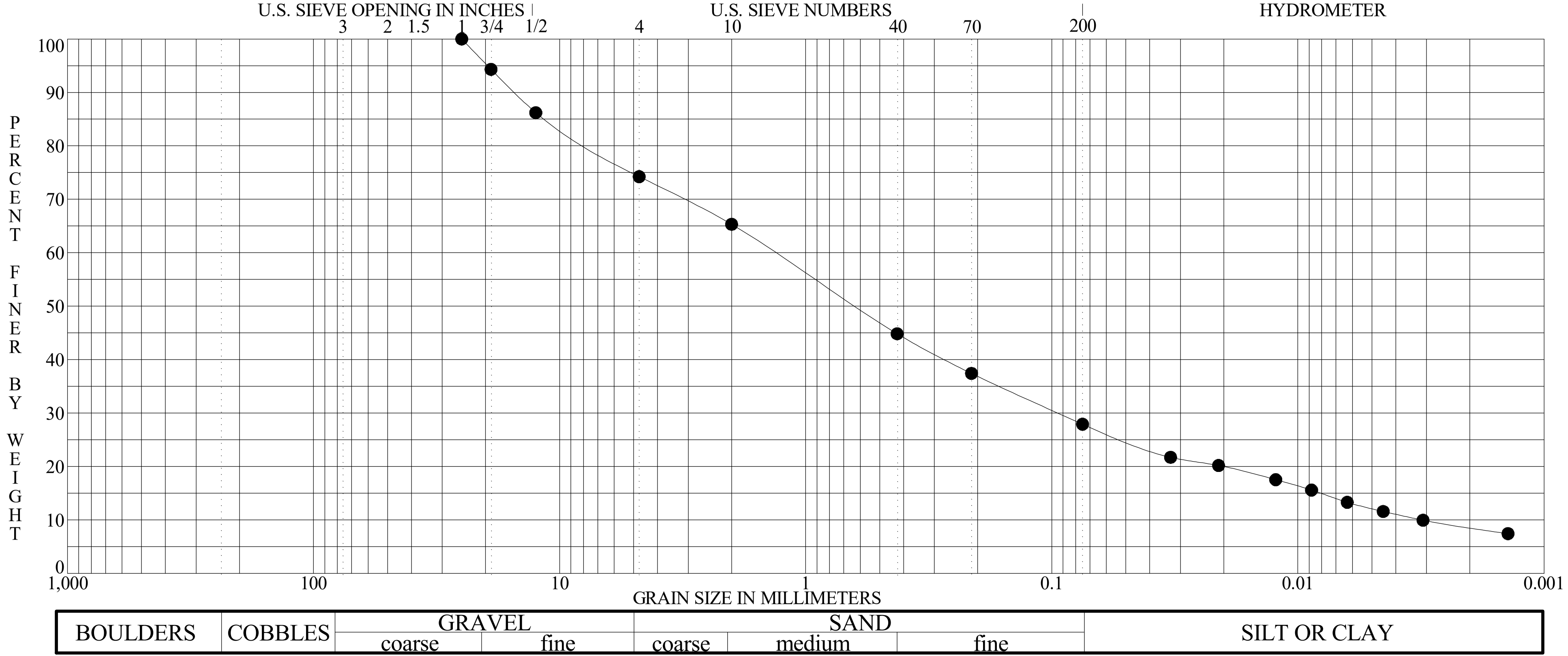
**ASTM D422**

## GRADATION CURVE

**PROJECT** BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
**LOCATION** CARDINAL PLANT, BRILLIANT, OH
**JOB NO.** 7217-15-007A **DATE** 12/30/15

PLATE 7

GRN-REG W/ASTM DESC.



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-1502 S-9 17.0' to 18.3** | **Gray fine to coarse sand, some fine to coarse gravel, some clayey silt.**<br>**CLAYEY SAND with GRAVEL SC** | **13** | **26** | **16** | **10** | **2.113** | **425.827** |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-1502 S-9 17.0' to 18.3** | **25.0000** | **19.6384** | **1.3380** | **0.6282** | **0.0031** | **25.8** | **46.3** | **15.8** | **12.1** |

**ASTM D422**

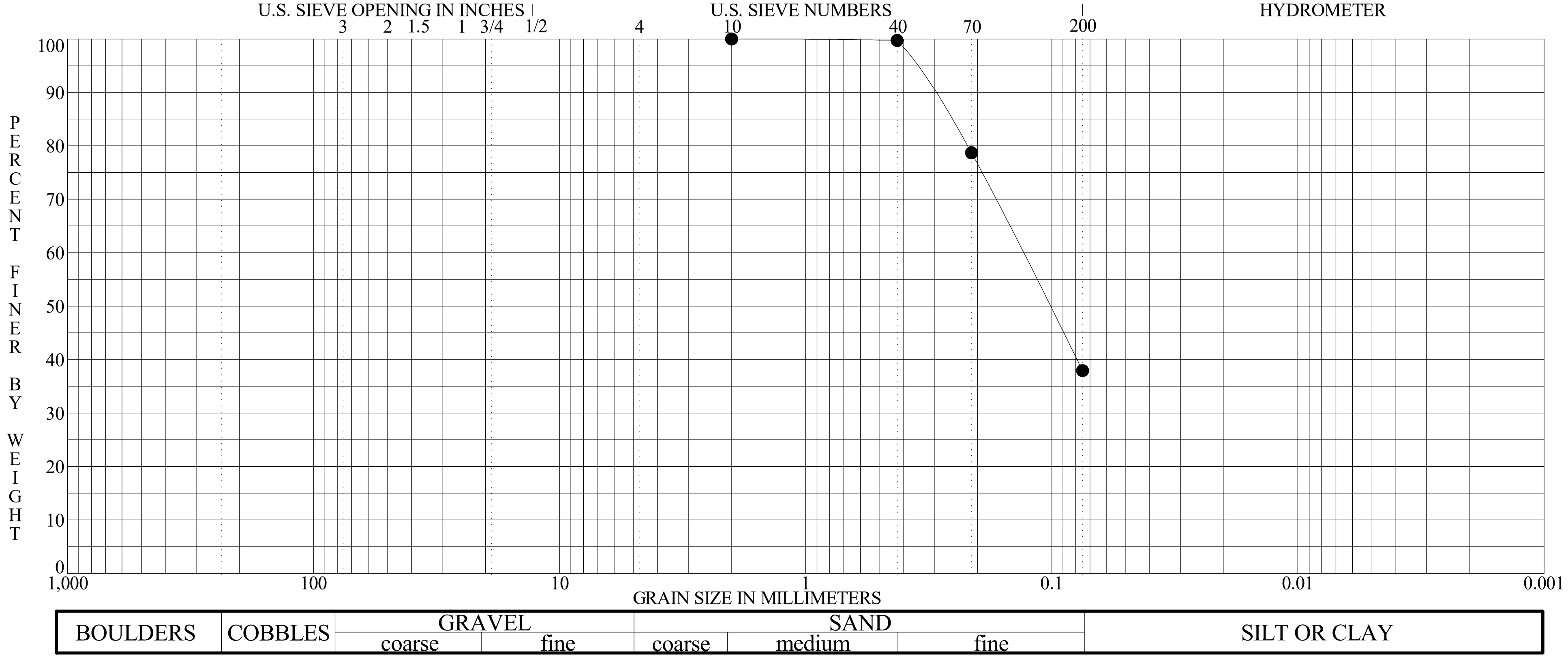
**GRADATION CURVE**

**PROJECT** BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION

**LOCATION** CARDINAL PLANT, BRILLIANT, OH

**JOB NO.** 7217-15-007A **DATE** 12/30/15

GRN-REG W/ASTM DESC.



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | CD-BAP-1502 S-18 40.0' to 41.0' | Brown fine to medium sand, "and" silt. | | | | | | |

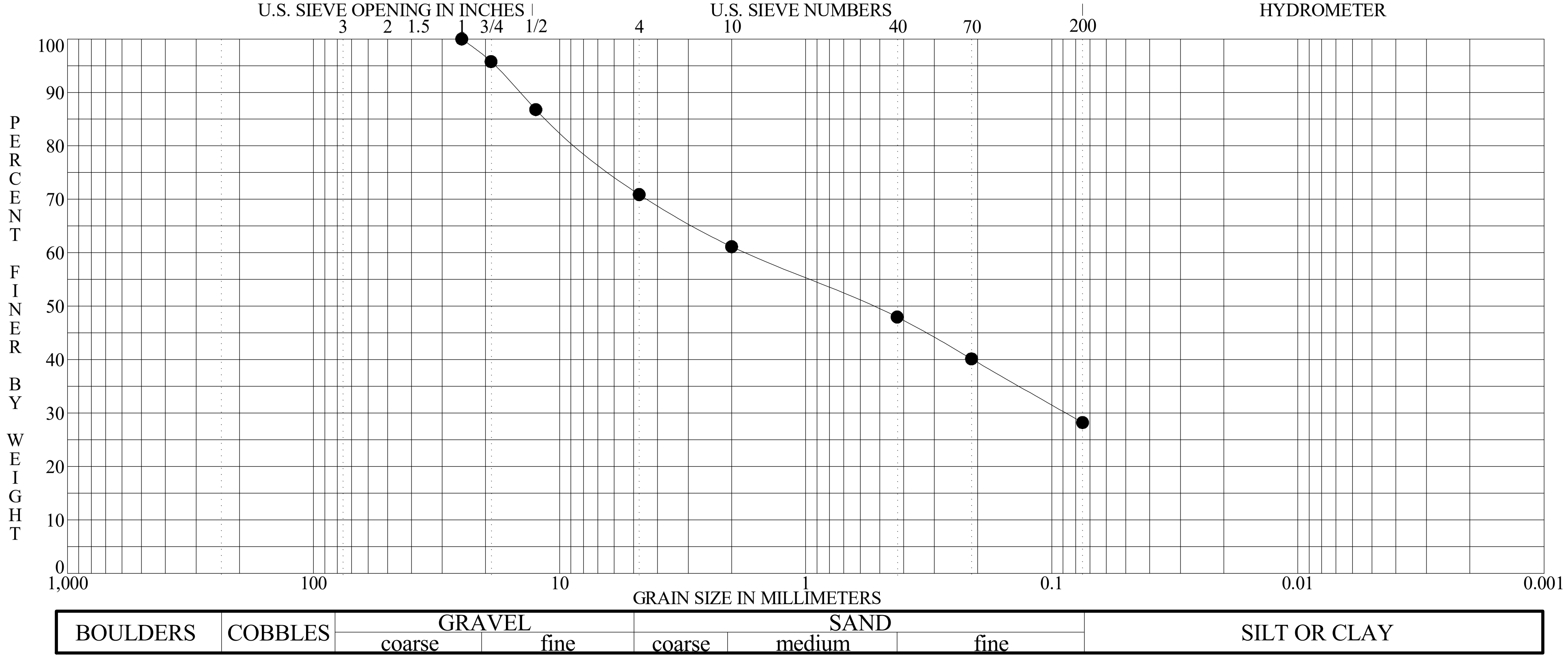
| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | CD-BAP-1502 S-18 40.0' to 41.0' | 2.0000 | 0.3633 | 0.1316 | 0.1020 | | 0.0 | 62.1 | 37.9 | |

**ASTM D422**

**GRADATION CURVE**

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A DATE 12/30/15

GRN-REG W/ASTM DESC.



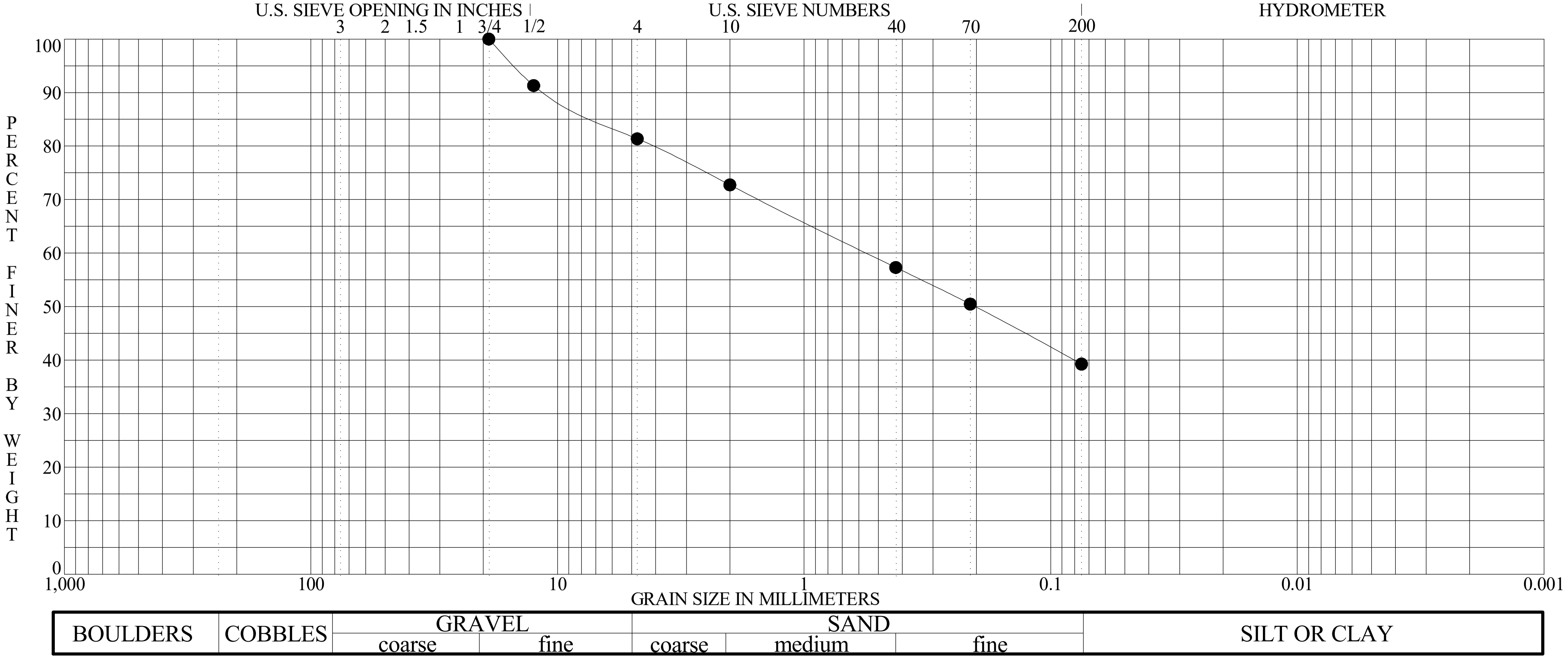
| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-1504 S-7 10.0' to 11.0'** | **Dark-gray fine to coarse sand, some fine to coarse gravel (sandstone fragments), some silty clay.** | | | | | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-1504 S-7 10.0' to 11.0'** | **25.0000** | **18.3349** | **1.7501** | **0.5398** | | **29.1** | **42.7** | **28.2** | |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
**LOCATION** CARDINAL PLANT, BRILLIANT, OH
**JOB NO.** 7217-15-007A **DATE** 12/30/15



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-1504 S-8 11.5' to 11.9'** | **Dark-gray and brown fine to coarse sand, little fine gravel, "and" silt.** | **12** | | | | | |

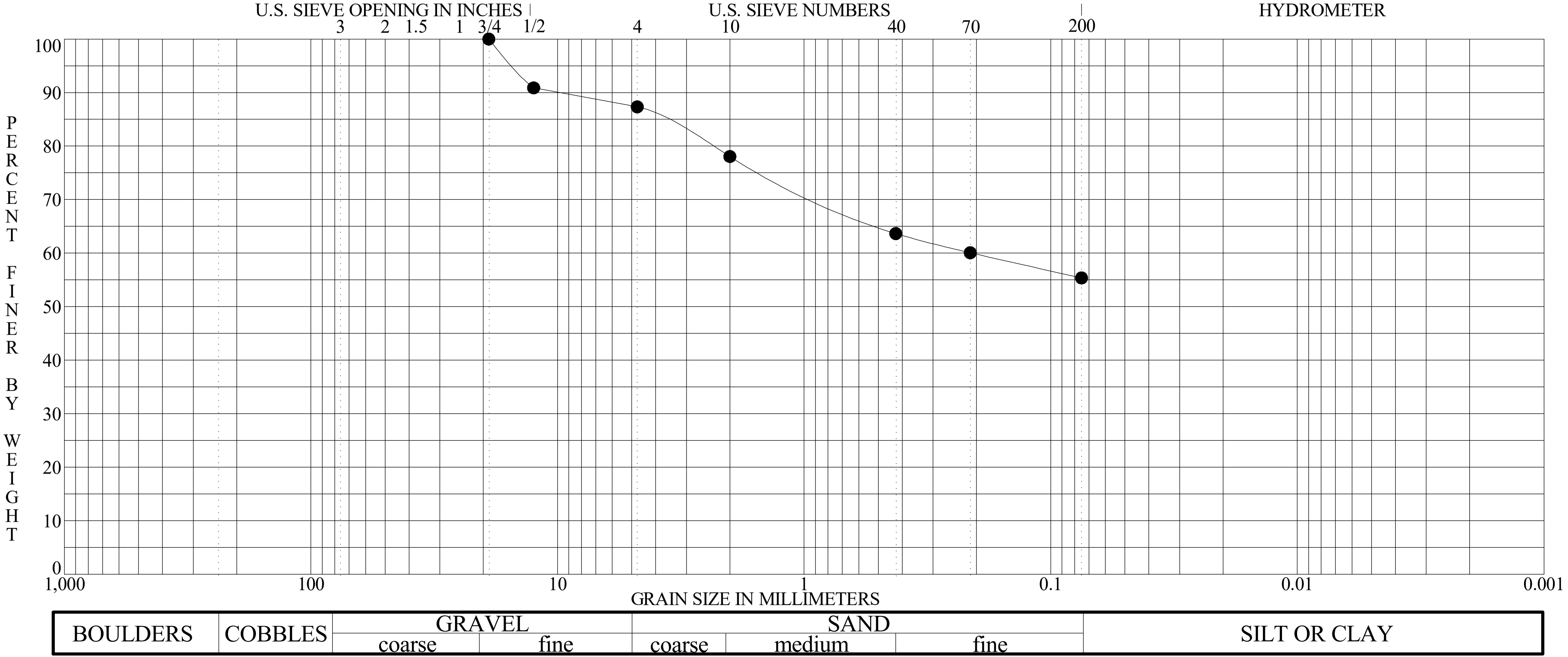
| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-1504 S-8 11.5' to 11.9'** | **19.0000** | **14.9354** | **0.5566** | **0.2026** | | **18.6** | **42.1** | **39.3** | |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
**LOCATION** CARDINAL PLANT, BRILLIANT, OH
**JOB NO.** 7217-15-007A **DATE** 12/30/15

GRN-REG W/ASTM DESC.



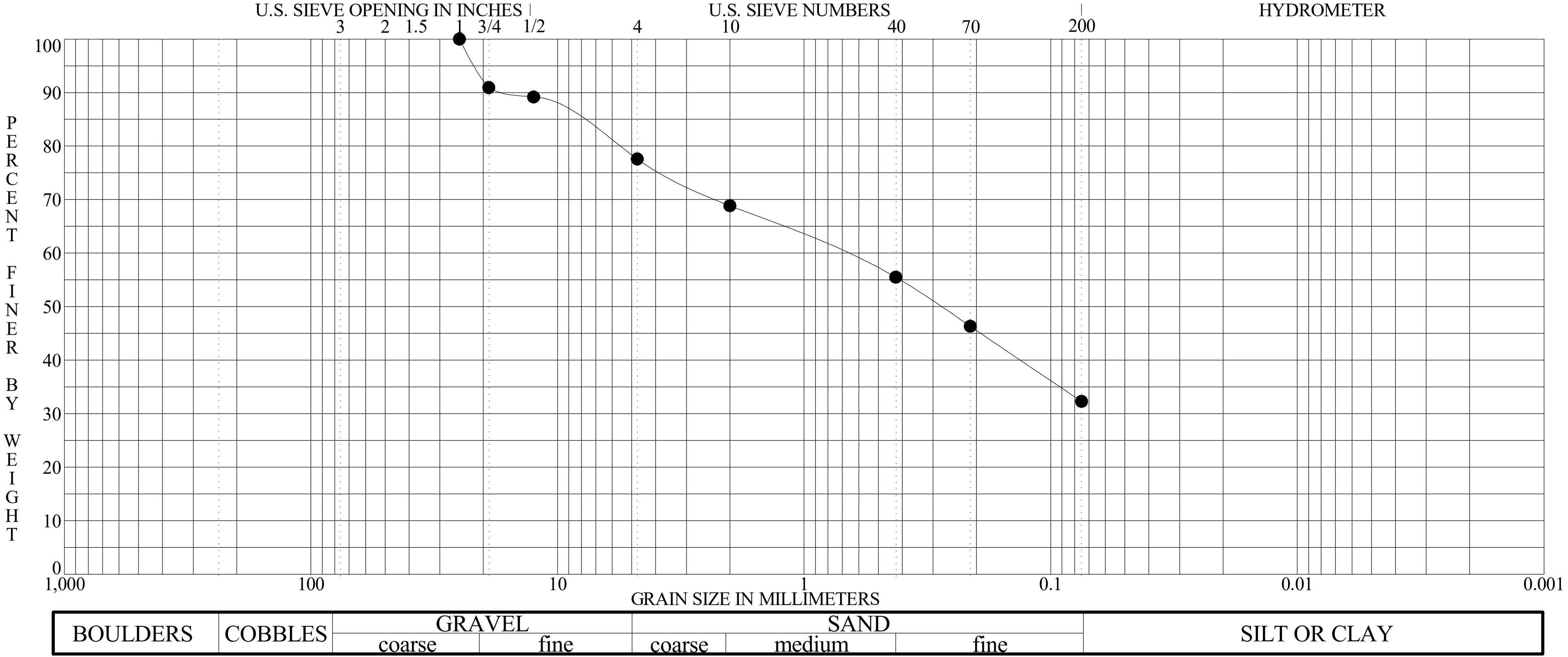
| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | CD-BAP-1505 S-10 14.5' to 15.8' | Yellow-brown and brown silty clay, some fine to coarse sand, little fine gravel. | 18 | | | | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | CD-BAP-1505 S-10 14.5' to 15.8' | 19.0000 | 15.1011 | 0.2089 | | | 12.7 | 32.0 | 55.4 | |

**ASTM D422**

**GRADATION CURVE**

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A DATE 12/30/15



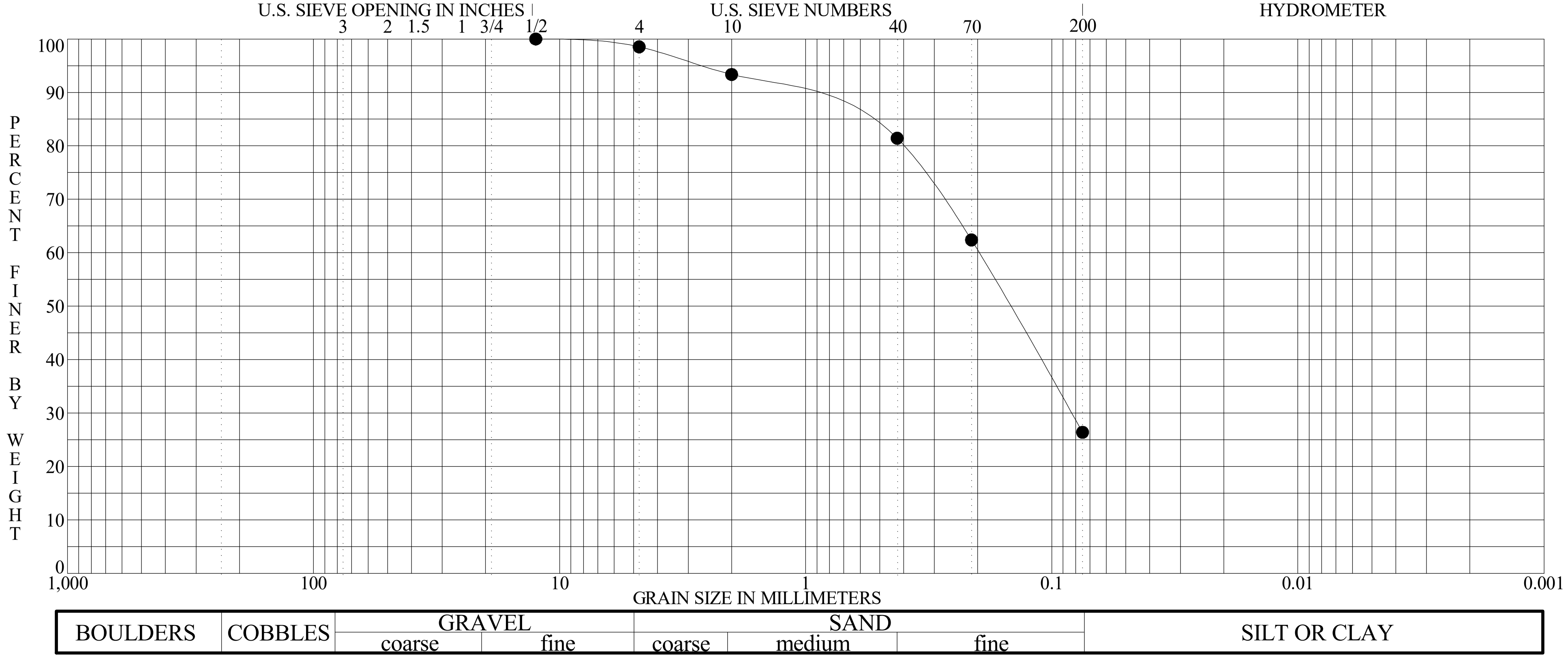
| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● CD-BAP-1501 S-3 4.0' to 4.8' | **Gray and brown fine to coarse sand, some fine to coarse gravel, some silt.** | | | | | | |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● CD-BAP-1501 S-3 4.0' to 4.8' | 25.0000 | 21.4832 | 0.7155 | 0.2797 | | 22.4 | 45.3 | 32.3 | |

**ASTM D422**

## GRADATION CURVE

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A DATE 12/30/15



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● CD-BAP-1501 S-6 8.5' to 9.7' | Red-brown and gray fine to coarse sand, trace fine gravel, some silt. | | | | | | |

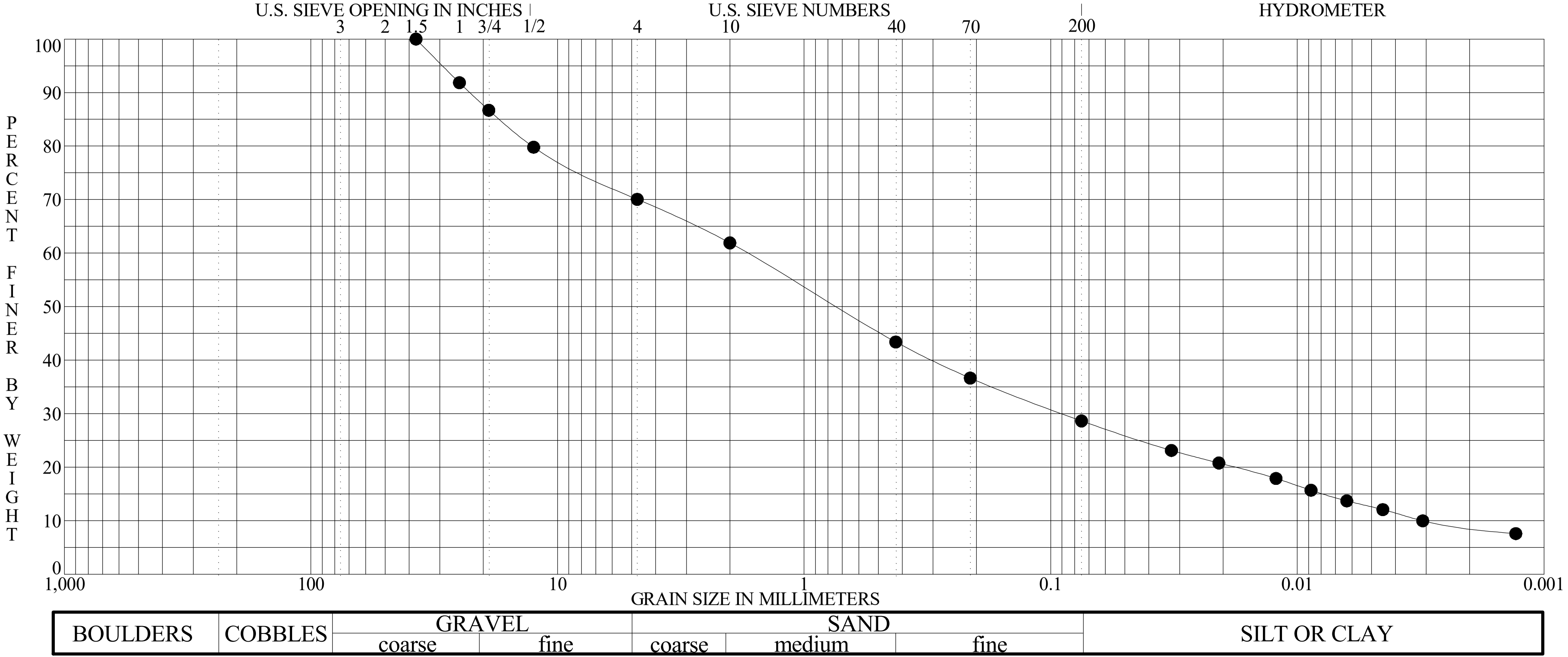
| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● CD-BAP-1501 S-6 8.5' to 9.7' | 12.5000 | 2.6291 | 0.1978 | 0.1482 | | 1.5 | 72.1 | 26.4 | |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
**LOCATION** CARDINAL PLANT, BRILLIANT, OH
**JOB NO.** 7217-15-007A **DATE** 12/30/15

GRN-REG W/ASTM DESC.



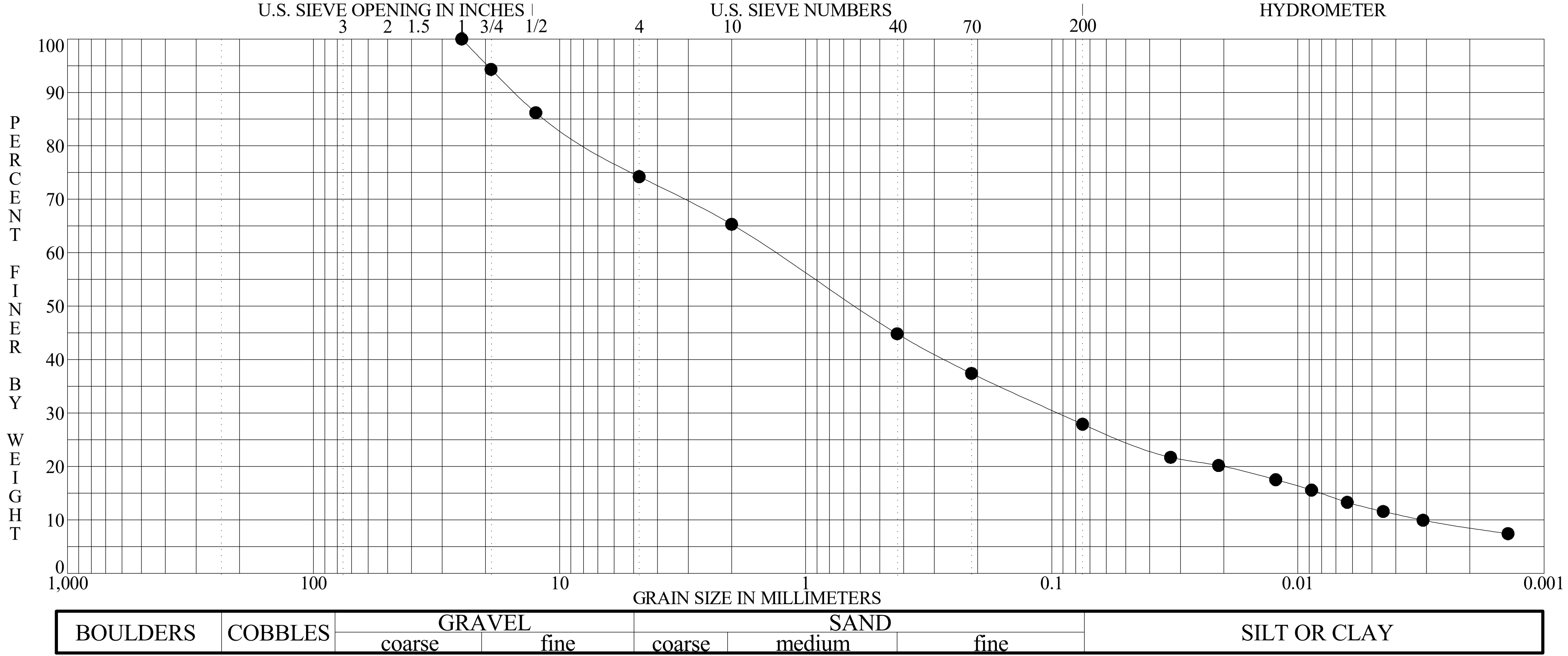
| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-BAP-1502 S-4 5.5' to 6.7'** | **Gray and brown fine to coarse sand, some fine to coarse gravel, some silty clay.**<br>**CLAYEY SAND with GRAVEL SC** | **9** | **27** | **16** | **11** | **1.508** | **547.388** |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-BAP-1502 S-4 5.5' to 6.7'** | **37.5000** | **29.2411** | **1.7048** | **0.7385** | **0.0031** | **29.9** | **41.4** | **16.1** | **12.6** |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
**LOCATION** CARDINAL PLANT, BRILLIANT, OH
**JOB NO.** 7217-15-007A **DATE** 12/30/15



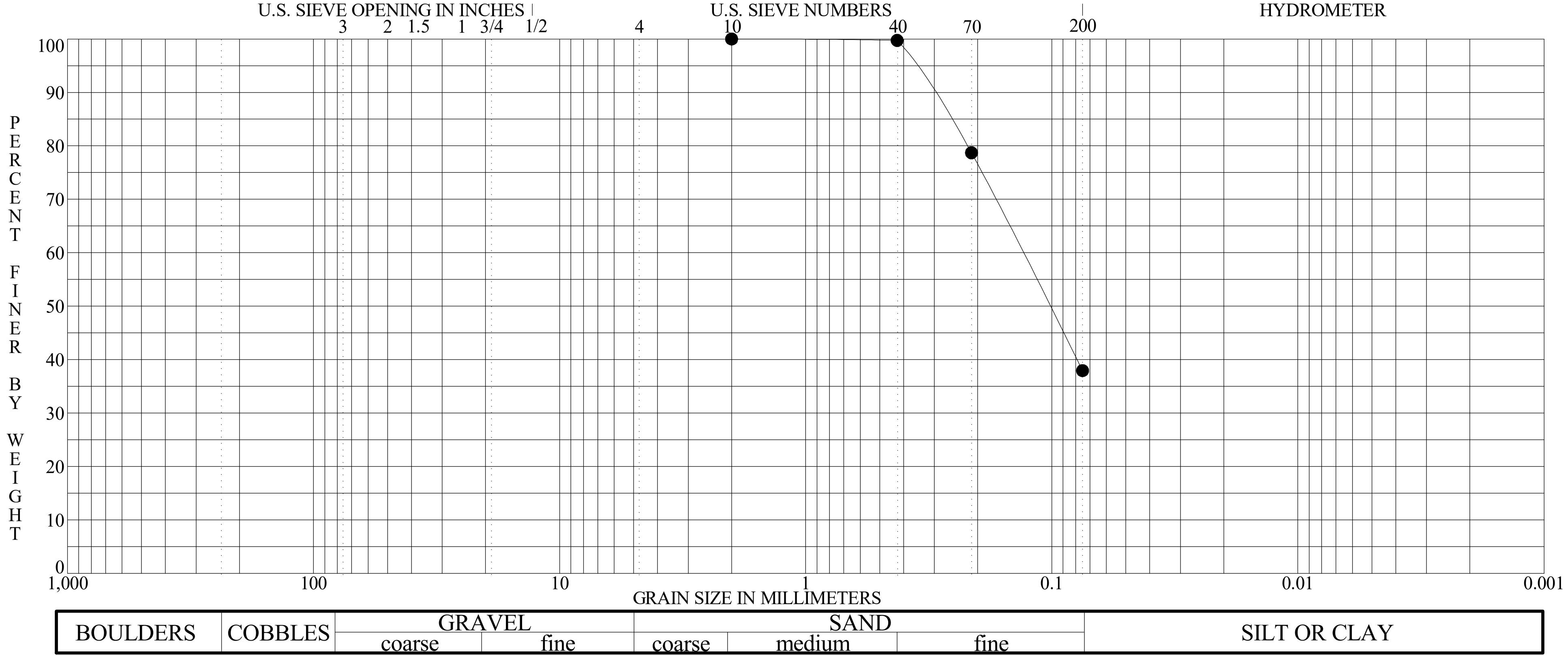
| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-1502 S-9 17.0' to 18.3** | **Gray fine to coarse sand, some fine to coarse gravel, some clayey silt.**<br>**CLAYEY SAND with GRAVEL SC** | **13** | **26** | **16** | **10** | **2.113** | **425.827** |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-1502 S-9 17.0' to 18.3** | **25.0000** | **19.6384** | **1.3380** | **0.6282** | **0.0031** | **25.8** | **46.3** | **15.8** | **12.1** |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
**LOCATION** CARDINAL PLANT, BRILLIANT, OH
**JOB NO.** 7217-15-007A **DATE** 12/30/15



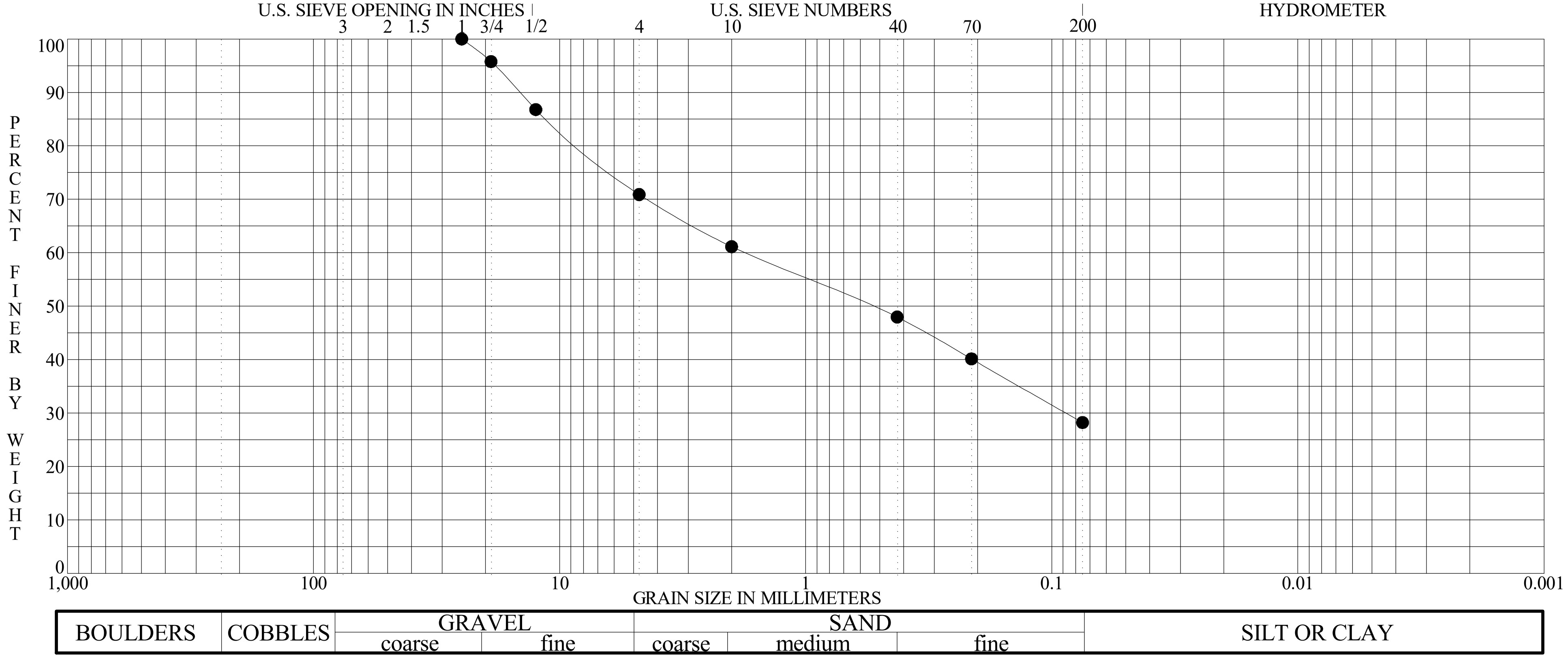
| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-1502 S-18 40.0' to 41.0'** | **Brown fine to medium sand, "and" silt.** | | | | | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-1502 S-18 40.0' to 41.0'** | **2.0000** | **0.3633** | **0.1316** | **0.1020** | | **0.0** | **62.1** | **37.9** | |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
**LOCATION** CARDINAL PLANT, BRILLIANT, OH
**JOB NO.** 7217-15-007A **DATE** 12/30/15



| Specimen Identification - Depth | | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | CD-BAP-1504 S-7 10.0' to 11.0' | Dark-gray fine to coarse sand, some fine to coarse gravel (sandstone fragments), some silty clay. | | | | | | |

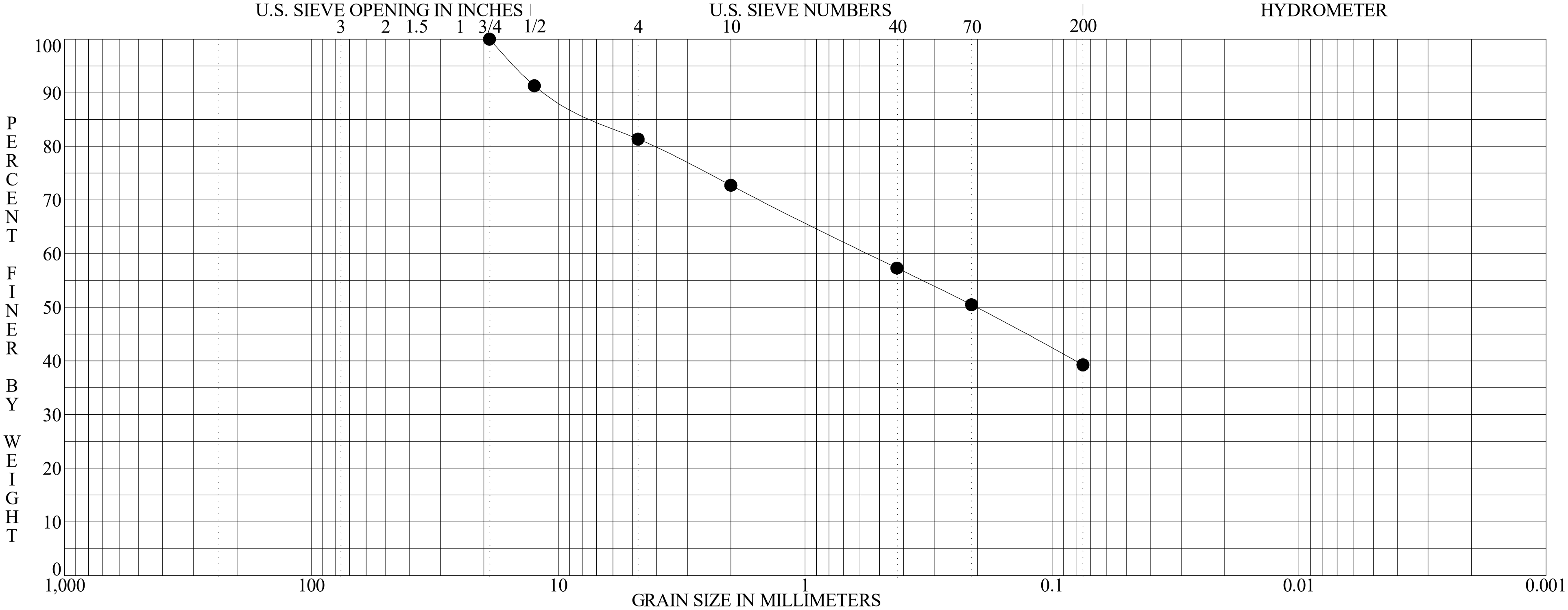
| Specimen Identification - Depth | | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | CD-BAP-1504 S-7 10.0' to 11.0' | 25.0000 | 18.3349 | 1.7501 | 0.5398 | | 29.1 | 42.7 | 28.2 | |

**ASTM D422**

**GRADATION CURVE**

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A DATE 12/30/15

GRN-REG W/ASTM DESC.



| BOULDERS | COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|---|
| | | coarse | fine | coarse | medium | fine | |

| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | CD-BAP-1504 S-8 11.5' to 11.9' | Dark-gray and brown fine to coarse sand, little fine gravel, "and" silt. | 12 | | | | | |

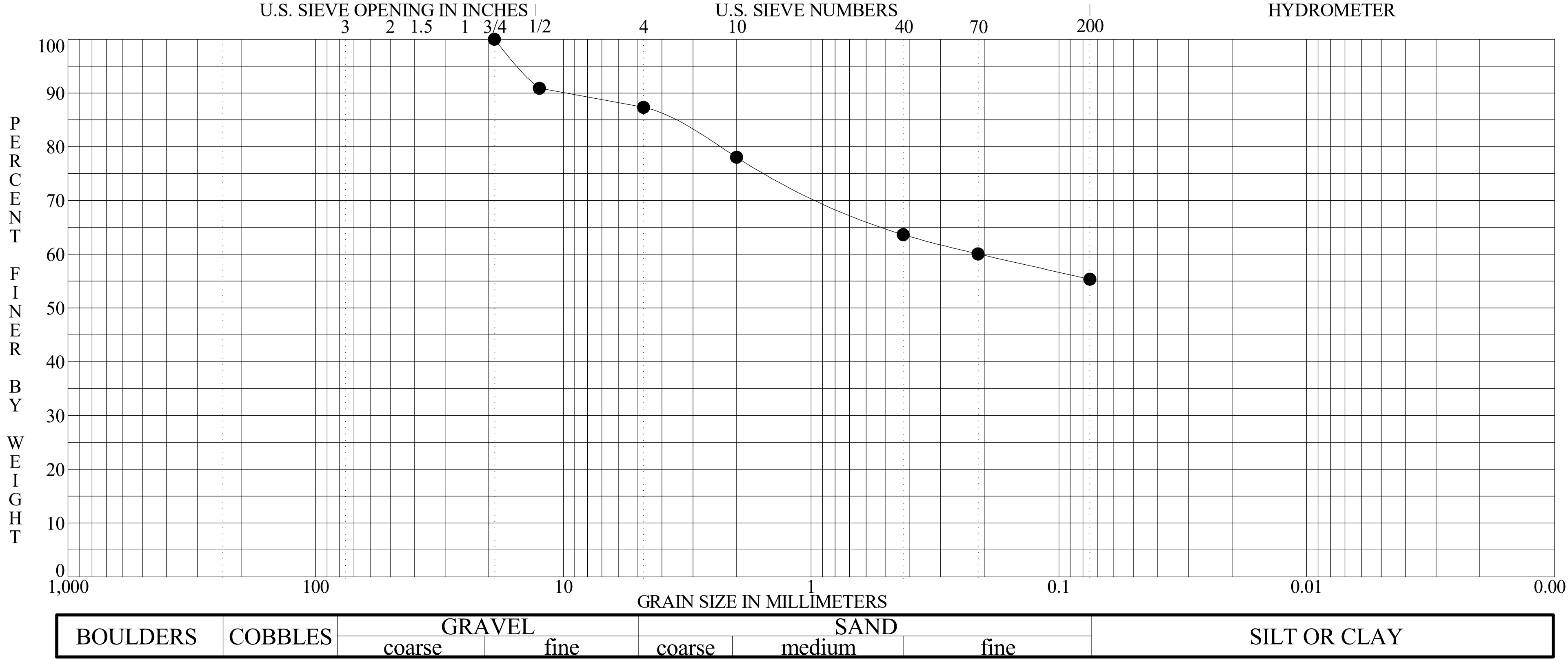
| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | CD-BAP-1504 S-8 11.5' to 11.9' | 19.0000 | 14.9354 | 0.5566 | 0.2026 | | 18.6 | 42.1 | 39.3 | |

**ASTM D422**

**GRADATION CURVE**

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A DATE 12/30/15

GRN-REG W/ASTM DESC.



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | CD-BAP-1505 S-10 14.5' to 15.8' | **Yellow-brown and brown silty clay, some fine to coarse sand, little fine gravel.** | **18** | | | | | |

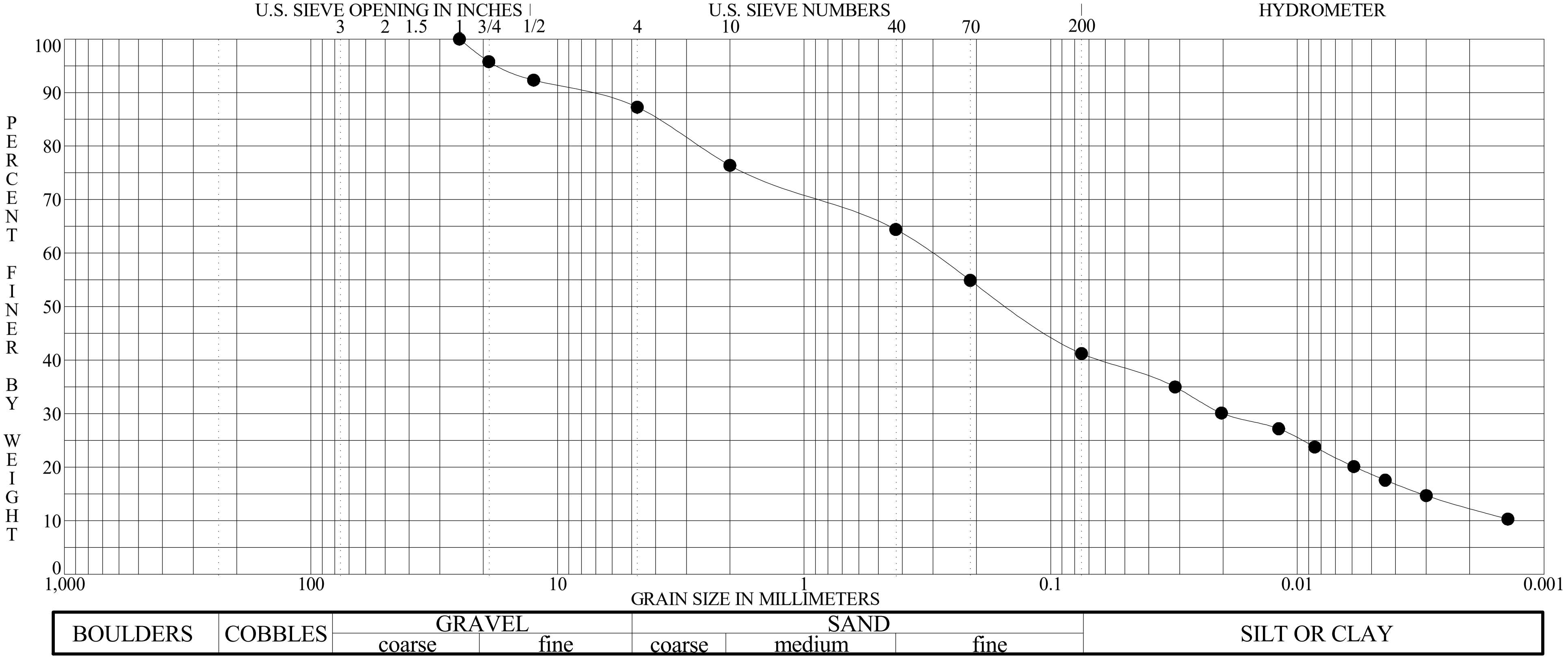
| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | CD-BAP-1505 S-10 14.5' to 15.8' | **19.0000** | **15.1011** | **0.2089** | | | **12.7** | **32.0** | **55.4** | |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
**LOCATION** CARDINAL PLANT, BRILLIANT, OH
**JOB NO.** 7217-15-007A **DATE** 12/30/15

GRN-REG W/ASTM DESC.



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | MW-BAP-4 S-4 5.5' to 6.8' | **Brown fine to coarse sand, little fine to coarse gravel, "and" clayey silt.** | 15 | 25 | 16 | 9 | | |
| | | **CLAYEY SAND SC** | | | | | | |

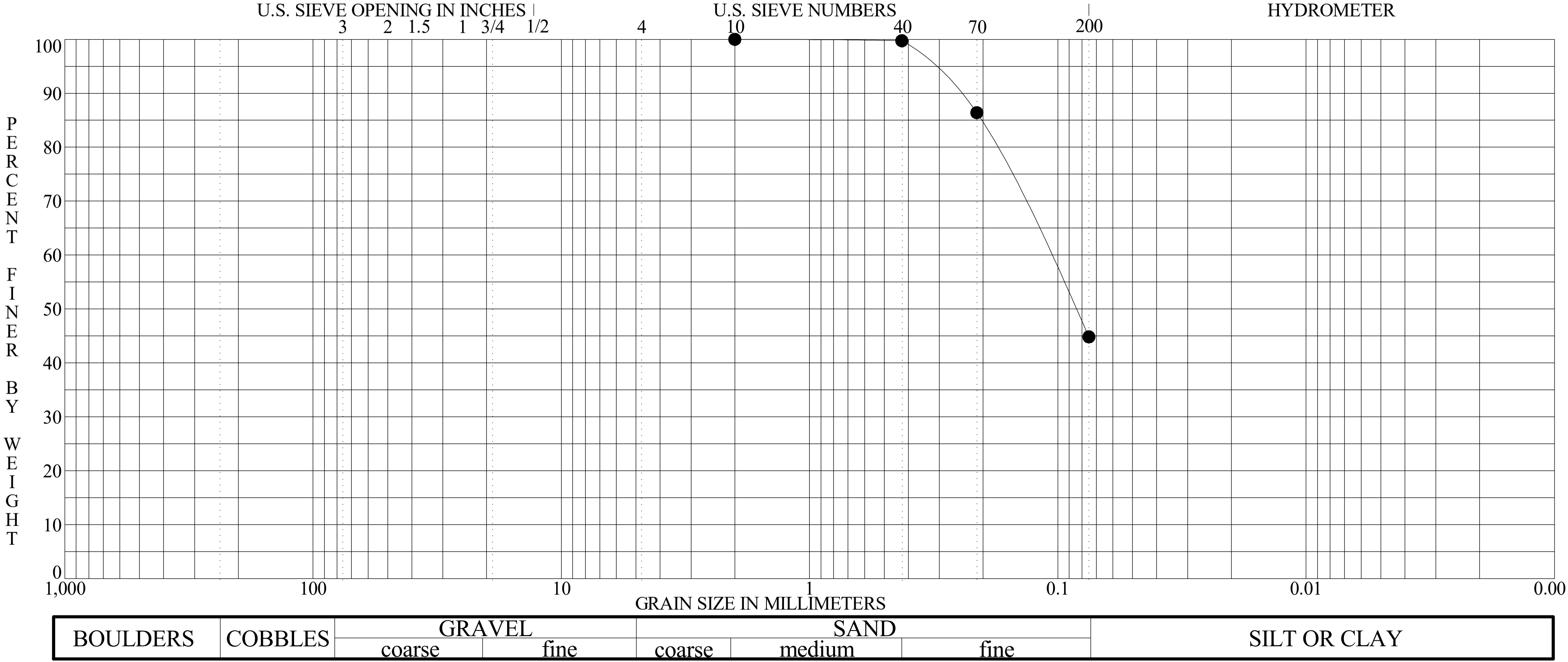
| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | MW-BAP-4 S-4 5.5' to 6.8' | 25.0000 | 17.2870 | 0.3075 | 0.1460 | | 12.7 | 46.0 | 22.5 | 18.7 |

**ASTM D422**

**GRADATION CURVE**

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A DATE 12/30/15

GRN-REG W/ASTM DESC.



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **MW-BAP-4 S-13 31.5' to 32.5'** | **Gray fine to medium sand, "and" silt.** | | | | | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **MW-BAP-4 S-13 31.5' to 32.5'** | **2.0000** | **0.3319** | **0.1096** | **0.0854** | | **0.0** | **55.2** | **44.8** | |

**ASTM D422**

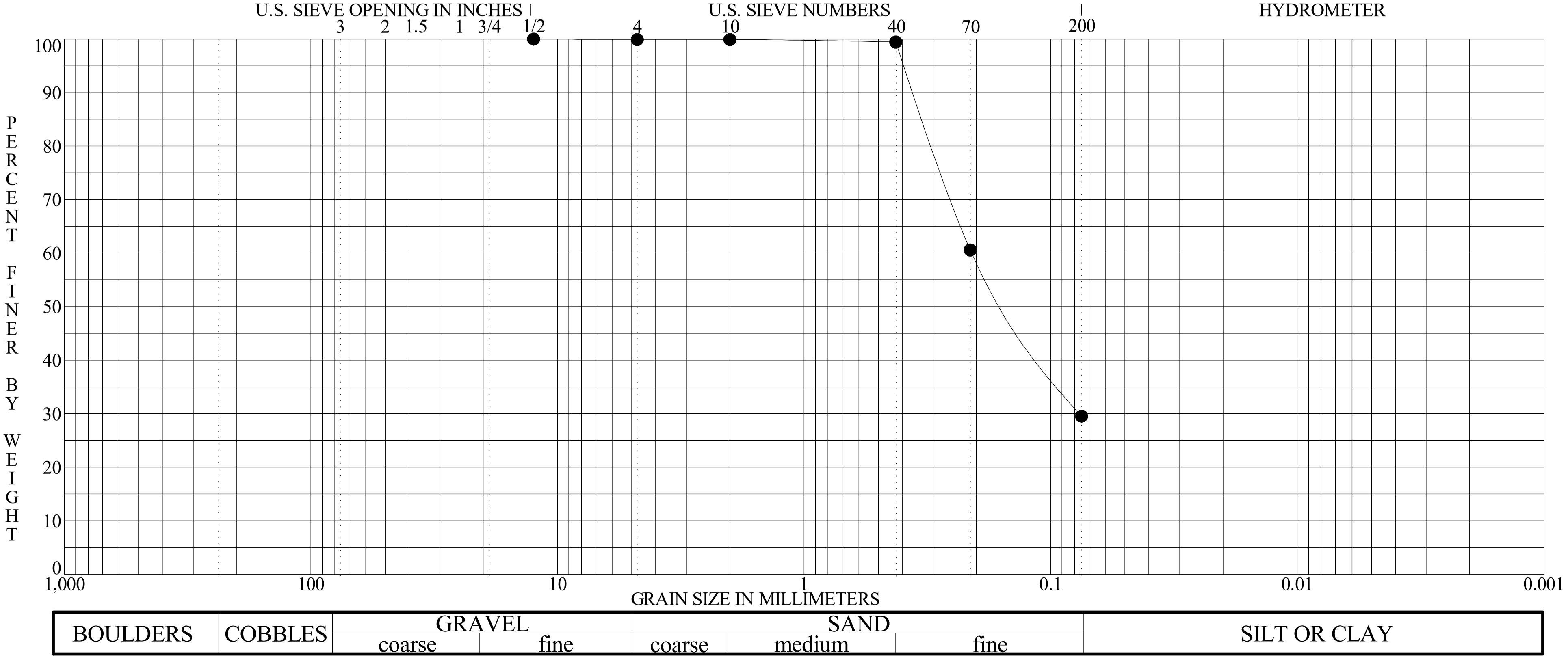
**GRADATION CURVE**

**PROJECT** BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
**LOCATION** CARDINAL PLANT, BRILLIANT, OH
**JOB NO.** 7217-15-007A **DATE** 12/30/15

**PLATE 22**

GRN-REG W/ASTM DESC.

S&ME



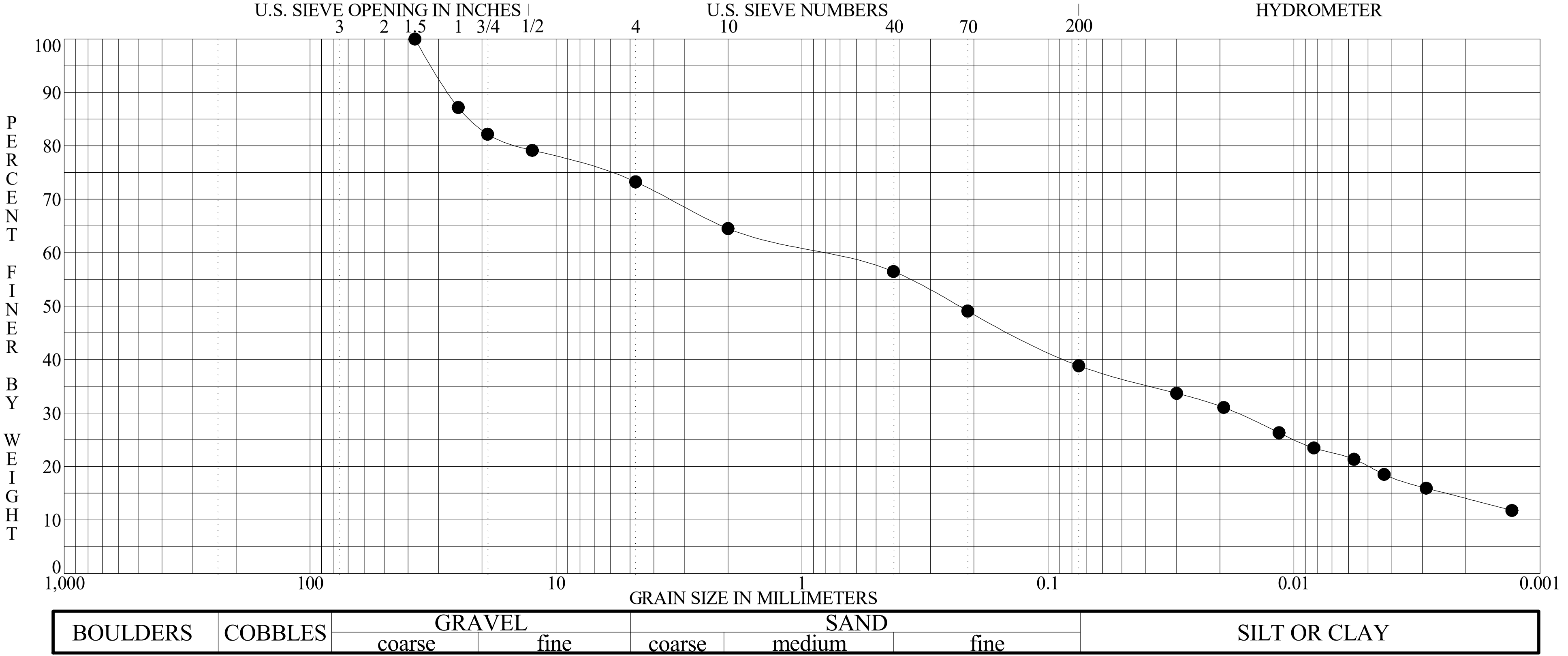
| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **MW-BAP-4 S-16 38.5' to 40.0'** | **Gray fine to coarse sand, trace fine gravel, some silt.** | | | | | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **MW-BAP-4 S-16 38.5' to 40.0'** | **12.5000** | **0.3925** | **0.2079** | **0.1488** | | **0.1** | **70.4** | **29.5** | |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
**LOCATION** CARDINAL PLANT, BRILLIANT, OH
**JOB NO.** 7217-15-007A **DATE** 12/30/15



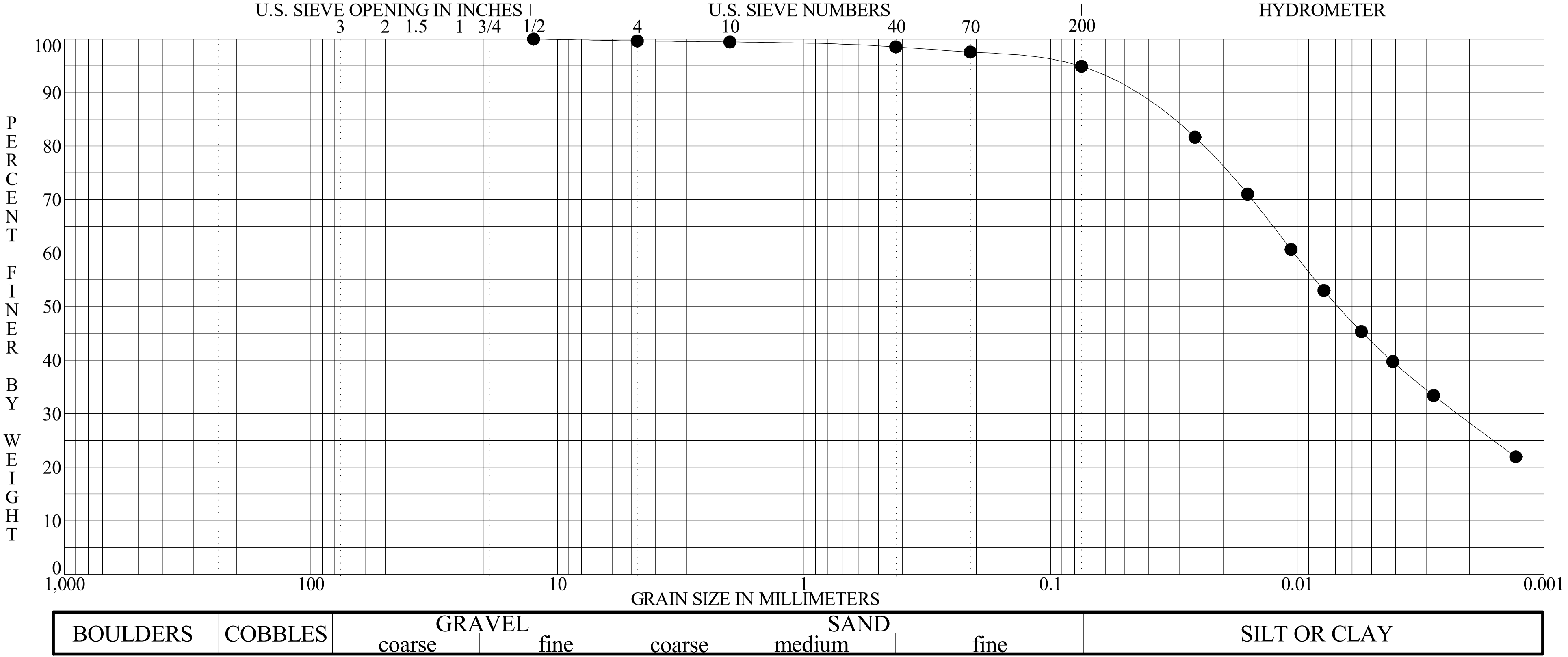
| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **MW-BAP-5 S-3 4.0' to 5.1'** | **Brown fine to coarse sand, some fine to coarse gravel, "and" silty clay.** | **13** | **30** | **17** | **13** | | |
| | | **CLAYEY SAND with GRAVEL SC** | | | | | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **MW-BAP-5 S-3 4.0' to 5.1'** | **37.5000** | **32.0064** | **0.8357** | **0.2310** | | **26.7** | **34.4** | **18.8** | **20.0** |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
**LOCATION** CARDINAL PLANT, BRILLIANT, OH
**JOB NO.** 7217-15-007A **DATE** 12/30/15



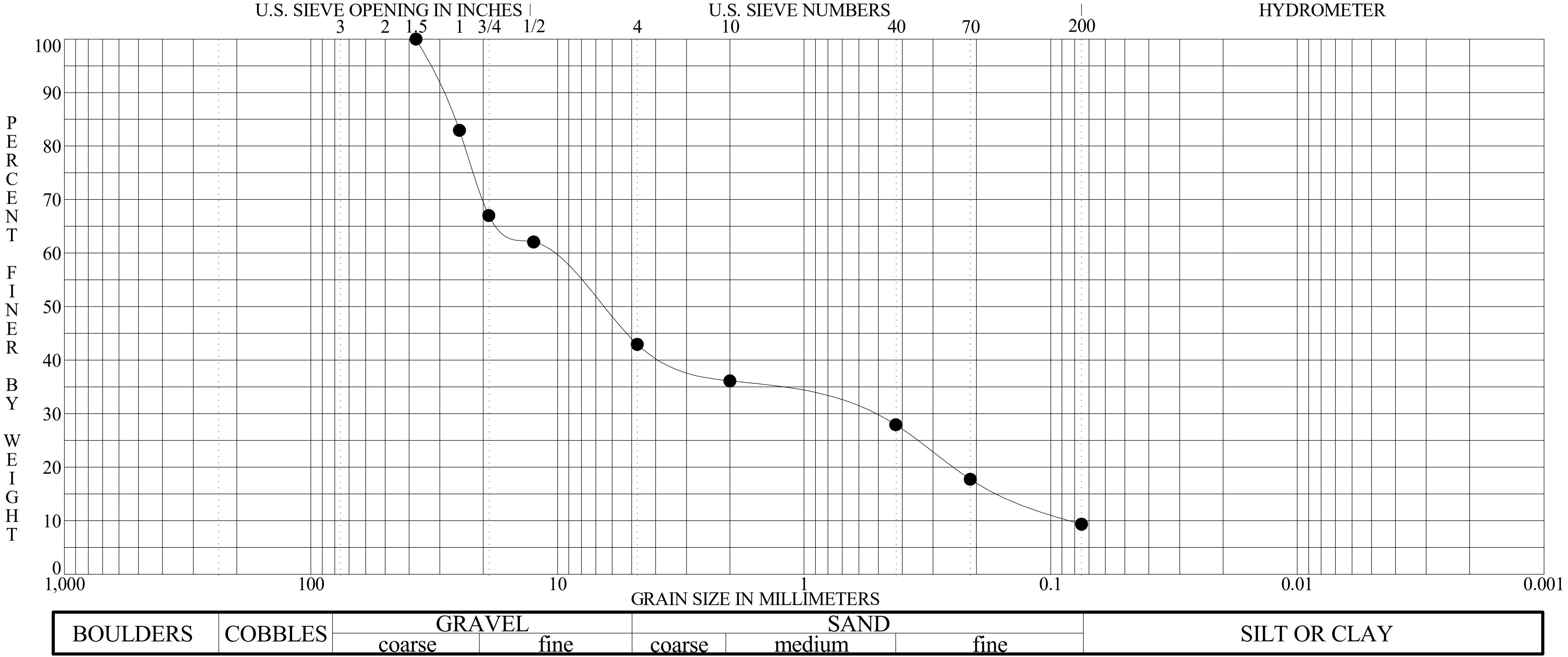
| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **MW-BAP-5 S-11 21.0' to 22.5'** | **Gray mottled with dark-gray and brown silty clay, trace fine to coarse sand, trace fine gravel, few roots and silt seams, slightly organic.**<br>**LEAN CLAY CL** | **40** | **48** | **26** | **22** | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **MW-BAP-5 S-11 21.0' to 22.5'** | **12.5000** | **0.0780** | **0.0103** | **0.0068** | | **0.3** | **4.8** | **51.4** | **43.5** |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
**LOCATION** CARDINAL PLANT, BRILLIANT, OH
**JOB NO.** 7217-15-007A **DATE** 12/30/15



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | MW-BAP-5 S-21 51.0' to 51.3' | Gray fine to coarse gravel, some fine to coarse sand, trace silt. | | | | | 0.432 | 138.404 |

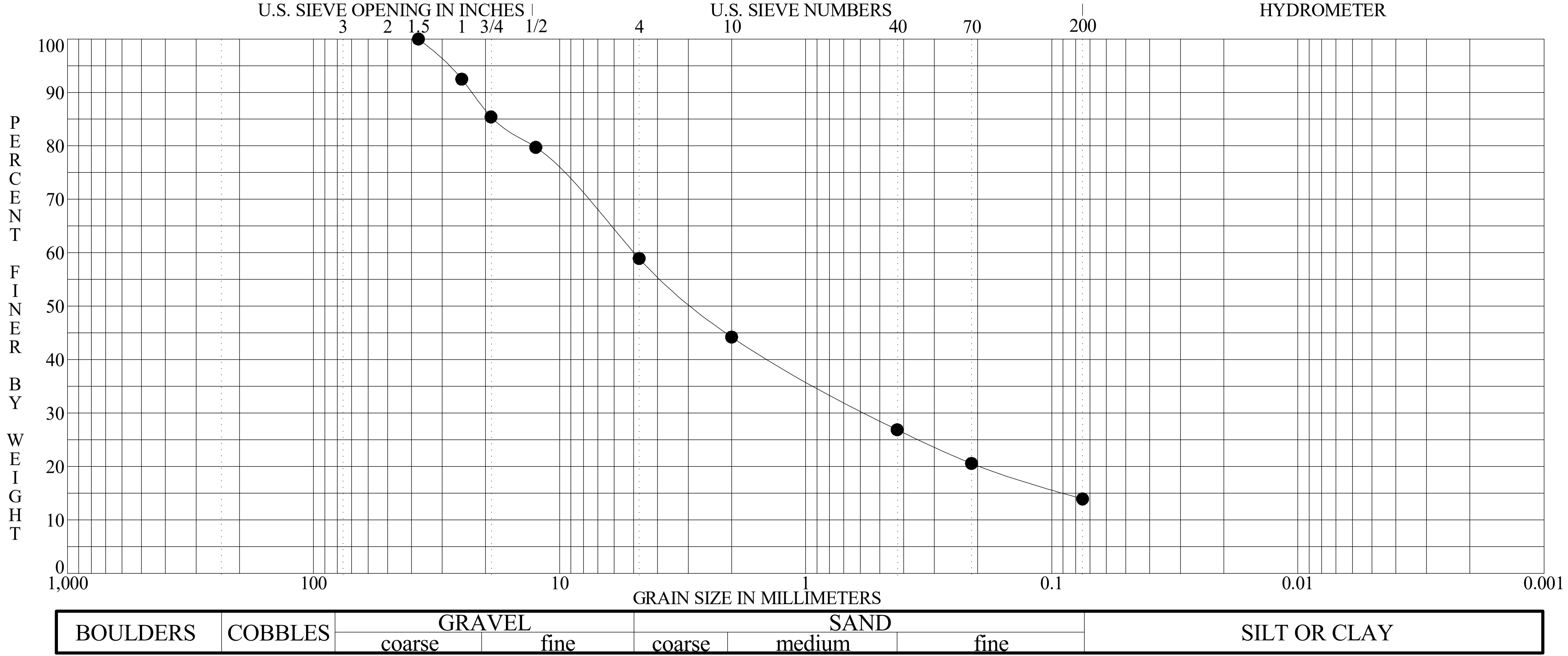
| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | MW-BAP-5 S-21 51.0' to 51.3' | 37.5000 | 33.2943 | 11.2464 | 6.7824 | 0.0813 | 57.0 | 33.6 | 9.4 | |

**ASTM D422**

**GRADATION CURVE**

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A DATE 12/30/15

GRN-REG W/ASTM DESC.



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **MW-BAP-5 S-24 58.5' to 59.4'** | **Gray fine to coarse sand, "and" fine to coarse gravel, little silt.** | | | | | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **MW-BAP-5 S-24 58.5' to 59.4'** | **37.5000** | **28.6237** | **4.9922** | **2.8092** | | **41.1** | **45.0** | **13.9** | |

**ASTM D422**

**GRADATION CURVE**

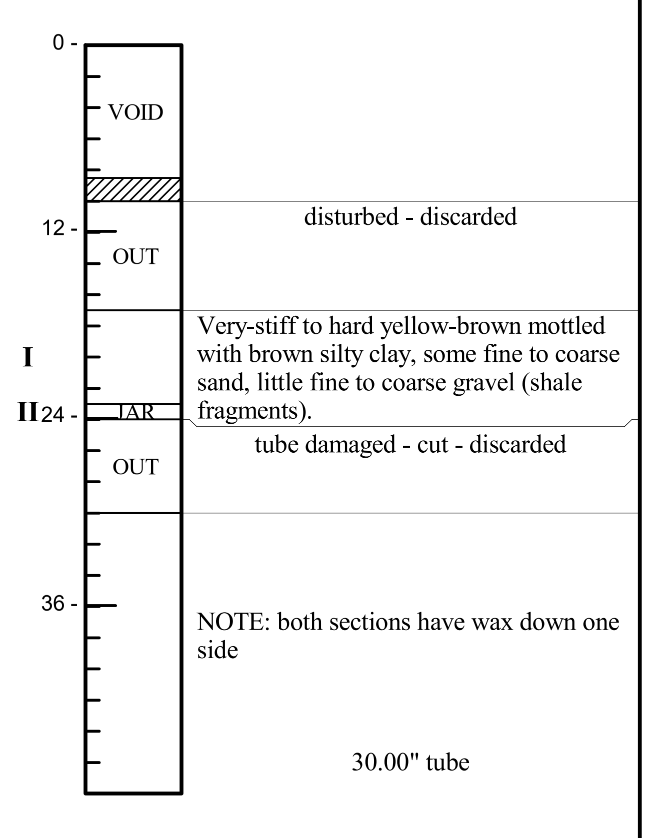
**PROJECT** BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
**LOCATION** CARDINAL PLANT, BRILLIANT, OH
**JOB NO.** 7217-15-007A **DATE** 12/30/15

**PLATE 27**

JOB NUMBER : **7217-15-007A**
PROJECT : **BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION**
LOCATION : **CARDINAL PLANT, BRILLIANT, OH**

# LABORATORY LOG OF SHELBY TUBES

| | | |
|---|---|---|
| Boring : **CD-BAP-1502** Sample : **ST-1** | Boring : **CD-BAP-1502** Sample : **ST-2** | Boring : Sample : |
| Depth : **20.0' to 22.0'** Recovery : **7.00"** | Depth : **32.5' to 34.5'** Recovery : **19.50"** | Depth : Recovery : |



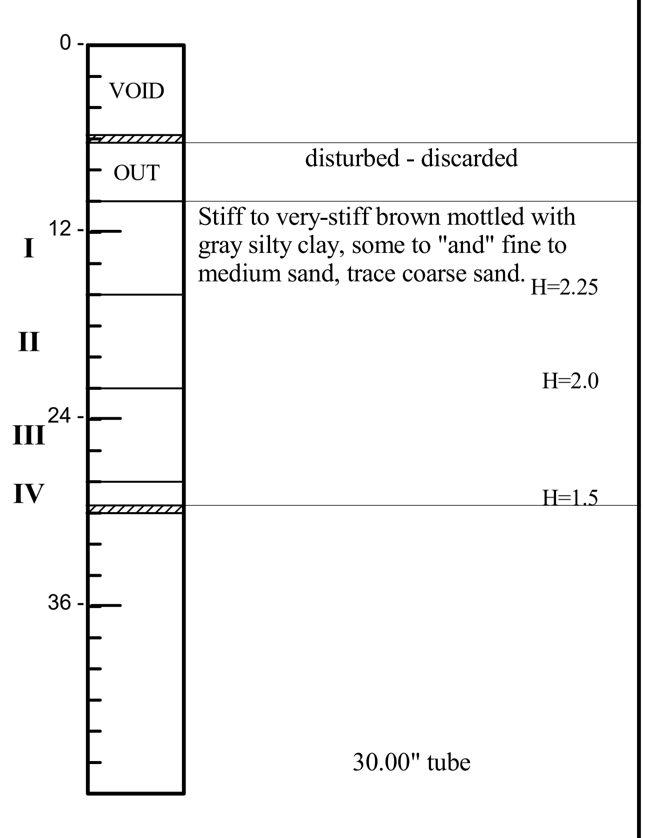
disturbed - discarded

Very-stiff to hard yellow-brown mottled with brown silty clay, some fine to coarse sand, little fine to coarse gravel (shale fragments).

tube damaged - cut - discarded

NOTE: both sections have wax down one side

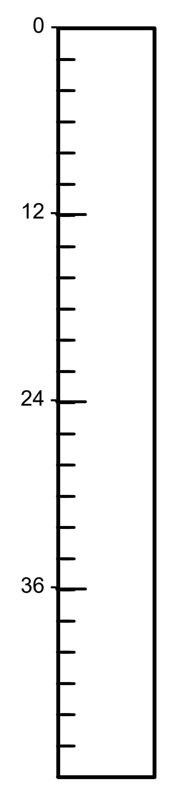
30.00" tube



disturbed - discarded

Stiff to very-stiff brown mottled with gray silty clay, some to "and" fine to medium sand, trace coarse sand.

30.00" tube



## LEGEND

■ - Consolidation, Incremental

C R S - Consolidation, C R S

P P - Permeability, Vertical / Horizontal

Swelling, Test

In/B Sa-Cl

▨ - Wax

- Unconfined Compression Test

☒ - Triaxial Compression Test

H - Hand Penetrometer (tsf)
Ds - Direct Shear
LOI - Loss on Ignition
AL - Atterberg Limits
MA - Sieve/Hydrometer
SG - Specific Gravity

SL - Shrinkage Limit
POR - Porosity
UDW - Unit Dry Weight
MC - Moisture Content
$D_R$ - Relative Density
S - Sieve

SHELBY TUBE LOG

# 2009 SITE INVESTIGATION

# SUMMARY OF LABORATORY TEST RESULTS

| BORING | G'int Id. | MC | LL | PL | PI | GRADATION | | | COMPACTION | | TRIAXIAL | | | DIRECT SHEAR | | | UNCONFIN COMPRESS | CONSOLID. | SPECIFIC GRAVITY | UNIT DRY WEIGHT | REMOLDED | PERMEABILITY | | | | RELATIVE DENSITY | LOI | ROCK CORE | SHELBY TUBE | CBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | sieve | Hydrometer short | Hydrometer long | standard | modified | uncons. undrain | consolid undrain w/pores | drained | drained | undrain | residual | | | | | | cohesive | non/cohes | rigid wall | flexible wall | | | | | |
| | | % | % | % | % | * SEE INDIVIDUAL TEST CURVES | | | | | | | | | | | | | | PCF | | | | | | % | % | | | |
| BAP-0901 | 4.75 | 16 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0901 | 7.75 | 16 | 28 | 18 | 10 | | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0901 | 13.75 | 13 | 27 | 17 | 10 | | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0901 | 18.25 | 14 | 37 | 24 | 13 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0901 | 22.75 | 30 | NP | NP | NP | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0901 | 24.50 | | | | | | | | | | | | | | | | | | | | | | | | | | | | * | |
| BAP-0901 | 29.25 | 27 | 37 | 22 | 15 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0901 | 31.25 | | | | | | | | | | | * | | | | | | | | | | | | | | | | | | |
| BAP-0901 | 31.75 | 33 | 35 | 28 | 7 | * | | * | | | | * | | | | | | | | | | | | | | | | | * | |
| BAP-0901 | 32.25 | | | | | | | | | | | * | | | | | | | | | | | | | | | | | | |
| BAP-0901 | 34.25 | 42 | 34 | 27 | 7 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0901 | 36.75 | 40 | 45 | 29 | 16 | * | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0901 | 39.25 | 42 | 40 | 23 | 17 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0902 | 6.25 | 13 | 27 | 17 | 10 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0902 | 10.75 | 20 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0902 | 12.25 | 10 | 26 | 17 | 9 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0902 | 16.75 | 24 | 37 | 19 | 18 | | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0902 | 18.25 | 21 | 35 | 17 | 18 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0902 | 19.75 | 31 | 29 | 17 | 12 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0902 | 21.25 | 26 | NP | NP | NP | * | | * | | | | | | | | | | | | | | | | | | | | | | |

BBCM
SOLUTIONS TO BUILD ON

TESTING SUMMARY - STANDARD

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

SUM REG 111497013.GPJ BBCM.GDT 7/6/09

# SUMMARY OF LABORATORY TEST RESULTS

| BORING | G'int Id. | MC | LL | PL | PI | GRADATION | | | COMPACTION | | TRIAXIAL | | | DIRECT SHEAR | | | UNCONFIN COMPRESS | CONSOLID. | SPECIFIC GRAVITY | UNIT DRY WEIGHT | REMOLDED | PERMEABILITY | | | | RELATIVE DENSITY | LOI | ROCK CORE | SHELBY TUBE | CBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | sieve | Hydrometer short | Hydrometer long | standard | modified | uncons. undrain | consolid undrain w/popres | drained | drained | undrain | residual | | | | | | cohesive | non/cohes | rigid wall | flexible wall | | | | | |
| | | % | % | % | % | * SEE INDIVIDUAL TEST CURVES | | | | | | | | | | | | | | PCF | | | | | | % | % | | | |
| BAP-0902 | 22.75 | | | | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0902 | 27.25 | 54 | NP | NP | NP | * | | * | | | | | | | | | | | | | | | | | | | 10.4 | | | |
| BAP-0902 | 28.75 | 43 | NP | NP | NP | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0902 | 32.25 | 38 | 36 | 28 | 8 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0902 | 37.25 | 22 | | | | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0902 | 39.75 | 24 | | | | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0902 | 42.25 | | | | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0903 | 3.25 | 24 | 48 | 24 | 24 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0903 | 4.75 | 22 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0903 | 7.75 | 20 | 36 | 20 | 16 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0903 | 9.25 | 49 | 41 | 38 | 3 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0903 | 14.25 | 43 | NP | NP | NP | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0903 | 16.75 | 43 | 37 | 24 | 13 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0903 | 19.25 | 44 | 35 | 24 | 11 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0903 | 21.75 | 35 | 34 | 21 | 13 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0903 | 24.25 | | | | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0904 | 4.75 | 13 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0904 | 9.25 | 14 | 25 | 16 | 9 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0904 | 13.75 | 16 | 35 | 21 | 14 | | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0904 | 16.75 | | | | | * | | | | | | | | | | | | | | | | | | | | | | | | |

BBCM
SOLUTIONS TO BUILD ON

TESTING SUMMARY - STANDARD

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013
DATE 7/6/09

# SUMMARY OF LABORATORY TEST RESULTS

| BORING | G'int Id. | MC | LL | PL | PI | GRADATION | | | COMPACTION | | TRIAXIAL | | | DIRECT SHEAR | | | UNCONFIN COMPRESS | CONSOLID. | SPECIFIC GRAVITY | UNIT DRY WEIGHT | REMOLDED | PERMEABILITY | | | | RELATIVE DENSITY | LOI | ROCK CORE | SHELBY TUBE | CBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Hydrometer | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | sieve | short | long | standard | modified | uncons. undrain | consolid undrain w/popres | drained | drained | undrain | residual | | | | | | cohesive | non/cohes | rigid wall | flexible wall | | | | | |
| | | % | % | % | % | * SEE INDIVIDUAL TEST CURVES | | | | | | | | | | | | | | PCF | | | | | | % | % | | | |
| BAP-0904 | 19.75 | 28 | NP | NP | NP | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0904 | 22.75 | 26 | NP | NP | NP | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0904 | 25.75 | 22 | NP | NP | NP | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0904 | 27.25 | 38 | 38 | 24 | 14 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0904 | 28.75 | 47 | 42 | 30 | 12 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0904 | 36.75 | | | | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0905 | 4.75 | 17 | 32 | 18 | 14 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0905 | 7.75 | 22 | 48 | 24 | 24 | | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0905 | 9.85 | 33 | | | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0905 | 14.25 | 45 | 43 | 27 | 16 | * | | * | | | | | | | | | | | | | | | | | | | 8.4 | | | |
| BAP-0905 | 16.75 | 42 | 40 | 25 | 15 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0905 | 21.75 | 38 | 38 | 23 | 15 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0905 | 26.75 | | | | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0906 | 2.90 | 11 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0906 | 4.75 | 15 | 27 | 17 | 10 | | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0906 | 12.75 | | | | | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0906 | 17.25 | 14 | 31 | 19 | 12 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0906 | 24.75 | 31 | NP | NP | NP | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0906 | 26.25 | | | | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0906 | 27.25 | 22 | NP | NP | NP | * | | * | | | | | | | | | | | | | | | | | | | | | | |

BBCM
SOLUTIONS TO BUILD ON

TESTING SUMMARY - STANDARD

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 DATE 7/6/09

SUM REG 11497013.GPJ BBCM.GDT 7/6/09

# SUMMARY OF LABORATORY TEST RESULTS

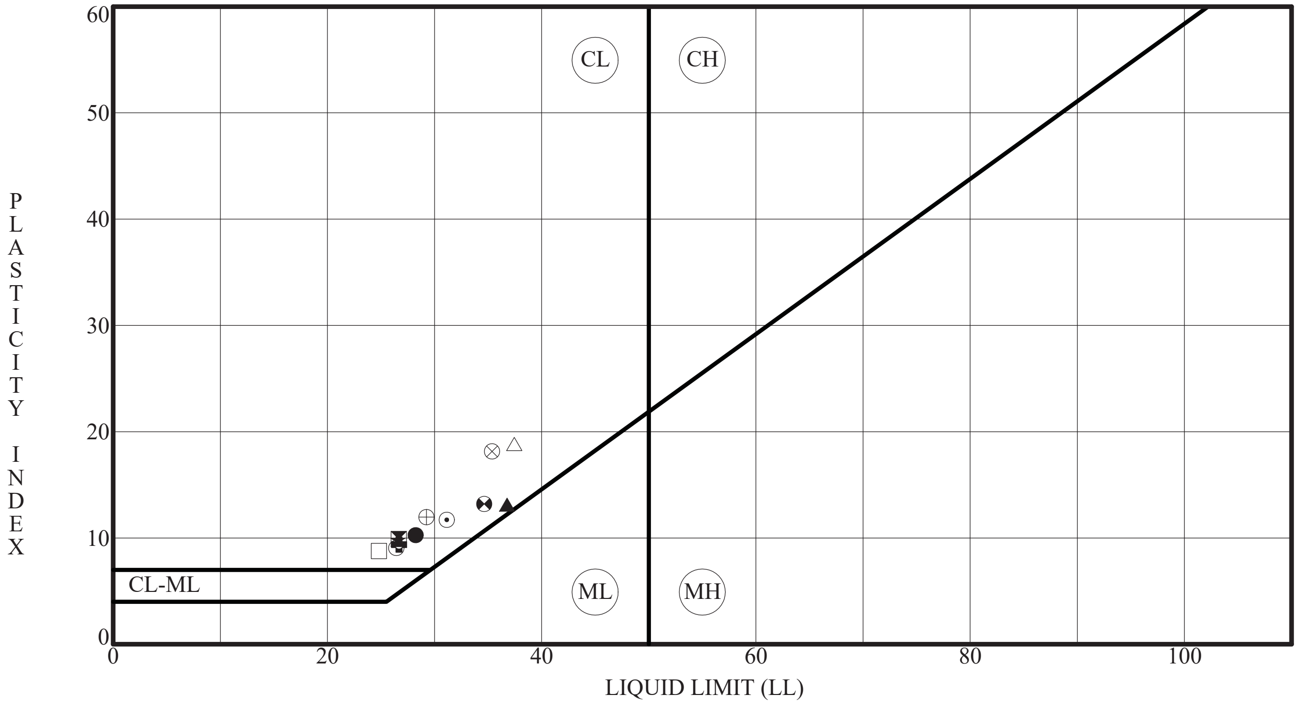
| BORING | G'int Id. | MC | LL | PL | PI | GRADATION | | | COMPACTION | | TRIAXIAL | | | DIRECT SHEAR | | | UNCONFIN COMPRESS | CONSOLID. | SPECIFIC GRAVITY | UNIT DRY WEIGHT | REMOLDED | PERMEABILITY | | | | RELATIVE DENSITY | LOI | ROCK CORE | SHELBY TUBE | CBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | sieve | Hydrometer short | Hydrometer long | standard | modified | uncons. undrain | consolid undrain w/pores | drained | drained | undrain | residual | | | | | | cohesive | non/cohes | rigid wall | flexible wall | | | | | |
| | | % | % | % | % | * SEE INDIVIDUAL TEST CURVES | | | | | | | | | | | | | | PCF | | | | | | % | % | | | |
| BAP-0906 | 31.75 | 34 | 33 | 22 | 11 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0906 | 34.25 | 43 | 50 | 30 | 20 | * | | * | | | | | | | | | | | | | | | | | | | 7.9 | | | |
| BAP-0906 | 36.75 | 38 | 43 | 26 | 17 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0906 | 44.25 | | | | | * | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0907 | 3.25 | 21 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0907 | 6.25 | 15 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0907 | 7.75 | 23 | 49 | 26 | 23 | | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0907 | 9.25 | 28 | 47 | 29 | 18 | * | | * | | | | | | | | | | | | | | * | | | * | | | | * | |
| BAP-0907 | 11.75 | | | | | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0907 | 14.25 | 43 | 44 | 28 | 16 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0907 | 16.75 | 44 | 45 | 29 | 16 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0907 | 19.25 | 40 | 48 | 29 | 19 | * | | | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0907 | 21.75 | 39 | 30 | 24 | 6 | * | | * | | | | | | | | | | | | | | | | | | | | | | |
| BAP-0907 | 26.75 | | | | | * | | | | | | | | | | | | | | | | | | | | | | | | |

BBCM
SOLUTIONS TO BUILD ON

TESTING SUMMARY - STANDARD

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 DATE 7/6/09

# ATTERBERG LIMITS' RESULTS



| | Specimen Id. | Depth | MC | LL | PL | PI | Fines | ASTM Classification |
|---|---|---|---|---|---|---|---|---|
| ● | **BAP-0901** | **7.75** | **16** | **28** | **18** | **10** | | |
| ⧗ | **BAP-0901** | **13.75** | **13** | **27** | **17** | **10** | | |
| ▲ | **BAP-0901** | **18.25** | **14** | **37** | **24** | **13** | **60.6** | **SANDY LEAN CLAY CL** |
| ★ | **BAP-0906** | **4.75** | **15** | **27** | **17** | **10** | | |
| ☉ | **BAP-0906** | **17.25** | **14** | **31** | **19** | **12** | **38.0** | **CLAYEY SAND with GRAVEL SC** |
| ✜ | **BAP-0902** | **6.25** | **13** | **27** | **17** | **10** | **23.6** | **CLAYEY GRAVEL with SAND GC** |
| ○ | **BAP-0902** | **12.25** | **10** | **26** | **17** | **9** | **28.8** | **CLAYEY SAND with GRAVEL SC** |
| △ | **BAP-0902** | **16.75** | **24** | **37** | **19** | **18** | | |
| ⊗ | **BAP-0902** | **18.25** | **21** | **35** | **17** | **18** | **54.2** | **SANDY LEAN CLAY CL** |
| ⊕ | **BAP-0902** | **19.75** | **31** | **29** | **17** | **12** | **78.8** | **LEAN CLAY with SAND CL** |
| □ | **BAP-0904** | **9.25** | **14** | **25** | **16** | **9** | **30.3** | **CLAYEY SAND with GRAVEL SC** |
| ⧓ | **BAP-0904** | **13.75** | **16** | **35** | **21** | **14** | | |
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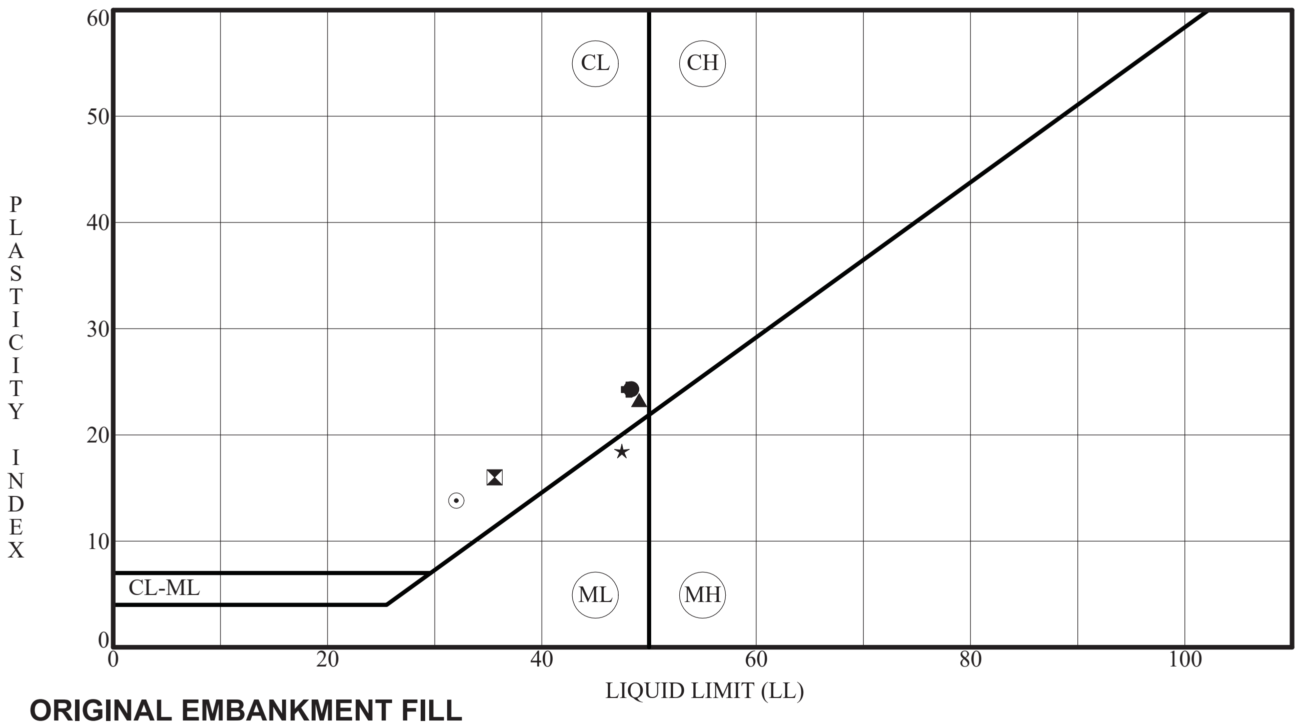
**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

# ATTERBERG LIMITS' RESULTS



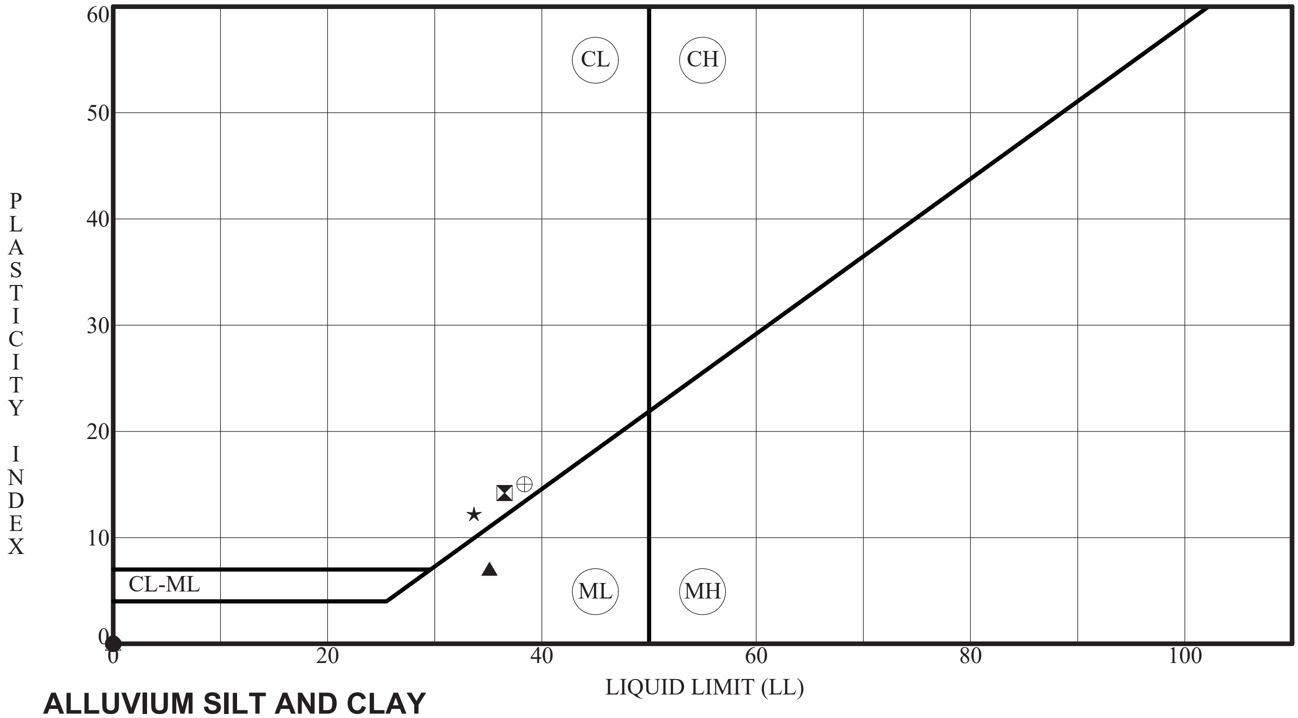
ALPI-REG 111497013.GPJ BBCM.GDT 7/6/09

## ORIGINAL EMBANKMENT FILL

| | Specimen Id. | Depth | MC | LL | PL | PI | Fines | ASTM Classification |
|---|---|---|---|---|---|---|---|---|
| ● | **BAP-0903** | **3.25** | **24** | **48** | **24** | **24** | **91.6** | **LEAN CLAY CL** |
| ⧗ | **BAP-0903** | **7.75** | **20** | **36** | **20** | **16** | **86.2** | **LEAN CLAY CL** |
| ▲ | **BAP-0907** | **7.75** | **23** | **49** | **26** | **23** | | |
| ★ | **BAP-0907** | **9.25** | **28** | **47** | **29** | **18** | **95.2** | **SILT ML** |
| ☉ | **BAP-0905** | **4.75** | **17** | **32** | **18** | **14** | **75.2** | **LEAN CLAY with SAND CL** |
| ✿ | **BAP-0905** | **7.75** | **22** | **48** | **24** | **24** | | |

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

# ATTERBERG LIMITS' RESULTS



## ALLUVIUM SILT AND CLAY

| | Specimen Id. | Depth | MC | LL | PL | PI | Fines | ASTM Classification |
|---|---|---|---|---|---|---|---|---|
| ● | **BAP-0901** | **22.75** | **30** | **NP** | **NP** | **NP** | **95.3** | **SILT ML** |
| ⧗ | **BAP-0901** | **29.25** | **27** | **37** | **22** | **15** | **91.0** | **LEAN CLAY CL** |
| ▲ | **BAP-0901** | **31.75** | **33** | **35** | **28** | **7** | **73.9** | **SILT with SAND ML** |
| ★ | **BAP-0903** | **21.75** | **35** | **34** | **21** | **13** | **70.1** | **LEAN CLAY with SAND CL** |
| ⊙ | **BAP-0906** | **24.75** | **31** | **NP** | **NP** | **NP** | **95.2** | **SILT ML** |
| ✜ | **BAP-0906** | **27.25** | **22** | **NP** | **NP** | **NP** | **75.2** | **SILT with SAND ML** |
| ○ | **BAP-0902** | **21.25** | **26** | **NP** | **NP** | **NP** | **86.8** | **SILT ML** |
| △ | **BAP-0904** | **22.75** | **26** | **NP** | **NP** | **NP** | **47.4** | **SILTY SAND SM** |
| ⊗ | **BAP-0904** | **25.75** | **22** | **NP** | **NP** | **NP** | **91.4** | **SILT ML** |
| ⊕ | **BAP-0905** | **21.75** | **38** | **38** | **23** | **15** | **62.0** | **SANDY LEAN CLAY CL** |
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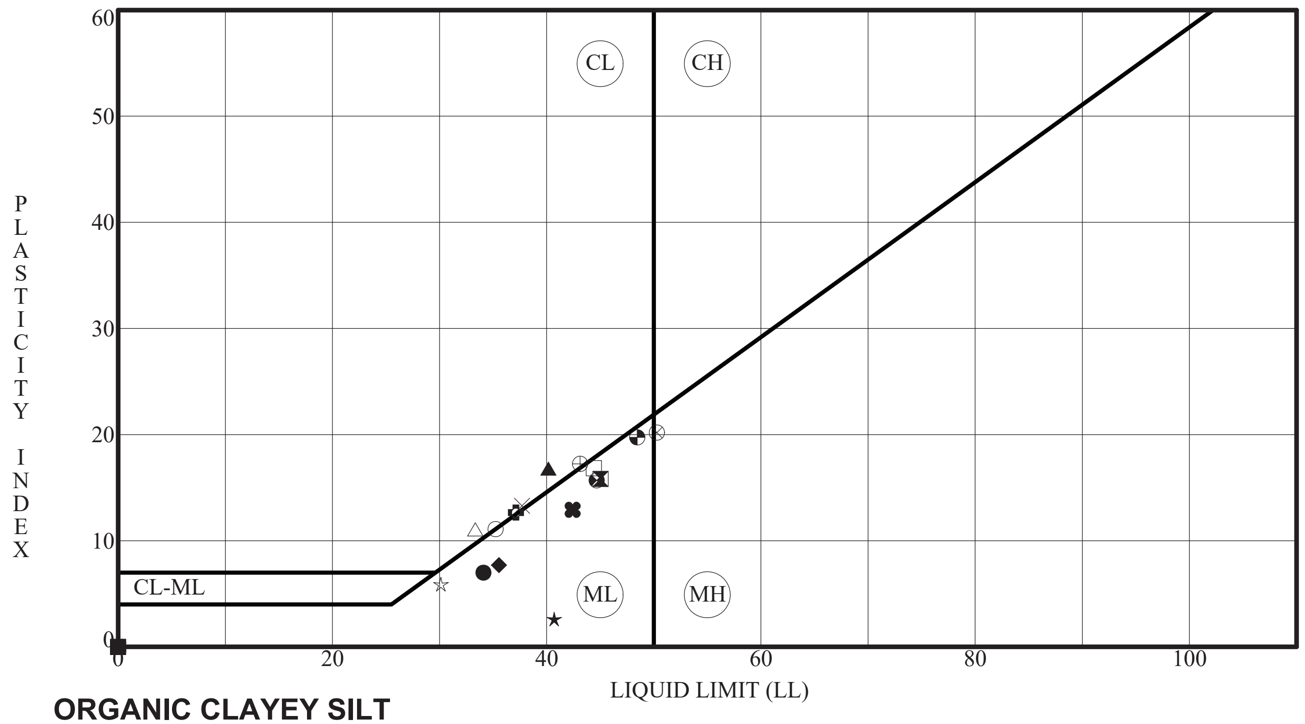
**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

ALPI-REG 111497013.GPJ BBCM.GDT 7/6/09

**PLATE 7**

# ATTERBERG LIMITS' RESULTS



ALPI-REG 111497013.GPJ BBCM.GDT 7/6/09

## ORGANIC CLAYEY SILT

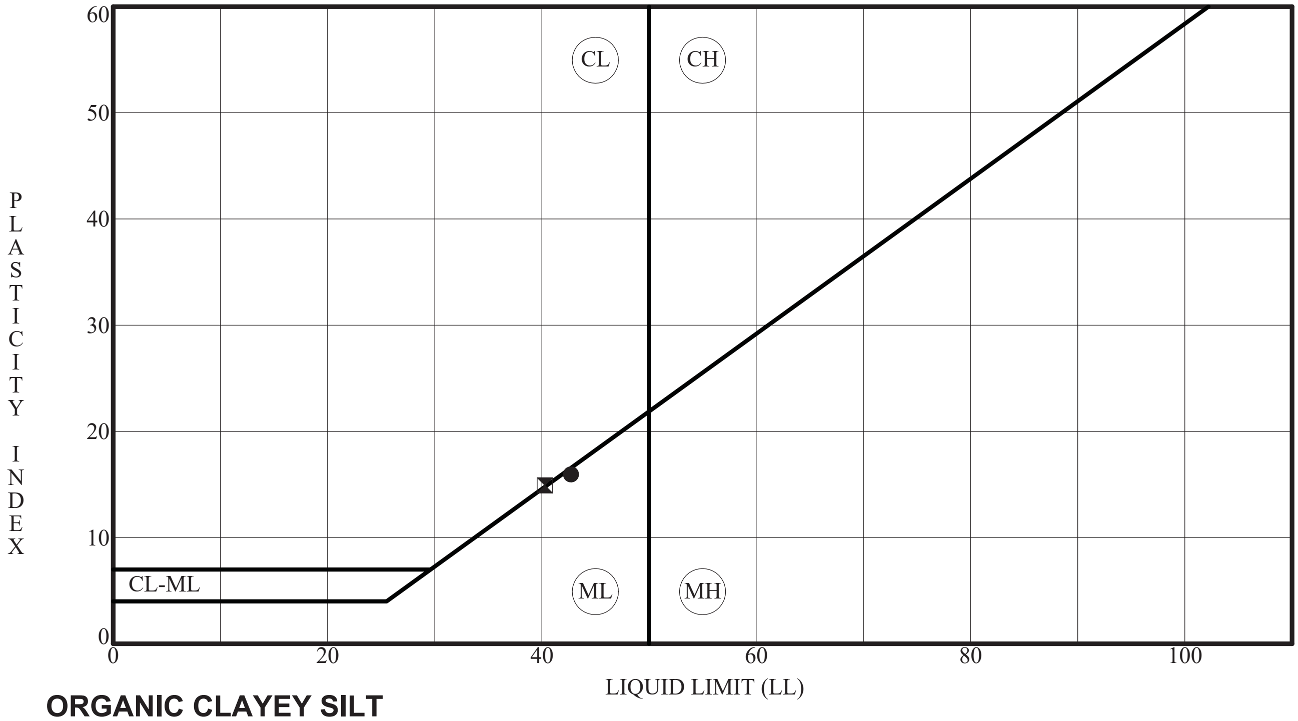
| Specimen Id. | | Depth | MC | LL | PL | PI | Fines | ASTM Classification |
|---|---|---|---|---|---|---|---|---|
| ● | BAP-0901 | 34.25 | 42 | 34 | 27 | 7 | 78.2 | ORGANIC SILT with SAND OL |
| ⧗ | BAP-0901 | 36.75 | 40 | 45 | 29 | 16 | 59.2 | SANDY ORGANIC SILT OL |
| ▲ | BAP-0901 | 39.25 | 42 | 40 | 23 | 17 | 81.5 | ORGANIC CLAY with SAND OL |
| ★ | BAP-0903 | 9.25 | 49 | 41 | 38 | 3 | 66.6 | SANDY ORGANIC SILT OL |
| ☉ | BAP-0903 | 14.25 | 43 | NP | NP | NP | 71.4 | ORGANIC SILT with SAND OL |
| ✥ | BAP-0903 | 16.75 | 43 | 37 | 24 | 13 | 75.9 | ORGANIC CLAY with SAND OL |
| ○ | BAP-0903 | 19.25 | 44 | 35 | 24 | 11 | 61.3 | SANDY ORGANIC CLAY OL |
| △ | BAP-0906 | 31.75 | 34 | 33 | 22 | 11 | 81.3 | ORGANIC CLAY with SAND OL |
| ⊗ | BAP-0906 | 34.25 | 43 | 50 | 30 | 20 | 96.9 | ORGANIC SILT OH |
| ⊕ | BAP-0906 | 36.75 | 38 | 43 | 26 | 17 | 91.1 | ORGANIC CLAY OL |
| □ | BAP-0907 | 14.25 | 43 | 44 | 28 | 16 | 84.7 | ORGANIC SILT with SAND OL |
| ◓ | BAP-0907 | 16.75 | 44 | 45 | 29 | 16 | 84.9 | ORGANIC SILT with SAND OL |
| ◑ | BAP-0907 | 19.25 | 40 | 48 | 29 | 19 | 90.9 | ORGANIC SILT OL |
| ☆ | BAP-0907 | 21.75 | 39 | 30 | 24 | 6 | 56.3 | SANDY ORGANIC SILT OL |
| ✿ | BAP-0902 | 27.25 | 54 | NP | NP | NP | 85.3 | ORGANIC SILT OL |
| ■ | BAP-0902 | 28.75 | 43 | NP | NP | NP | 74.9 | ORGANIC SILT with SAND OL |
| ◆ | BAP-0902 | 32.25 | 38 | 36 | 28 | 8 | 75.4 | ORGANIC SILT with SAND OL |
| ◇ | BAP-0904 | 19.75 | 28 | NP | NP | NP | 92.1 | ORGANIC SILT OL |
| × | BAP-0904 | 27.25 | 38 | 38 | 24 | 14 | 79.2 | ORGANIC CLAY with SAND OL |
| ✖ | BAP-0904 | 28.75 | 47 | 42 | 30 | 12 | 78.4 | ORGANIC SILT with SAND OL |

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION

**LOCATION** BRILLIANT, OHIO

**JOB NO.** 011-11497-013 **DATE** 7/6/09

# ATTERBERG LIMITS' RESULTS



ALPI-REG 111497013.GPJ BBCM.GDT 7/6/09

## ORGANIC CLAYEY SILT

| | Specimen Id. | Depth | MC | LL | PL | PI | Fines | ASTM Classification |
|---|---|---|---|---|---|---|---|---|
| ● | **BAP-0905** | **14.25** | **45** | **43** | **27** | **16** | **80.5** | **ORGANIC SILT with SAND OL** |
| ⧗ | **BAP-0905** | **16.75** | **42** | **40** | **25** | **15** | **84.5** | **ORGANIC CLAY with SAND OL** |

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

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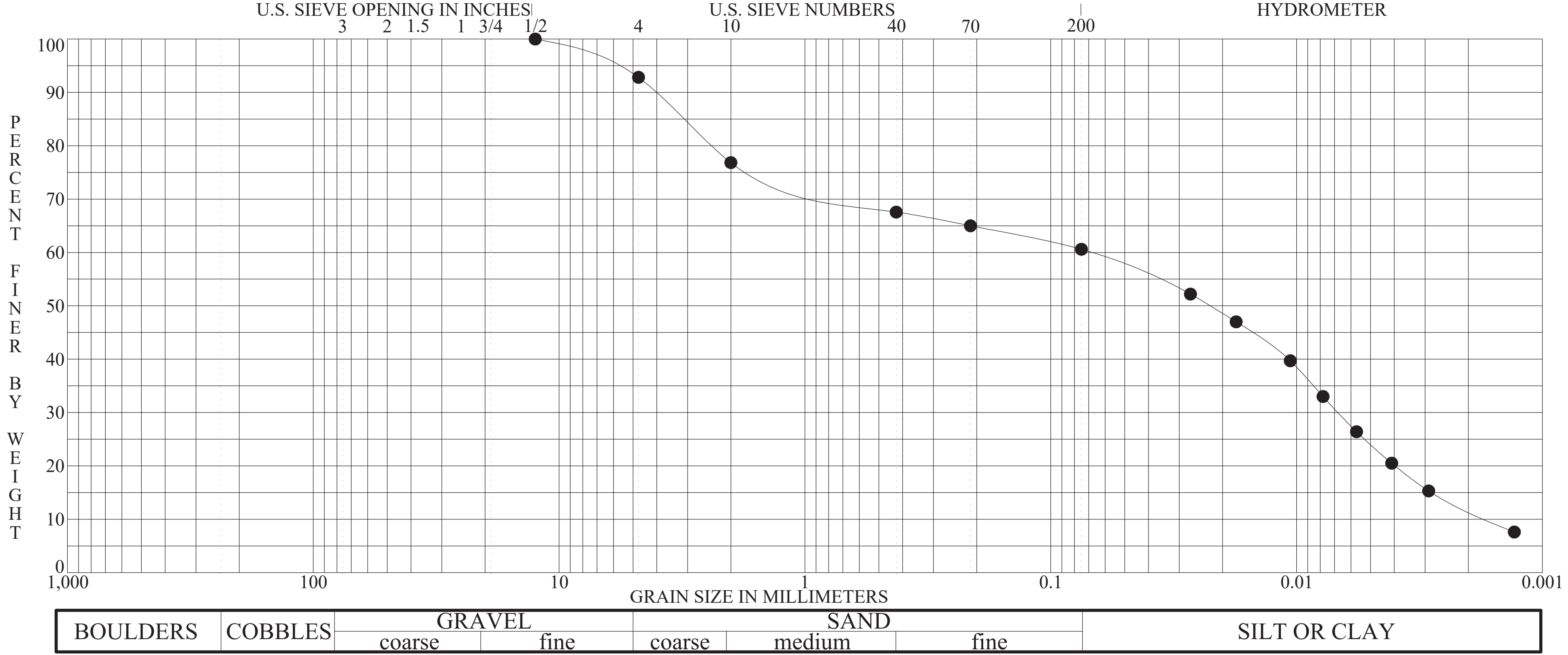


| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0901 S-12 17.5' to 18.3'** | **FILL: Gray and brown silty clay, some fine to coarse sand, trace fine gravel(shale fragments).**<br>**SANDY LEAN CLAY CL** | **14** | **37** | **24** | **13** | **0.393** | **41.763** |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0901 S-12 17.5' to 18.3'** | **12.5000** | **6.3655** | **0.0697** | **0.0225** | **0.0017** | **7.17** | **32.23** | **48.87** | **11.73** |

**ASTM D422**

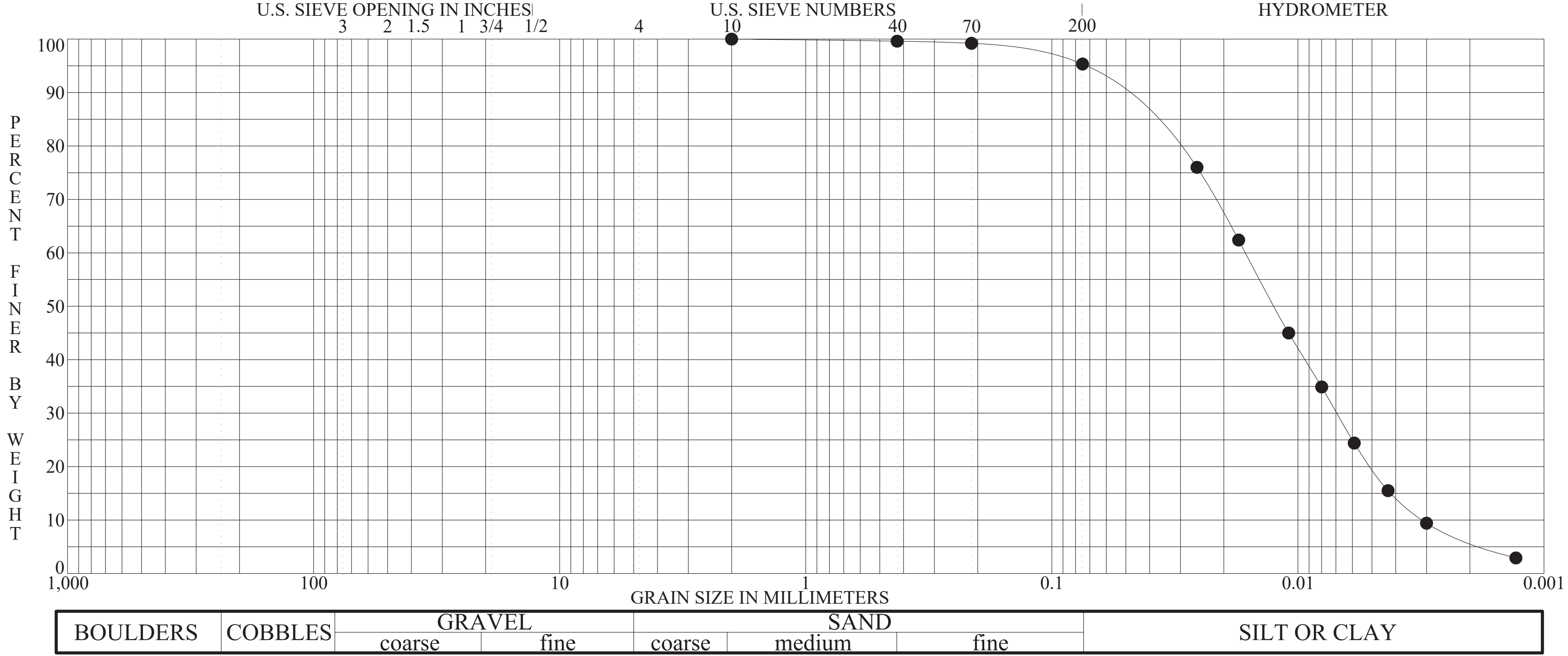
**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

**PLATE 10**

GRN-EPA W/ASTM-BBCM

**BBCM**



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0901 S-15 22.0' to 23.2'** | **Dark-gray brown silt, trace clay, trace fine to medium sand.** | **30** | **NP** | **NP** | **NP** | **0.950** | **5.248** |
| | **SILT ML** | | | | | | |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0901 S-15 22.0' to 23.2'** | **2.0000** | **0.0736** | **0.0163** | **0.0125** | **0.0031** | **0.00** | **4.67** | **89.08** | **6.25** |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION

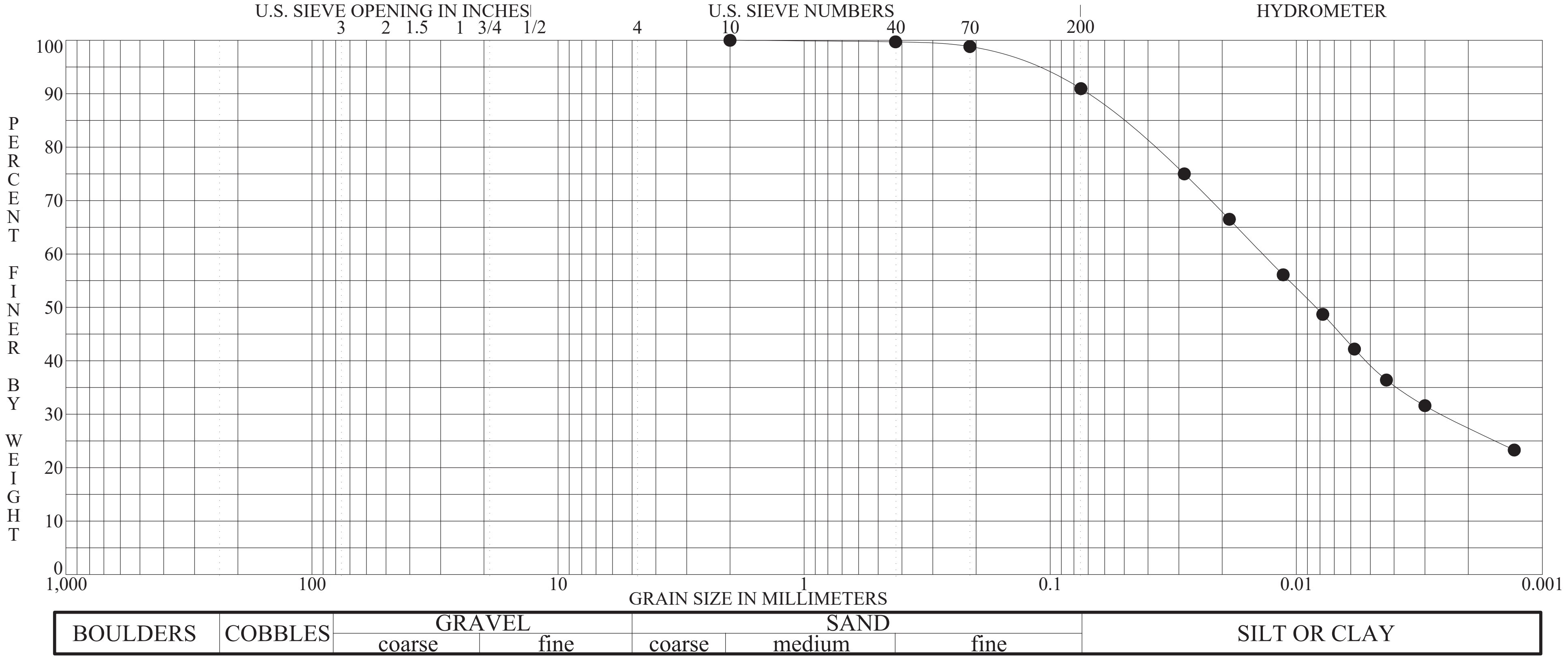
**LOCATION** BRILLIANT, OHIO

**JOB NO.** 011-11497-013 **DATE** 7/6/09

**PLATE 11**

GRN-EPA W/ASTM-BBCM

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0901 S-18 28.5' to 30.0'** | **Brown mottled with gray and dark-gray siltty clay inter-bedded with organic silt, trace fine to medium sand.**<br>**LEAN CLAY CL** | **27** | **37** | **22** | **15** | | |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0901 S-18 28.5' to 30.0'** | **2.0000** | **0.1279** | **0.0136** | **0.0083** | | **0.00** | **9.04** | **63.38** | **27.58** |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

**PLATE 12**

GRN-EPA W/ASTM-BBCM

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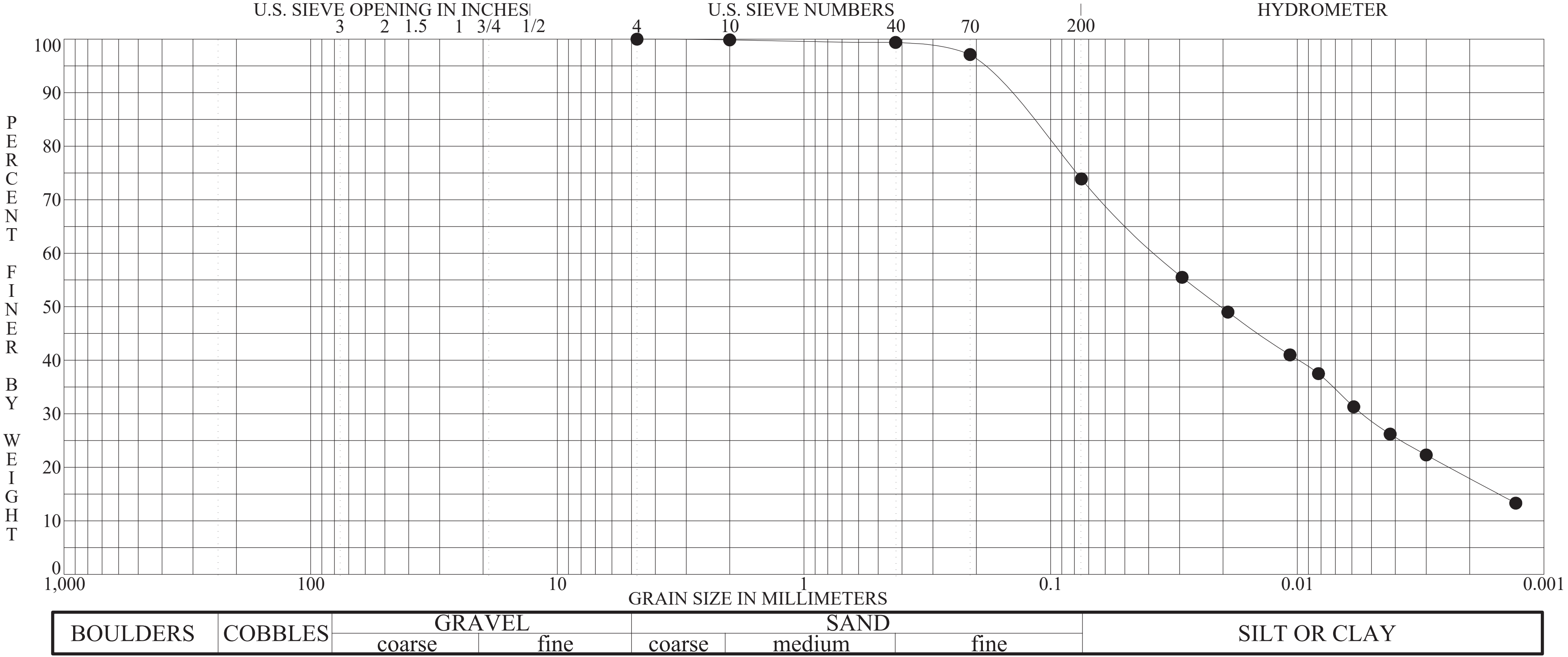


| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0901 ST-19A II**<br>**31.0' to 32.8'** | **Gray mottled with dark-gray and brown clayey silt, some fine sand, trace medium to coarse sand, few seams and lenses of silty clay and fine sand.**<br>**SILT with SAND ML** | **33** | **35** | **28** | **7** | | |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0901 ST-19A II**<br>**31.0' to 32.8'** | **4.7500** | **0.1927** | **0.0369** | **0.0204** | | **0.00** | **26.12** | **55.95** | **17.94** |

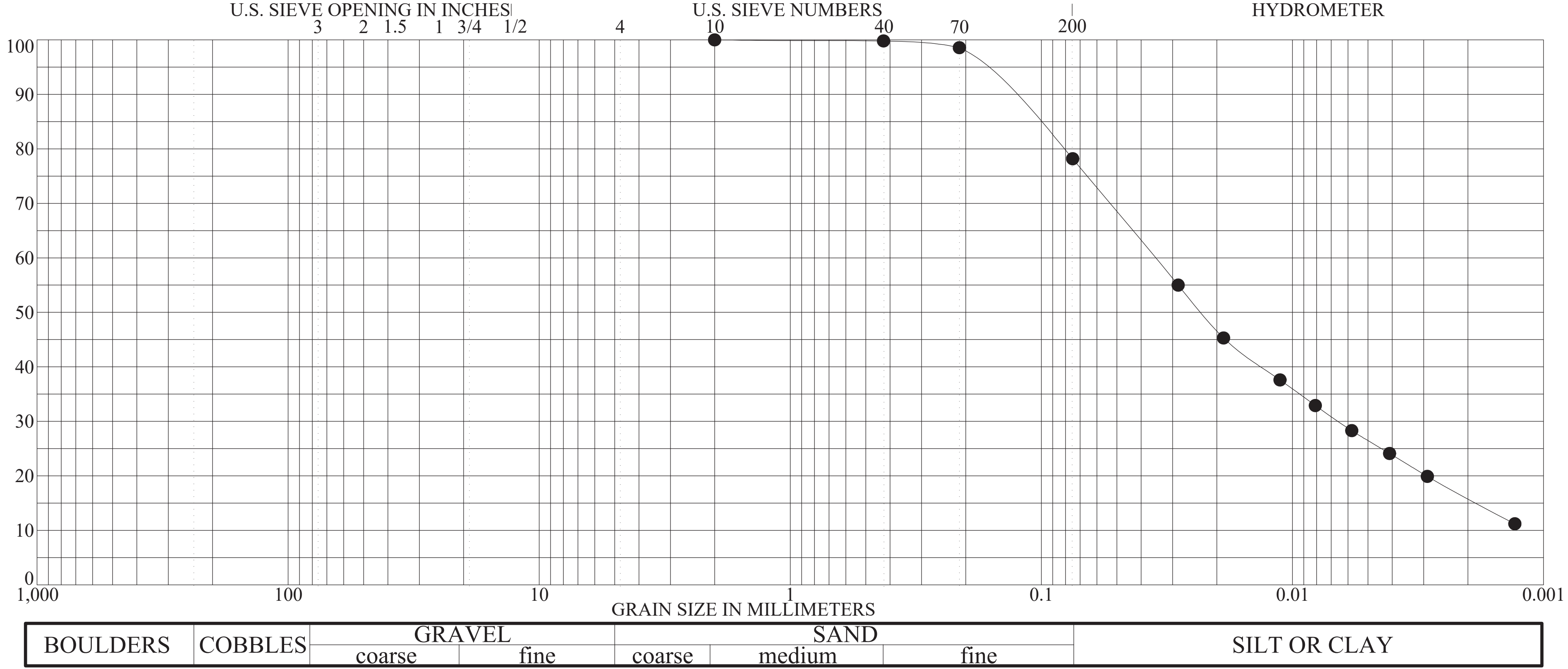
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

PLATE 13

GRN-EPA W/ASTM-BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0901 S-20 33.5' to 35.0'** | **Dark-gray organic clayey silt, some fine sand, trace medium sand.**<br>**ORGANIC SILT with SAND OL** | **42** | **34** | **27** | **7** | | |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0901 S-20 33.5' to 35.0'** | **2.0000** | **0.1767** | **0.0351** | **0.0230** | | **0.00** | **21.81** | **62.32** | **15.87** |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

PLATE 14

GRN-EPA W/ASTM-BBCM

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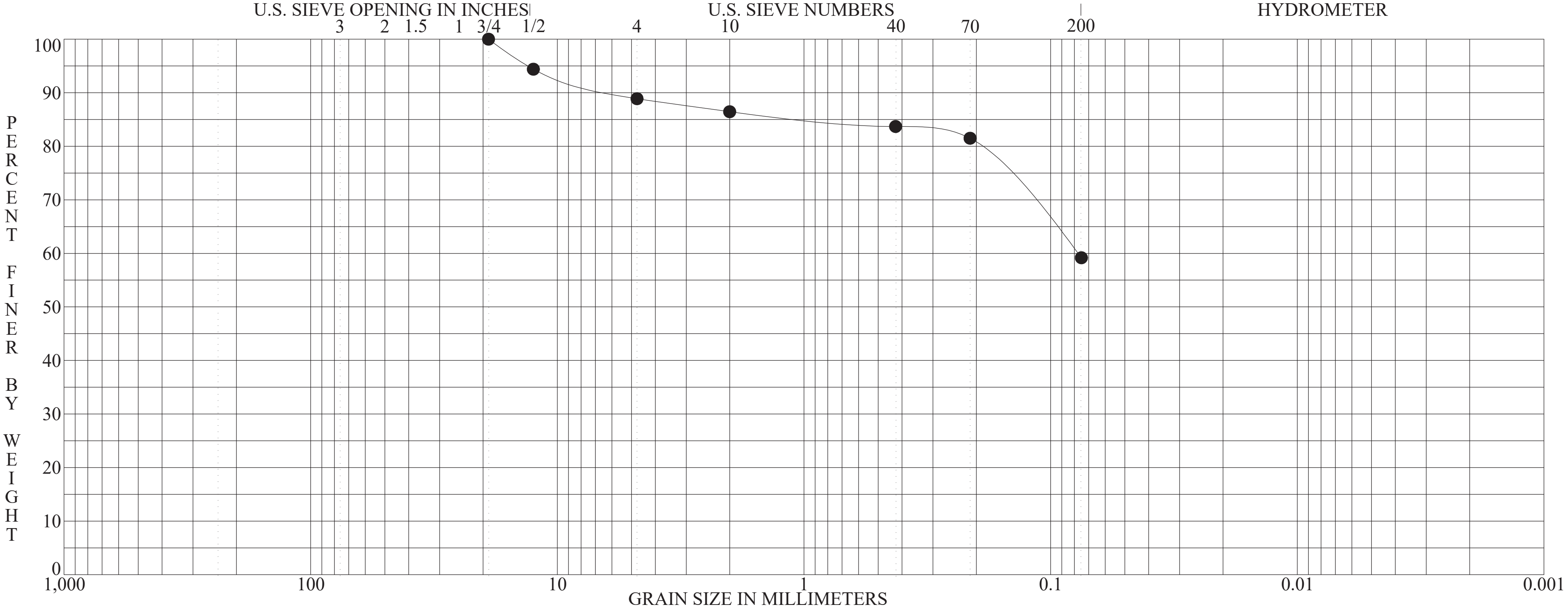


| BOULDERS | COBBLES | GRAVEL |  | SAND |  |  | SILT OR CLAY |
|---|---|---|---|---|---|---|---|
|  |  | coarse | fine | coarse | medium | fine |  |

| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0901 S-21 36.0' to 37.5'** | **Gray mottled with dark-gray organic clayey silt inter-bedded with organic silt, some fine sand, trace medium to coarse sand, little fine gravel.**<br>**SANDY ORGANIC SILT OL** | **40** | **45** | **29** | **16** |  |  |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0901 S-21 36.0' to 37.5'** | **19.0000** | **13.0775** | **0.0779** |  |  | **11.11** | **29.71** | **59.18** |  |

**ASTM D422**

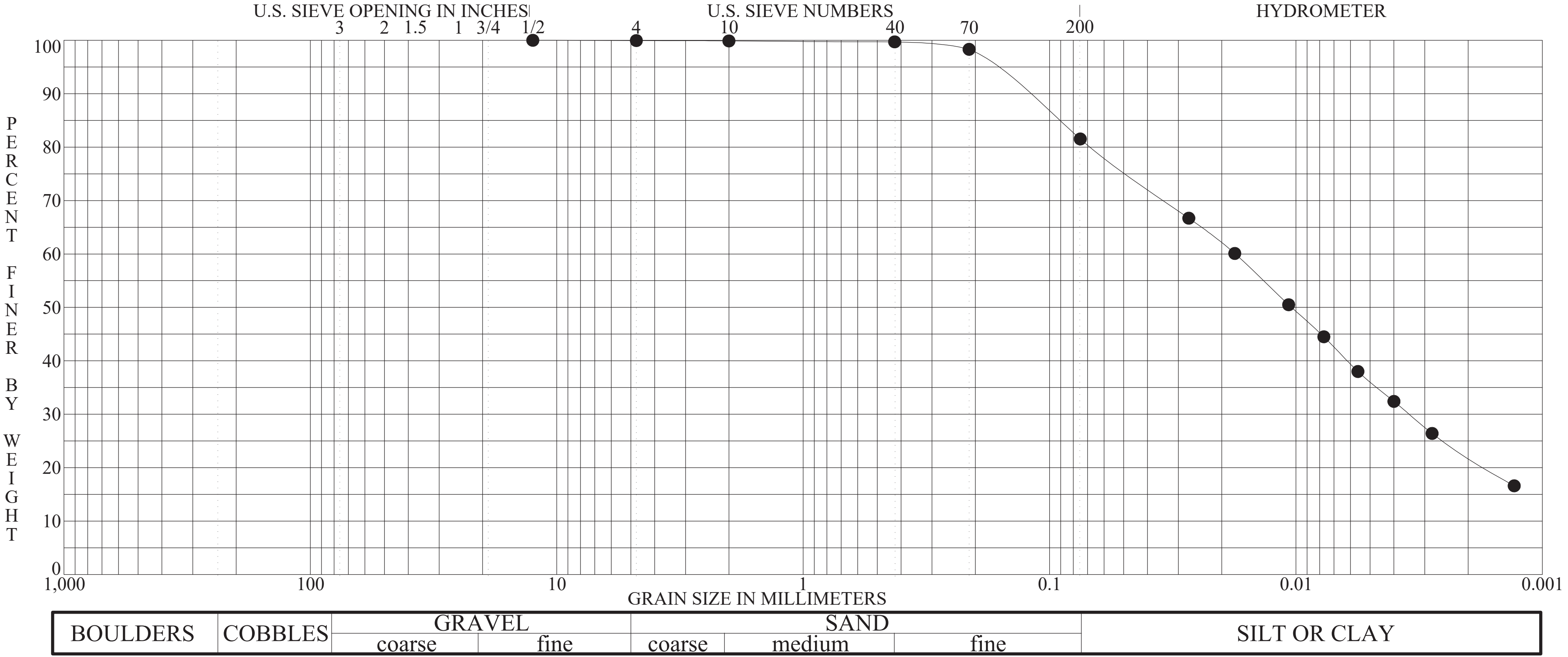
**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

**PLATE 15**

GRN-EPA W/ASTM-BBCM

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0901 S-22 38.5' to 40.0'** | **Gray mottled with dark-gray organic clayey silt, little fine sand, trace medium to coarse sand, trace fine gravel, few lenses of fine sand.**<br>**ORGANIC CLAY with SAND OL** | **42** | **40** | **23** | **17** | | |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0901 S-22 38.5' to 40.0'** | **12.5000** | **0.1726** | **0.0176** | **0.0104** | | **0.05** | **18.42** | **59.43** | **22.10** |

**ASTM D422**

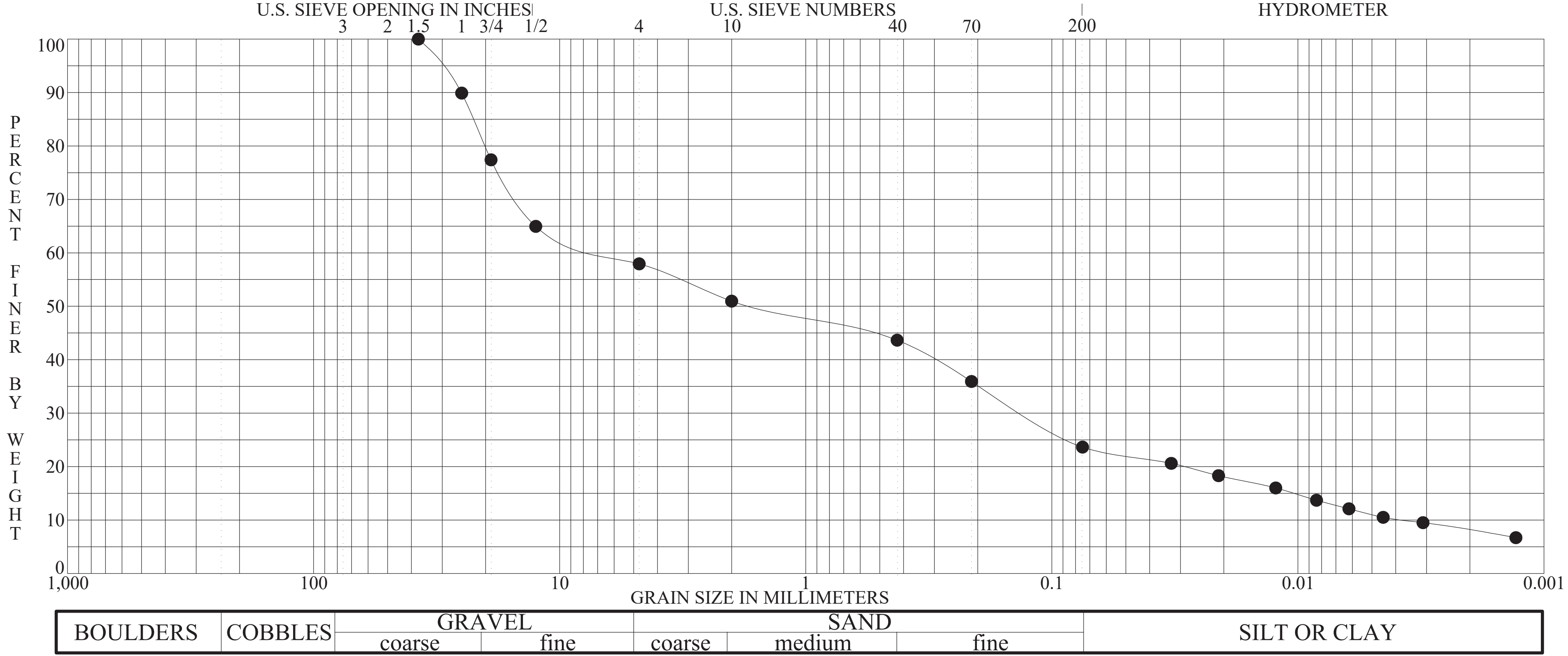
**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

**PLATE 16**

GRN-EPA W/ASTM-BBCM

BBCM



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-PZ-BAP-0902 S-4 5.5' to 6.6'** | **FILL: Brown and gray fine to coarse gravel(sandstone, siltstone and shale fragments), some fine to coarse sand, some clayey silt.**<br>**CLAYEY GRAVEL with SAND GC** | **13** | **27** | **17** | **10** | **0.699** | **1690.044** |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-PZ-BAP-0902 S-4 5.5' to 6.6'** | **37.5000** | **30.6832** | **6.3123** | **1.6307** | **0.0037** | **42.06** | **34.29** | **15.56** | **8.09** |

**ASTM D422**

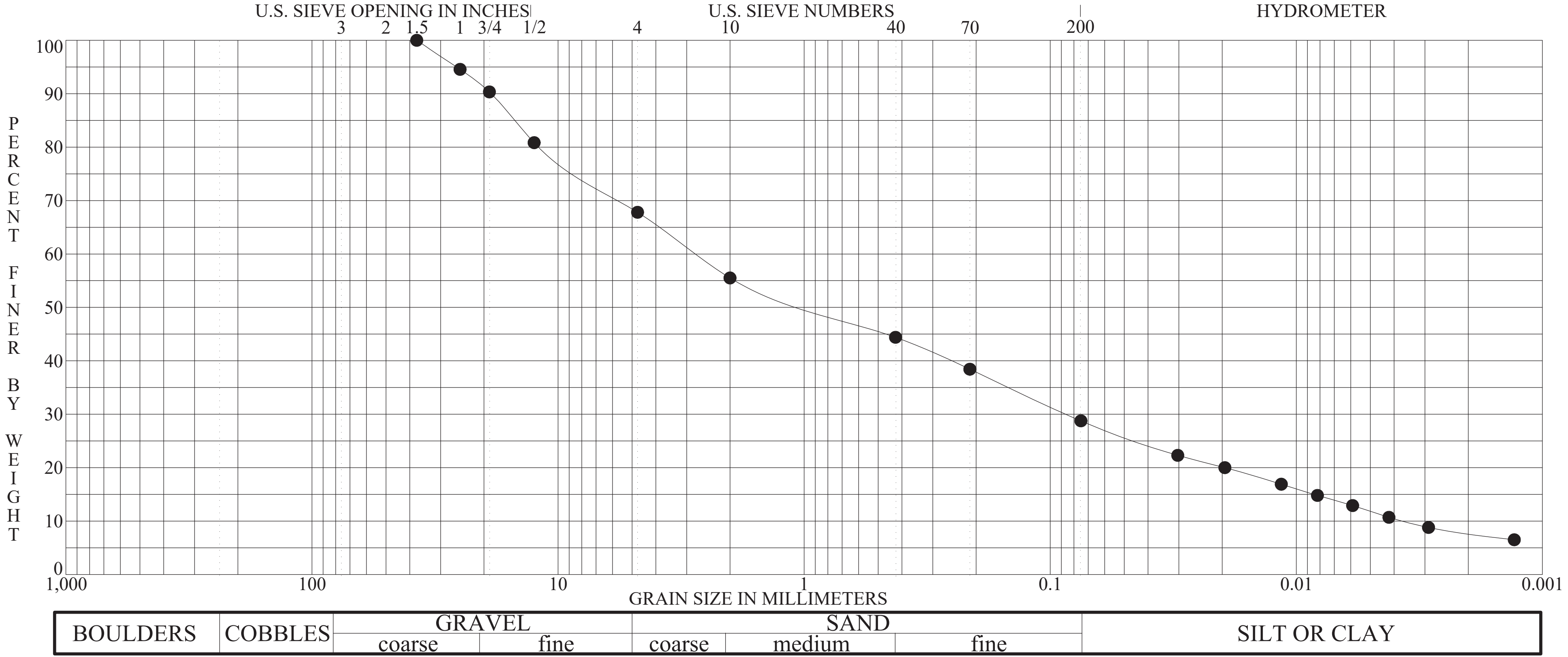
**GRADATION CURVE**

**PROJECT** **CARDINAL PLANT ASH POND INVESTIGATION**
**LOCATION** **BRILLIANT, OHIO**
**JOB NO.** **011-11497-013** **DATE** **7/6/09**

**PLATE 17**

GRN-EPA W/ASTM-BBCM

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0902 S-8 11.5' to 12.6'** | **FILL: Brown and gray fine to coarse sand, some fine to coarse gravel(sandstone, siltstone and shale fragments), some clayey silt.**<br>**CLAYEY SAND with GRAVEL SC** | **10** | **26** | **17** | **9** | **0.731** | **748.575** |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0902 S-8 11.5' to 12.6'** | **37.5000** | **25.8279** | **2.7430** | **0.9275** | **0.0037** | **32.20** | **39.04** | **21.02** | **7.73** |

**ASTM D422**

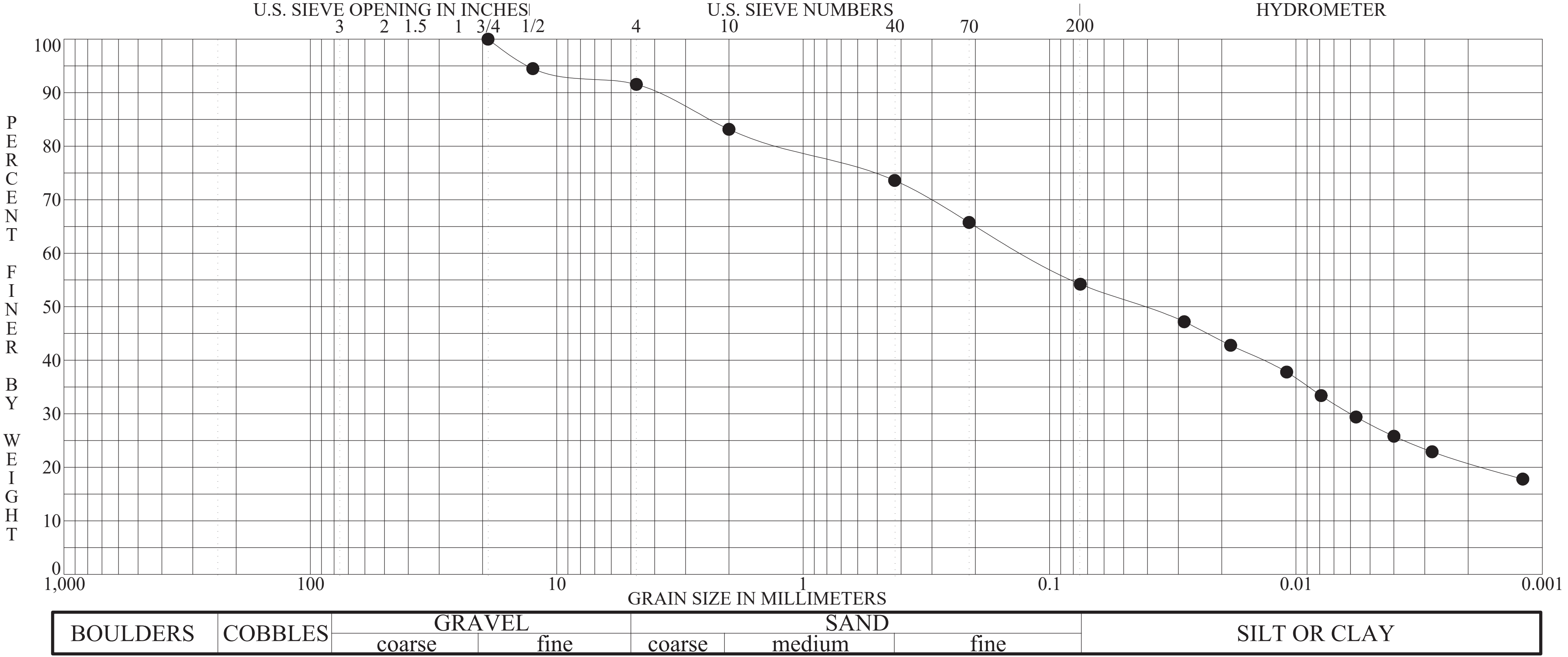
**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

**PLATE 18**

GRN-EPA W/ASTM-BBCM

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0902 S-12 17.5' to 18.1'** | **FILL: Brown and gray silty clay, "and" fine to coarse sand, trace fine gravel(shale fragments).**<br>**SANDY LEAN CLAY CL** | **21** | **35** | **17** | **18** | | |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0902 S-12 17.5' to 18.1'** | **19.0000** | **12.9863** | **0.1263** | **0.0418** | | **8.45** | **37.34** | **33.34** | **20.87** |

**ASTM D422**

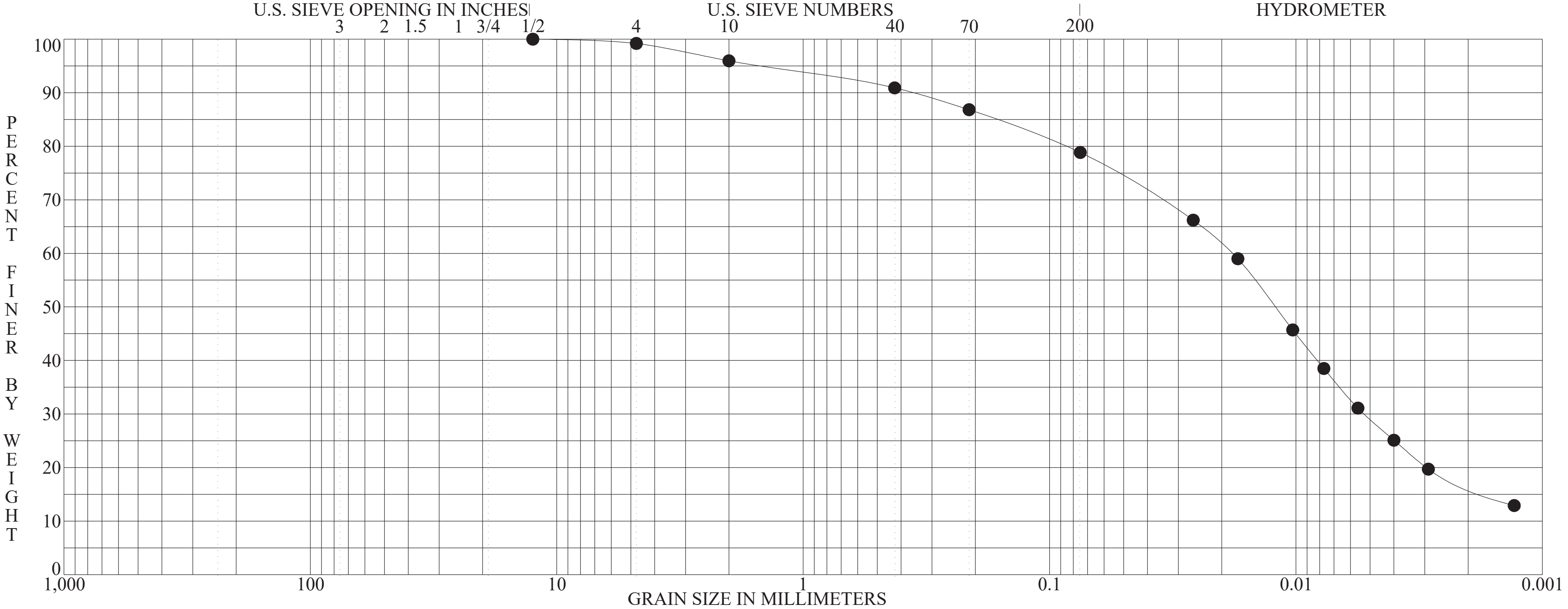
**GRADATION CURVE**

**PROJECT** **CARDINAL PLANT ASH POND INVESTIGATION**
**LOCATION** **BRILLIANT, OHIO**
**JOB NO.** **011-11497-013** **DATE** **7/6/09**

PLATE 19

GRN-EPA W/ASTM-BBCM

BBCM



| BOULDERS | COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|---|
| | | coarse | fine | coarse | medium | fine | |

| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-PZ-BAP-0902 S-13 19.0' to 19.3'** | **FILL: Gray and brown silty clay, litle fine to coarse sand, trace fine gravel(shale fragments).**<br><br>**LEAN CLAY with SAND CL** | **31** | **29** | **17** | **12** | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-PZ-BAP-0902 S-13 19.0' to 19.3'** | **12.5000** | **1.4898** | **0.0182** | **0.0122** | | **0.79** | **20.36** | **62.29** | **16.55** |

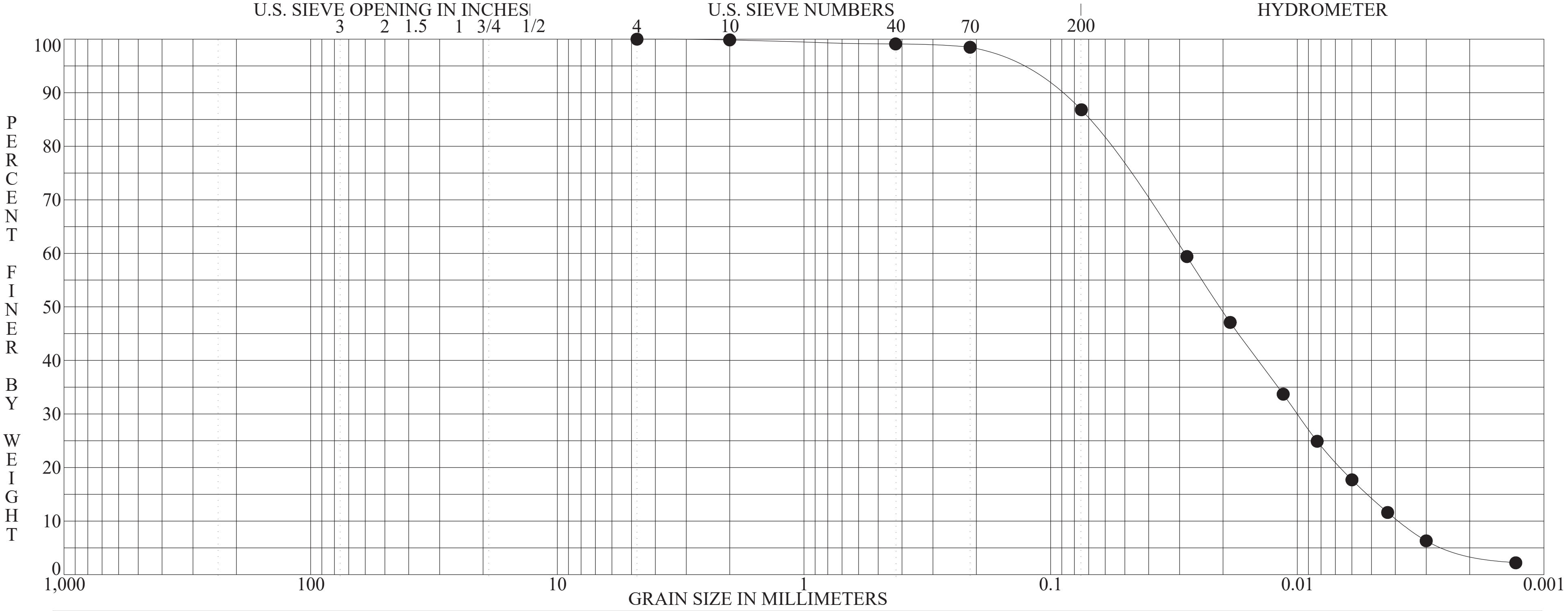
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

PLATE 20

GRN-EPA W/ASTM-BBCM



| BOULDERS | COBBLES | GRAVEL |  | SAND |  |  | SILT OR CLAY |
|---|---|---|---|---|---|---|---|
|  |  | coarse | fine | coarse | medium | fine |  |

| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0902 S-14 20.5' to 22.0'** | **Gray and dark-gray silt, trace clay, little fine to coarse sand.** | **26** | **NP** | **NP** | **NP** | **0.902** | **7.417** |
|  | **SILT ML** |  |  |  |  |  |  |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0902 S-14 20.5' to 22.0'** | **4.7500** | **0.1554** | **0.0286** | **0.0206** | **0.0039** | **0.00** | **13.18** | **82.51** | **4.31** |

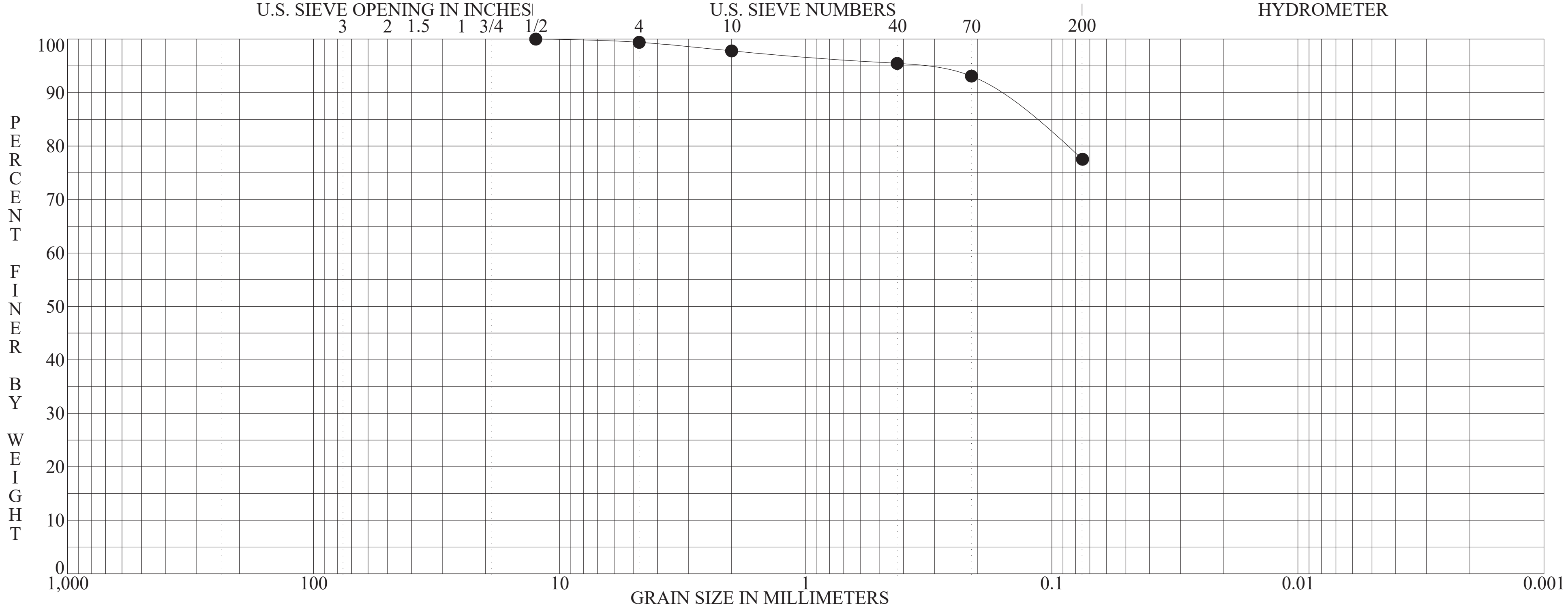
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

**PLATE 21**

BBCM



| BOULDERS | COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|---|
| | | coarse | fine | coarse | medium | fine | |

| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0902 S-15 22.0' to 22.8'** | **Gray and dark-gray silt, some clay, little fine sand, trace medium to coarse sand, trace fine gravel.** | | | | | | |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0902 S-15 22.0' to 22.8'** | **12.5000** | **0.3717** | | | | **0.59** | **21.88** | **77.52** | |

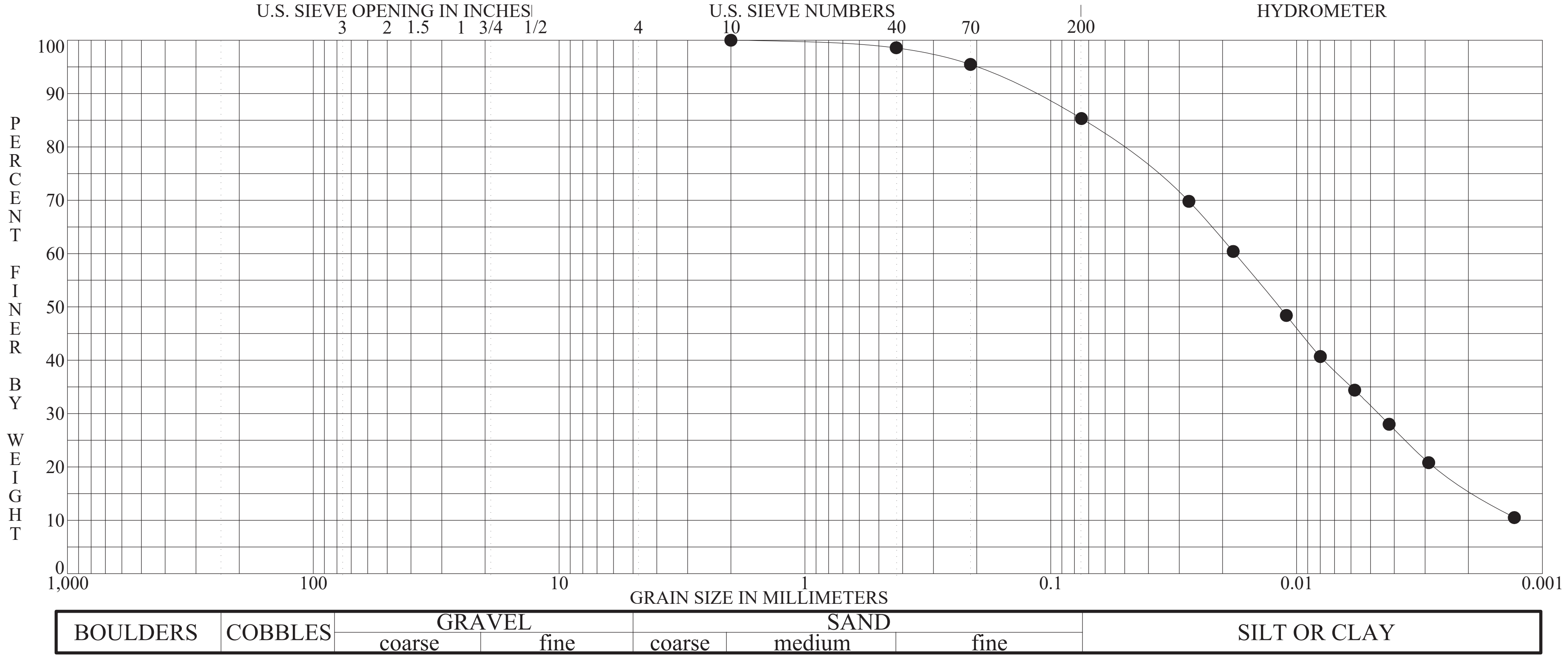
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0902 S-18 26.5' to 27.7'** | **Gray mottled with dark-gray organic silt, little clay, little fine to medium sand.**<br>**ORGANIC SILT OL** | **54** | **NP** | **NP** | **NP** | | |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0902 S-18 26.5' to 27.7'** | **2.0000** | **0.2020** | **0.0178** | **0.0118** | | **0.00** | **14.68** | **69.29** | **16.03** |

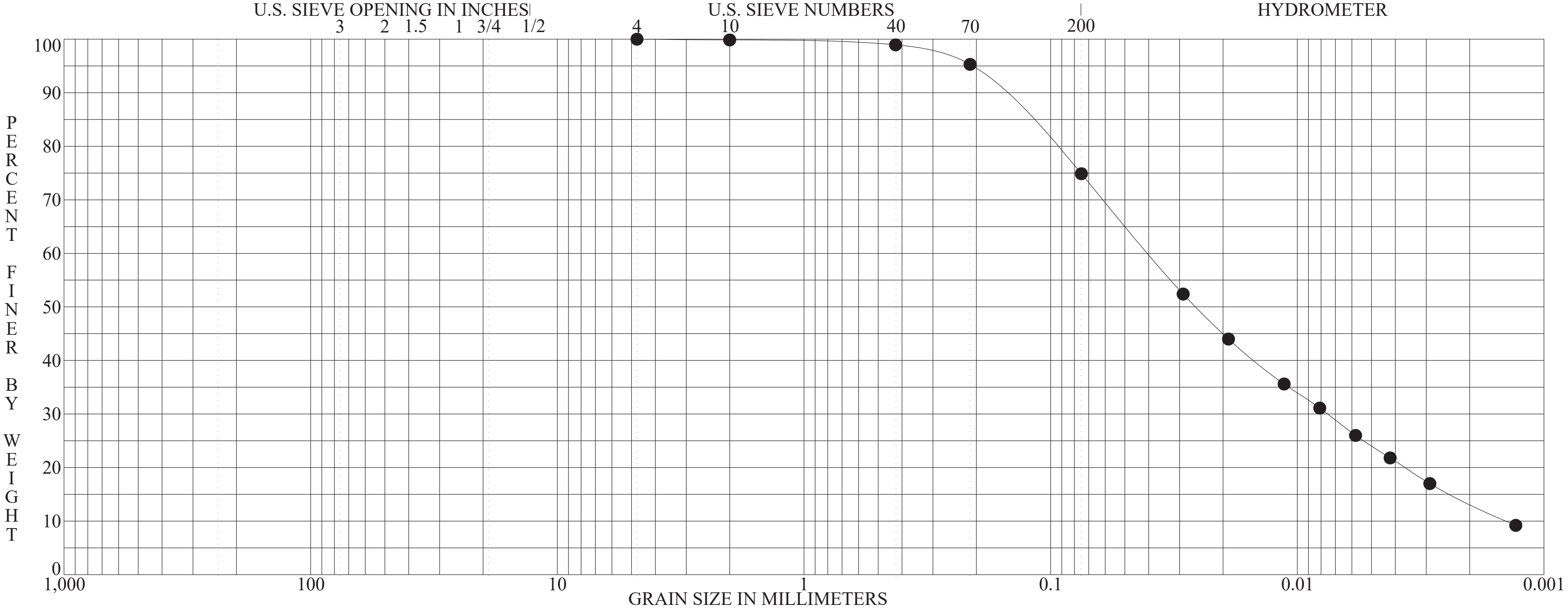
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



| BOULDERS | COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|---|
| | | coarse | fine | coarse | medium | fine | |

| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0902 S-19 28.0' to 29.5'** | **Gray mottled with dark-gray organic silt, little clay, some fine sand, trace medium to coarse sand.**<br>**ORGANIC SILT with SAND OL** | **43** | **NP** | **NP** | **NP** | **1.006** | **28.333** |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0902 S-19 28.0' to 29.5'** | **4.7500** | **0.2088** | **0.0400** | **0.0257** | **0.0014** | **0.00** | **25.13** | **61.48** | **13.39** |

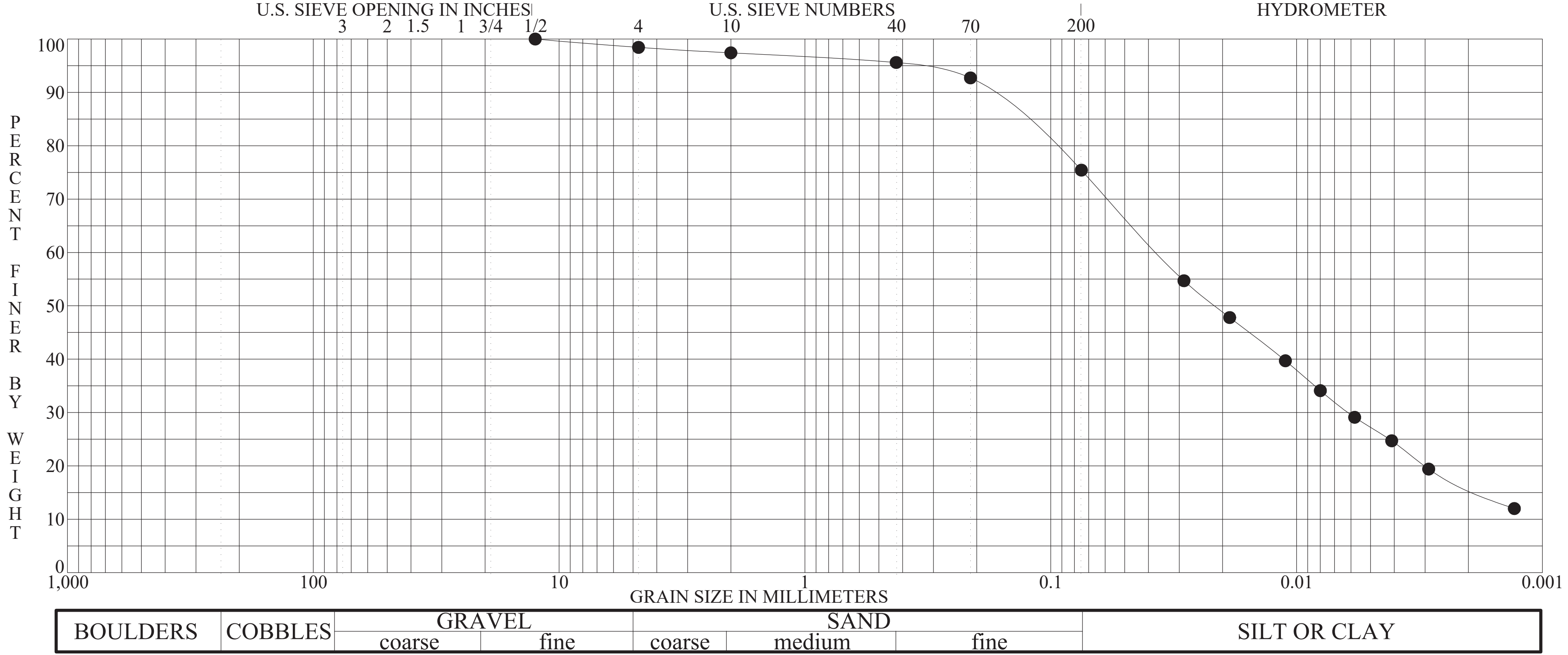
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0902 S-20 31.5' to 32.6'** | **Gray mottled with dark-gray organic clayey silt, some fine to medium sand, trace coarse sand, trace fine gravel.**<br>**ORGANIC SILT with SAND OL** | **38** | **36** | **28** | **8** | | |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0902 S-20 31.5' to 32.6'** | **12.5000** | **0.3667** | **0.0367** | **0.0214** | | **1.56** | **23.01** | **59.45** | **15.97** |

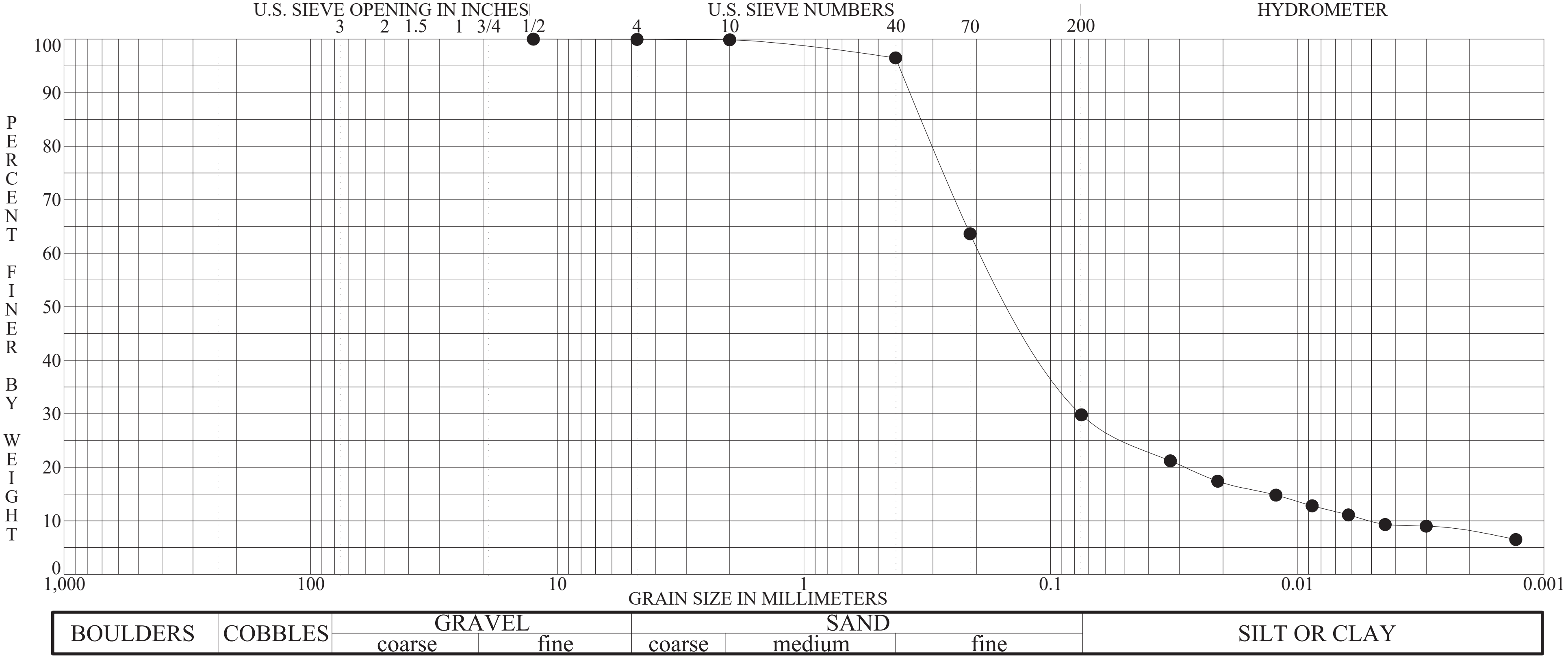
**ASTM D422**

**GRADATION CURVE**

**PROJECT** **CARDINAL PLANT ASH POND INVESTIGATION**
**LOCATION** **BRILLIANT, OHIO**
**JOB NO.** **011-11497-013** **DATE** **7/6/09**

GRN-EPA W/ASTM-BBCM

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0902 S-22 36.5' to 37.6'** | **Brown fine sand, trace medium to coarse sand, trace fine gravel, some silt, trace clay.** | **22** | | | | **5.969** | **37.720** |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0902 S-22 36.5' to 37.6'** | **12.5000** | **0.4117** | **0.1896** | **0.1395** | **0.0050** | **0.04** | **70.15** | **22.02** | **7.79** |

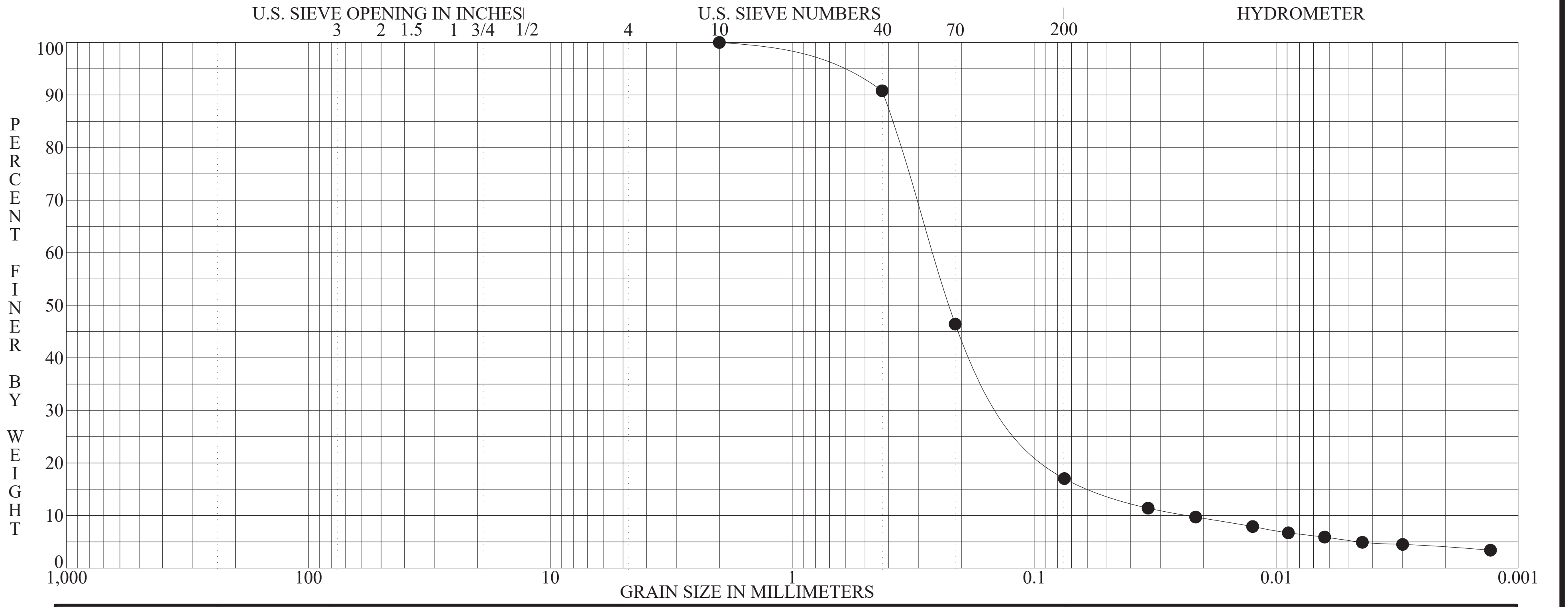
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



| BOULDERS | COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|---|
| | | coarse | fine | coarse | medium | fine | |

| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0902 S-23 39.0' to 40.2'** | **Brown fine sand, trace medium sand, little silt, trace clay.** | **24** | | | | **2.305** | **11.263** |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0902 S-23 39.0' to 40.2'** | **2.0000** | **0.8615** | **0.2623** | **0.2242** | **0.0233** | **0.00** | **82.98** | **13.06** | **3.97** |

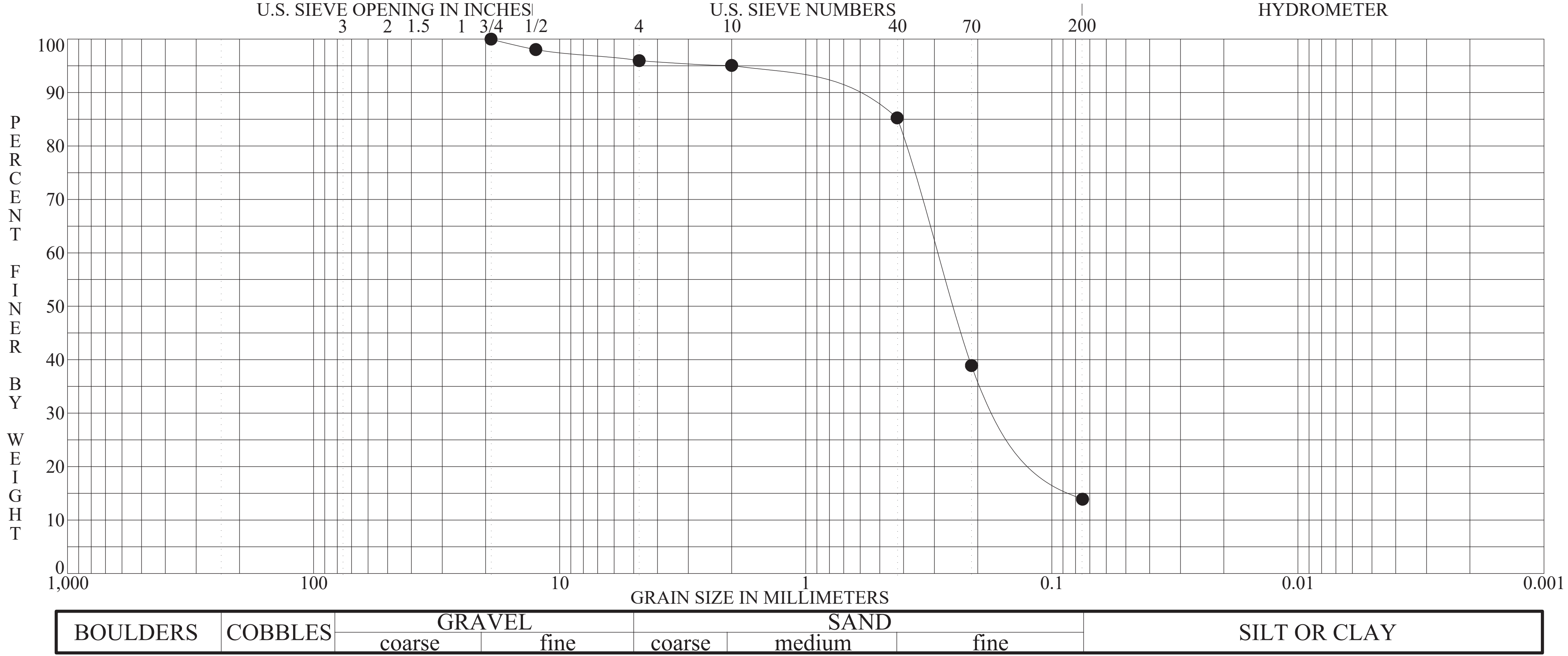
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

**PLATE 27**

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0902 S-24 41.5' to 43.0'** | **Brown fine to medium sand, trace coarse sand, trace silt.** | | | | | | |

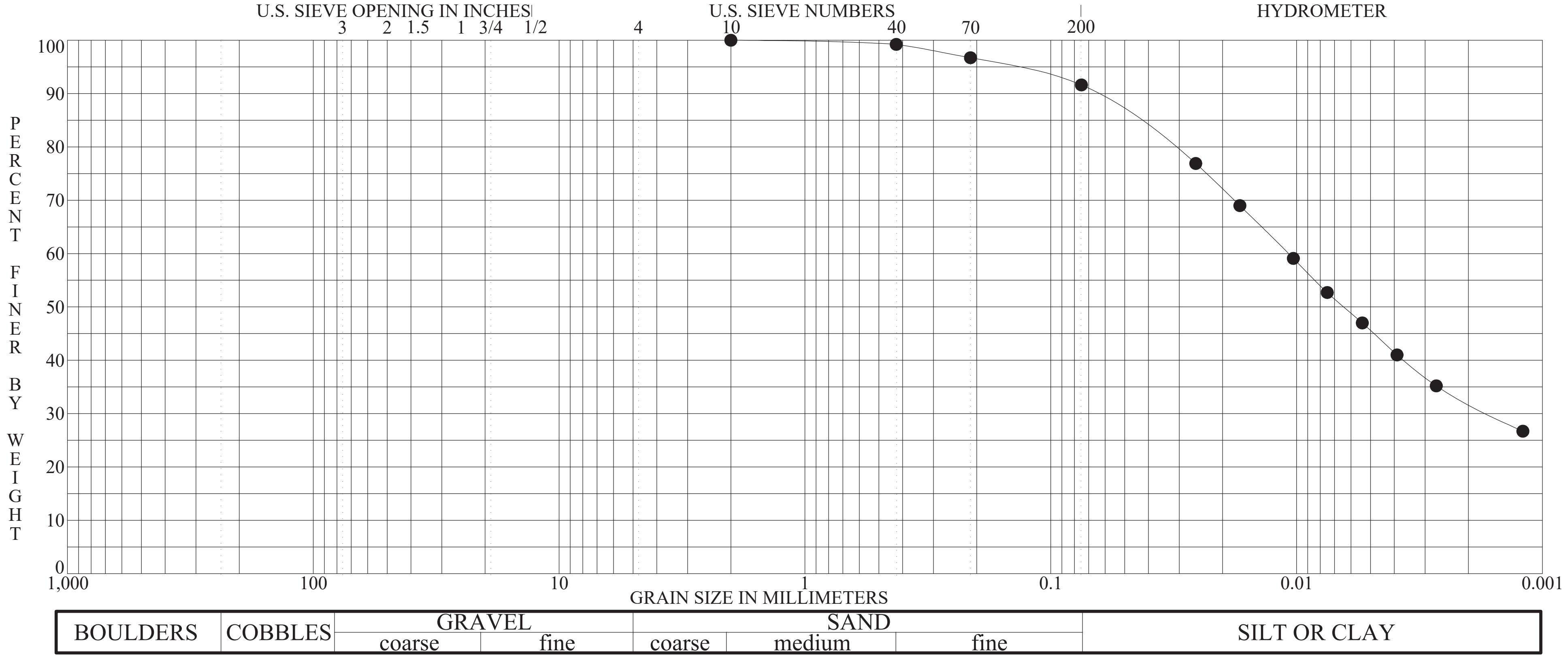
| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0902 S-24 41.5' to 43.0'** | **19.0000** | **1.9735** | **0.2909** | **0.2504** | | **4.03** | **82.08** | **13.90** | |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0903 S-2 2.5' to 3.3'** | **FILL: Brown mottled with dark-brown and gray silty clay, trace fine to medium sand.**<br>**LEAN CLAY CL** | **24** | **48** | **24** | **24** | | |

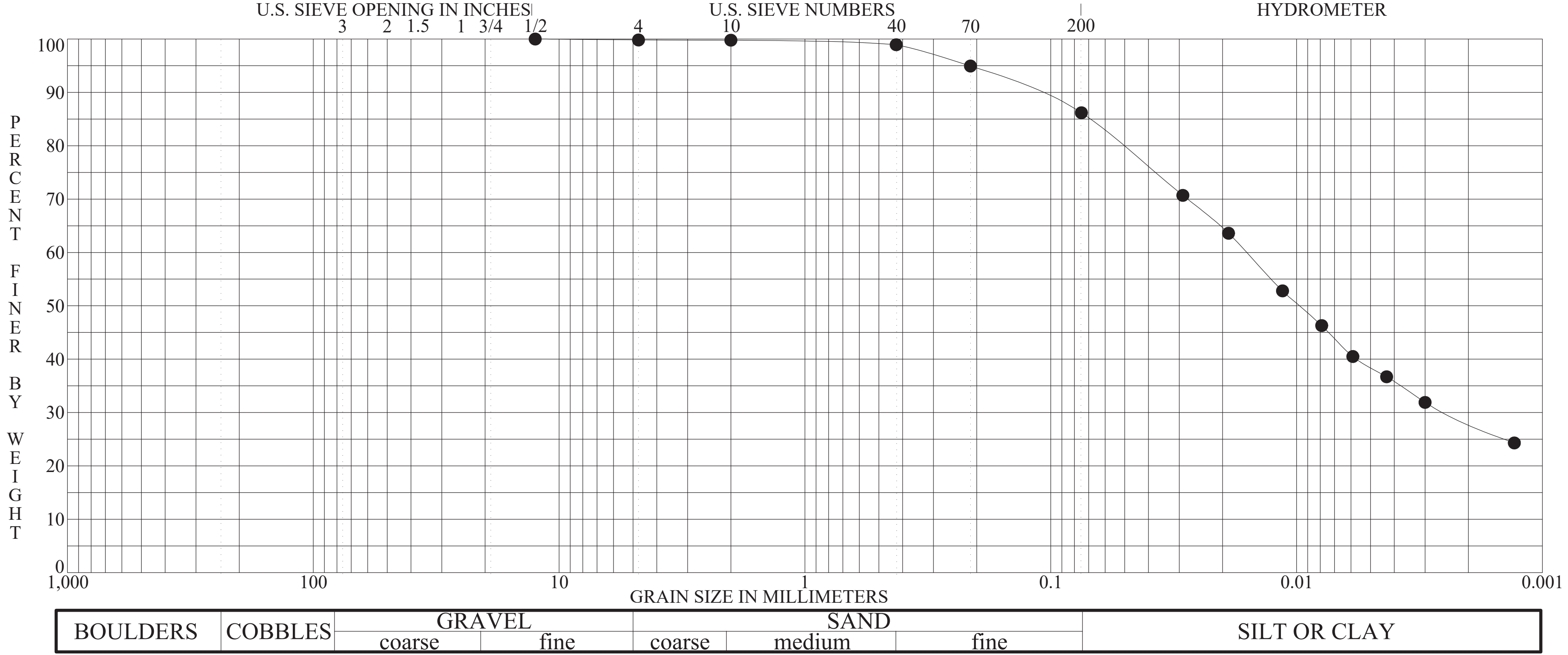
| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0903 S-2 2.5' to 3.3'** | **2.0000** | **0.1492** | **0.0108** | **0.0064** | | **0.00** | **8.37** | **59.57** | **32.05** |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0903 S-5 7.0' to 8.0'** | **FILL: Brown mottled with dark-brown and gray silty clay, little fine to coarse sand, trace fine gravel, few lenses of organic silt.**<br>**LEAN CLAY CL** | **20** | **36** | **20** | **16** | | |

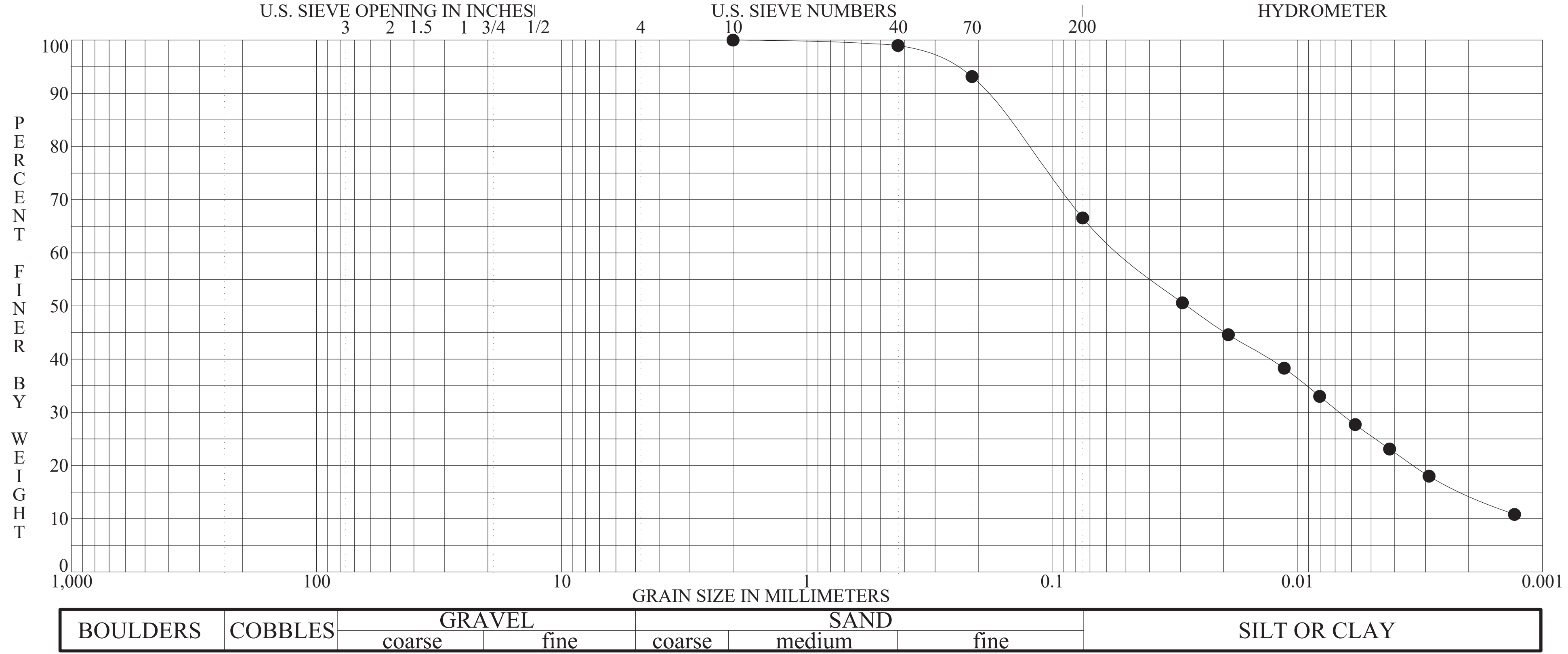
| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0903 S-5 7.0' to 8.0'** | **12.5000** | **0.2141** | **0.0160** | **0.0097** | | **0.17** | **13.64** | **57.97** | **28.22** |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0903 S-6 8.5' to 9.5'** | **Dark-gray organic silt, little clay, some fine sand, trace medium sand, few lenses of fine sand.** | **49** | **41** | **38** | **3** | | |
| | | **SANDY ORGANIC SILT OL** | | | | | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0903 S-6 8.5' to 9.5'** | **2.0000** | **0.2643** | **0.0510** | **0.0282** | | **0.00** | **33.45** | **51.89** | **14.67** |

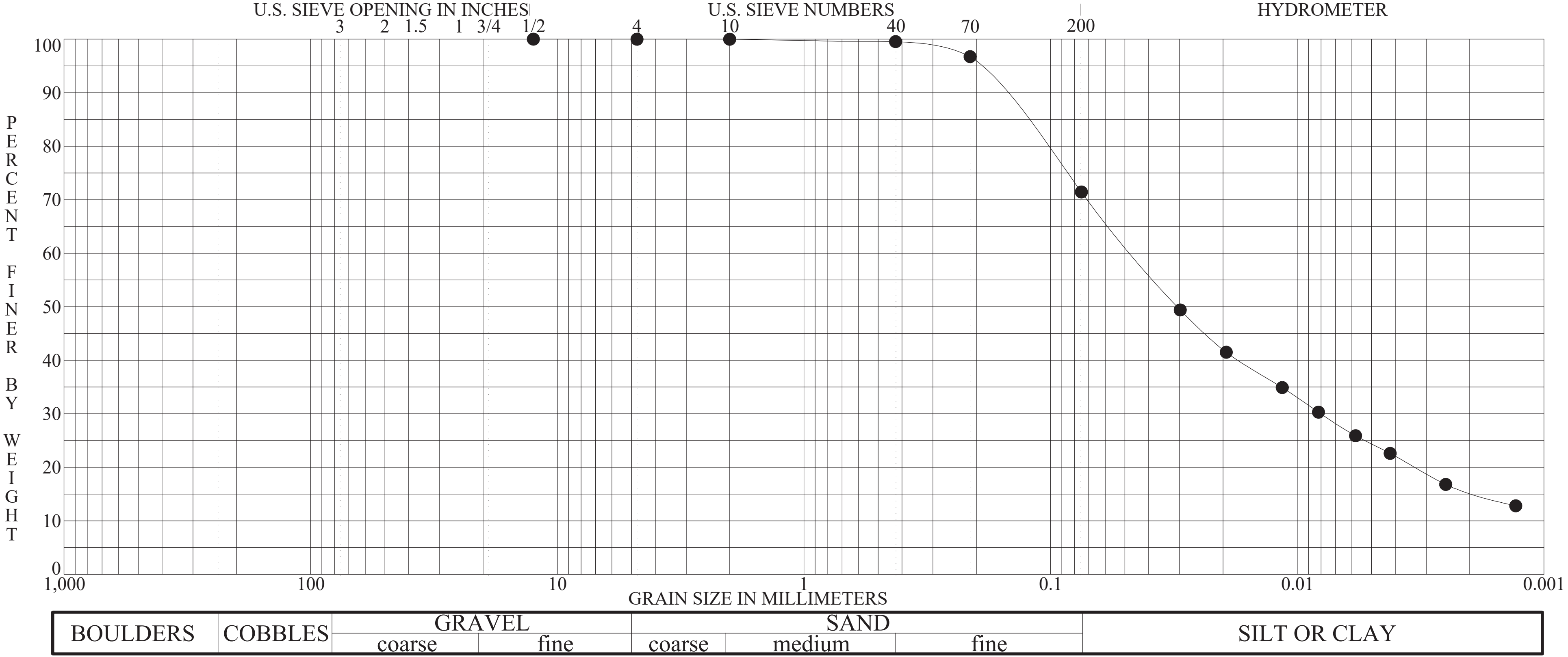
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

**PLATE 31**

BBCM



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0903 S-7 13.5' to 14.5'** | **Gray mottled with dark-gray organic silt inter-bedded with organic clayey silt, some fine sand, trace medium to coarse sand, trace fine gravel.**<br>**ORGANIC SILT with SAND OL** | **43** | **NP** | **NP** | **NP** | | |

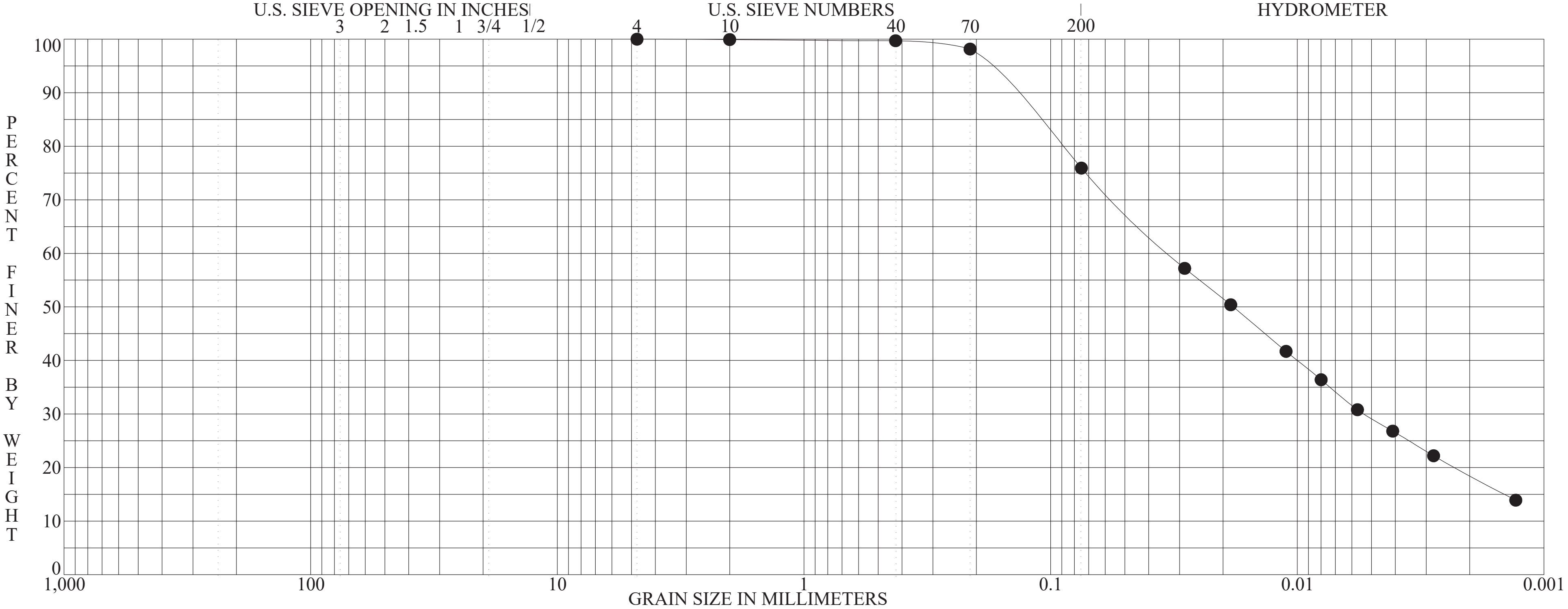
| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0903 S-7 13.5' to 14.5'** | **12.5000** | **0.1974** | **0.0464** | **0.0306** | | **0.01** | **28.55** | **56.01** | **15.44** |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM



| BOULDERS | COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|---|
| | | coarse | fine | coarse | medium | fine | |

| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0903 S-8 16.0' to 17.0'** | **Gray mottled with dark-gray organic clayey silt, some fine sand, trace medium to coarse sand, few seams of silt and fine sand.**<br>**ORGANIC CLAY with SAND OL** | **43** | **37** | **24** | **13** | | |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0903 S-8 16.0' to 17.0'** | **4.7500** | **0.1829** | **0.0330** | **0.0182** | | **0.00** | **24.07** | **57.37** | **18.56** |

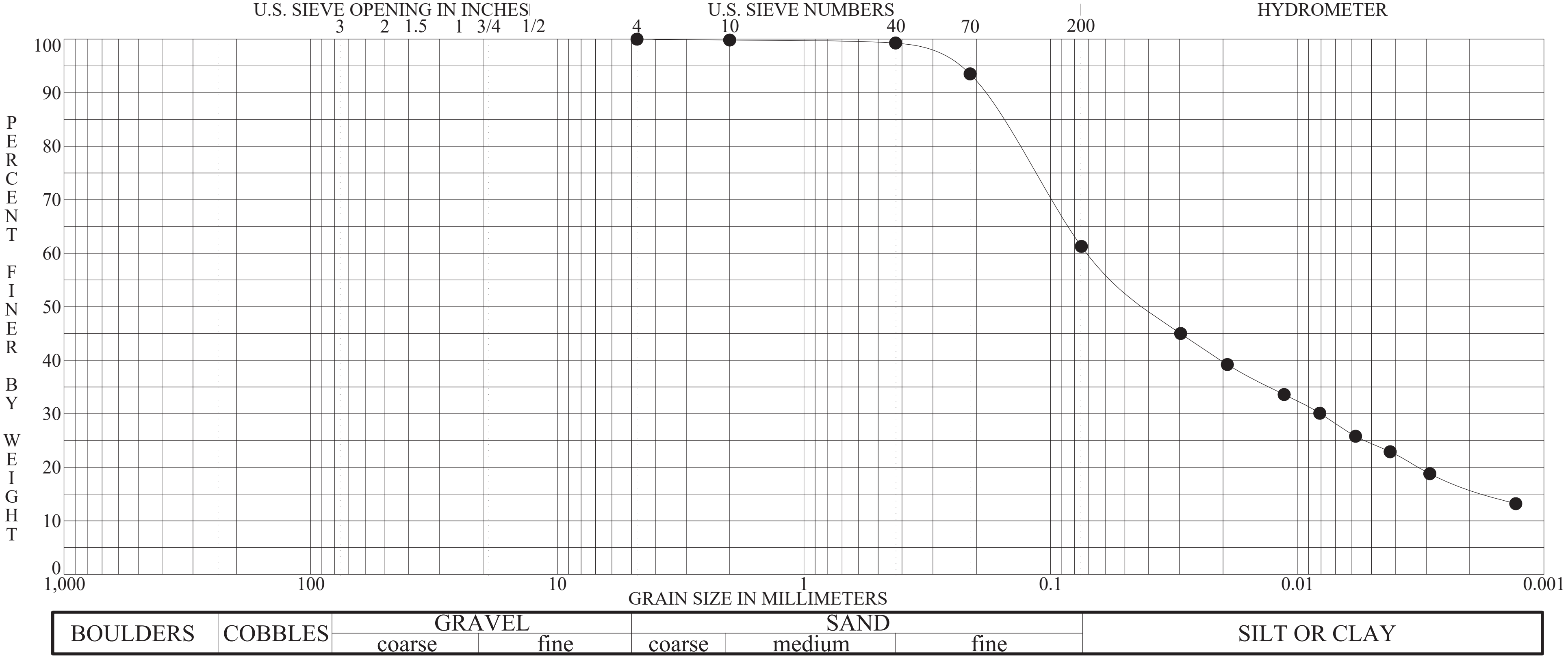
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0903 S-9 18.5' to 19.6'** | **Gray mottled with dark-gray organic clayey silt inter-bedded with organic silt, "and" fine sand, trace medium to coarse sand, few lenses of fine sand.**<br>**SANDY ORGANIC CLAY OL** | **44** | **35** | **24** | **11** | | |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0903 S-9 18.5' to 19.6'** | **4.7500** | **0.2536** | **0.0697** | **0.0395** | | **0.00** | **38.72** | **45.07** | **16.21** |

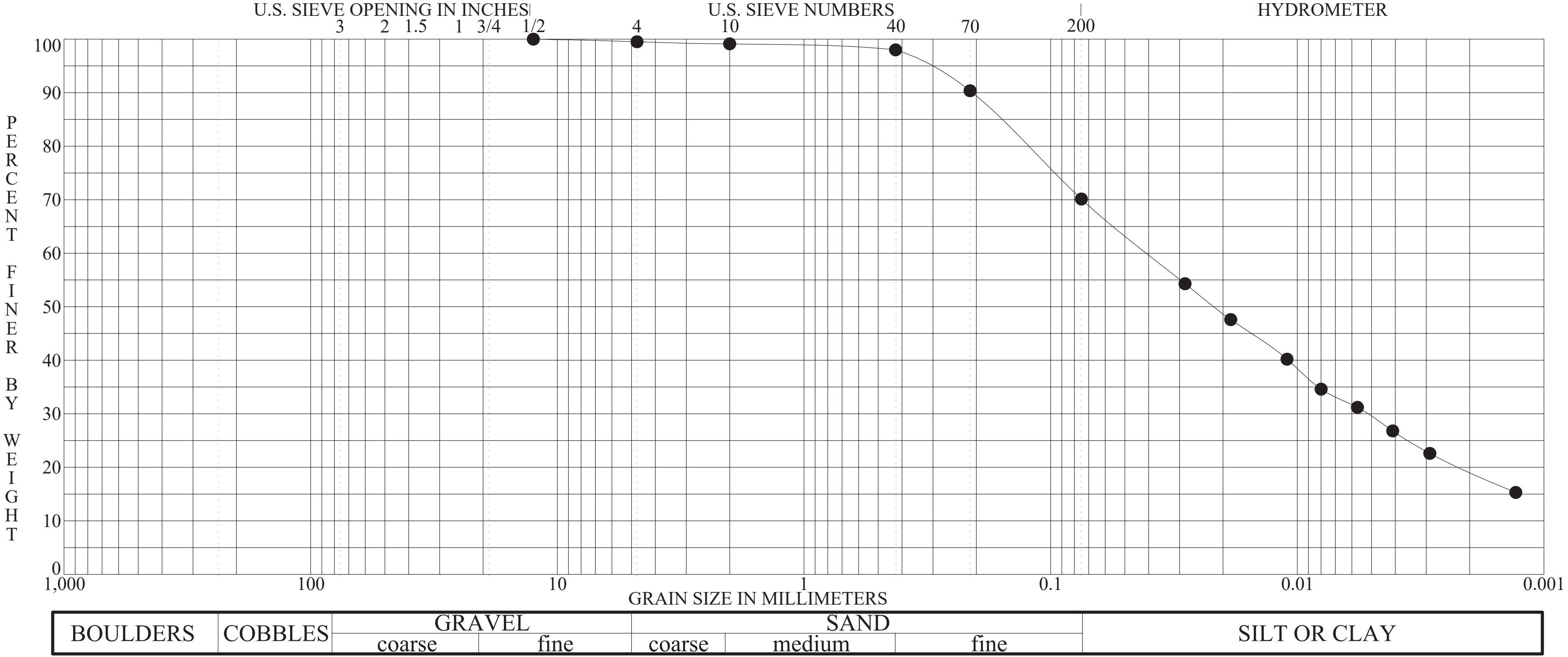
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0903 S-10 21.0' to 21.9'** | **Gray silty clay inter-bedded with silt, some fine sand, trace medium to coarse sand, trace fine gravel, few seams of fine sand.**<br>**LEAN CLAY with SAND CL** | **35** | **34** | **21** | **13** | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0903 S-10 21.0' to 21.9'** | **12.5000** | **0.3233** | **0.0404** | **0.0217** | | **0.48** | **29.39** | **50.91** | **19.22** |

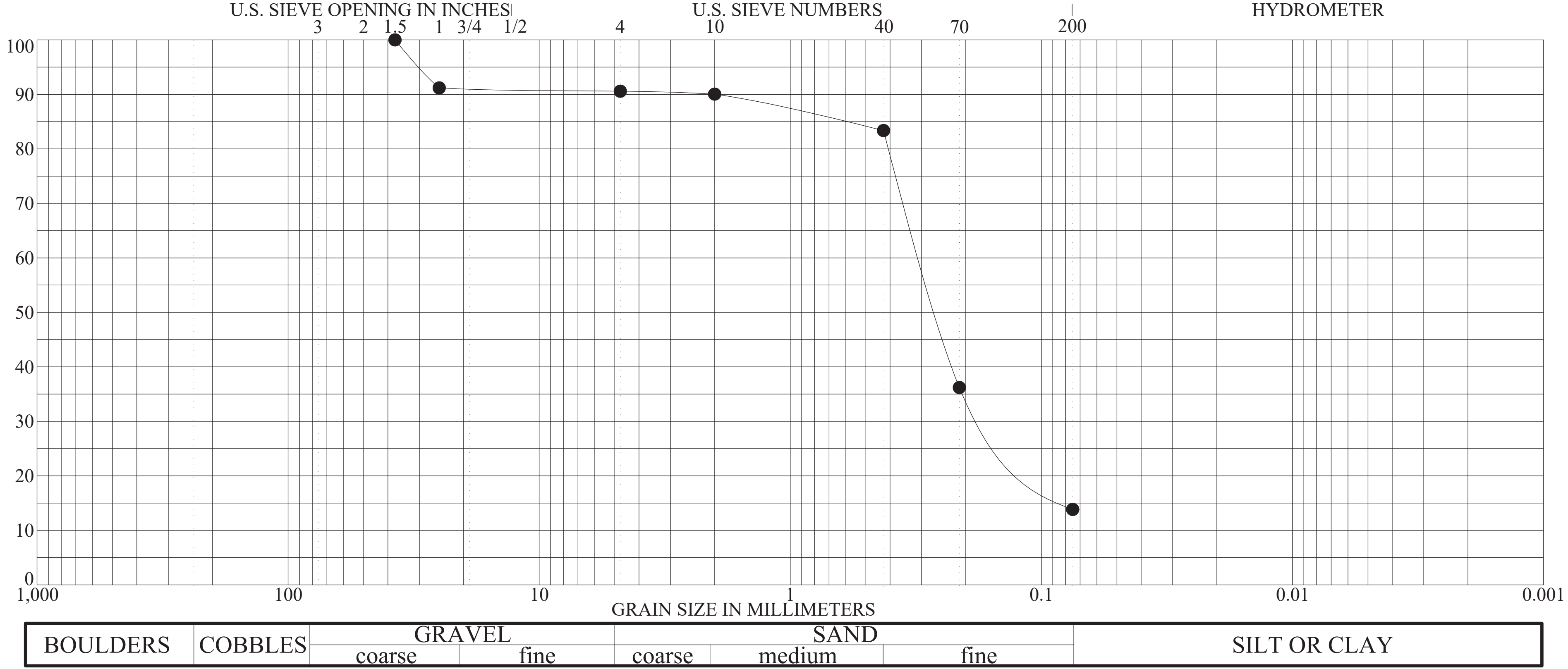
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0903 S-11 23.5' to 24.2'** | **Brown and gray fine sand, trace medium to coarse sand, trace fine to coarse gravel, little silt, few seams of silty clay.** | | | | | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0903 S-11 23.5' to 24.2'** | **37.5000** | **29.7874** | **0.3011** | **0.2598** | | **9.42** | **76.74** | **13.84** | |

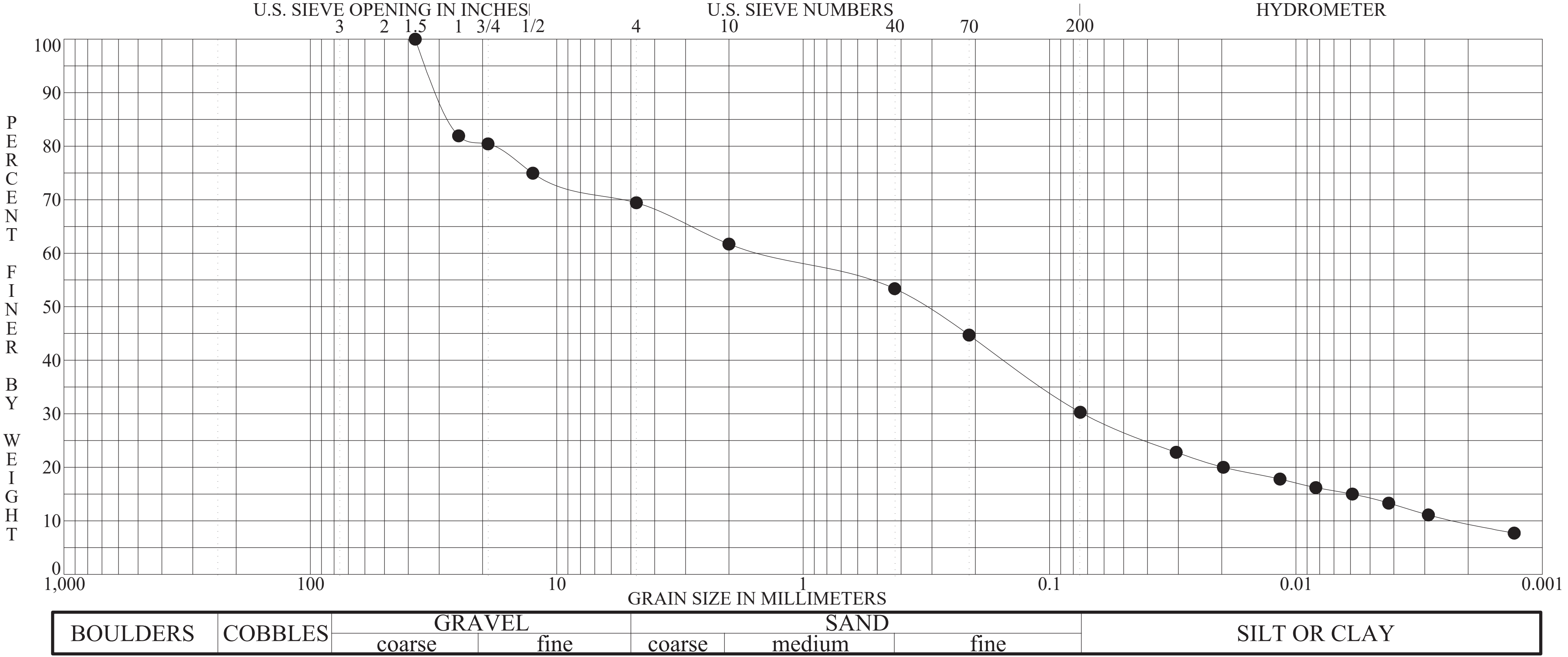
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

**PLATE 36**

GRN-EPA W/ASTM-BBCM



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-PZ-BAP-0904 S-6 8.5' to 9.7'** | **FILL: Brown and gray fine to coarse sand, some fine to coarse gravel(sandstone, siltstone and shale fragments), some clayey silt.**<br>**CLAYEY SAND with GRAVEL SC** | **14** | **25** | **16** | **9** | **1.616** | **650.322** |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-PZ-BAP-0904 S-6 8.5' to 9.7'** | **37.5000** | **33.5189** | **1.4548** | **0.3242** | **0.0022** | **30.57** | **39.15** | **20.76** | **9.53** |

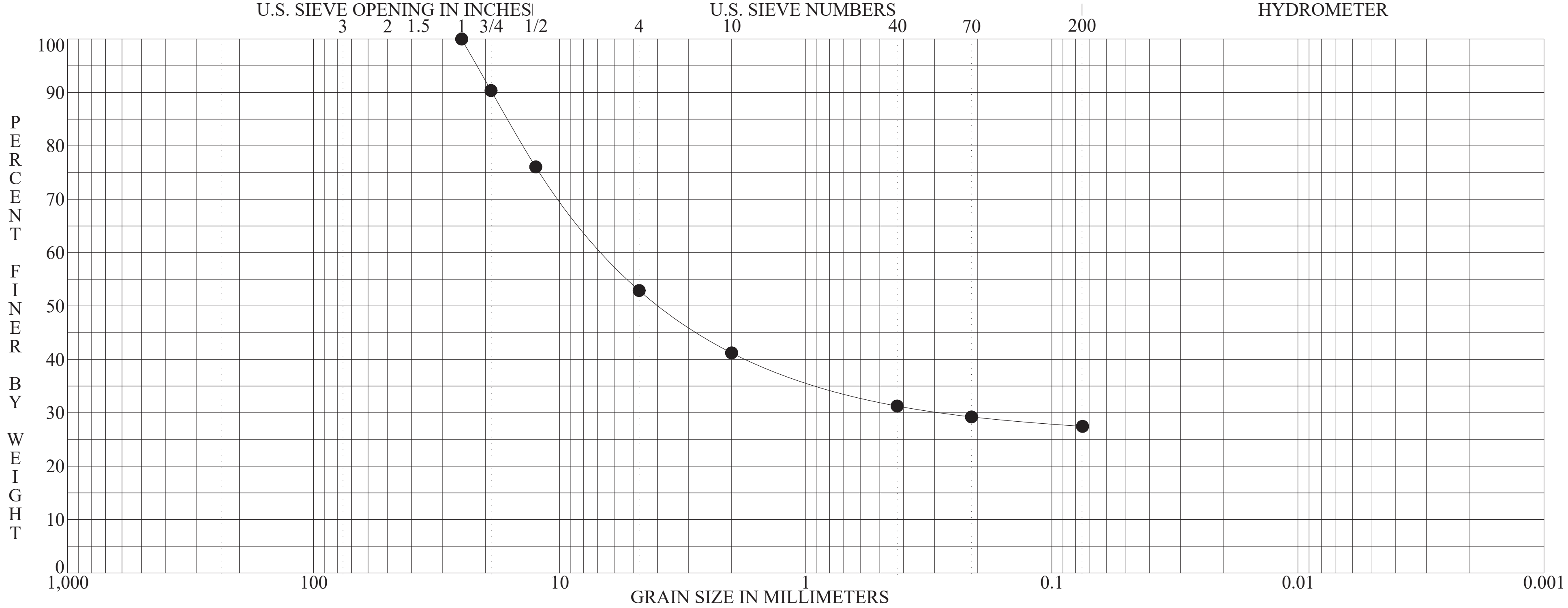
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



| BOULDERS | COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|---|
| | | coarse | fine | coarse | medium | fine | |

| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-PZ-BAP-0904 S-11 16.0' to 16.9'** | **FILL: Brown and gray fine to coarse gravel(very-soft shale fragments), some fine to coarse sand, some silty clay.** | | | | | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-PZ-BAP-0904 S-11 16.0' to 16.9'** | **25.0000** | **21.6832** | **6.3914** | **3.8325** | | **47.10** | **25.44** | **27.45** | |

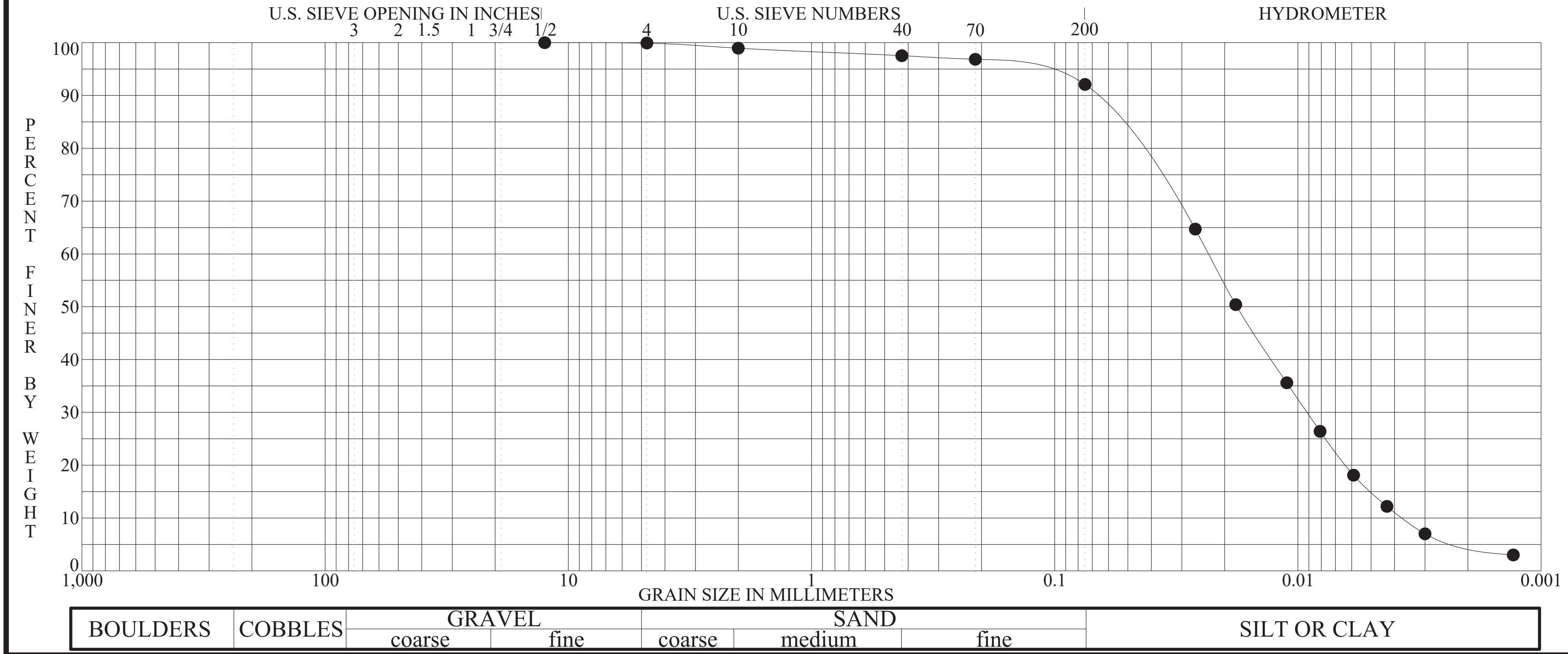
**ASTM D422**

**GRADATION CURVE**

**PROJECT** **CARDINAL PLANT ASH POND INVESTIGATION**
**LOCATION** **BRILLIANT, OHIO**
**JOB NO.** **011-11497-013** **DATE** **7/6/09**

GRN-EPA W/ASTM-BBCM

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0904 S-13 19.0' to 20.3'** | **Gray and dark-gray organic silt, trace clay, trace fine to coarse sand, trace fine gravel.** | **28** | **NP** | **NP** | **NP** | **0.977** | **6.304** |
| | **ORGANIC SILT OL** | | | | | | |

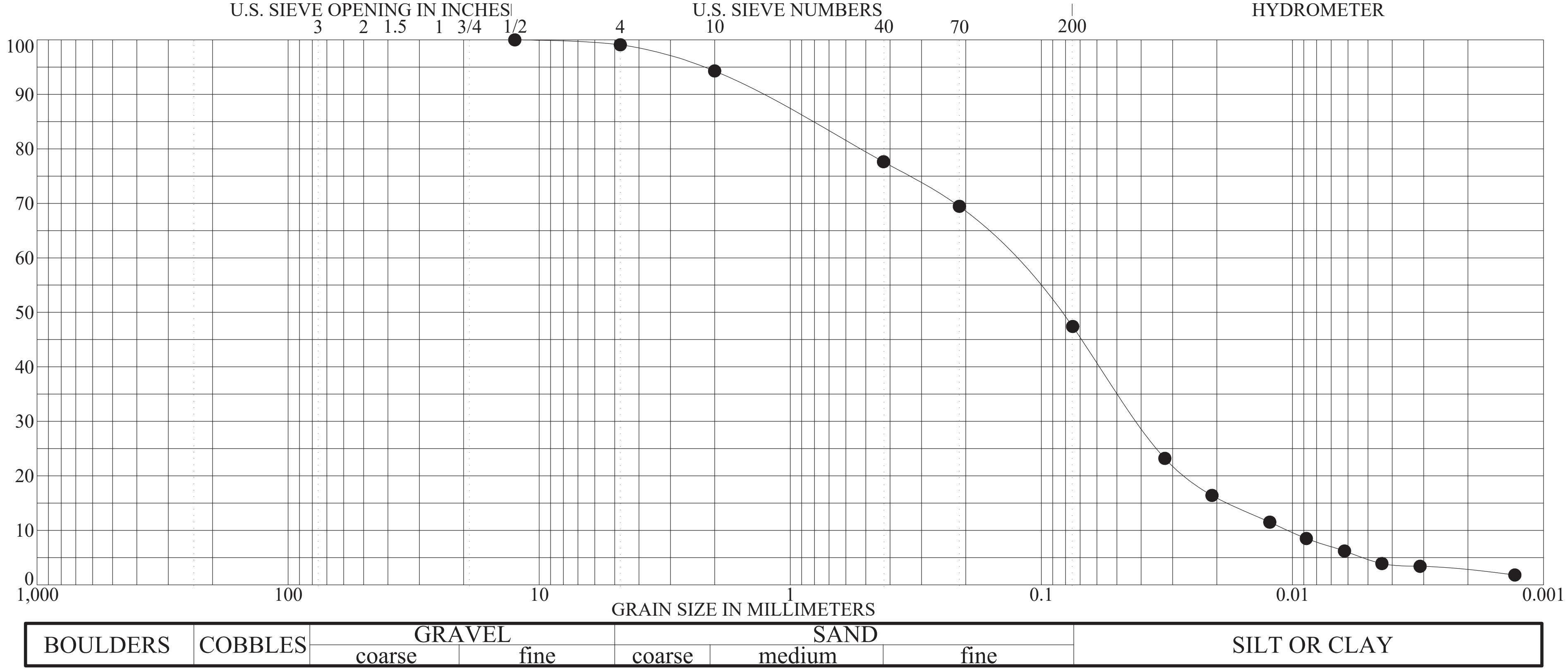
| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0904 S-13 19.0' to 20.3'** | **12.5000** | **0.1414** | **0.0233** | **0.0178** | **0.0037** | **0.06** | **7.85** | **87.03** | **5.06** |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0904 S-15 22.0' to 22.7'** | **Gray and dark-gray fine to medium sand, trace coarse sand, trace fine gravel, "and" organic silt, trace clay.**<br>**SILTY SAND SM** | **26** | **NP** | **NP** | **NP** | **1.180** | **13.048** |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0904 S-15 22.0' to 22.7'** | **12.5000** | **2.2672** | **0.1358** | **0.0847** | **0.0104** | **0.90** | **51.69** | **44.82** | **2.59** |

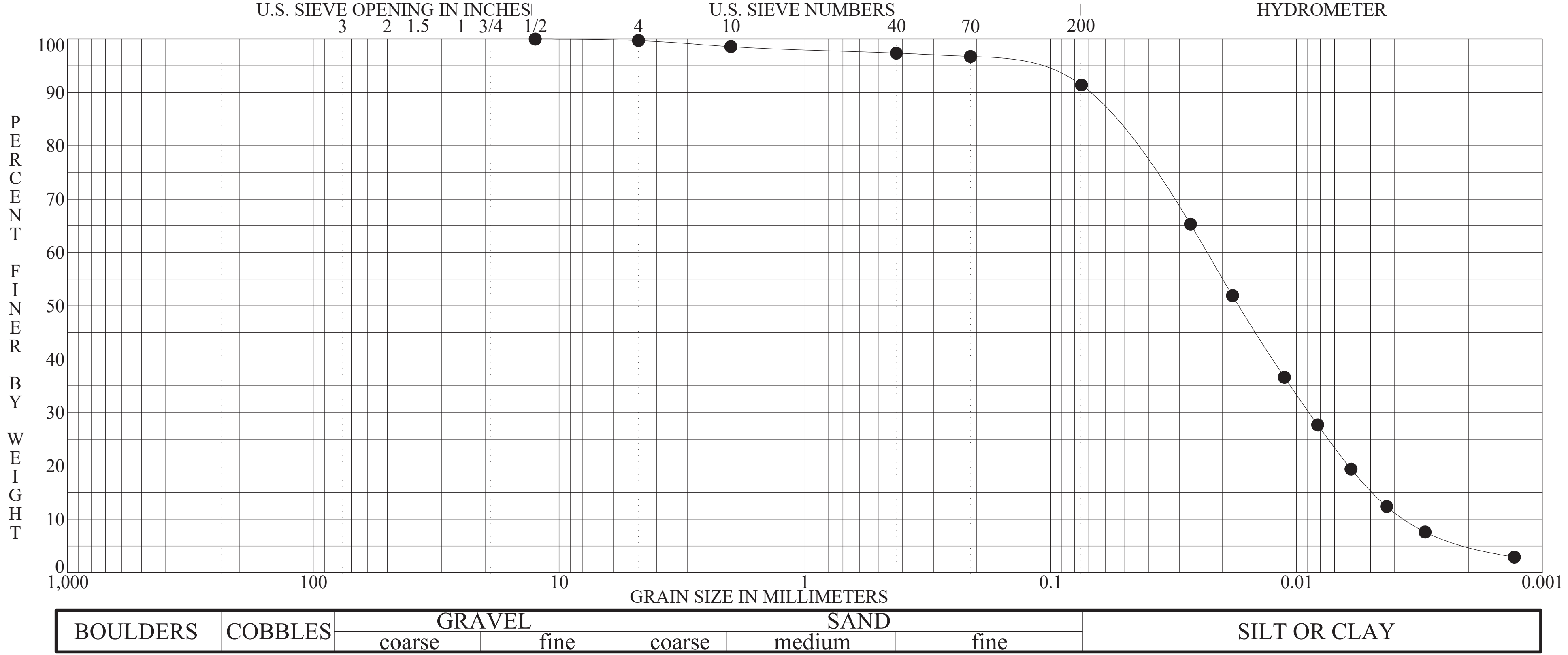
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0904 S-17 25.0' to 25.8'** | **Gray silt, trace clay, trace fine to coarse sand, trace fine gravel.**<br>**SILT ML** | **22** | **NP** | **NP** | **NP** | **0.952** | **6.432** |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0904 S-17 25.0' to 25.8'** | **12.5000** | **0.1513** | **0.0231** | **0.0171** | **0.0036** | **0.26** | **8.35** | **86.07** | **5.32** |

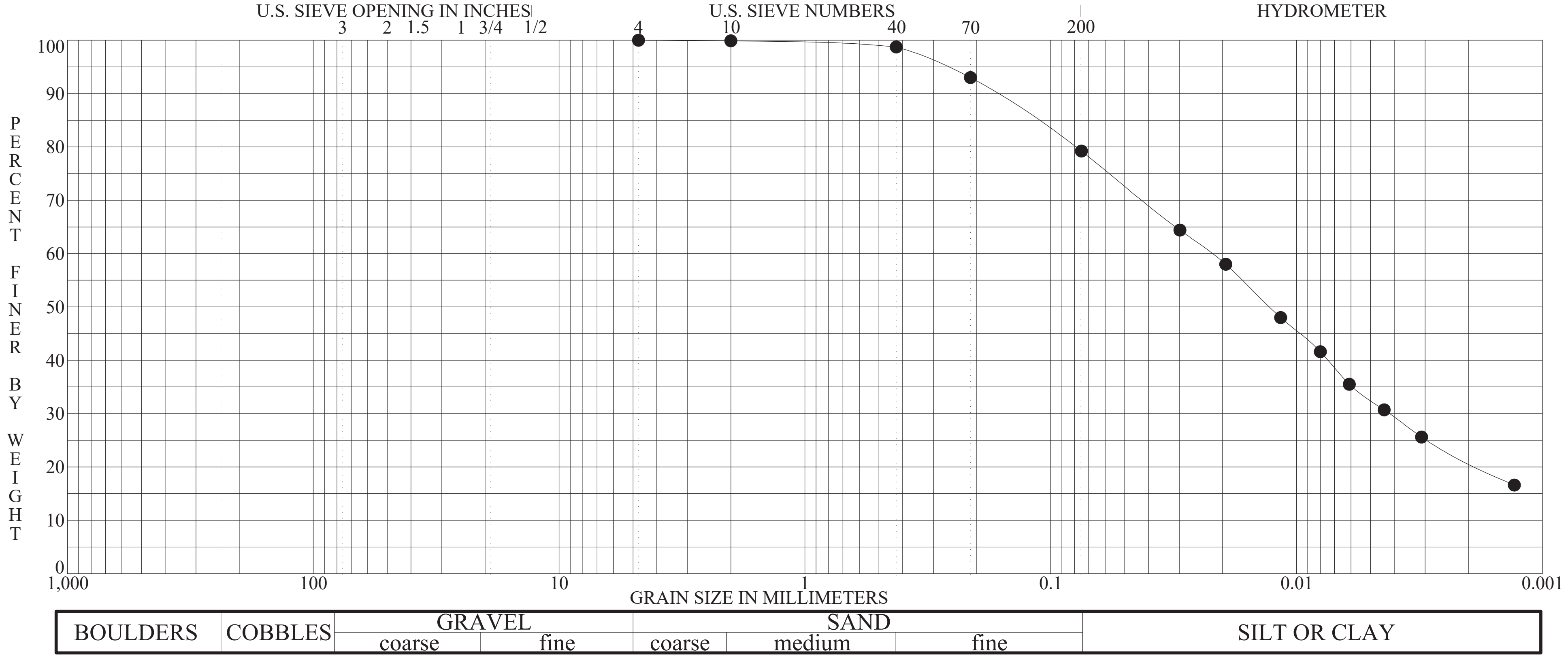
**ASTM D422**

**GRADATION CURVE**

**PROJECT** **CARDINAL PLANT ASH POND INVESTIGATION**
**LOCATION** **BRILLIANT, OHIO**
**JOB NO.** **011-11497-013** **DATE** **7/6/09**

GRN-EPA W/ASTM-BBCM

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0904 S-18 26.5' to 28.0'** | **Gray mottled with dark-gray organic clayey silt inter-bedded with organic silt, Little fine to coarse sand, trace fine gravel.**<br>**ORGANIC CLAY with SAND OL** | **38** | **38** | **24** | **14** | | |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0904 S-18 26.5' to 28.0'** | **4.7500** | **0.2701** | **0.0222** | **0.0129** | | **0.00** | **20.78** | **58.16** | **21.06** |

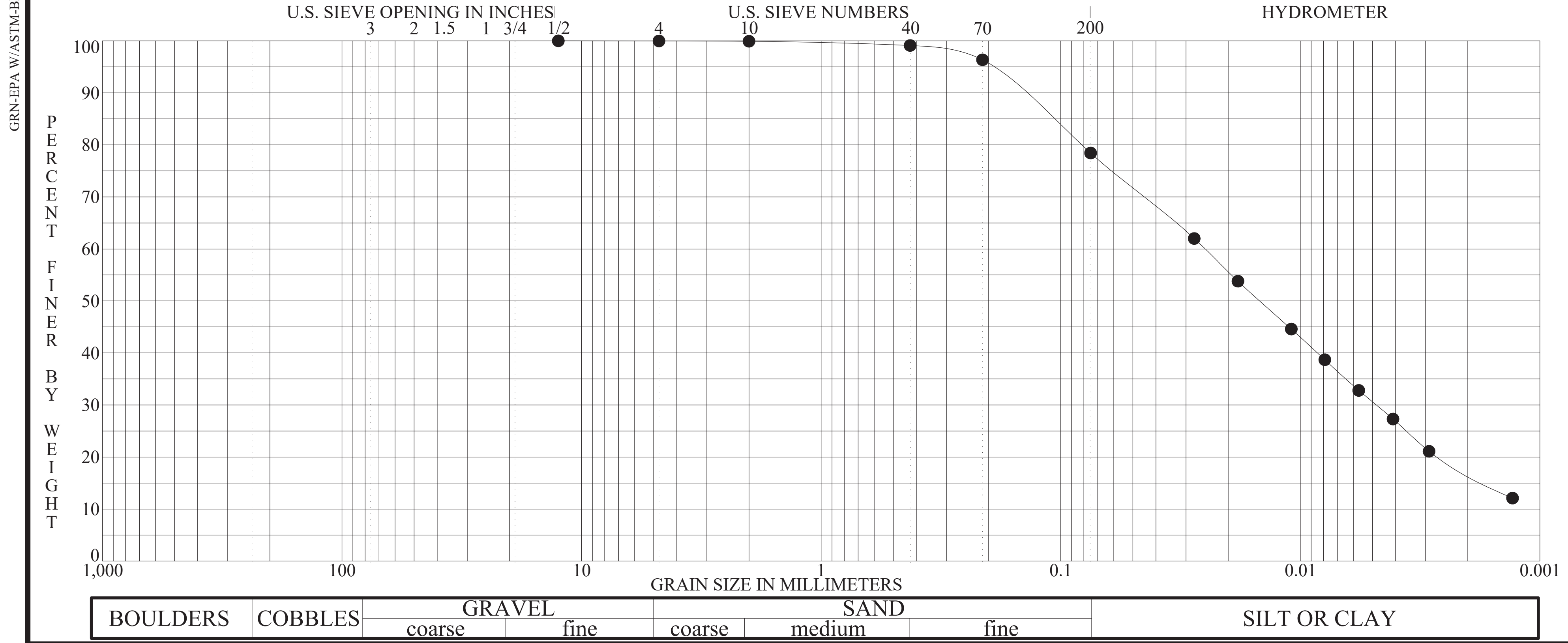
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

PLATE 42

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0904 S-19 28.0' to 29.3'** | **Gray mottled with dark-gray organic clayey silt, some fine sand, trace medium to coarse sand, trace fine gravel.**<br>**ORGANIC SILT with SAND OL** | **47** | **42** | **30** | **12** | | |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0904 S-19 28.0' to 29.3'** | **12.5000** | **0.1959** | **0.0250** | **0.0147** | | **0.03** | **21.53** | **61.51** | **16.93** |

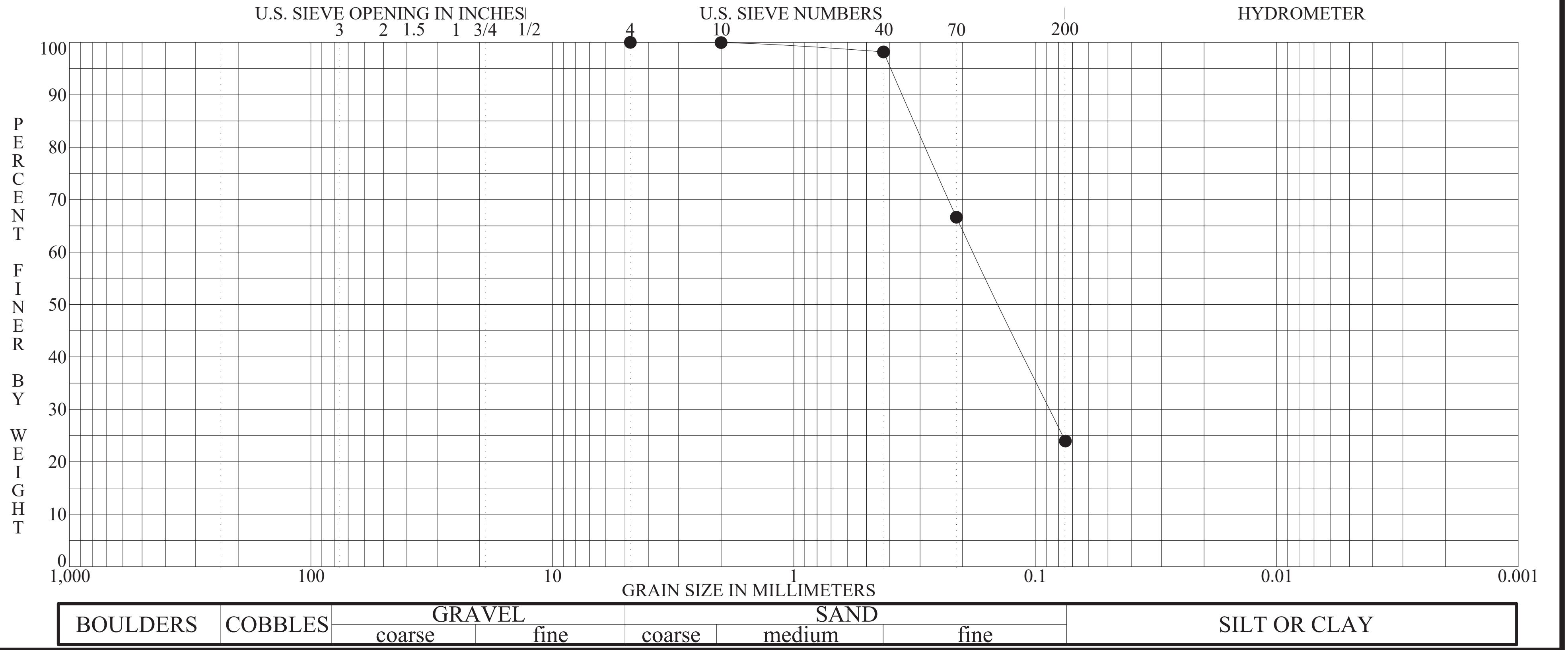
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

**BBCM**



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-PZ-BAP-0904 S-21 36.0' to 37.4'** | **Brown and gray fine sand, trace medium to coarse sand, some silt.** | | | | | | |

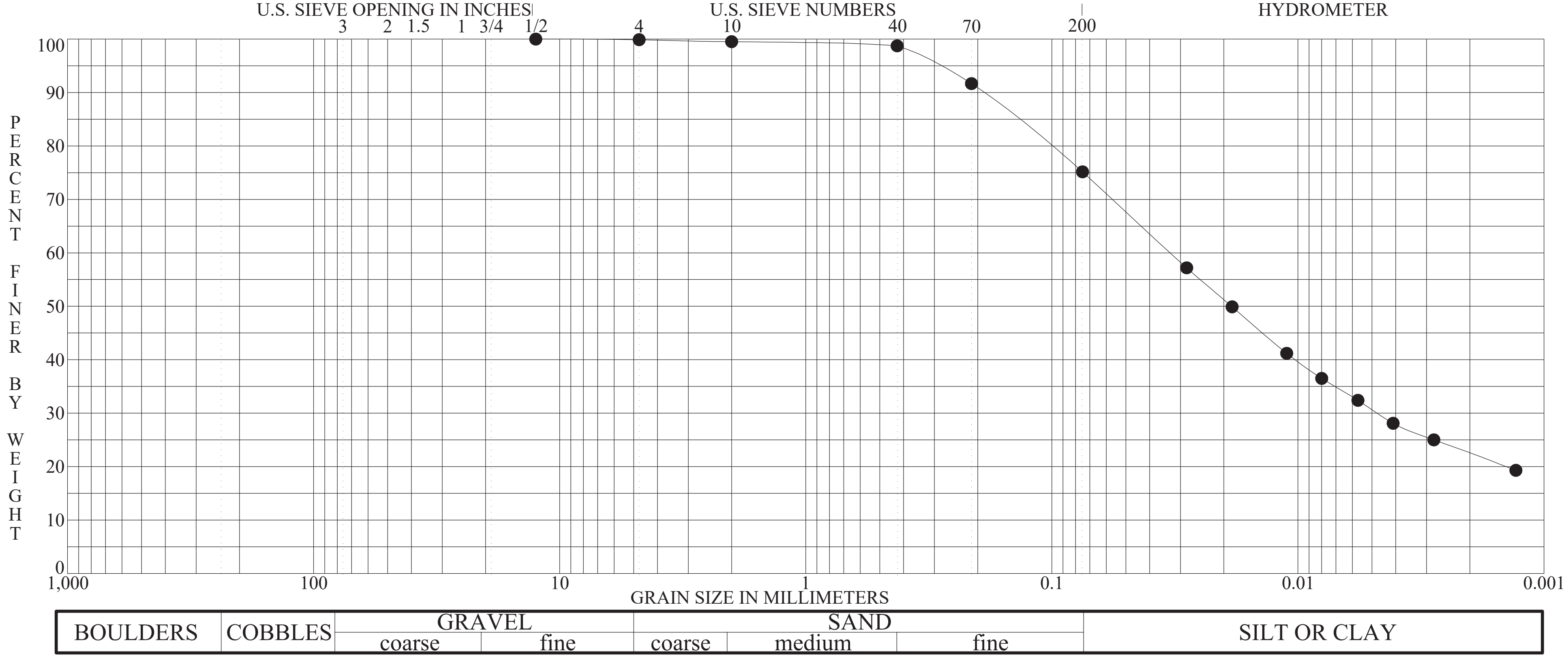
| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-PZ-BAP-0904 S-21 36.0' to 37.4'** | **4.7500** | **0.3963** | **0.1804** | **0.1414** | | **0.00** | **76.04** | **23.96** | |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0905 S-3 4.0' to 5.5'** | **FILL: Brown mottled with gray silty clay, some fine sand, trace medium to coarse sand, trace fine gravel.**<br>**LEAN CLAY with SAND CL** | **17** | **32** | **18** | **14** | | |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0905 S-3 4.0' to 5.5'** | **12.5000** | **0.2941** | **0.0329** | **0.0186** | | **0.10** | **24.74** | **52.66** | **22.50** |

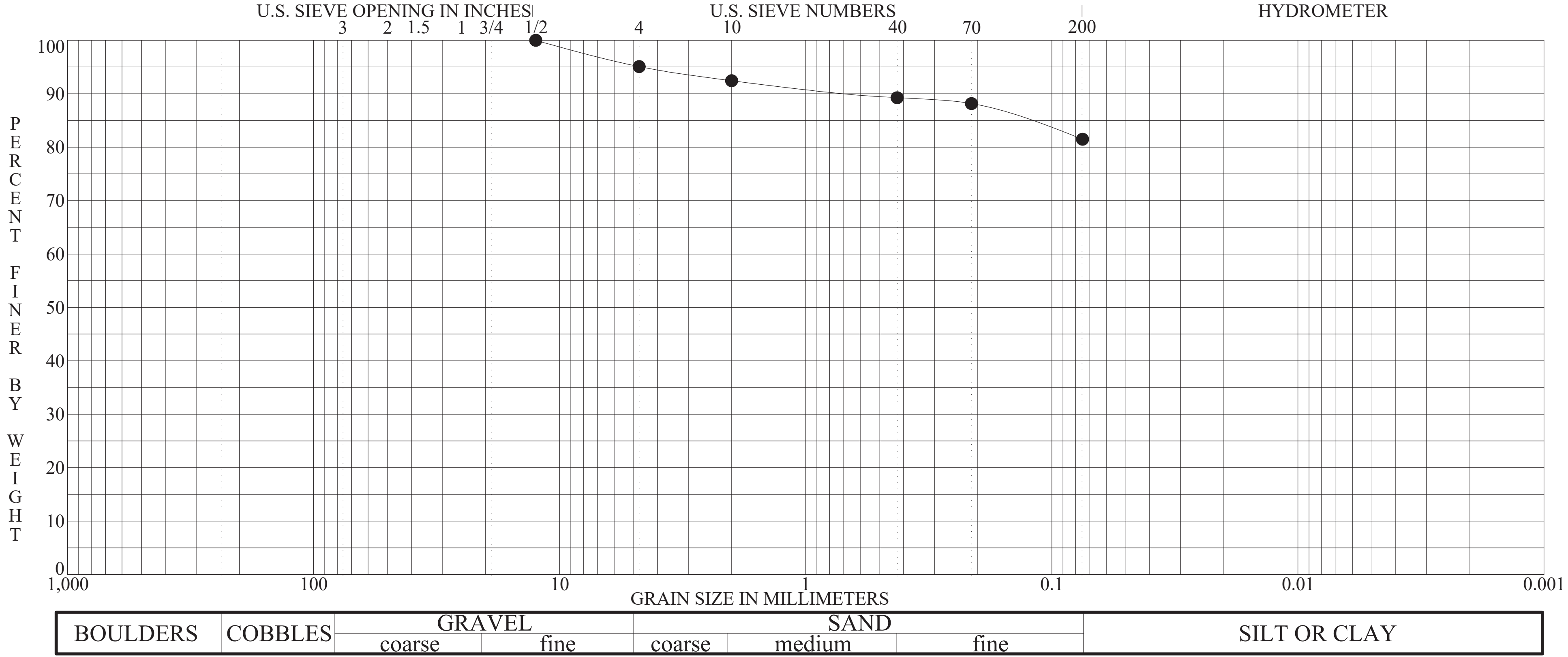
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

PLATE 45

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0905 S-6B 9.7' to 10.0'** | **FILL: Brown mottled with gray silty clay inter-bedded with dark-gray organic silt, little fine to coarse sand, trace fine gravel.** | **33** | | | | | |

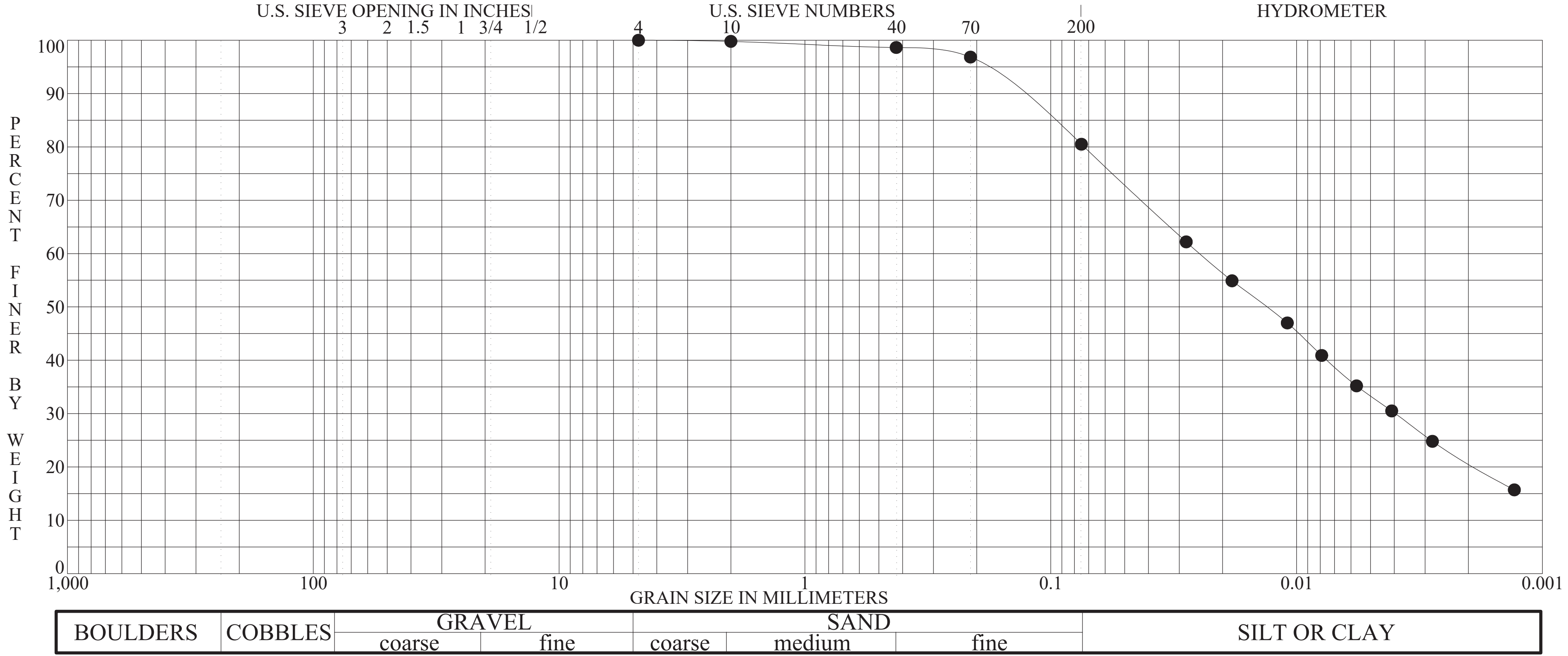
| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0905 S-6B 9.7' to 10.0'** | **12.5000** | **4.6215** | | | | **4.92** | **13.60** | **81.48** | |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0905 S-8 13.5' to 15.0'** | **Gray mottled with dark-gray organic clayey silt, little fine sand, trace medium to coarse sand.**<br>**ORGANIC SILT with SAND OL** | **45** | **43** | **27** | **16** | | |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0905 S-8 13.5' to 15.0'** | **4.7500** | **0.1885** | **0.0247** | **0.0133** | | **0.00** | **19.49** | **59.70** | **20.81** |

**ASTM D422**

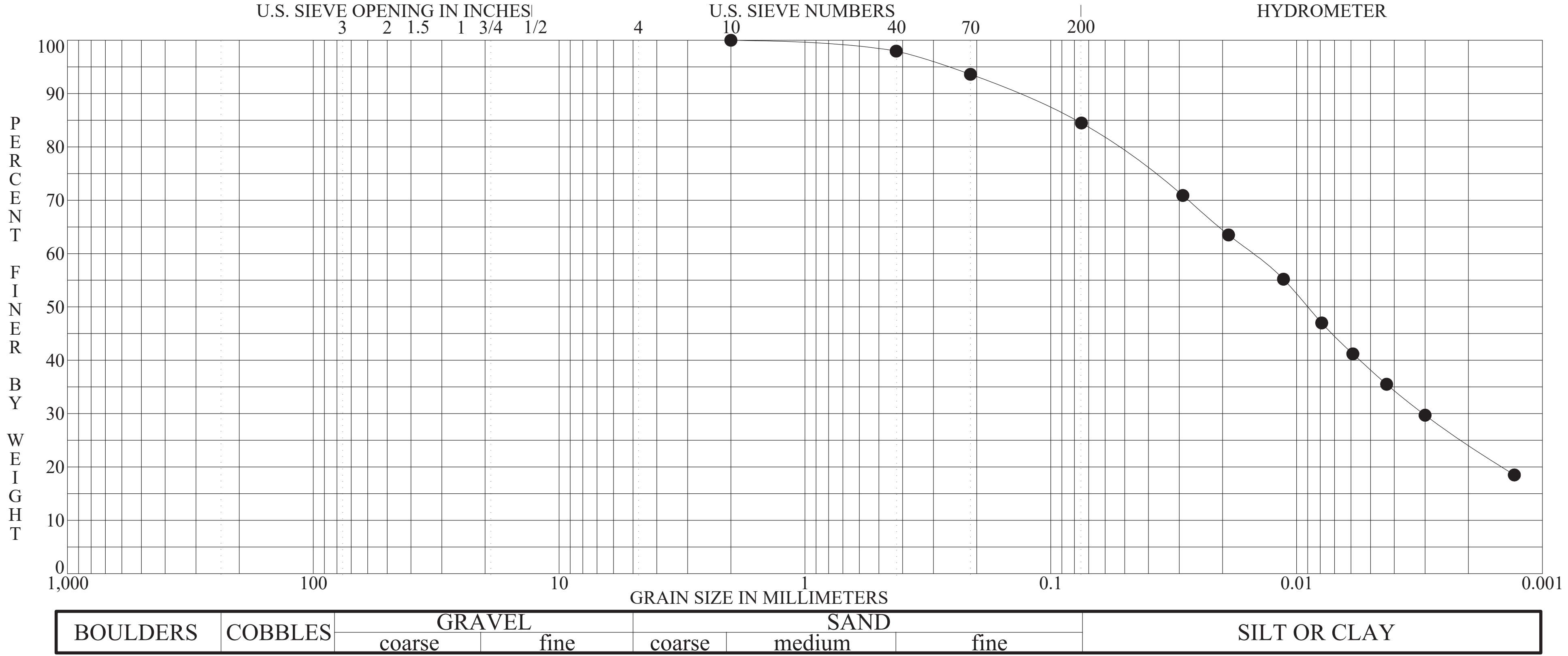
**GRADATION CURVE**

**PROJECT** **CARDINAL PLANT ASH POND INVESTIGATION**
**LOCATION** **BRILLIANT, OHIO**
**JOB NO.** **011-11497-013** **DATE** **7/6/09**

**PLATE 47**

GRN-EPA W/ASTM-BBCM

BBCM



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-PZ-BAP-0905 S-9 16.0' to 17.5'** | **Gray mottled with dark-gray organic clayey silt, little fine to medium sand.** | **42** | **40** | **25** | **15** | | |
| | | **ORGANIC CLAY with SAND OL** | | | | | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-PZ-BAP-0905 S-9 16.0' to 17.5'** | **2.0000** | **0.2645** | **0.0152** | **0.0090** | | **0.00** | **15.51** | **60.22** | **24.27** |

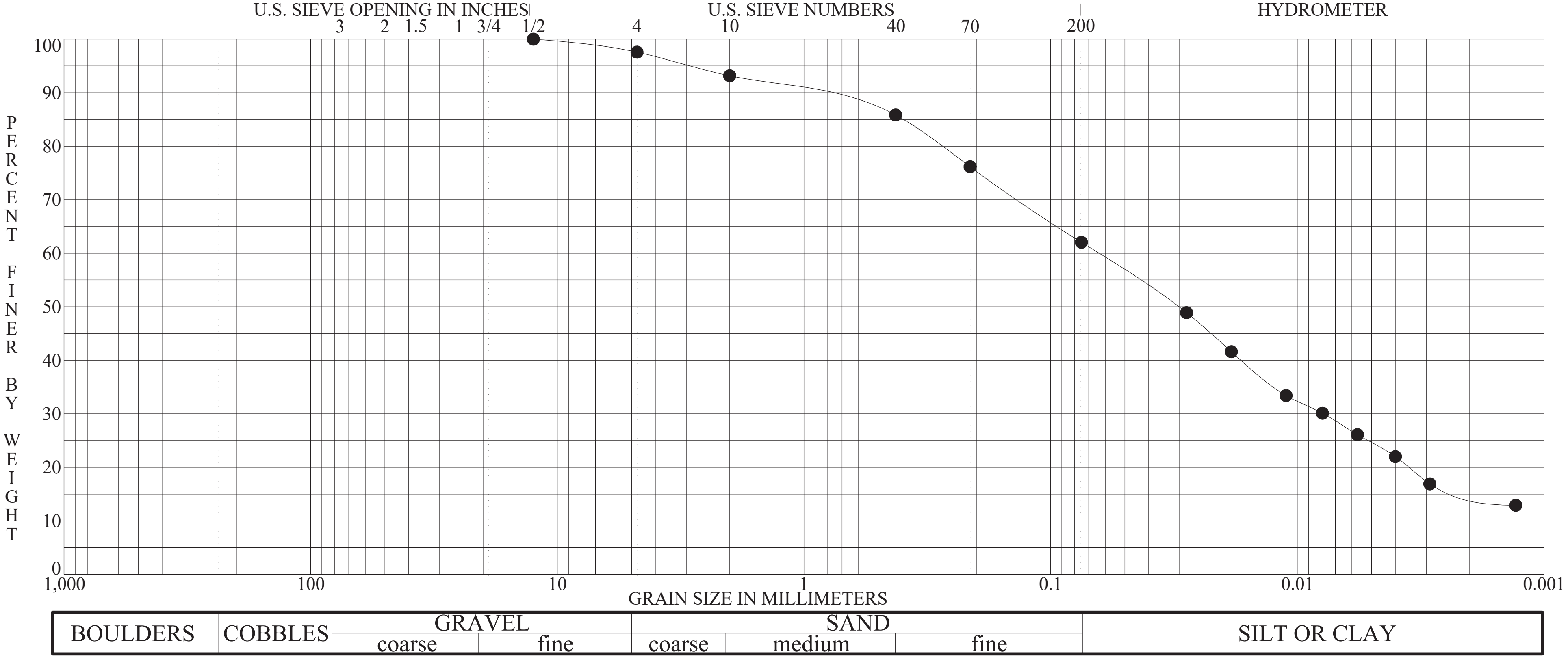
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0905 S-11 21.0' to 21.4'** | **Gray mottled with brown silty clay, some fine to medium sand, trace coarse sand, trace fine gravel, few seams of fine to medium sand.**<br>**SANDY LEAN CLAY CL** | **38** | **38** | **23** | **15** | | |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-PZ-BAP-0905 S-11 21.0' to 21.4'** | **12.5000** | **2.8652** | **0.0644** | **0.0305** | | **2.41** | **35.54** | **47.00** | **15.05** |

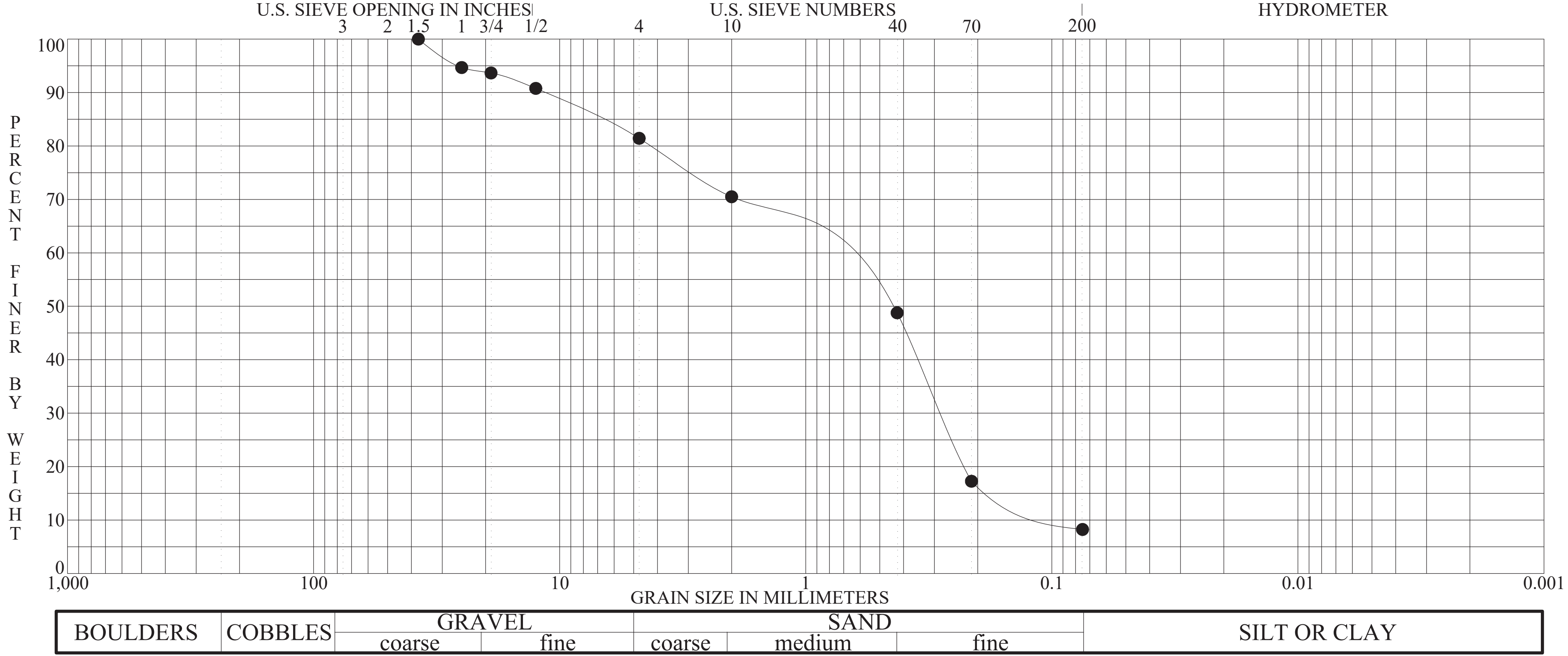
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

**PLATE 49**

BBCM



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-PZ-BAP-0905 S-13 26.0' to 27.0'** | **Brown and gray fine to coarse sand, little fine gravel, trace silt.** | | | | | **0.907** | **10.293** |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-PZ-BAP-0905 S-13 26.0' to 27.0'** | **37.5000** | **25.6140** | **0.9461** | **0.4637** | **0.0919** | **18.56** | **73.20** | **8.23** | |

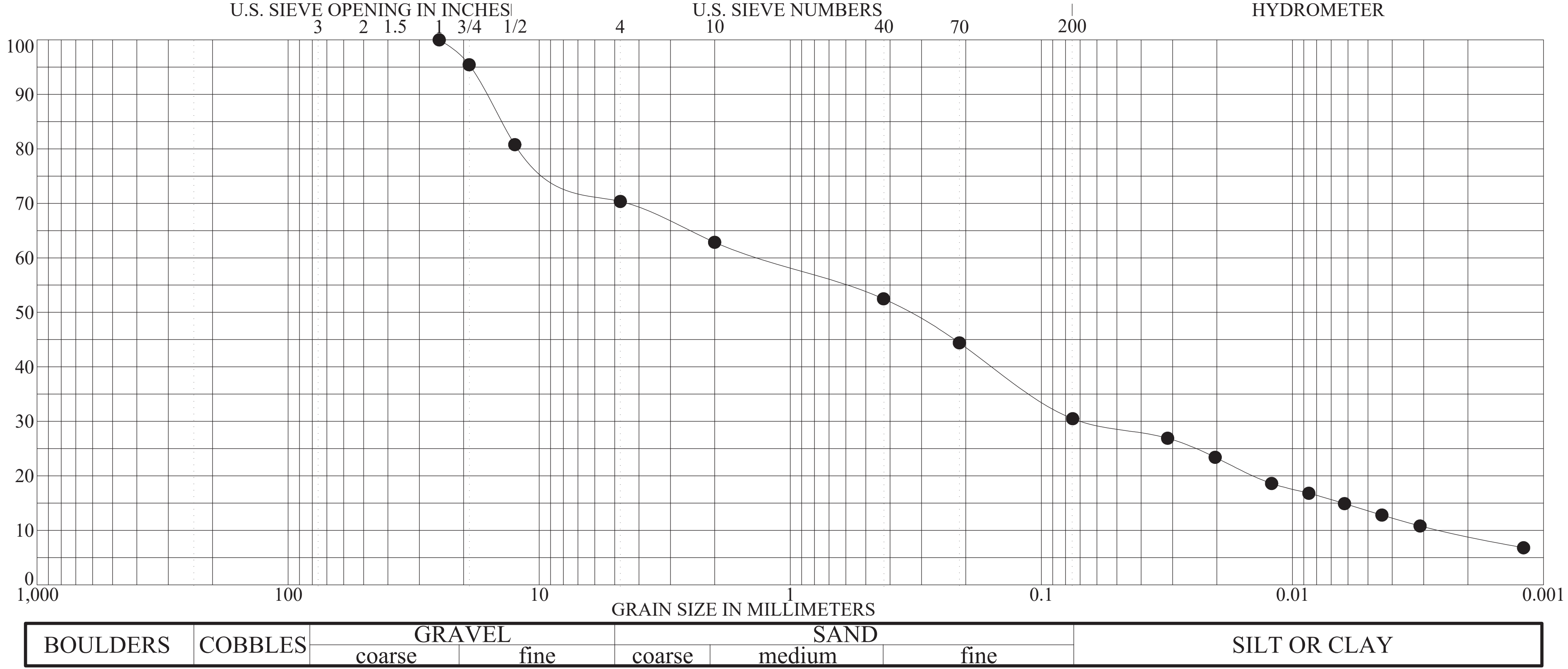
**ASTM D422**

**GRADATION CURVE**

**PROJECT** **CARDINAL PLANT ASH POND INVESTIGATION**
**LOCATION** **BRILLIANT, OHIO**
**JOB NO.** **011-11497-013** **DATE** **7/6/09**

GRN-EPA W/ASTM-BBCM

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0906 S-8 12.0' to 13.0'** | **FILL: Gray and brown fine to coarse sand, some fine to coarse gravel(sandstone fragments), some silty clay.** | | | | | **1.328** | **509.008** |

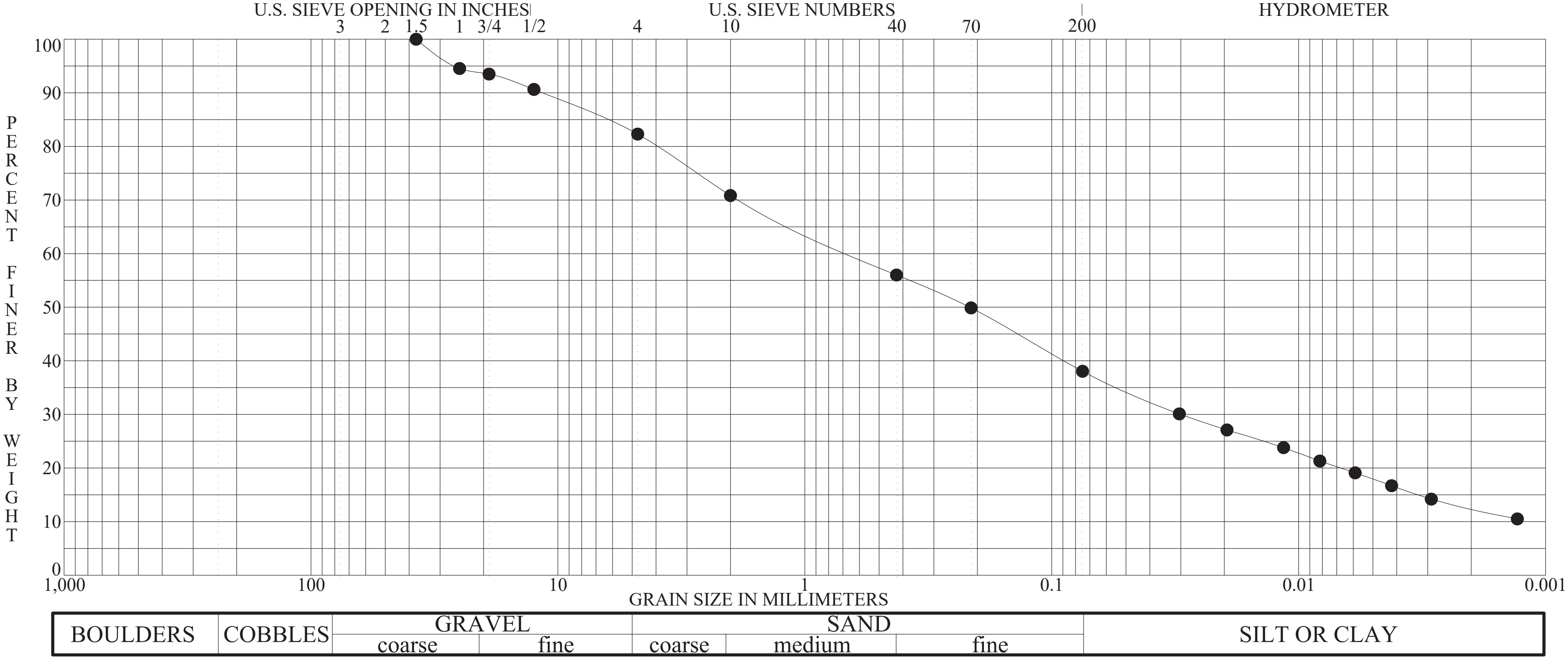
| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0906 S-8 12.0' to 13.0'** | **25.0000** | **18.7626** | **1.3051** | **0.3431** | **0.0026** | **29.65** | **39.87** | **21.53** | **8.95** |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

**PLATE 51**



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0906 S-11 16.5' to 17.3'** | **FILL: Brown fine to coarse sand, little fine to coarse gravel, "and" silty clay.**<br>**CLAYEY SAND with GRAVEL SC** | **14** | **31** | **19** | **12** | | |

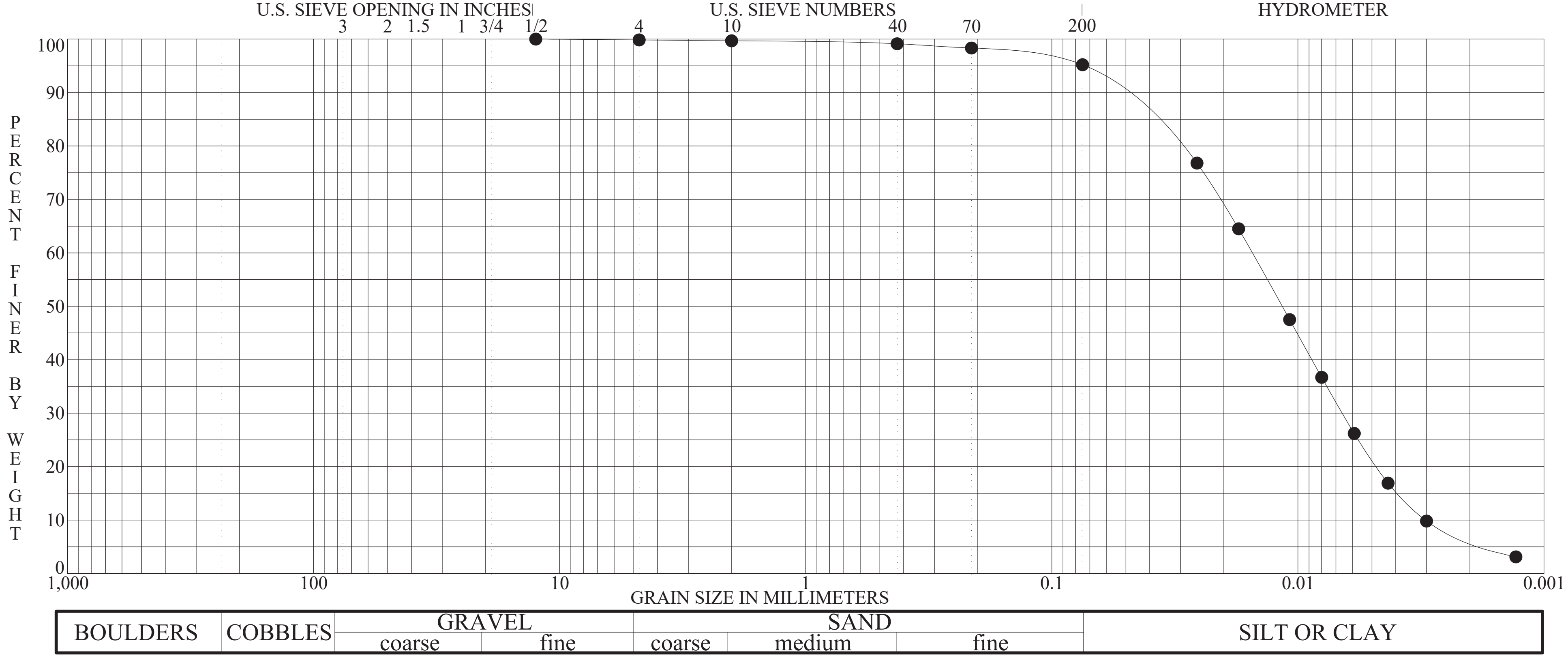
| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0906 S-11 16.5' to 17.3'** | **37.5000** | **25.8719** | **0.6448** | **0.2152** | | **17.70** | **44.25** | **25.56** | **12.49** |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** **CARDINAL PLANT ASH POND INVESTIGATION**
**LOCATION** **BRILLIANT, OHIO**
**JOB NO.** **011-11497-013** **DATE** **7/6/09**

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0906 S-15 24.0' to 25.0'** | **Gray silt, trace clay, trace fine to coarse sand, trace fine gravel.**<br>**SILT ML** | **31** | **NP** | **NP** | **NP** | **0.934** | **5.061** |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0906 S-15 24.0' to 25.0'** | **12.5000** | **0.0741** | **0.0153** | **0.0116** | **0.0030** | **0.15** | **4.64** | **88.66** | **6.55** |

**ASTM D422**

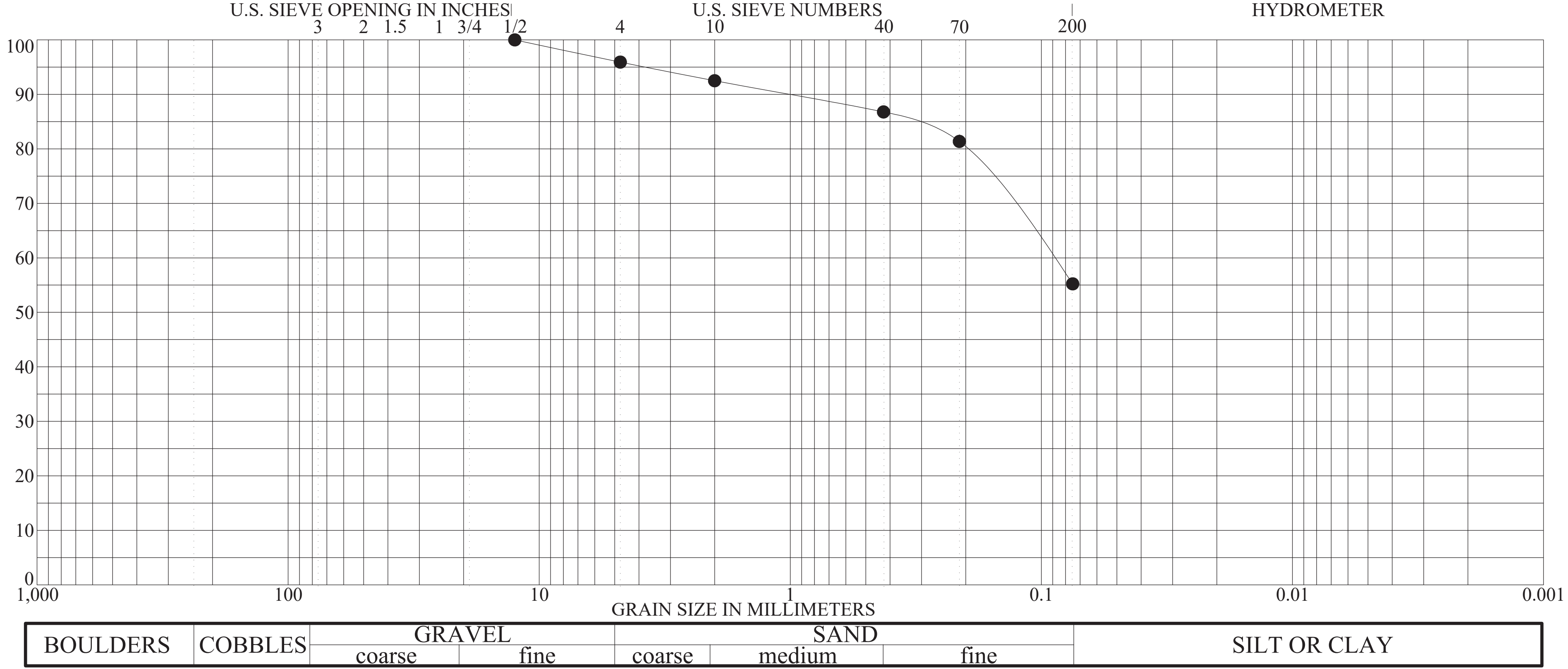
**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

GRN-EPA W/ASTM-BBCM

BBCM



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0906 S-16 25.5' to 26.5'** | **Gray silt, some fine sand, trace medium to coarse sand, trace fine gravel.** | | | | | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0906 S-16 25.5' to 26.5'** | **12.5000** | **3.7584** | **0.0907** | | | **4.08** | **40.69** | **55.23** | |

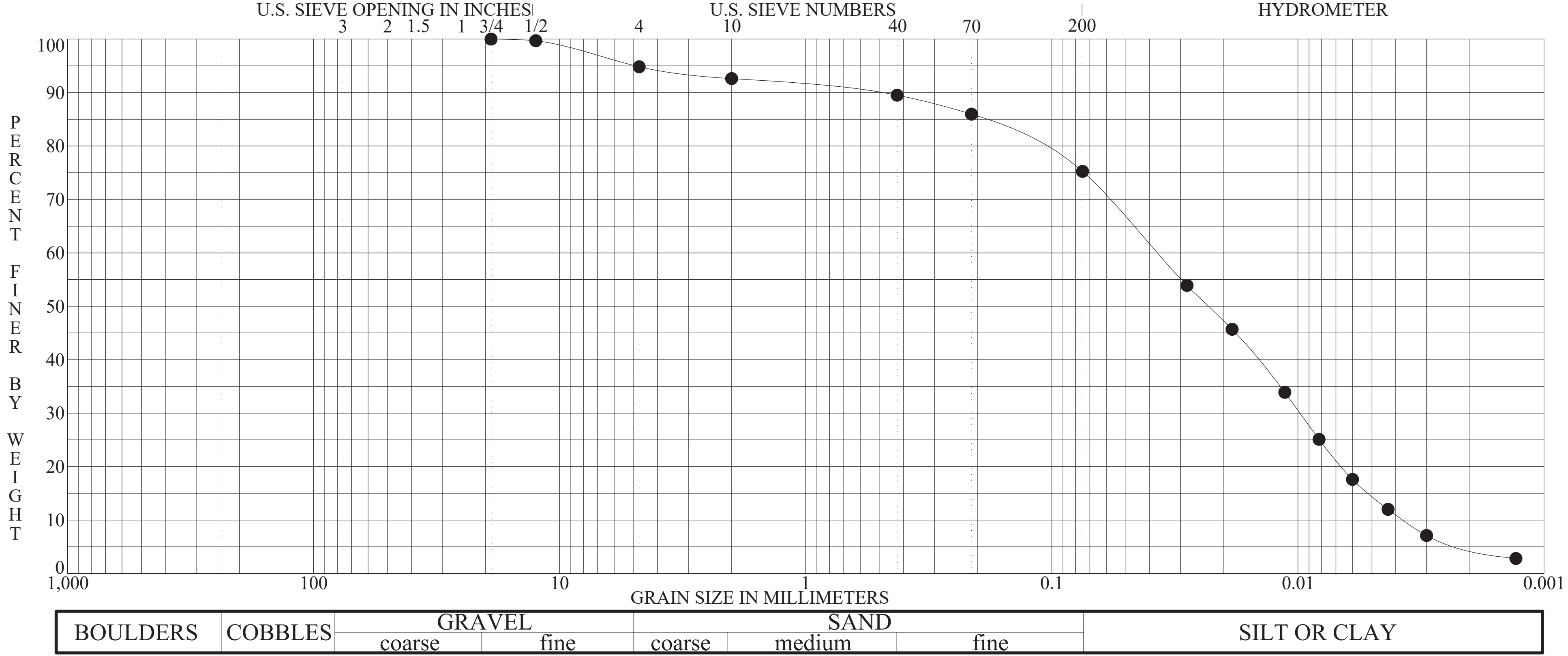
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0906 S-17 27.0' to 28.2'** | **Graybrown silt, trace clay, little fine to coarse sand, trace fine gravel** | **22** | **NP** | **NP** | **NP** | **0.694** | **10.046** |
| | | **SILT with SAND ML** | | | | | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0906 S-17 27.0' to 28.2'** | **19.0000** | **4.9211** | **0.0373** | **0.0231** | **0.0037** | **5.18** | **19.58** | **70.23** | **5.02** |

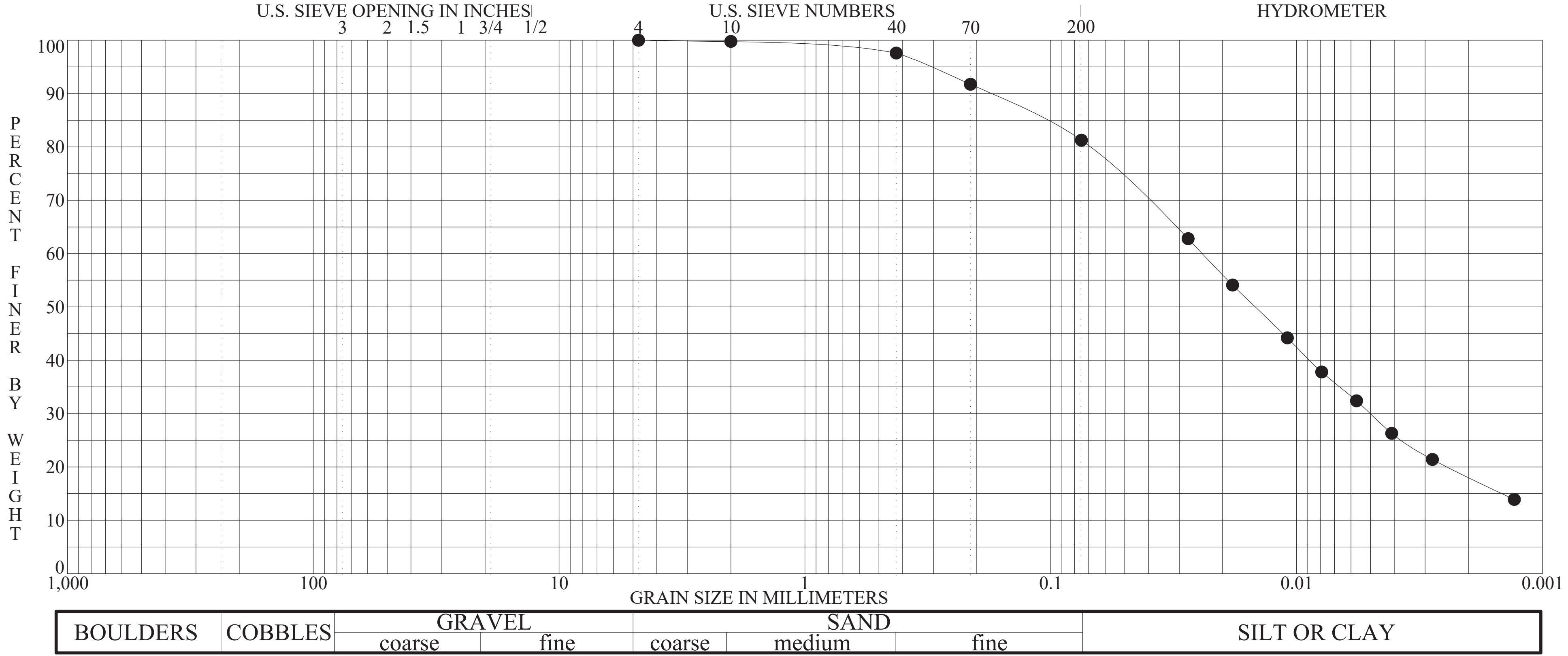
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0906 S-19 31.0' to 32.0'** | **Dark-gray organic clayey silt, little fine sand, trace medium to coarse sand inter-bedded with silt and silty clay.**<br>**ORGANIC CLAY with SAND OL** | **34** | **33** | **22** | **11** | | |

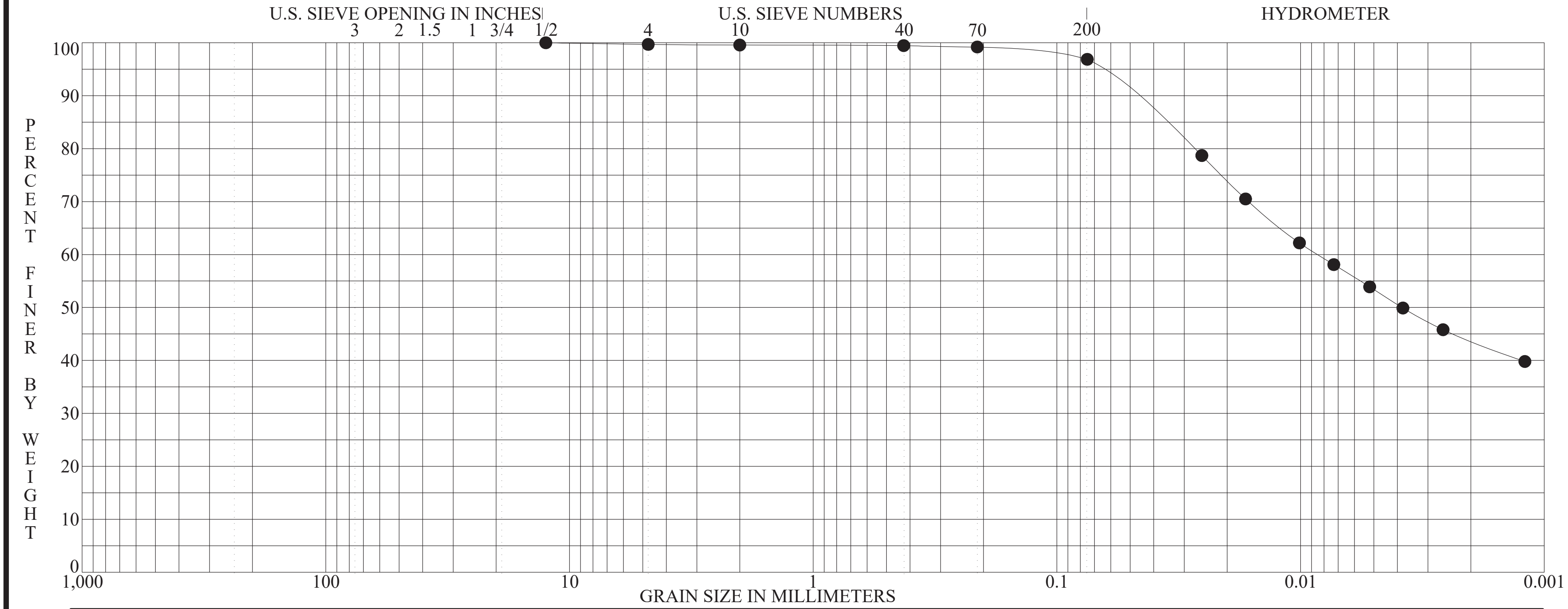
| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0906 S-19 31.0' to 32.0'** | **4.7500** | **0.3120** | **0.0241** | **0.0147** | | **0.00** | **18.75** | **63.14** | **18.11** |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM



| BOULDERS | COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|---|
| | | coarse | fine | coarse | medium | fine | |

| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0906 S-20 33.5' to 34.4'** | **Gray organic clayey silt, trace fine to coarse sand, trace fine gravel.**<br>**ORGANIC SILT OH** | **43** | **50** | **30** | **20** | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0906 S-20 33.5' to 34.4'** | **12.5000** | **0.0671** | **0.0085** | **0.0038** | | **0.30** | **2.82** | **53.11** | **43.76** |

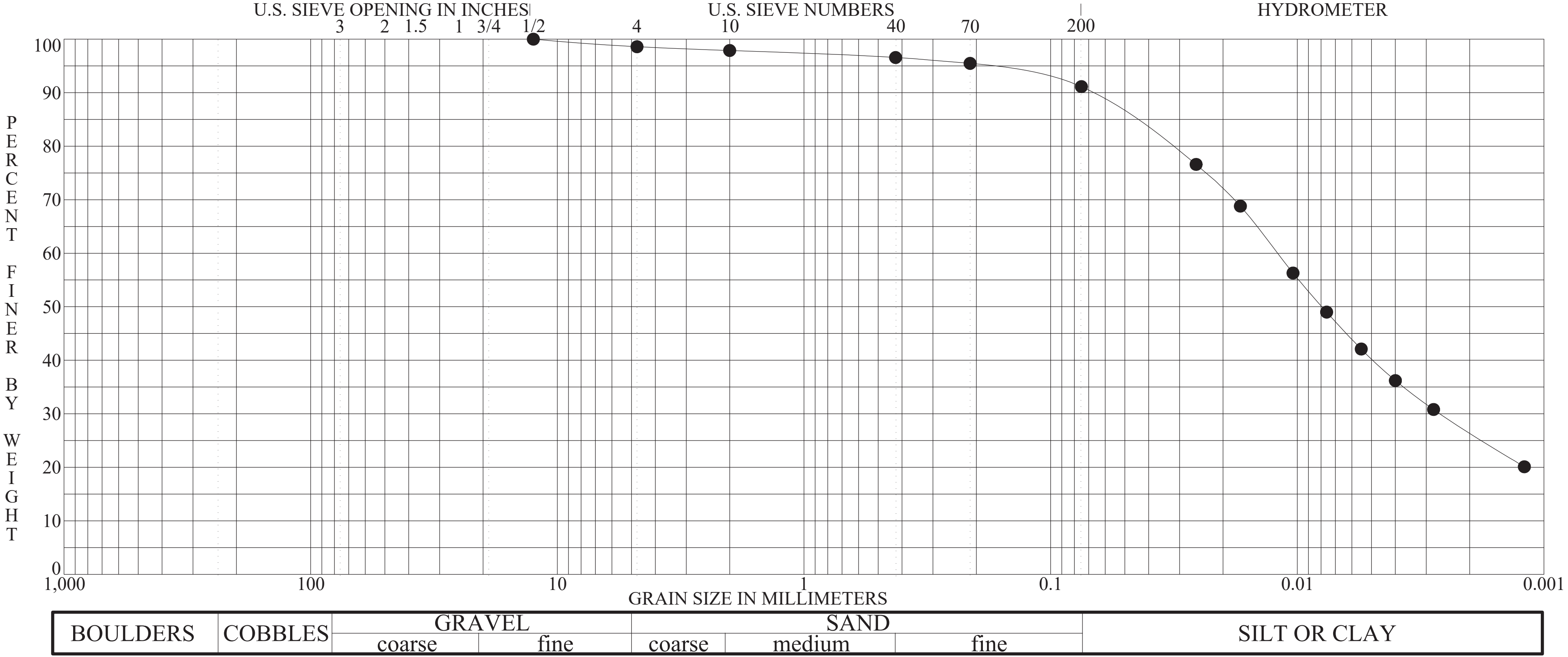
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

PLATE 57

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0906 S-21 36.0' to 36.7'** | **Gray organic clayey silt, trace fine to coarse sand, trace fine gravel.**<br>**ORGANIC CLAY OL** | **38** | **43** | **26** | **17** | | |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0906 S-21 36.0' to 36.7'** | **12.5000** | **0.1891** | **0.0120** | **0.0079** | | **1.41** | **7.45** | **64.58** | **26.55** |

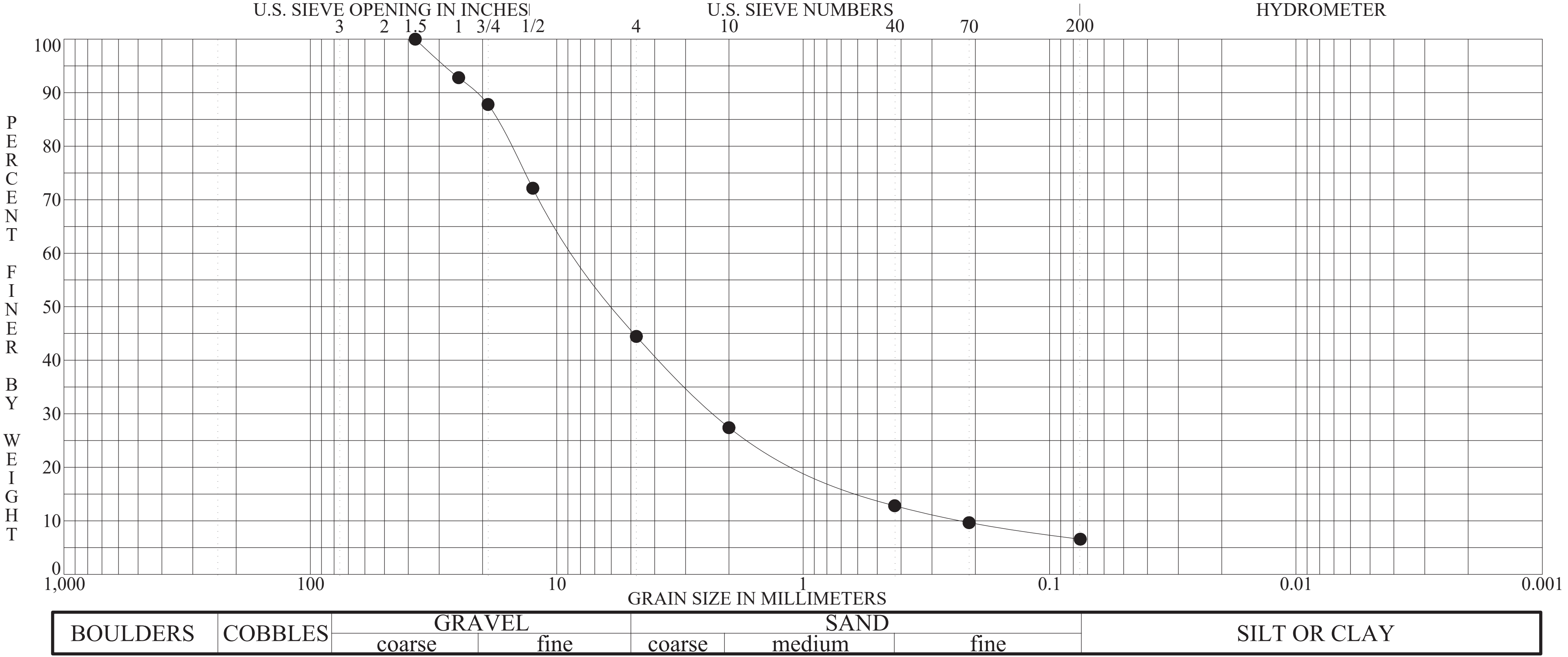
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0906 S-24 43.5' to 44.2'** | **Brown fine to coarse gravel, "and" fine to coarse sand, trace silt.** | | | | | **2.781** | **35.724** |

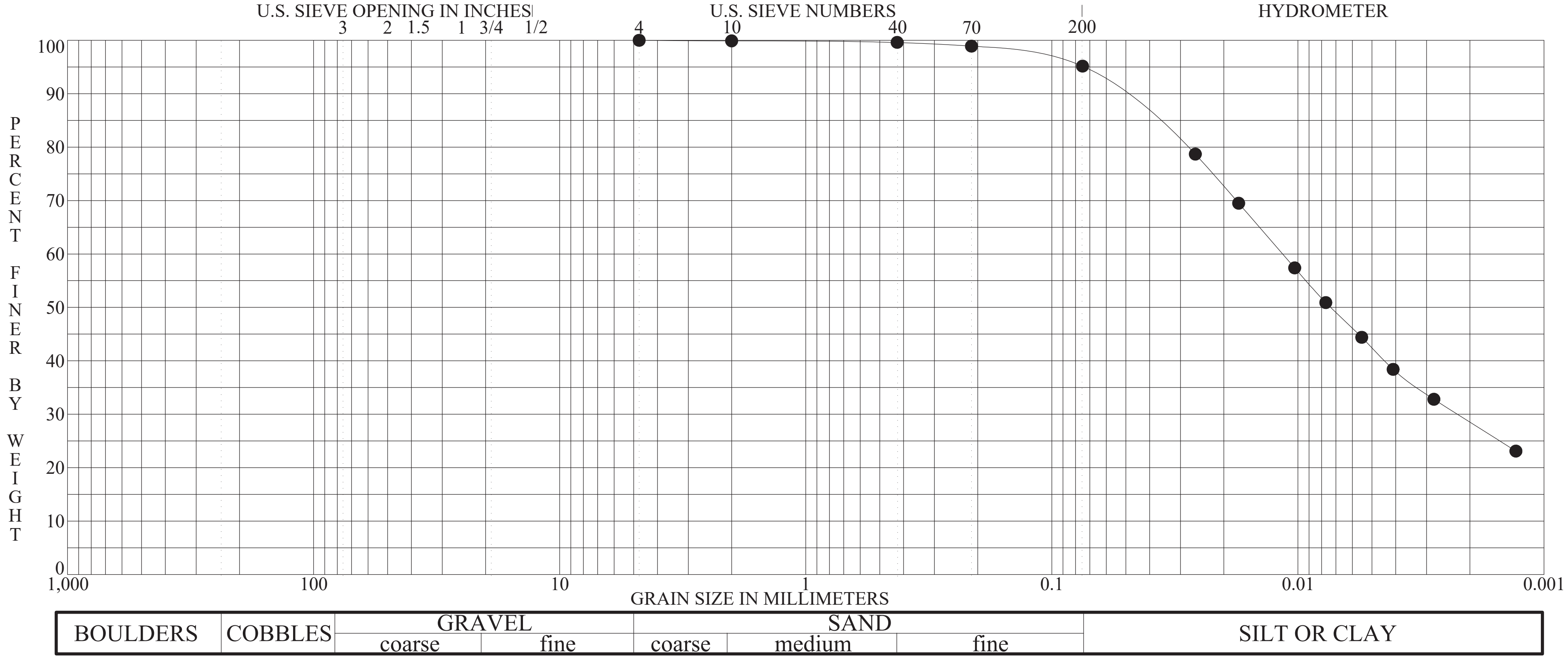
| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0906 S-24 43.5' to 44.2'** | **37.5000** | **28.2858** | **8.1765** | **5.7650** | **0.2289** | **55.54** | **37.89** | **6.57** | |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0907 ST-6A II 8.5' to 9.9'** | **FILL: Hard brown, gray and dark-gray silty clay inter-mixed with organic silt, trace fine to coarse sand.**<br>**SILT ML** | **28** | **47** | **29** | **18** | | |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0907 ST-6A II 8.5' to 9.9'** | **4.7500** | **0.0742** | **0.0115** | **0.0073** | | **0.00** | **4.83** | **66.62** | **28.55** |

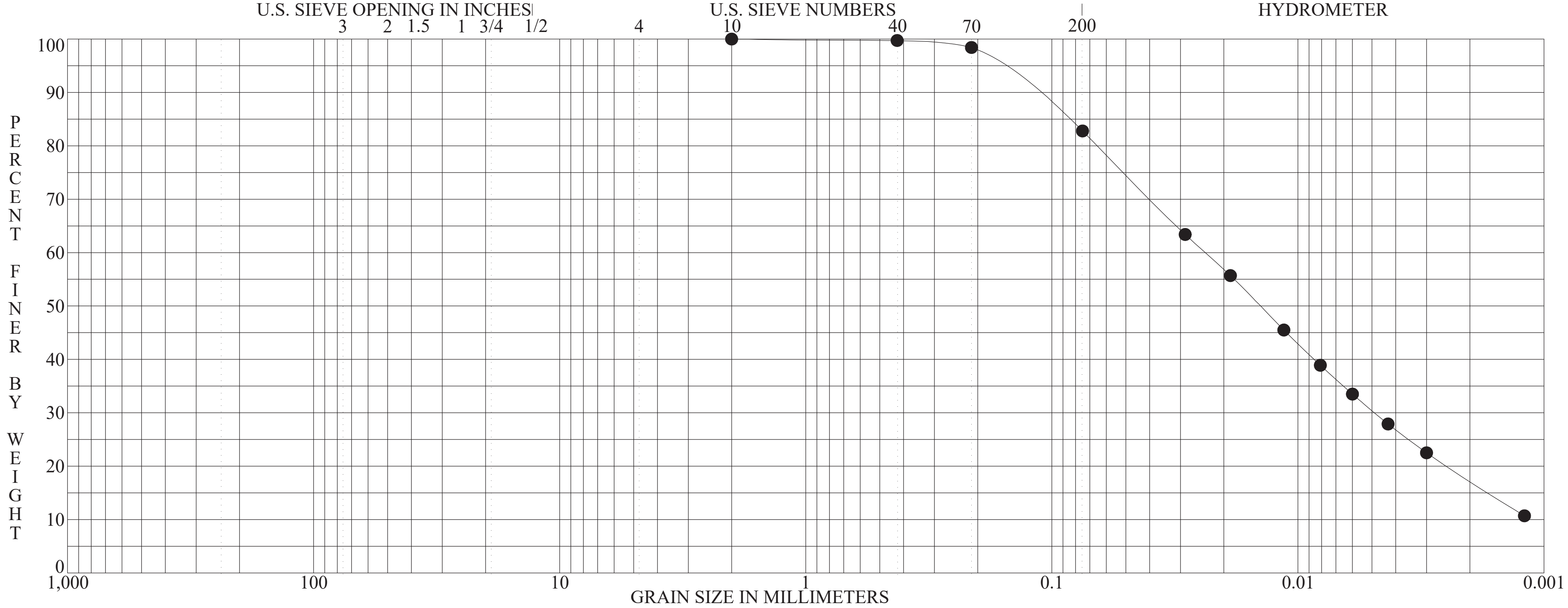
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



| BOULDERS | COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|---|
| | | coarse | fine | coarse | medium | fine | |

| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0907 S-7 11.0' to 12.0'** | **Gray organic clayey silt, little fine to medium sand.** | | | | | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0907 S-7 11.0' to 12.0'** | **2.0000** | **0.1688** | **0.0238** | **0.0142** | | **0.00** | **17.21** | **65.51** | **17.28** |

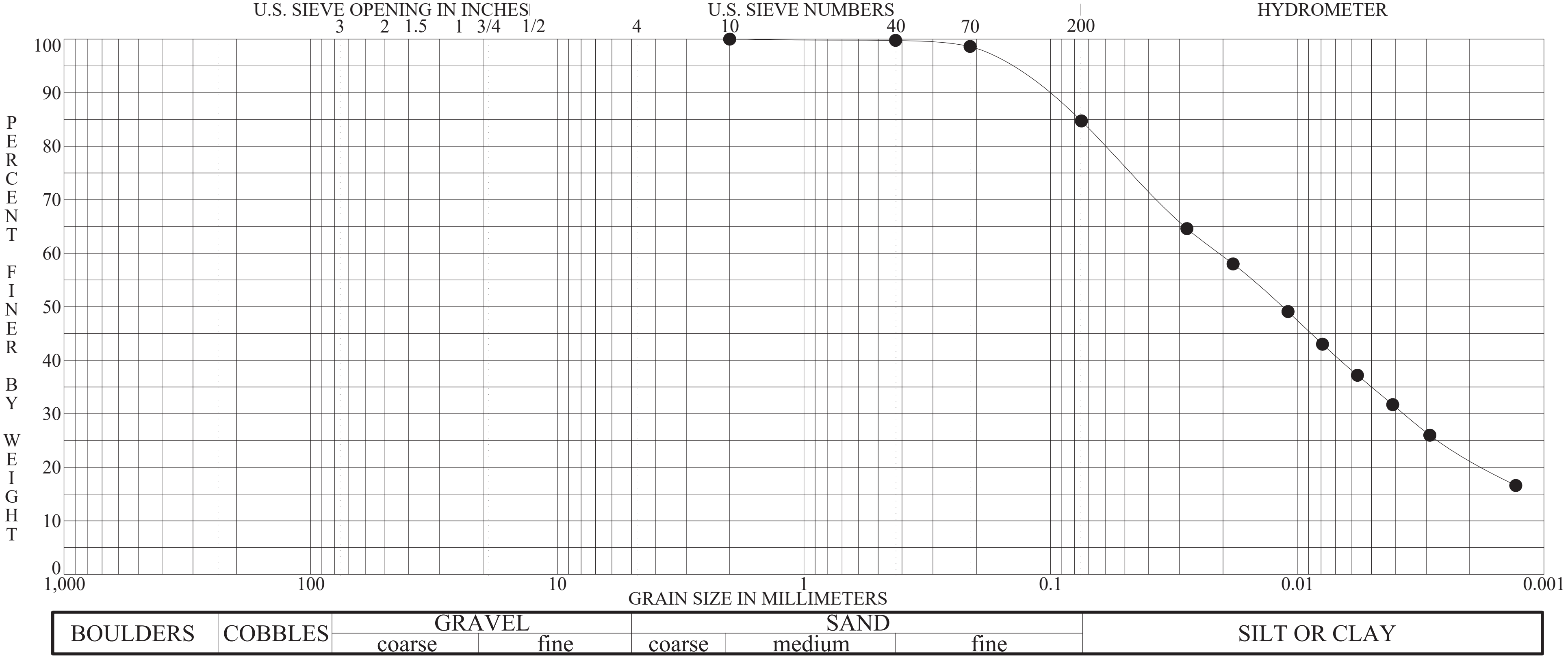
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

PLATE 61

BBCM



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0907 S-8 13.5' to 14.6'** | **Gray organic clayey silt, little fine to medium sand, few seams of fine sand.**<br>**ORGANIC SILT with SAND OL** | **43** | **44** | **28** | **16** | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0907 S-8 13.5' to 14.6'** | **2.0000** | **0.1615** | **0.0207** | **0.0115** | | **0.00** | **15.27** | **63.08** | **21.65** |

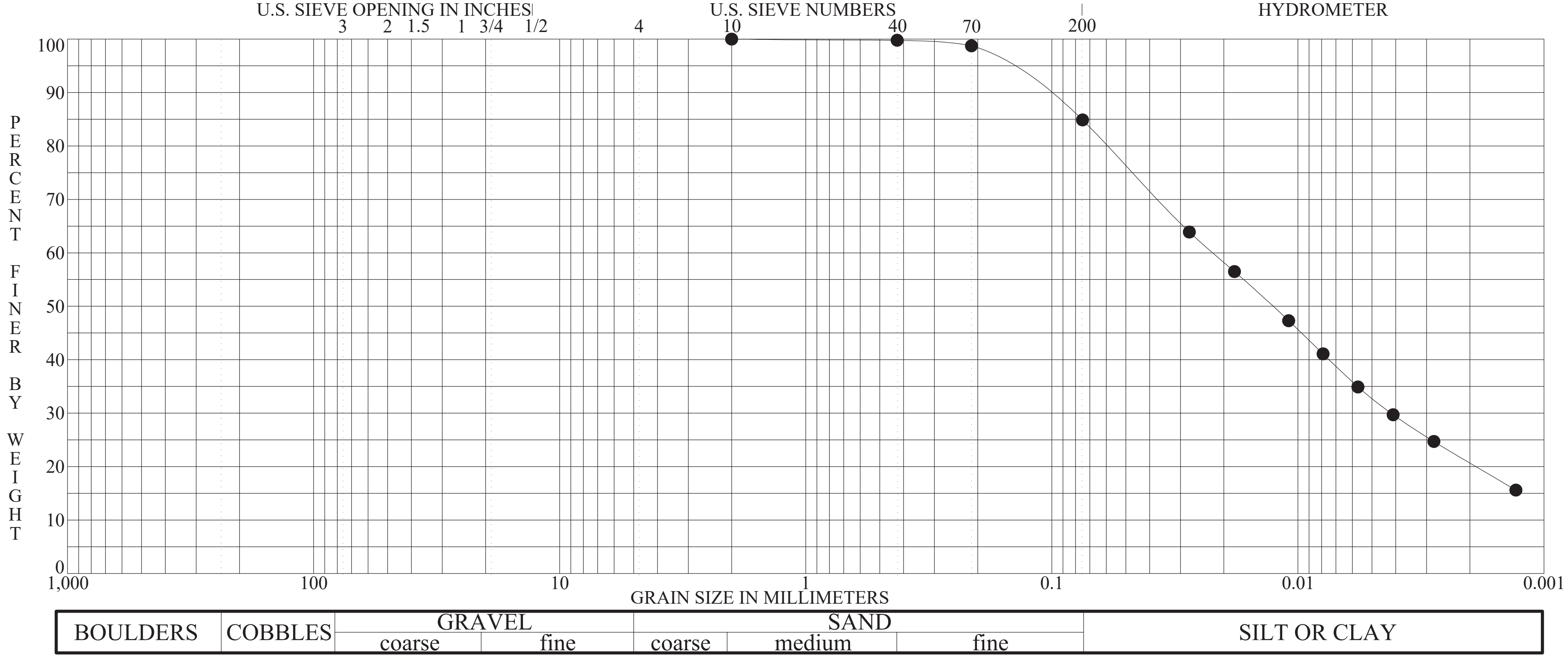
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0907 S-9 16.0' to 17.0'** | **Gray organic clayey silt, little fine sand, trace medium sand.**<br>**ORGANIC SILT with SAND OL** | **44** | **45** | **29** | **16** | | |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0907 S-9 16.0' to 17.0'** | **2.0000** | **0.1601** | **0.0221** | **0.0126** | | **0.00** | **15.12** | **64.17** | **20.71** |

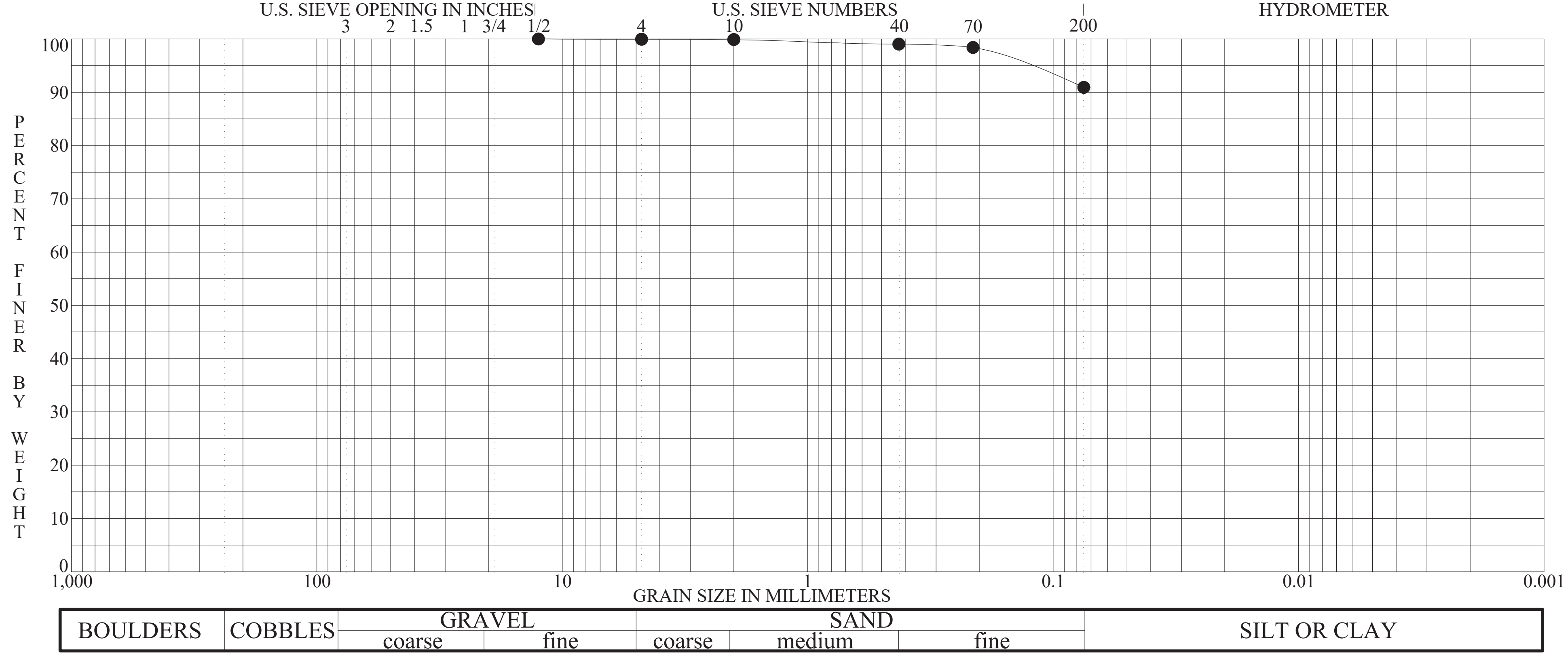
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



| | Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0907 S-10 18.5' to 19.6'** | **Gray organic clayey silt, trace fine to coarse sand, trace fine gravel.**<br>**ORGANIC SILT OL** | **40** | **48** | **29** | **19** | | |

| | Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **CD-BAP-0907 S-10 18.5' to 19.6'** | **12.5000** | **0.1321** | | | | **0.05** | **9.03** | **90.92** | |

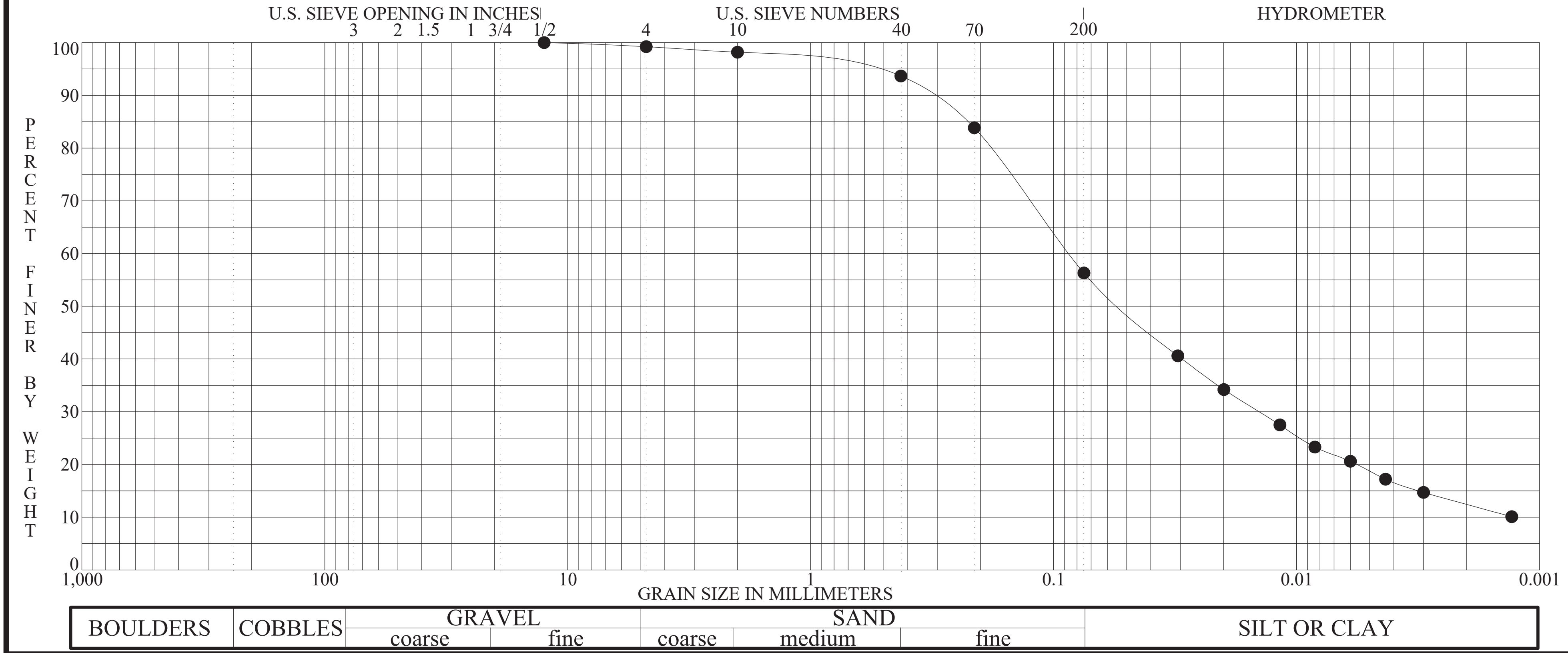
**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

GRN-EPA W/ASTM-BBCM

BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0907 S-11 21.0' to 22.0'** | **Gray organic silt, little clay, "and" fine sand, trace medium to coarse sand, trace fine gravel.**<br>**SANDY ORGANIC SILT OL** | **39** | **30** | **24** | **6** | | |

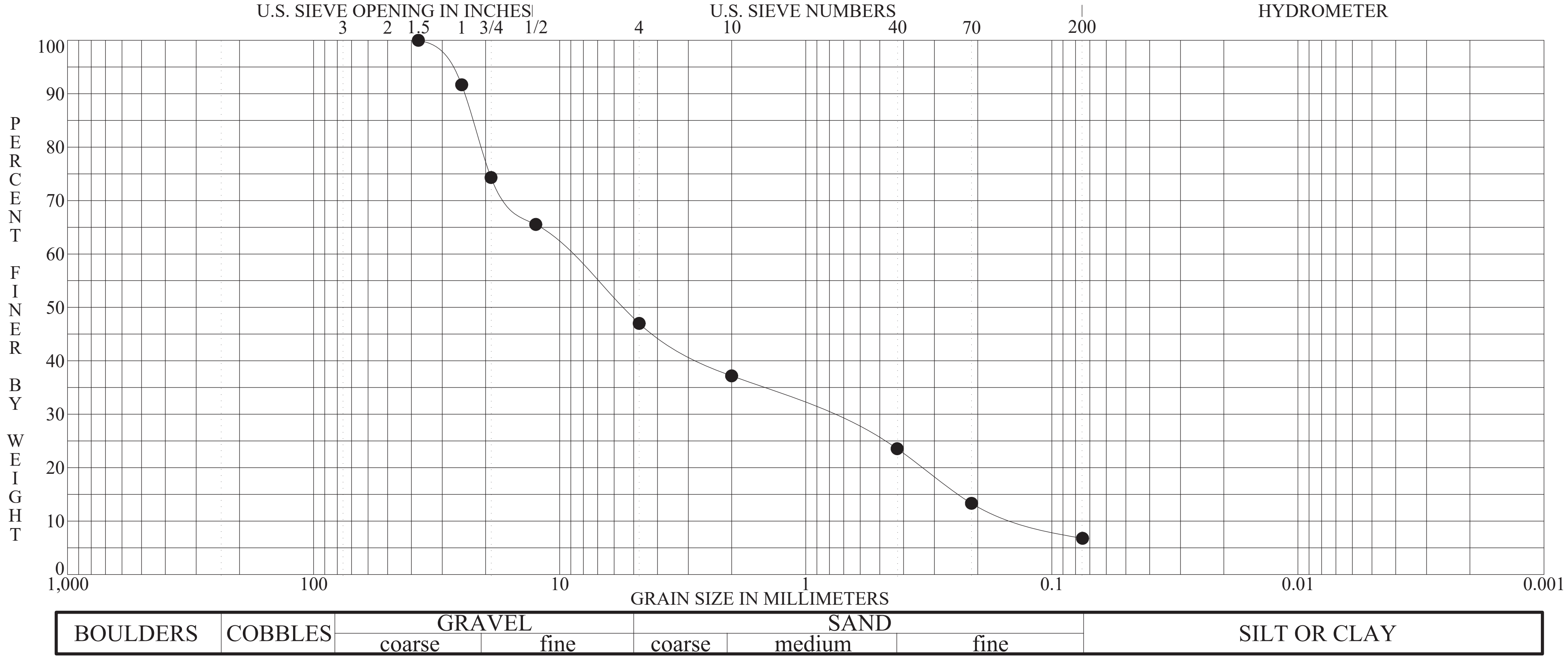
| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0907 S-11 21.0' to 22.0'** | **12.5000** | **0.6714** | **0.0862** | **0.0525** | | **0.77** | **42.92** | **43.85** | **12.47** |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** **CARDINAL PLANT ASH POND INVESTIGATION**
**LOCATION** **BRILLIANT, OHIO**
**JOB NO.** **011-11497-013** **DATE** **7/6/09**

GRN-EPA W/ASTM-BBCM



| Specimen Identification - Depth | Classification | MC% | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0907 S-13 26.0' to 26.6'** | **Brown fine to coarse gravel, "and" fine to coarse sand, trace silt.** | | | | | **0.668** | **74.823** |

| Specimen Identification - Depth | D100 | D95 | D60 | D50 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|
| ● **CD-BAP-0907 S-13 26.0' to 26.6'** | **37.5000** | **29.3892** | **9.3620** | **5.5538** | **0.1251** | **52.99** | **40.23** | **6.77** | |

**ASTM D422**

**GRADATION CURVE**

**PROJECT** CARDINAL PLANT ASH POND INVESTIGATION
**LOCATION** BRILLIANT, OHIO
**JOB NO.** 011-11497-013 **DATE** 7/6/09

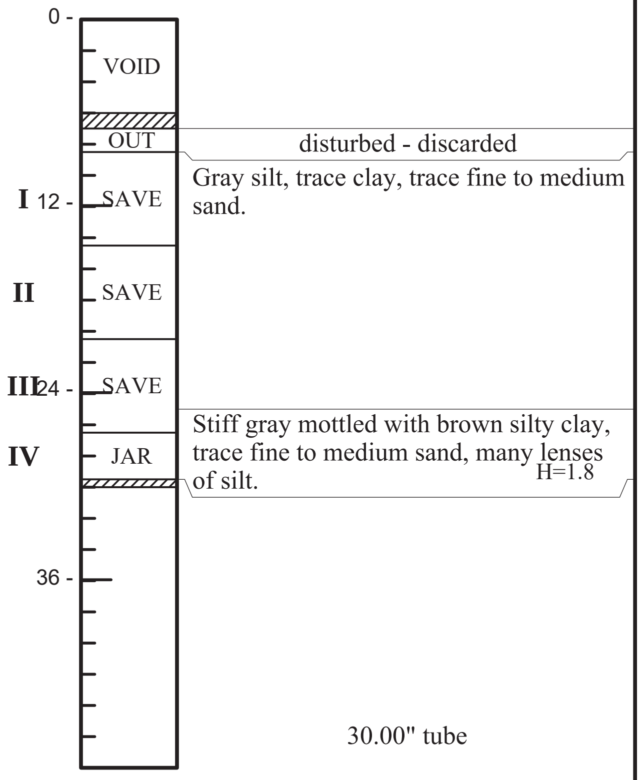
**PLATE 66**

JOB NUMBER : **011-11497-013**
PROJECT : **CARDINAL PLANT ASH POND INVESTIGATION**
LOCATION : **BRILLIANT, OHIO**

BBCM

# LABORATORY LOG OF SHELBY TUBES

| Boring | Sample | Depth | Recovery |
|---|---|---|---|
| **CD-PZ-BAP-0901** | **16A** | **23.5' to 25.3'** | **21.00"** |
| **CD-PZ-BAP-0901** | **19A** | **31.0' to 32.8'** | **20.50"** |
| **CD-PZ-BAP-0906** | **6A** | **8.5' to 9.4'** | **0.00"** |

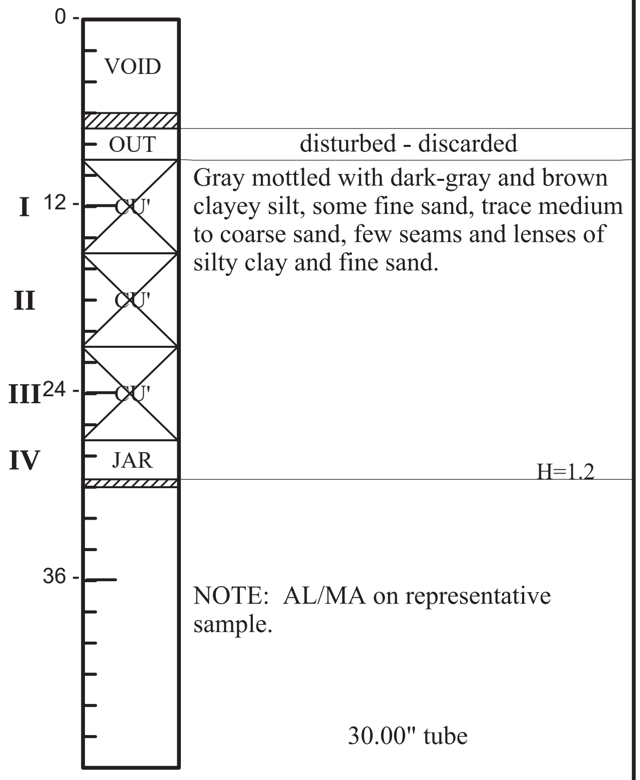


disturbed - discarded

Gray silt, trace clay, trace fine to medium sand.

Stiff gray mottled with brown silty clay, trace fine to medium sand, many lenses of silt.

30.00" tube

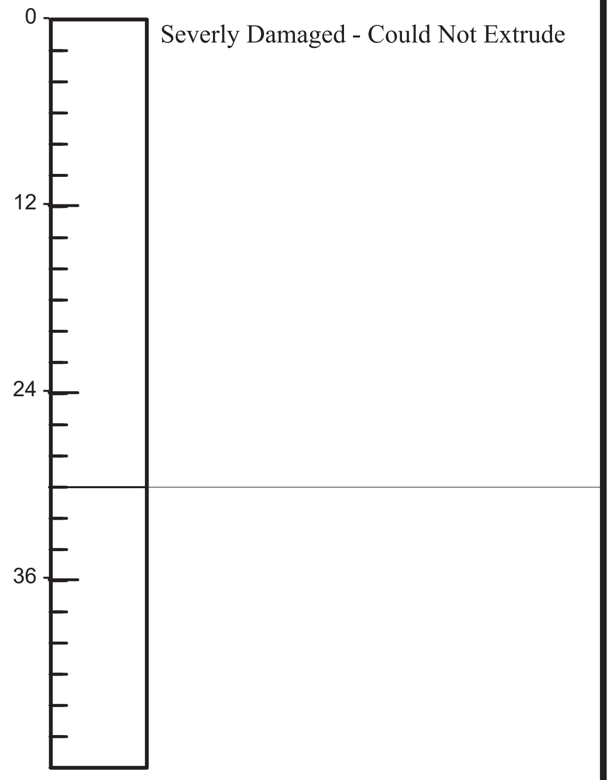


disturbed - discarded

Gray mottled with dark-gray and brown clayey silt, some fine sand, trace medium to coarse sand, few seams and lenses of silty clay and fine sand.

NOTE: AL/MA on representative sample.

30.00" tube



Severly Damaged - Could Not Extrude

## LEGEND

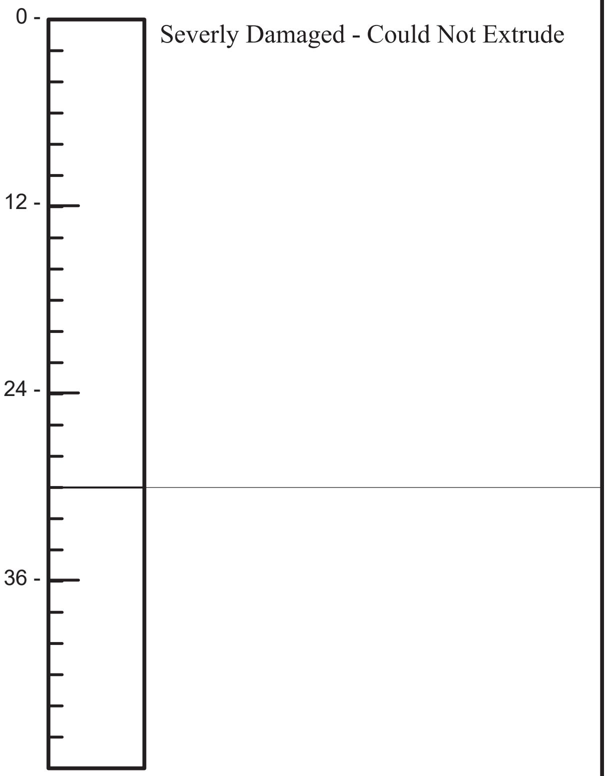
■ - Consolidation, Incremental
CRS - Consolidation, C R S
P P - Permeability, Vertical / Horizontal
≋ Swelling, Test
▨ - Wax
◿ - Unconfined Compression Test
☒ - Triaxial Compression Test

H - Hand Penetrometer (tsf)
Ds - Direct Shear
LOI - Loss on Ignition
AL - Atterberg Limits
MA - Sieve/Hydrometer
SG - Specific Gravity
SL - Shrinkage Limit
POR - Porosity
UDW - Unit Dry Weight
MC - Moisture Content
$D_R$ - Relative Density
S - Sieve

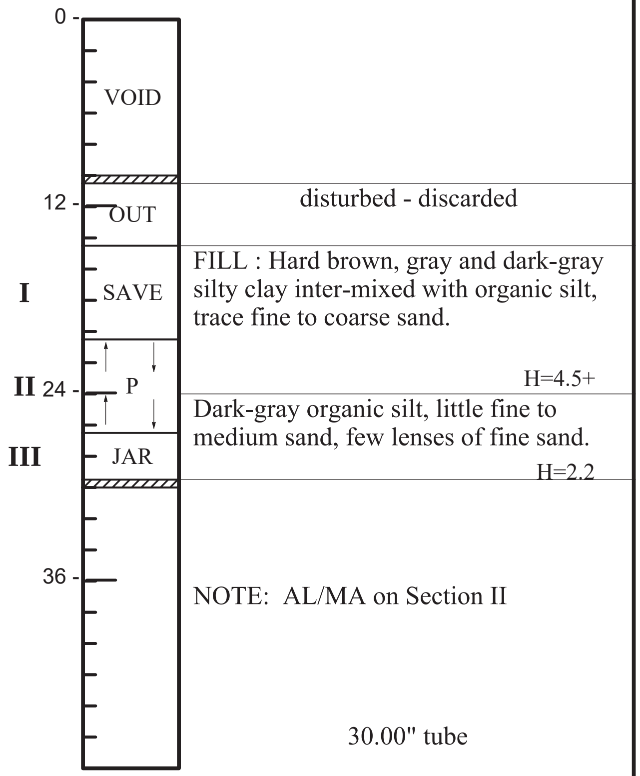
JOB NUMBER : **011-11497-013**
PROJECT : **CARDINAL PLANT ASH POND INVESTIGATION**
LOCATION : **BRILLIANT, OHIO**

# LABORATORY LOG OF SHELBY TUBES

| | | |
|---|---|---|
| Boring : **CD-PZ-BAP-0906** Sample : **12A** | Boring : **CD-PZ-BAP-0907** Sample : **6A** | Boring : Sample : |
| Depth : **18.0' to 18.8'** Recovery : **0.00"** | Depth : **8.5' to 9.9'** Recovery : **15.00"** | Depth : Recovery : |



Severly Damaged - Could Not Extrude



disturbed - discarded

FILL : Hard brown, gray and dark-gray silty clay inter-mixed with organic silt, trace fine to coarse sand.

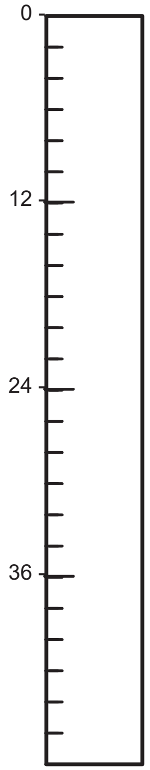
H=4.5+

Dark-gray organic silt, little fine to medium sand, few lenses of fine sand.

H=2.2

NOTE: AL/MA on Section II

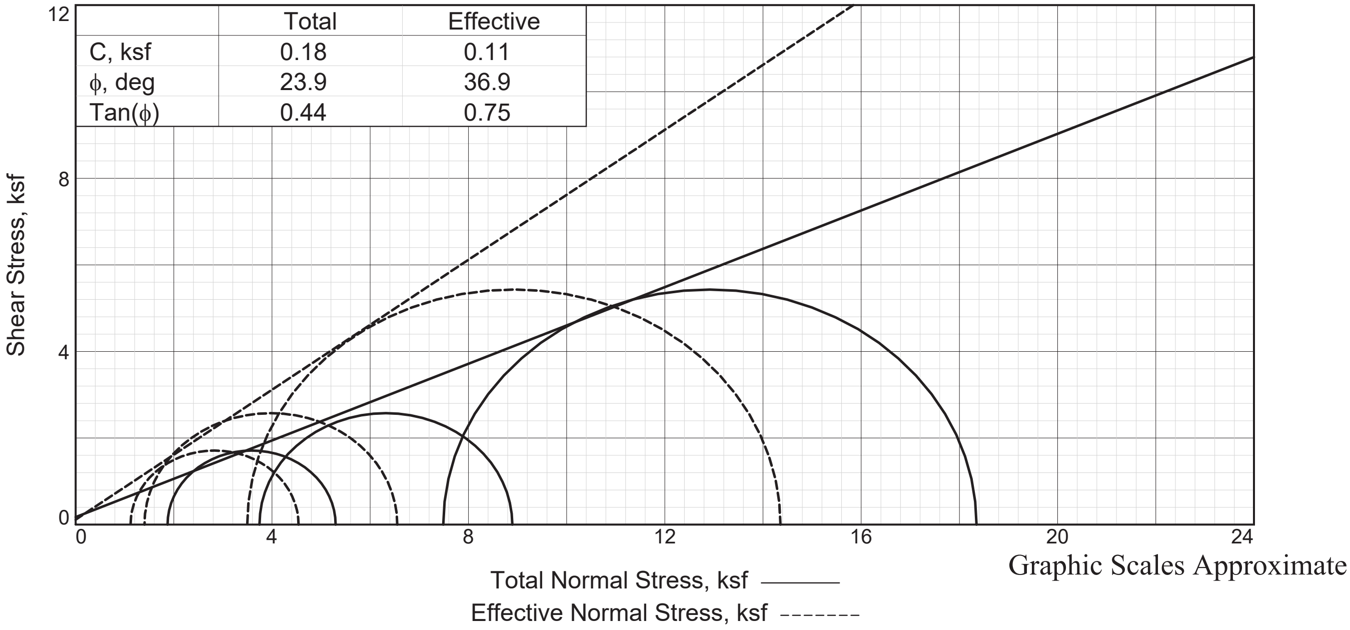
30.00" tube



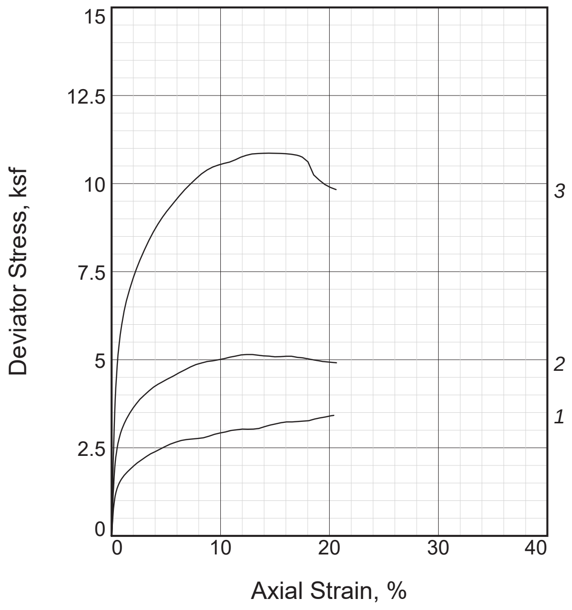
## LEGEND

- ■ - Consolidation, Incremental
- ▭ Swelling, Test
- ▨ - Wax
- CRS - Consolidation, C R S
- P P - Permeability, Vertical / Horizontal
- ◿ - Unconfined Compression Test
- ☒ - Triaxial Compression Test

H - Hand Penetrometer (tsf)
Ds - Direct Shear
LOI - Loss on Ignition
AL - Atterberg Limits
MA - Sieve/Hydrometer
SG - Specific Gravity
SL - Shrinkage Limit
POR - Porosity
UDW - Unit Dry Weight
MC - Moisture Content
$D_R$ - Relative Density
S - Sieve



|  | Total | Effective |
|---|---|---|
| C, ksf | 0.18 | 0.11 |
| ϕ, deg | 23.9 | 36.9 |
| Tan(ϕ) | 0.44 | 0.75 |



| Sample No. |  | 1 | 2 | 3 |
|---|---|---|---|---|
| Initial | Water Content, % | 35.1 | 43.8 | 31.9 |
|  | Dry Density, pcf | 83.0 | 76.2 | 85.0 |
|  | Saturation, % | 92.2 | 97.7 | 87.6 |
|  | Void Ratio | 1.0297 | 1.2123 | 0.9833 |
|  | Diameter, in. | 2.90 | 2.85 | 2.90 |
|  | Height, in. | 5.59 | 5.59 | 5.59 |
| At Test | Water Content, % | 33.3 | 38.9 | 31.0 |
|  | Dry Density, pcf | 86.9 | 82.6 | 90.3 |
|  | Saturation, % | 95.6 | 101.0 | 96.5 |
|  | Void Ratio | 0.9402 | 1.0401 | 0.8674 |
|  | Diameter, in. | 2.86 | 2.78 | 2.85 |
|  | Height, in. | 5.49 | 5.42 | 5.43 |
| Strain rate, in./min. |  | 0.00 | 0.00 | 0.00 |
| Back Pressure, psi |  | 40.00 | 40.00 | 40.00 |
| Cell Pressure, psi |  | 53.00 | 66.00 | 92.00 |
| Fail. Stress, ksf |  | 3.4 | 5.1 | 10.9 |
| Total Pore Pr., ksf |  | 6.5 | 8.1 | 9.8 |
| Ult. Stress, ksf |  | 3.4 | 4.9 | 9.8 |
| Total Pore Pr., ksf |  | 6.5 | 8.0 | 9.9 |
| $\bar{\sigma}_1$ Failure, ksf |  | 4.5 | 6.6 | 14.4 |
| $\bar{\sigma}_3$ Failure, ksf |  | 1.1 | 1.4 | 3.5 |

**Type of Test:**
CU with Pore Pressures

**Sample Type:** Shelby Tube

**Description:** Gray mottled with dark-gray and brown clayey silt, some fine sand, trace medium to

**LL=** 35 **PL=** 28 **PI=** 7

**Assumed Specific Gravity=** 2.7

**Remarks:**

1

**Client:**

**Project:** Cardinal Plant Ash Pond Investigation
Brilliant, Ohio

**Location:** CD-PZ-BAP-0901

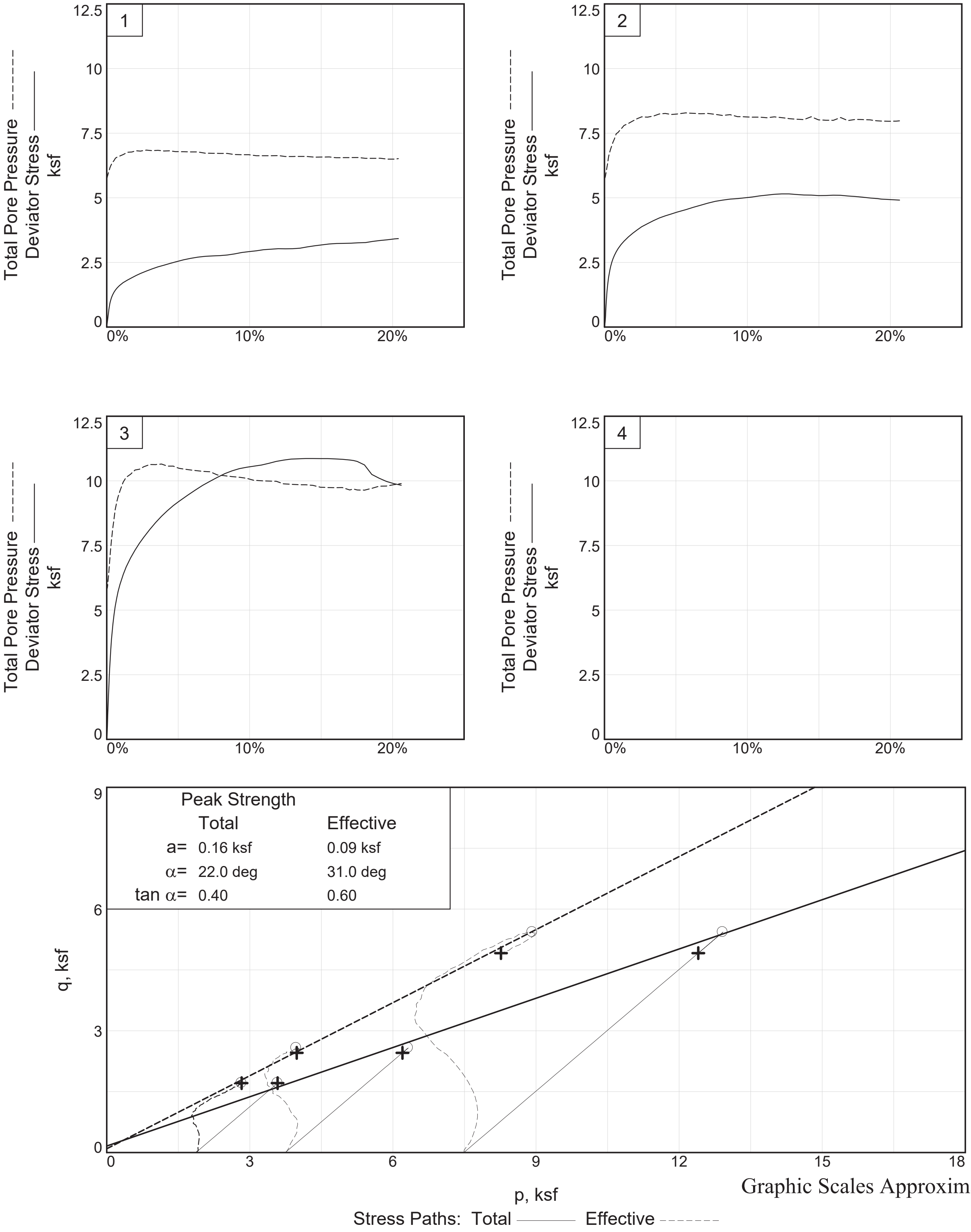
**Sample Number:** ST-19A **Depth:** 31.0' to 32.8'

**Proj. No.:** 011.11497.013 **Date Sampled:** 5/1/09

TRIAXIAL SHEAR TEST REPORT

BBC&M Engineering, Inc.

**Tested By:** PJM **Checked By:** JJ



Peak Strength

|  | Total | Effective |
|---|---|---|
| a= | 0.16 ksf | 0.09 ksf |
| α= | 22.0 deg | 31.0 deg |
| tan α= | 0.40 | 0.60 |

Graphic Scales Approximate

**Client:**

**Project:** Cardinal Plant Ash Pond Investigation

**Location:** CD-PZ-BAP-0901 **Depth:** 31.0' to 32.8' **Sample Number:** ST-19A

2

**Project No.:** 011.11497.013

**BBC&M Engineering, Inc.**

**Tested By:** PJM **Checked By:** JJ

**PLATE 70**

# PERMEABILITY TEST DATA AND COMPUTATION SHEET

## ((ASTM D-5084) FALLING HEAD, METHOD C)

Job Number: **011.11497.013**
Project Name: **Cardinal Ash Pond Investigation**
Project Location: **Brilliant, Ohio**
Tested By: **PJM**
Remarks:
Material: **FILL : Hard brown, gray and dark-gray silty clay inter-mixed with organic silt, trace fine to coarse sand.**

Date: **5/6-7/2009**
Boring: **CD-PZ-BAP-0907**
Sample: **ST-6A Sec. II**
Depth: **8.5' to 9.9'**

Maximum Dry Density:
Optimum Moisture Content:
% Compaction.:
Optimum +/-:
Natural: X
Remolded:

*Sample:*

Initial Length: 5.5945 in = 14.210 cm
Final Ave. Length (L): 5.6042 in = 14.235 cm
Diameter: 2.8765 in = 7.31 cm
Area (A): 6.499 sq in = 41.93 sq cm
Volume (V): 36.356 cu in = 595.77 cu cm
Wet Wt.: 1144.17 grams
Unit Wet Wt.: 119.90 pcf
Unit Dry Wt.: 93.99 pcf

*Test Conditions:*

Chamber Pressure: 62 psi
Back Pressure: 58 psi
Confining Pressure: 4 psi
Temp. @ Start: 22.5 °C
Temp. @ End: 22.5 °C
Average Temp.: 22.5 °C
*B* Parameter: 0.96

| *Moisture Content:* | Before Test | After Test |
|---|---|---|
| Pan No. = | D | D |
| Wet Wt. + Pan = | 1144.17 | 1157.03 |
| Dry Wt. + Pan = | 896.92 | 896.92 |
| Wt. of Pan = | 0.00 | 0.00 |
| Wt. of Dry Soil = | 896.92 | 896.92 |
| Wt. of Water = | 247.25 | 260.11 |
| % Moisture = | 27.57 | 29.00 |
| **% SATURATIO** | **93.80** | **98.30** |

S.G.(est) = 2.7000

*Pipette Pressures During Test:*

Top Pipette: 60 psi = 4220.3 cm
Bottom Pipette: 58 psi = 4079.6 cm

*Pipette:*

Area (a): 0.3435 sq in = 0.8725 sq cm

*Calculations:*

$$\boxed{k = \frac{a \cdot L}{2 \cdot A \cdot \Delta t} \ln\left(\frac{h_1}{h_2}\right)}$$

where:

k = Hydraulic Conductivity
a = Pipette Cross-Sectional Area
L = Length of Sample
A = Sample Cross-Sectional Area

$\Delta t$ = Time Interval ($t_2$ - $t_1$)
$h_1$ = Head Loss Across Permeameter/Specimen at $t_1$
$h_2$ = Head Loss Across Permeameter/Specimen at $t_2$
ln = Natural Logarithm (Base e = 2.71828)

| Date | Time Readings | Time Interval $\Delta t$ Seconds | Top Pipette cc | Hydraulic Head Headwater $H_1$ cm | Bottom Pipette cc | Hydraulic Head Tailwater $H_2$ cm | Head Loss h = $H_1$-$H_2$ cm | ℓn ($h_1$/$h_2$) | Temp. Corr. Permeability k cm/sec |
|---|---|---|---|---|---|---|---|---|---|
| 5/6/2009 | 9:45 AM | 0.00 | 48.45 | 4092.08 | 14.20 | 4272.01 | -179.93 | – | – |
| 5/6/2009 | 10:51 AM | 3,960 | 48.40 | 4092.14 | 14.45 | 4271.73 | -179.59 | 0.00191 | 6.740E-08 |
| 5/6/2009 | 12:15 PM | 5,040 | 48.20 | 4092.36 | 14.65 | 4271.50 | -179.13 | 0.00256 | 7.077E-08 |
| 5/6/2009 | 1:45 PM | 5,400 | 48.05 | 4092.54 | 15.00 | 4271.09 | -178.56 | 0.00320 | 8.280E-08 |
| 5/6/2009 | 3:17 PM | 5,520 | 47.85 | 4092.77 | 15.25 | 4270.81 | -178.04 | 0.00289 | 7.312E-08 |
| 5/7/2009 | 8:21 AM | 61,440 | 45.60 | 4095.34 | 18.00 | 4267.66 | -172.31 | 0.03272 | 7.431E-08 |
| | | | | | | | | | |
| | | | | | | | | | |
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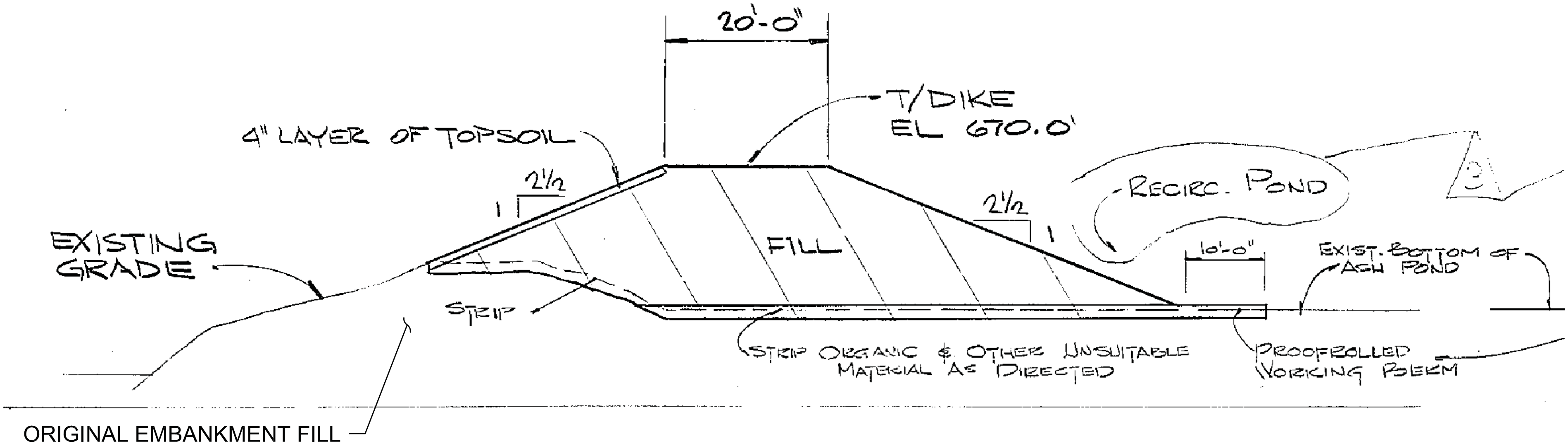
| | | | | | | | | | |

**Time Weighted Average, k** [cm/sec] = **7.423E-08**

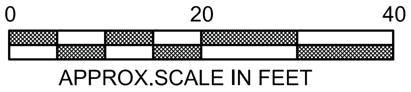
# Appendix III – Shear Strength Parameter Justification

Images: ~Cardinal Plant Aerial.jpg ~Cardinal Plant Aerial2.jpg ~Scan71615.JPG ~Scan71616.tif
Xrefs: ~94151038.dwg
File Last Updated: Jul 06, 2009
Plot Info: 7-6-2009 @ 9:20am By: MRomanello
BBC&M Filename: I:\DEPTS\CADD\Drawings\Projects\011-11497-013\EaglePoint\011-11497-013 BASE.dwg Layout: Hist Sec A-A



SECTION A-A (3-3017)

SECTION THROUGH RIVER-SIDE EMBANKMENT AT RECIRCULATION POND



REFERENCE: SITE DEVELOPMENT PLANS - ASH STORAGE AREA SECTIONS, 1973
DRAWING NO. 3-3027-3

PLATE 1

# HISTORIC SECTION A-A

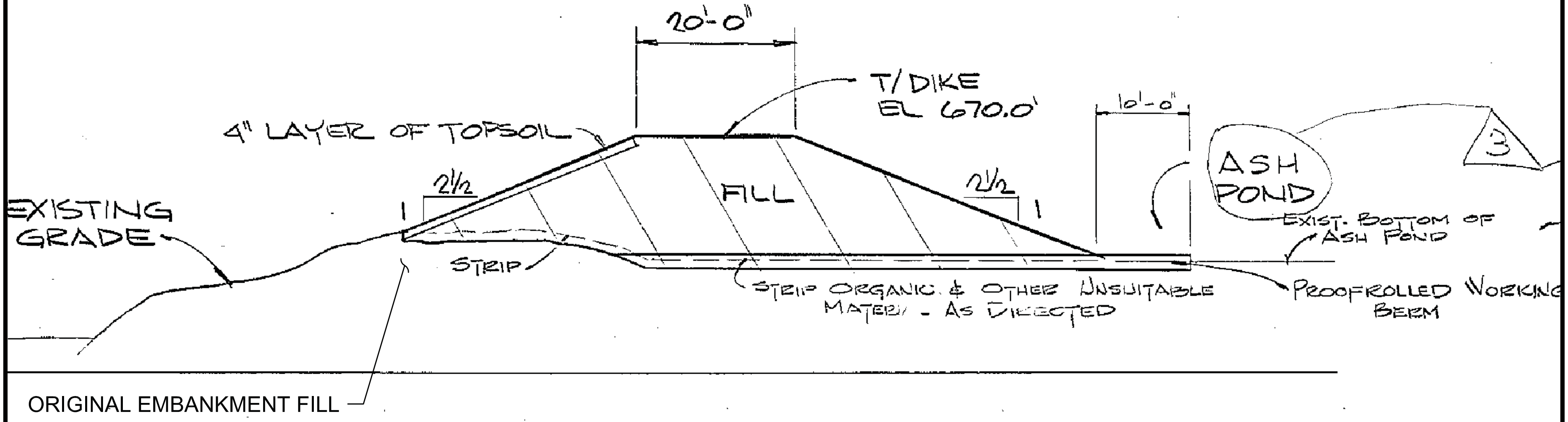
Cardinal Generating Plant
Bottom Ash Pond Investigation
Brilliant, Ohio

BBCM
SOLUTIONS TO BUILD ON

Columbus (614) 793-2226
Cleveland (216) 901-1000
Cincinnati (513) 771-8471
Dayton (937) 424-1011

Project: 011-11497-013
Drawn By: MTR
Drawing Date: 6-16-2009
Approved By: MGR
Last Updated: 7-6-2009
Scale: 1" = 20' 1:1

Images: ~Cardinal Plant Aerial.jpg ~Cardinal Plant Aerial2.jpg ~Scan71615.JPG ~Scan71616.tif
Xrefs: ~94151038.dwg
File Last Updated: Jul 06, 2009
Plot Info: 7-6-2009 @ 9:21am By: MRomanello
BBC&M Filename: I:\DEPTS\CADD\Drawings\Projects\011-11497-013\EaglePoint\011-11497-013 BASE.dwg Layout: Hist Sec C-C



SECTION C-C (3-3017)

SECTION THROUGH RIVER-SIDE EMBANKMENT AT BOTTOM ASH POND

0 20 40
APPROX.SCALE IN FEET

REFERENCE: SITE DEVELOPMENT PLANS - ASH STORAGE AREA SECTIONS, 1973
DRAWING NO. 3-3027-3

PLATE 2

# HISTORIC SECTION C-C

Cardinal Generating Plant
Bottom Ash Pond Investigation
Brilliant, Ohio

| | | |
|---|---|---|
| Project: 011-11497-013 | Drawn By: MTR | |
| Drawing Date: 6-16-2009 | Approved By: MGR | |
| Last Updated: 7-6-2009 | Scale: 1" = 20' | 1:1 |

BBCM
SOLUTIONS TO BUILD ON
Columbus (614) 793-2226
Cleveland (216) 901-1000
Cincinnati (513) 771-8471
Dayton (937) 424-1011

**Layer: NEWER EMBANKMENT FILL**

| BORING NUMBER | SAMPLE NUMBER | SAMPLE DEPTH | NATURAL MOISTURE CONTENT | LIQUID LIMIT % | PLASTIC LIMIT % | PLASTIC INDEX % | GRAVEL % | SAND % | SILT % | CLAY .002 mm % | SILT/CLAY % | USCS CLASSIFICATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BAP-0901 | S-3 | 4.75 | 16 | | | | | | | | | |
| BAP-0901 | S-5 | 7.75 | 16 | 28 | 18 | 10 | | | | | | |
| BAP-0901 | S-9 | 13.75 | 13 | 27 | 17 | 10 | | | | | | |
| BAP-0901 | S-12 | 18.25 | 14 | 37 | 24 | 13 | 7 | 32 | 49 | 12 | 61 | SANDY LEAN CLAY CL |
| BAP-0902 | S-4 | 6.25 | 13 | 27 | 17 | 10 | 42 | 34 | 16 | 8 | 24 | CLAYEY GRAVEL with SAND GC |
| BAP-0902 | S-7 | 10.75 | 20 | | | | | | | | | |
| BAP-0902 | S-8 | 12.25 | 10 | 26 | 17 | 9 | 32 | 39 | 21 | 8 | 29 | CLAYEY SAND with GRAVEL SC |
| BAP-0902 | S-11 | 16.75 | 24 | 37 | 19 | 18 | | | | | | |
| BAP-0902 | S-12 | 18.25 | 21 | 35 | 17 | 18 | 8 | 37 | 33 | 21 | 54 | SANDY LEAN CLAY CL |
| BAP-0902 | S-13 | 19.75 | 31 | 29 | 17 | 12 | 1 | 20 | 62 | 17 | 79 | LEAN CLAY with SAND CL |
| BAP-0904 | S-3 | 4.75 | 13 | | | | | | | | | |
| BAP-0904 | S-6 | 9.25 | 14 | 25 | 16 | 9 | 31 | 39 | 21 | 10 | 31 | CLAYEY SAND with GRAVEL SC |
| BAP-0904 | S-9 | 13.75 | 16 | 35 | 21 | 14 | | | | | | |
| BAP-0904 | S-11 | 16.75 | | | | | 47 | 25 | | | 27 | |
| BAP-0906 | S-2A | 2.9 | 11 | | | | | | | | | |
| BAP-0906 | S-3 | 4.75 | 15 | 27 | 17 | 10 | | | | | | |
| BAP-0906 | S-8 | 12.75 | | | | | 30 | 40 | 22 | 9 | 31 | |
| BAP-0906 | S-11 | 17.25 | 14 | 31 | 19 | 12 | 18 | 44 | 26 | 12 | 38 | CLAYEY SAND with GRAVEL SC |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample Size | 18 | 16 | 12 | 12 | 12 | 9 | 9 | 8 | 8 | 9 |
| Minimum | 3 | 10 | 25 | 16 | 9 | 1 | 20 | 16 | 8 | 24 |
| Maximum | 20 | 31 | 37 | 24 | 18 | 47 | 44 | 62 | 21 | 79 |
| Mean | 11.7 | 16.3 | 30.3 | 18.3 | 12.1 | 24.0 | 34.4 | 31.3 | 12.1 | 41.6 |
| Median | 13 | 15 | 29 | 17 | 11 | 30 | 37 | 24 | 11 | 31 |
| Mode | 5 | 16 | 27 | 17 | 10 | #N/A | 39 | 21 | 12 | 31 |
| Std Dev | - | 5.4 | 4.5 | 2.3 | 3.2 | 16.2 | 7.7 | 16.1 | 4.6 | 18.9 |

**PLATE 3**

**Layer: ORIGINAL EMBANKMENT FILL**

| BORING NUMBER | SAMPLE NUMBER | SAMPLE DEPTH | NATURAL MOISTURE CONTENT | LIQUID LIMIT % | PLASTIC LIMIT % | PLASTIC INDEX % | GRAVEL % | SAND % | SILT % | CLAY .002 mm % | SILT/CLAY % | USCS CLASSIFICATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BAP-0903 | S-2 | 3.25 | 24 | 48 | 24 | 24 | 0 | 8 | 60 | 32 | 92 | LEAN CLAY CL |
| BAP-0903 | S-3 | 4.75 | 22 | | | | | | | | | |
| BAP-0903 | S-5 | 7.75 | 20 | 36 | 20 | 16 | 0 | 14 | 58 | 28 | 86 | LEAN CLAY CL |
| BAP-0905 | S-3 | 4.75 | 17 | 32 | 18 | 14 | 0 | 25 | 53 | 23 | 76 | LEAN CLAY with SAND CL |
| BAP-0905 | S-5 | 7.75 | 22 | 48 | 24 | 24 | | | | | | |
| BAP-0905 | S-6B | 9.85 | 33 | | | | 5 | 14 | | | 81 | |
| BAP-0907 | S-2 | 3.25 | 21 | | | | | | | | | |
| BAP-0907 | S-4 | 6.25 | 15 | | | | | | | | | |
| BAP-0907 | S-5 | 7.75 | 23 | 49 | 26 | 23 | | | | | | |
| BAP-0907 | S-6A | 9.25 | 28 | 47 | 29 | 18 | 0 | 5 | 67 | 29 | 96 | SILT ML |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample Size | 10 | 10 | 6 | 6 | 6 | 5 | 5 | 4 | 4 | 5 |
| Minimum | 3 | 15 | 32 | 18 | 14 | 0 | 5 | 53 | 23 | 76 |
| Maximum | 10 | 33 | 49 | 29 | 24 | 5 | 25 | 67 | 32 | 96 |
| Mean | 6.5 | 22.5 | 43.3 | 23.5 | 19.8 | 1.0 | 13.2 | 59.5 | 28.0 | 86.2 |
| Median | 7 | 22 | 48 | 24 | 21 | 0 | 14 | 59 | 29 | 86 |
| Mode | 8 | 22 | 48 | 24 | 24 | 0 | 14 | #N/A | #N/A | #N/A |
| Std Dev | - | 5.1 | 7.4 | 4.0 | 4.4 | 2.2 | 7.7 | 5.8 | 3.7 | 8.1 |

**Layer: ALLUVIUM SILT AND CLAY**

| BORING NUMBER | SAMPLE NUMBER | SAMPLE DEPTH | NATURAL MOISTURE CONTENT | LIQUID LIMIT % | PLASTIC LIMIT % | PLASTIC INDEX % | GRAVEL % | SAND % | SILT % | CLAY .002 mm % | SILT/CLAY % | USCS CLASSIFICATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BAP-0901 | S-15 | 22.75 | 30 | NP | NP | NP | 0 | 5 | 89 | 6 | 95 | SILT ML |
| BAP-0901 | S-16A | 24.5 | | | | | | | | | | |
| BAP-0901 | S-18 | 29.25 | 27 | 37 | 22 | 15 | 0 | 9 | 63 | 28 | 91 | LEAN CLAY CL |
| BAP-0901 | S-19A | 31.25 | | | | | | | | | | |
| BAP-0901 | S-19B | 31.75 | 33 | 35 | 28 | 7 | 0 | 26 | 56 | 18 | 74 | SILT with SAND ML |
| BAP-0901 | | 32.25 | | | | | | | | | | |
| BAP-0902 | S-14 | 21.25 | 26 | NP | NP | NP | 0 | 13 | 83 | 4 | 87 | SILT ML |
| BAP-0902 | S-15 | 22.75 | | | | | 1 | 22 | | | 78 | |
| BAP-0903 | S-10 | 21.75 | 35 | 34 | 21 | 13 | 0 | 29 | 51 | 19 | 70 | LEAN CLAY with SAND CL |
| BAP-0904 | S-15 | 22.75 | 26 | NP | NP | NP | 1 | 52 | 45 | 3 | 48 | SILTY SAND SM |
| BAP-0904 | S-17 | 25.75 | 22 | NP | NP | NP | 0 | 8 | 86 | 5 | 91 | SILT ML |
| BAP-0905 | S-11 | 21.75 | 38 | 38 | 23 | 15 | 2 | 36 | 47 | 15 | 62 | SANDY LEAN CLAY CL |
| BAP-0906 | S-15 | 24.75 | 31 | NP | NP | NP | 0 | 5 | 89 | 7 | 96 | SILT ML |
| BAP-0906 | S-16A | 26.25 | | | | | 4 | 41 | | | 55 | |
| BAP-0906 | S-17 | 27.25 | 22 | NP | NP | NP | 5 | 20 | 70 | 5 | 75 | SILT with SAND ML |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample Size | 15 | 10 | 4 | 4 | 4 | 12 | 12 | 10 | 10 | 12 |
| Minimum | 21 | 22 | 34 | 21 | 7 | 0 | 5 | 45 | 3 | 48 |
| Maximum | 32.25 | 38 | 38 | 28 | 15 | 5 | 52 | 89 | 28 | 96 |
| Mean | 25.73 | 29.0 | 36.0 | 23.5 | 12.5 | 1.1 | 22.2 | 67.9 | 11.0 | 76.8 |
| Median | 24.75 | 29 | 36 | 23 | 14 | 0 | 21 | 67 | 7 | 77 |
| Mode | 22.75 | 26 | #N/A | #N/A | 15 | 0 | 5 | 89 | 5 | 91 |
| Std Dev | - | 5.4 | 1.8 | 3.1 | 3.8 | 1.7 | 15.2 | 17.8 | 8.5 | 15.9 |

NP - Non Plastic

**Layer: ORGANIC CLAYEY SILT**

| BORING NUMBER | SAMPLE NUMBER | SAMPLE DEPTH | NATURAL MOISTURE CONTENT | LIQUID LIMIT % | PLASTIC LIMIT % | PLASTIC INDEX % | GRAVEL % | SAND % | SILT % | CLAY .002 mm % | SILT/CLAY % | USCS CLASSIFICATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BAP-0901 | S-20 | 34.25 | 42 | 34 | 27 | 7 | 0 | 22 | 62 | 16 | 78 | ORGANIC SILT with SAND OL |
| BAP-0901 | S-21 | 36.75 | 40 | 45 | 29 | 16 | 11 | 30 | | | 59 | SANDY ORGANIC SILT OL |
| BAP-0901 | S-22 | 39.25 | 42 | 40 | 23 | 17 | 0 | 18 | 59 | 22 | 81 | ORGANIC CLAY with SAND OL |
| BAP-0902 | S-18 | 27.25 | 54 | NP | NP | NP | 0 | 15 | 69 | 16 | 85 | ORGANIC SILT OL |
| BAP-0902 | S-19 | 28.75 | 43 | NP | NP | NP | 0 | 25 | 61 | 13 | 74 | ORGANIC SILT with SAND OL |
| BAP-0902 | S-20 | 32.25 | 38 | 36 | 28 | 8 | 2 | 23 | 59 | 16 | 75 | ORGANIC SILT with SAND OL |
| BAP-0903 | S-6 | 9.25 | 49 | 41 | 38 | 3 | 0 | 33 | 52 | 15 | 67 | SANDY ORGANIC SILT OL |
| BAP-0903 | S-7 | 14.25 | 43 | NP | NP | NP | 0 | 29 | 56 | 15 | 71 | ORGANIC SILT with SAND OL |
| BAP-0903 | S-8 | 16.75 | 43 | 37 | 24 | 13 | 0 | 24 | 57 | 19 | 76 | ORGANIC CLAY with SAND OL |
| BAP-0903 | S-9 | 19.25 | 44 | 35 | 24 | 11 | 0 | 39 | 45 | 16 | 61 | SANDY ORGANIC CLAY OL |
| BAP-0904 | S-13 | 19.75 | 28 | NP | NP | NP | 0 | 8 | 87 | 5 | 92 | ORGANIC SILT OL |
| BAP-0904 | S-18 | 27.25 | 38 | 38 | 24 | 14 | 0 | 21 | 58 | 21 | 79 | ORGANIC CLAY with SAND OL |
| BAP-0904 | S-19 | 28.75 | 47 | 42 | 30 | 12 | 0 | 22 | 62 | 17 | 79 | ORGANIC SILT with SAND OL |
| BAP-0905 | S-8 | 14.25 | 45 | 43 | 27 | 16 | 0 | 19 | 60 | 21 | 81 | ORGANIC SILT with SAND OL |
| BAP-0905 | S-9 | 16.75 | 42 | 40 | 25 | 15 | 0 | 16 | 60 | 24 | 84 | ORGANIC CLAY with SAND OL |
| BAP-0906 | S-19 | 31.75 | 34 | 33 | 22 | 11 | 0 | 19 | 63 | 18 | 81 | ORGANIC CLAY with SAND OL |
| BAP-0906 | S-20 | 34.25 | 43 | 50 | 30 | 20 | 0 | 3 | 53 | 44 | 97 | ORGANIC SILT OH |
| BAP-0906 | S-21 | 36.75 | 38 | 43 | 26 | 17 | 1 | 7 | 65 | 27 | 92 | ORGANIC CLAY OL |
| BAP-0907 | S-7 | 11.75 | | | | | 0 | 17 | 66 | 17 | 83 | |
| BAP-0907 | S-8 | 14.25 | 43 | 44 | 28 | 16 | 0 | 15 | 63 | 22 | 85 | ORGANIC SILT with SAND OL |
| BAP-0907 | S-9 | 16.75 | 44 | 45 | 29 | 16 | 0 | 15 | 64 | 21 | 85 | ORGANIC SILT with SAND OL |
| BAP-0907 | S-10 | 19.25 | 40 | 48 | 29 | 19 | 0 | 9 | | | 91 | ORGANIC SILT OL |
| BAP-0907 | S-11 | 21.75 | 39 | 30 | 24 | 6 | 1 | 43 | 44 | 12 | 56 | SANDY ORGANIC SILT OL |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample Size | 23 | 22 | 18 | 18 | 18 | 23 | 23 | 21 | 21 | 23 |
| Minimum | 9 | 28 | 30 | 22 | 3 | 0 | 3 | 44 | 5 | 56 |
| Maximum | 39.25 | 54 | 50 | 38 | 20 | 11 | 43 | 87 | 44 | 97 |
| Mean | 23.97 | 41.8 | 40.2 | 27.1 | 13.2 | 0.7 | 20.5 | 60.2 | 18.9 | 78.8 |
| Median | 21.75 | 43 | 41 | 27 | 15 | 0 | 19 | 60 | 17 | 81 |
| Mode | 14.25 | 43 | 45 | 24 | 16 | 0 | 15 | 62 | 16 | 81 |
| Std Dev | - | 5.2 | 5.4 | 3.7 | 4.7 | 2.3 | 9.8 | 8.8 | 7.4 | 10.6 |

**Layer: GLACIAL OUTWASH SAND AND GRAVEL**

| BORING NUMBER | SAMPLE NUMBER | SAMPLE DEPTH | NATURAL MOISTURE CONTENT | GRAVEL % | SAND % | SILT % | CLAY .002 mm % | SILT/CLAY % |
|---|---|---|---|---|---|---|---|---|
| BAP-0902 | S-22 | 37.25 | 22 | 0 | 70 | 22 | 8 | 30 |
| BAP-0902 | S-23 | 39.75 | 24 | 0 | 83 | 13 | 4 | 17 |
| BAP-0902 | S-24 | 42.25 |  | 4 | 82 |  |  | 14 |
| BAP-0903 | S-11 | 24.25 |  | 9 | 77 |  |  | 14 |
| BAP-0904 | S-21 | 36.75 |  | 0 | 76 |  |  | 24 |
| BAP-0905 | S-13 | 26.75 |  | 19 | 73 |  |  | 8 |
| BAP-0906 | S-24 | 44.25 |  | 56 | 38 |  |  | 7 |
| BAP-0907 | S-13 | 26.75 |  | 53 | 40 |  |  | 7 |

|  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|
| Sample Size | 8 | 2 | 8 | 8 | 2 | 2 | 8 |
| Minimum | 24 | 22 | 0 | 38 | 13 | 4 | 7 |
| Maximum | 44.25 | 24 | 56 | 83 | 22 | 8 | 30 |
| Mean | 34.75 | 23.0 | 17.6 | 67.4 | 17.5 | 6.0 | 15.1 |
| Median | 37.00 | 23 | 7 | 75 | 18 | 6 | 14 |
| Mode | 26.75 | #N/A | 0 | #N/A | #N/A | #N/A | 14 |
| Std Dev | - | 1.4 | 23.7 | 18.0 | 6.4 | 2.8 | 8.4 |

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ONLY DRAINED STRENGTH PARAMETERS ARE REQUIRED FOR STABILITY ANALYSIS SINCE NO MODIFICATIONS HAVE BEEN MADE SINCE ~1978. – CONSTANT NORMAL POOL – NO RDD ANALYSIS AT THIS TIME

\+ STRENGTH PARAMETERS
ESTIMATE EFFECTIVE ANGLE OF INTERNAL FRICTION, $\phi'$ OF COHESIVE LAYERS BY COMPARING RESULTS FROM THE FOLLOWING METHODS

1) CORRELATIONS TO LL, CLAY SIZED FRACTION, AND OVERBURDEN STRESS DEVELOPED BY STARK ET AL. FOR THE SECANT FULLY SOFTENED FRICTION ANGLE

2) RELATIONSHIP BETWEEN $\phi'$ AND PLASTICITY INDEX AS DEVELOPED BY TERZAGHI, PECK, AND MESRI, 1996

3) CORRELATION TO CLAY SIZED FRACTION FOR NORMALLY CONSOLIDATED CLAY – DISSERTATION BY G.A. HALL, WVU, 1974. (ALLUVIUM ONLY)
WHERE $\phi'_{NC} = 36 - 0.2665 (\% \text{ CLAY})$

4) FOR FILL SOILS, ESTIMATE DRAINED STRENGTH VALUES FROM NAVFAC DESIGN MANUAL 7.2 USING TABLE 1 – 'TYPICAL PROPERTIES OF COMPACTED SOILS'

\+ GRANULAR FOUNDATION LAYERS (GLACIAL OUTWASH SAND & GRAVEL)
ESTIMATE $\phi'$ BASED ON SPT CORRELATIONS AND GRAIN SIZE ANALYSIS

1) $\phi' = \sqrt{15.4 (N_{60})} + 20°$ (HANTANAKA AND UCHIDA, 1996)

2) COMPARE EQN 1) WITH TYPICAL VALUES ESTABLISHED BY SCHROEDER ET AL

**TABLE 7.1 Relative Density of Cohesionless Soils**

| *Relative Density Designation* | $\gamma_{MOIST}$ (PCF) | *Approximate Relative Density, %* | *$N_{60}$ Standard Penetration Resistance* | *Approximate Angle of Friction of Soil $\phi$, degrees* |
|---|---|---|---|---|
| Very loose | 70-100 | 0–5 | 0–4 | 25–28 |
| Loose | 90-115 | 5–30 | 4–10 | 28–30 |
| Medium | 110-130 | 30–60 | 10–30 | 30–36 |
| Dense | 110-140 | 60–85 | 30–50 | 36–41 |
| Very dense | 130-150 | >85 | Over 50 | >41 |

**PLATE 8**

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+ PERMEABILITY

- EMBANKMENT FILL:
  ESTIMATE PERM BASED ON RESULTS FROM FLEX WALL PERMEABILITY TEST PERFORMED ON UNDISTURBED SAMPLE. ESTIMATE PERM. HIGHER THAN TEST VALUE TO ACCOUNT FOR PERMEABILITY ON A MACRO SCALE, AS WELL AS ACCOUNTING FOR SAMPLES WITH A HIGHER GRANULAR CONTENT.
  → ADJUST K, $K_V/K_H$ RATIO DURING ANALYSIS TO MATCH FIELD CONDITIONS.

- ORIGINAL EMBANKMENT FILL & NATURAL COHESIVE LAYERS
  ESTIMATE PERM. BASED ON TYPICAL PUBLISHED VALUES USING SOIL DESCRIPTION & GRAIN SIZE ANALYSIS

- GRANULAR FOUNDATION LAYERS
  ESTIMATE PERMEABILITY BASED ON TYPICAL PUBLISHED VALUES BASED ON RELATIVE DENSITY & GRAIN SIZE ANALYSIS.

AS A GUIDE, USE $K = (\underline{100}\ D_{10})^2$ μsec $(\text{cm} \times 10^{-4}/\text{sec})$

(HAZEN)

ALSO USE $d_{15}$ VALUE AND COMPARE TYPICAL RANGE OF PERMEABILITY BASED ON GRAIN SIZE (GEOSYNTEC, 1991)

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Sheet 3 of 8

LAYER: NEWER EMBANKMENT FILL (1970s)

- DESCRIPTION: CONTAINS ZONES AND POCKETS OF THE FOLLOWING
  1) MED DENSE TO DENSE BROWN AND GRAY FINE TO COARSE GRAVEL, SOME FINE TO COARSE SAND, SOME TO "AND" SILTY CLAY
  2) SOFT TO HARD BROWN AND GRAY SILTY CLAY, SOME FINE TO COARSE SAND, SOME FINE TO COARSE GRAVEL

- $N_{60}$ VALUES (IN GRANULAR ZONES)

LOW: 16
HIGH: 50
AVG: 26

- HAND PENETROMETER (ON SAMPLES EXHIBITING COHESION)

H = 0.0 - 4.5+ tsf

- STRENGTH PARAMETER:

IF CONSIDERED GRANULAR, $\phi$ = 34-35° BASED ON TABLE 7.1 USING AVERAGE $N_{60}$-VALUE. ADJUST FOR HIGH FINE GRAINED CONTENT, SAY $\phi'$ = 32°

1) CORRELATION TO STARK CHARTS
   - FOR CORRELATION, CONSIDER BOTH $\phi_{v0}'$ = 50 KPa AND 100 KPa TO ACCOUNT FOR PROBABLE DEPTH OF FAILURE SURFACE.
   - RESULTS: $\phi_{fs}'$ = 31° (SEE CORRELATIONS THIS APPENDIX)

2) GRAPH OF $\phi'$ VRS PI:
   - RESULTS: $\phi'$ = 33° (SEE CHART THIS APPENDIX)

3) N/A FOR FILL SOILS

4) NAVFAC TABLE 1:

| GROUP | SOIL TYPE | TYP STRENGTH | TYP K (cm/sec) |
|---|---|---|---|
| GC | CLAYEY GRAVEL | $C'=0$, $\phi' > 31°$ | $>10^{-7}$ |
| SC | CLAYEY SANDS | $C'$= 230 psf, $\phi'$ = 31° | $5 \times 10^{-7}$ |
| CL | INORG CLAYS OF LOW-MED PI | $C'$= 270 psf, $\phi'$ = 28° | $>10^{-7}$ |

DESIGN STRENGTH: $C'$ = 0 psf, $\phi'$ = 31°

- PERMEABILITY: BASED ON PERMEABILITY CORRELATIONS & TYPICAL RANGE OF PERMEABILITY, USE $K_v = 1 \times 10^{-5}$ cm/sec. SEE CORRELATION THIS APPENDIX. ADJUST $K_v/K_H$ RATIO DURING ANALYSIS TO MATCH FIELD CONDITIONS

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Sheet 4 of 8

LAYER : ORIGINAL EMBANKMENT FILL (OLDER FILL)

- DESCRIPTION : STIFF TO HARD BROWN MOTTLED WITH GRAY SILTY CLAY (USCS : LEAN CLAY)

- HAND PENETROMETER RANGE : 1.5 - 4.5 tsf

- STRENGTH PARAMETER :

1) CORRELATION TO STARK CHARTS
CONSIDER $\phi_{v0}' = 50$ KPa BASED ON RELATION OF THIS LAYER TO THE FAILURE PLANE.
- RESULTS : $\phi_{FS}' = 30°$
(SEE CORRELATION THIS APPENDIX)

2) $\phi'$ VRS PI
- RESULTS : FOR PI = 24 , $\phi' = 30°$ (SEE CHART THIS APPENDIX)

3) N/A FOR FILL SOILS

4) NAVFAC TABLE 1

| GROUP | SOIL TYPE | TYP UNDRAINED STRENGTH | TYP K (cm/sec) |
|---|---|---|---|
| CL | INORGANIC CLAYS OF LOW TO MED PLASTICITY | $c' = 270$ psf<br>$\phi' = 28°$ | $> 10^{-7}$ |

DESIGN STRENGTH PARAMETER : $c' = 100$ psf , $\phi' = 30°$

- PERMEABILITY :

FLEX WALL PERMEABILITY TEST PERFORMED ON SAMPLE ST-6A OF BORING BAP-0907

- RESULTS $K_v = 7.42 \times 10^{-8}$ cm/sec

- DESIGN : USE $K_v = 1 \times 10^{-7}$ cm/sec TO ACCOUNT FOR PERM ON A MACRO SCALE.

$\Rightarrow$ $K_v$ ADJUSTED TO $5 \times 10^{-8}$ cm/sec WITH $K_H/K_V = 5$ DURING SEEPAGE ANALYSIS

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Project/Proposal Name CARDINAL ASH POND Checked By MGR Date 7-2-09
Subject STRENGTH & PERM. Sheet 5 of 8

LAYER: ALLUVIUM SILT & CLAY

- DESCRIPTION: VERY LOOSE TO MED DENSE GRAY SILT, CONTAINS ZONES OF STIFF TO HARD SILTY CLAY AND THIN LAYERS OF VERY LOOSE TO LOOSE FINE TO COARSE SAND

- $N_{60}$ RANGE: 0 TO 27, AVG = 8 bpf

- HAND PENETROMETER: 0 - 3.5 tsf ON SICL SAMPLES

- STRENGTH PARAMETERS

1) STARK CORRELATION:
   - CONSIDER BOTH $\sigma'_{vo}$ = 100 kPa AND 400 kPa WITH TENDANCY TOWARD 100 kPa
   - RESULTS: $\phi'_{FS}$ = 30° (SEE CORRELATION THIS APPENDIX)

2) $\phi'$ VRS PI
   - RESULTS: FOR PI = 15, $\phi'$ = 31.5° (SEE CHART THIS APPENDIX)

3) HALL'S THESIS

$$\phi'_{NC} = 36 - 0.2665\,(\%\ \text{CLAY})$$

FOR CF = 10.9, $\phi'_{NC}$ = 33°

4) N/A FOR NATURAL SOILS – USE TABLE 3.28 - COMMON PROPERTIES OF COHESIONLESS SOILS (SOURCE )
   - FOR 'LOOSE INORGANIC SILTS' $\phi'$ = 27°

Design Strength Parameter: Use $\phi'_{NC}$ = 30°, $c'$ = 0 psf

- Permeability: Based on soil description.

$k_v = 1 \times 10^{-5}$ cm/s (typical published value)

PLATE 12

Project/Proposal No. 01/11497.013
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Subject STRENGTH & PERMEABILITY
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LAYER : ORGANIC CLAYEY SILT

- DESCRIPTION : VERY SOFT TO STIFF ORGANIC CLAYEY SILT, CONTAINS SEAMS OF VERY LOOSE ORGANIC SILT

* - LOSS ON IGNITION : RANGE = 7.9% TO 10.4% FROM 3 ✓ SAMPLES TESTED.

- HAND PENETROMETER : 0.0 - 1.25 tsf

- STRENGTH PARAMETER :

1) STARK CORRELATION :
   - CONSIDER $\phi_{vo}'$ = 100 KPa AND 400 KPa WITH TENDANCY TOWARD 100 KPa
   - RESULTS : $\phi_{FS}' = 26°$ (SEE CORRELATION THIS APPENDIX)

2) $\phi'$ VRS PI
   - RESULTS : FOR PI = 16 , $\phi' = 31°$ (SEE CHART THIS APPENDIX)

3) HALL'S THESIS

   $\phi_{NC}' = 36 - 0.2665$ (% CLAY)

   FOR CF = 16 , $\phi_{NC}' = 31.7°$

5) CU TRIAXIAL TEST - SAMPLE WAS NOT DESCRIBED AS 'ORGANIC', BUT DESCRIPTION BEST MATCHES THIS LAYER

   RESULTS : $\phi' = 36.9°$ , $c' = 110$ psf

- PERMEABILITY : $D_{15}$ -

  LOW = 0.0015
  HIGH = 0.005
  AVG = 0.0023

  } $K_v = 5 \times 10^{-6}$ cm/s (GEOSYNTEC, SEE APPENDIX)

  (4 SAMPLES TOO COARSE FOR $D_{15}$ VALUE

* PER FHWA GEC 5, LOI < 20% SOIL PROPERTIES CONTROLLED BY NON-ORGANIC PORTION ∴ REGULAR CORRELATIONS OK

DESIGN STRENGTH PARAMETER : $\phi' = 30°$, $c' = 0$ psf

PLATE 13

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Subject STRENGTH & PERM. Sheet 7 of 8

+ LAYER: VERY LOOSE - LOOSE GLACIAL OUTWASH SAND & GRAVEL

- DESCRIPTION: VERY LOOSE TO LOOSE BROWN AND GY FINE TO MEDIUM SAND, TRACE TO SOME SILT OR INTERBEDDED WITH SILT, FEW SEAMS OF SILTY CLAY

- $N_{60}$ RANGE:

| | | $\phi'$ | |
|---|---|---|---|
| | | EQN 72 | TABLE 7.1 |
| LOW | 4 | 27.8 | 28° |
| HIGH | 29 | 41.1 | 35°- 36° |
| AVG | 12 | 33.6 | 30 - 31° |

USE $\phi' = 29°$ & $c' = 0$

- PERMEABILITY: USE GRAIN SIZE ANALYSIS

BORING CV-PZ-BAP-0904, SAMPLE 21, $D_{15} \approx 0.06$

$k_v = 1 \times 10^{-2}$ cm/s (See appendix → Geosyntec, 1991)

+ LAYER: MED DENSE GLACIAL OUTWASH SAND & GRAVEL

- DESCRIPTION: MED DENSE TO DENSE BROWN AND GRAY FINE TO COARSE GRAVEL AND FINE TO MED SAND.

- $N_{60}$ RANGE:

| | | $\phi'$ | |
|---|---|---|---|
| | | EQN 72 | TABLE 7.1 |
| LOW | 14 | 34.7 | 31°- 32° |
| HIGH | 69 | 52.6 | >41 |
| AVG | 32 | 42.2 | 36° |

USE $\phi' = 34°$ & $c' = 0$

Permeability:

| BORING | SAMPLE | $D_{15}$ |
|---|---|---|
| 0903 | S-11 | 0.09 |
| 0905 | S-13 | 0.19 |
| 0906 | S-24 | 0.6 |
| 0907 | S-13 | 0.25 |
| 0902 | S-24 | 0.09 |

(See appendix)

**PLATE 14**

Use $k_v = 1 \times 10^{-3}$ cm/s (Geosyntec, 1991)

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Subject SEISMIC STRENGTH PARAMETERS Sheet 8 of 8

- PERFORM SEISMIC STABILITY ANALYSIS, WITH A PSEUDOSTATIC APPROACH USING LIMIT EQUILIBRIUM METHOD

⇒ APPLY HORIZONTAL LOAD TO STATIC MODEL EQUAL TO THE PEAK HORIZONTAL ACCELERATION, a, DETERMINED FROM SEISMIC HAZARD MAPPING

- ASSUMED ORIGINAL EMBANKMENT FILL LAYER WILL EXHIBIT UNDRAINED RESPONSE DURING AN EARTHQUAKE EVENT.
  ∴ USE USACE 'R' ENVELOPE TO MODEL THE STRENGTH PROPERTIES.

SINCE NO CU TEST DATA IS AVAILABLE FOR THE ORIGINAL FILL, COMPARE INDEX TESTING RESULTS TO VALUES PRESENTED BY DUNCAN AND WRIGHT (2005) FOR 'R' TEST RESULTS.

BASED ON COMPARISON, USE THE FOLLOWING STRENGTH VALUES

| LAYER | C | $\phi$ |
|---|---|---|
| ORIGINAL EMBANKMENT FILL | 50 psf | 22° |

SEE TABLE 10.3 ON FOLLOWING PG.

CU TEST PERFORMED IN ORG CLSI LAYER – USE R-ENVELOPE TO MODEL STRENGTHS FOR SEISMIC

ORG. CLSI ⟶ $c = 180$ psf, $\phi = 24°$

ALLUVIUM & GLACIAL OUTWASH FOUNDATION LAYERS WILL LIKELY EXHIBIT DRAINED STRENGTHS DURING EARTHQUAKE. ∴ USE PARAMETERS DEVELOPED FOR DRAINED ANALYSIS

NEWER EMBANKMENT FILL LAYER HAS SUFFICIENT GRANULAR MATERIAL TO ASSUME IT WILL EXHIBIT A DRAINED RESPONSE

DUNCAN & WRIGHT (2005)

**Table 10.3 Summary of Soil Properties Used in Comparison of $R$ and $\tau_{ff}$ vs. $\sigma'_{fc}$ Strength Envelopes**

| Soil no. | Description and reference | Index properties | $c'$ (psf) | $\phi'$ (deg) | $c_R$ (psf) | $\phi_R$ (deg) | $d^a$ (psf) | $\psi^b$ (deg) |
|---|---|---|---|---|---|---|---|---|
| 1 | Sandy clay (CL) material from Pilarcitos Dam; envelope for low (0–10 psi) confining pressures. (Wong et al., 1983) | Percent minus No. 200: 60–70<br>Liquid limit: 45<br>Plasticity index: 23 | 0 | 45 | 60 | 23 | 64 | 24.4 |
| 2 | Brown sandy clay from dam site in Rio Blanco, Colorado (Wong et al., 1983) | Percent minus No. 200: 25<br>Liquid limit: 34<br>Plasticity index: 12 | 200 | 31 | 700 | 15 | 782 | 16.7 |
| 3 | Same as soil 1 except envelope fit to 0–100 psi range in confining pressure (Wong et al., 1983) | Percent minus No. 200: 60–70<br>Liquid limit: 45<br>Plasticity index: 23 | 0 | 34 | 300 | 15.5 | 327 | 16.8 |
| 4 | Hirfanli Dam fill material (Lowe and Karafiath, 1960) | Percent minus No. 200: 82<br>Liquid limit: 32.4<br>Plastic limit: 19.4 | 0 | 35 | 1400 | 22.5 | 1716 | 26.9 |

ORIGINAL EMBANKMENT FILL
USE C=50psf & $\phi$=22°
LL=48, PI=24

[a] Intercept of $\tau_{ff}$ vs. $\sigma'_{fc}$ envelope—can be calculated knowing $c'$, $\phi'$, $c_R$, and $\phi_R$.
[b] Slope of $\tau_{ff}$ vs. $\sigma'_{fc}$ envelope—can be calculated knowing $c'$, $\phi'$, $c_R$, and $\phi_R$.

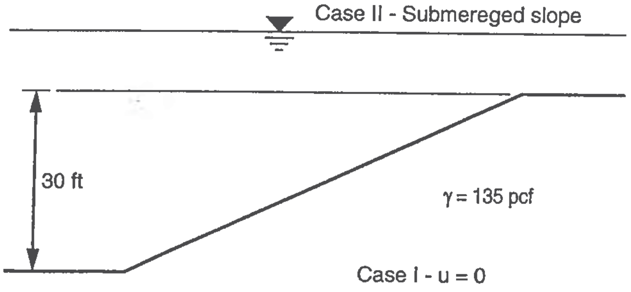

**Figure 10.6** Slope used to compare simple, single-stage and rigorous, two-stage pseudostatic analyses.

**Table 10.4 Summary of Pseudostatic Safety Factors Computed Using Simple Single-Stage and Rigorous Two-Stage Procedures**

| | Case I: dry slope | | Case II: submerged slope | |
|---|---|---|---|---|
| Soil | Single-stage analysis | Two-stage analysis | Single-stage analysis | Two-stage analysis |
| 1 | 0.95 | 1.06 | 0.83 | 0.95 |
| 2 | 1.56 | 1.77 | 1.59 | 1.79 |
| 3 | 1.07 | 1.19 | 1.10 | 1.21 |
| 4 | 2.76 | 3.42 | 2.83 | 3.49 |

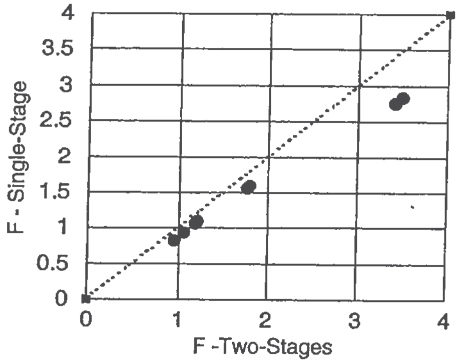

**Figure 10.7** Comparison of factors of safety by simplified single-stage pseudostatic and more rigorous two-stage pseudostatic analyses.

used for cases where significant (more than 15 to 20%) strength losses are not anticipated.

## POSTEARTHQUAKE STABILITY ANALYSES

Following an earthquake, the stability of a slope may be diminished because cyclic loading has reduced the shear strength of the soil. The reductions in shear strength are generally treated differently depending on whether or not liquefaction occurs. Stability follow-

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# DRAINED SHEAR STRENGTH PARAMETER CORRELATION

Project No: 011-11497-014 Date: 5/29/09
Project: Gavin Plant Bottom Ash Pond Investigation

**Reference:**
Drained Shear Strength Parameters for Analysis of Landslides. Timothy D. Stark; Hangseok Choi; and Sean McCone. Journal of Geotechnical Engineering, May 2005. pp 575 - 588

**Purpose:**
Estimate effective stress, or drained, shear strength parameters of cohesive soils through emperical correlations using laboratory index testing and the effective normal stress. Secant residual and secant fully softened friction angles can be estimated from charts developed by Stark et al.

**Laboratory Data**

Soil Layer: Newer Embankment Fill

Statistical Results from 4 Borings

| | PI | LL | MC | % Passing #200 Sieve (.075 mm) | Clay Sized Fraction (.002 mm) |
|---|---|---|---|---|---|
| Number in Statistical Sample | 12 | 12 | 16 | 9 | 8 |
| Minimum | 9 | 25 | 10 | 24 | 8 |
| Maximum | 18 | 37 | 31 | 79 | 21 |
| Mean | 12.1 | 30.3 | 16.3 | 41.6 | 12.1 |
| Median | 11 | 28.5 | 14.5 | 31 | 11 |
| Mode | 10 | 27 | 16 | 31 | 12 |
| Std Dev | 3.2 | 4.5 | 5.4 | 18.9 | 4.6 |
| *Design Value* | *10* | 27 | - | - | 12 |

**Adjustment Factor for ASTM Derived Values**

$$\frac{\textit{ball-milled derived LL}}{\textit{ASTM derived LL}} = .003\ (\textit{ASTM derived LL}) + 1.23$$

$LL_{ASTM}$ = 27
$LL_{BM}$ = 35.4

$$\frac{\textit{ball-milled derived CF}}{\textit{ASTM derived CF}} = 0.0003\ (\textit{ASTM derived CF})2 - 0.037(\textit{ASTM derived CF}) + 2.254$$

$CF_{ASTM}$ = 12
$CF_{BM}$ = 22.2

where: LL = Liquid Limit
CF = Clay-sized Fraction

**PLATE 17**

## DRAINED SHEAR STRENGTH PARAMETER CORRELATION

Soil Layer: Newer Embankment Fill
$LL_{BM}$ = 35.4
$CF_{BM}$ = 22.2

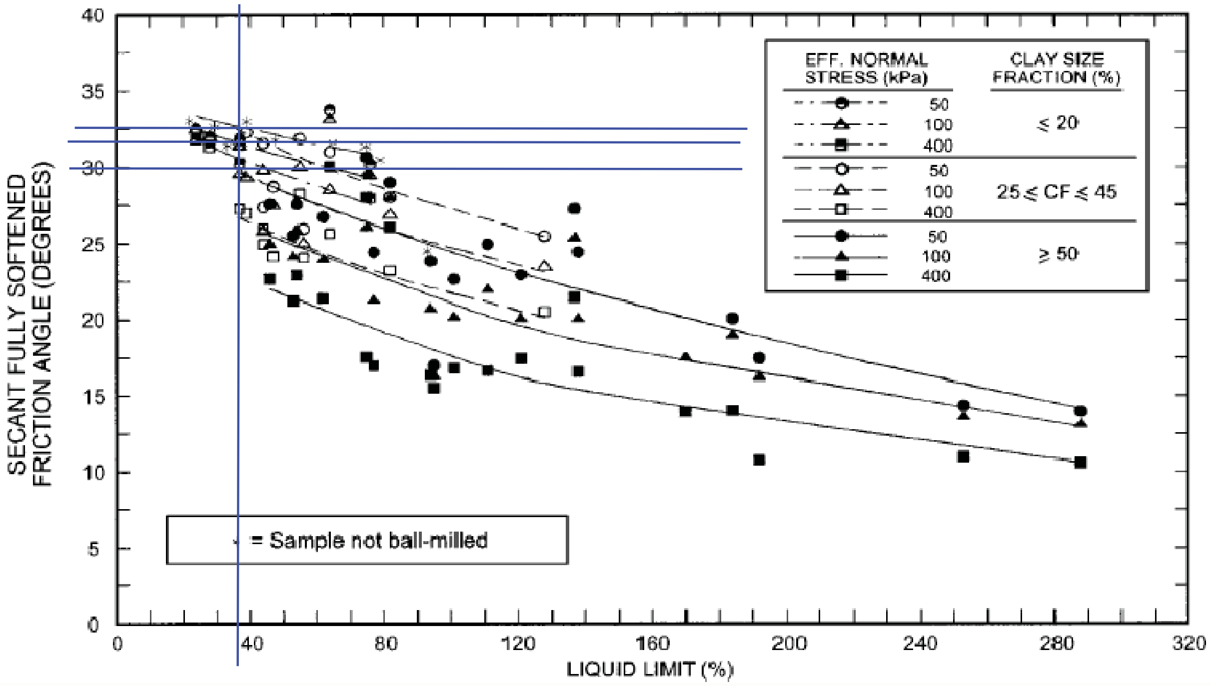

**Fig. 5.** Secant fully softened friction angle relationships with liquid limit, clay-size fraction, and effective normal stress

### Secant Fully Softened Friction Angle

| | | Effective Normal Stress | |
|---|---|---|---|
| | | *50 kPa* | *100 kPa* |
| Clay Sized Fraction, % | *CF ≤ 20* | 32.5° | 31.5° |
| | *25 ≤ CF ≤ 45* | 32.5° | 30° |

| | |
|---|---|
| **Design Friction Angle Value** | 31° |

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# DRAINED SHEAR STRENGTH PARAMETER CORRELATION

Project No: 011-11497-014 Date: 5/29/09
Project: Gavin Plant Bottom Ash Pond Investigation

**Reference:**
Drained Shear Strength Parameters for Analysis of Landslides. Timothy D. Stark; Hangseok Choi; and Sean McCone. Journal of Geotechnical Engineering, May 2005. pp 575 - 588

**Purpose:**
Estimate effective stress, or drained, shear strength parameters of cohesive soils through emperical correlations using laboratory index testing and the effective normal stress. Secant residual and secant fully softened friction angles can be estimated from charts developed by Stark et al.

**Laboratory Data**

Soil Layer: Original Embankment Fill

Statistical Results from 3 Borings

| | PI | LL | MC | % Passing #200 Sieve (.075 mm) | Clay Sized Fraction (.002 mm) |
|---|---|---|---|---|---|
| Number in Statistical Sample | 6 | 6 | 10 | 5 | 4 |
| Minimum | 14 | 32 | 15 | 76 | 23 |
| Maximum | 24 | 49 | 33 | 96 | 32 |
| Mean | 19.8 | 43.3 | 22.5 | 86.2 | 28.0 |
| Median | 20.5 | 47.5 | 22 | 86 | 28.5 |
| Mode | 24 | 48 | 22 | #N/A | #N/A |
| Std Dev | 4.4 | 7.4 | 5.1 | 8.1 | 3.7 |
| | | | | | |
| *Design Value* | *24* | 48 | - | - | 28 |

**Adjustment Factor for ASTM Derived Values**

$$\frac{\text{ball-milled derived LL}}{\text{ASTM derived LL}} = .003\ (\text{ASTM derived LL}) + 1.23$$

$LL_{ASTM}$ = 48
$LL_{BM}$ = 66.0

$$\frac{\text{ball-milled derived CF}}{\text{ASTM derived CF}} = 0.0003\ (\text{ASTM derived CF})2 - 0.037(\text{ASTM derived CF}) + 2.254$$

$CF_{ASTM}$ = 28
$CF_{BM}$ = 40.7

where: LL = Liquid Limit
CF = Clay-sized Fraction

PLATE 19

## DRAINED SHEAR STRENGTH PARAMETER CORRELATION

Soil Layer: Original Embankment Fill

$LL_{BM}$ = 66.0

$CF_{BM}$ = 40.7

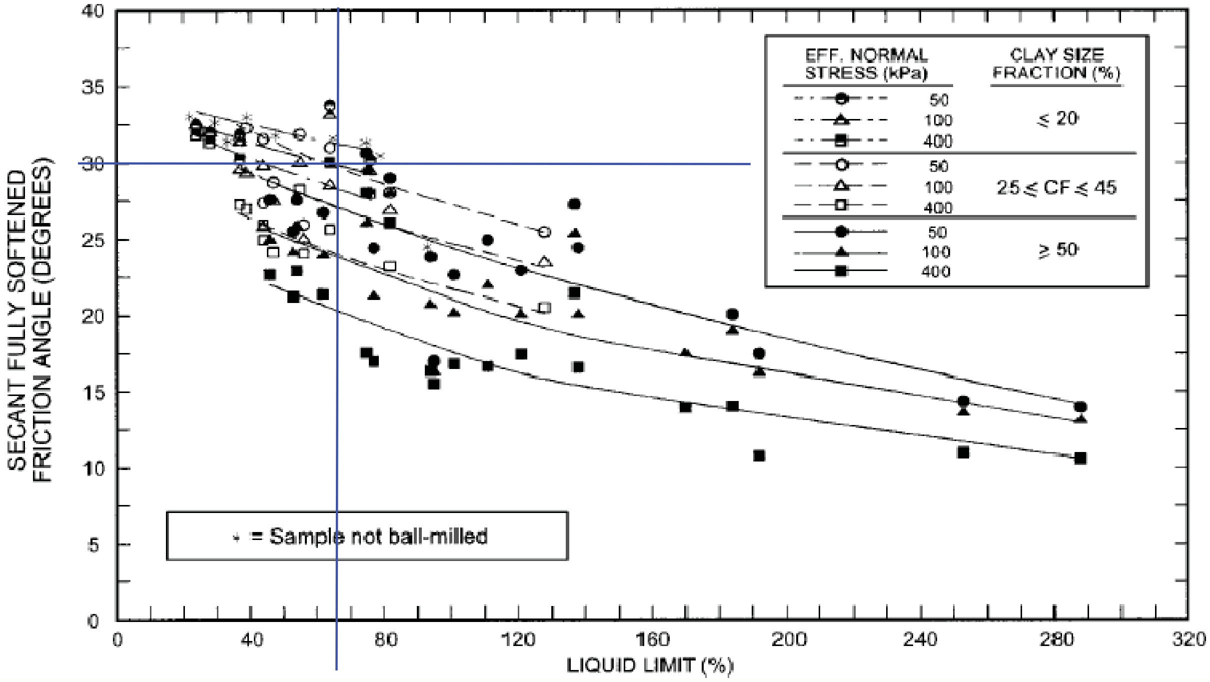

**Fig. 5.** Secant fully softened friction angle relationships with liquid limit, clay-size fraction, and effective normal stress

| | |
|---|---|
| Effective Normal Stress, kPa | 50 |
| **Secant Fully Softened Friction Angle** | **$30^o$** |

# DRAINED SHEAR STRENGTH PARAMETER CORRELATION

Project No: 011-11497-014 Date: 5/29/09
Project: Gavin Plant Bottom Ash Pond Investigation

**Reference:**
Drained Shear Strength Parameters for Analysis of Landslides. Timothy D. Stark; Hangseok Choi; and Sean McCone. Journal of Geotechnical Engineering, May 2005. pp 575 - 588

**Purpose:**
Estimate effective stress, or drained, shear strength parameters of cohesive soils through emperical correlations using laboratory index testing and the effective normal stress. Secant residual and secant fully softened friction angles can be estimated from charts developed by Stark et al.

**Laboratory Data**

Soil Layer: Organic Clayey Silt

Statistical Results from 7 Borings

| | PI | LL | MC | % Passing #200 Sieve (.075 mm) | Clay Sized Fraction (.002 mm) |
|---|---|---|---|---|---|
| Number in Statistical Sample | 17 | 17 | 20 | 21 | 19 |
| Minimum | 3 | 30 | 34 | 56 | 12 |
| Maximum | 20 | 50 | 54 | 97 | 44 |
| Mean | 13.5 | 40.6 | 42.5 | 78.2 | 19.8 |
| Median | 15 | 41 | 43 | 81 | 18 |
| Mode | 16 | 45 | 43 | 81 | 16 |
| Std Dev | 4.6 | 5.3 | 4.4 | 10.7 | 7.0 |
| | | | | | |
| *Design Value* | *16* | 45 | - | - | 20.0 |

**Adjustment Factor for ASTM Derived Values**

$$\frac{\textit{ball-milled derived LL}}{\textit{ASTM derived LL}} = .003\ (\textit{ASTM derived LL}) + 1.23$$

$LL_{ASTM}$ = 45
$LL_{BM}$ = 61.4

$$\frac{\textit{ball-milled derived CF}}{\textit{ASTM derived CF}} = 0.0003\ (\textit{ASTM derived CF})2 - 0.037(\textit{ASTM derived CF}) + 2.254$$

$CF_{ASTM}$ = 20.0
$CF_{BM}$ = 32.7

where: LL = Liquid Limit
CF = Clay-sized Fraction

**PLATE 21**

## DRAINED SHEAR STRENGTH PARAMETER CORRELATION

Soil Layer: Organic Clayey Silt

$LL_{BM}$ = 61.4

$CF_{BM}$ = 32.7

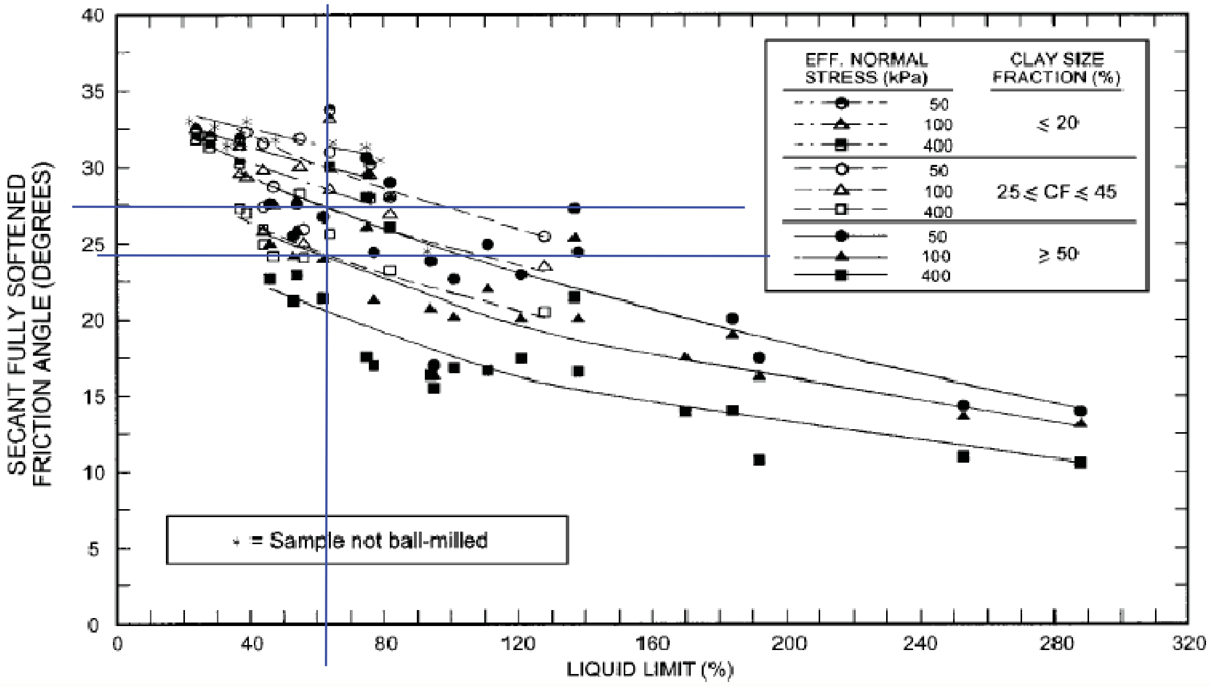

**Fig. 5.** Secant fully softened friction angle relationships with liquid limit, clay-size fraction, and effective normal stress

**Secant Fully Softened Friction Angle**

| Clay Sized Fraction, % | | Effective Normal Stress<br>100 kPa | 400 kPa |
|---|---|---|---|
| | *CF ≤ 20* | 27.5° | 24° |
| | *25 ≤ CF ≤ 45* | - | - |

| | |
|---|---|
| **Design Friction Angle Value** | 26° |

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# DRAINED SHEAR STRENGTH PARAMETER CORRELATION

Project No: 011-11497-014 Date: 5/29/09
Project: Gavin Plant Bottom Ash Pond Investigation

**Reference:**

Drained Shear Strength Parameters for Analysis of Landslides. Timothy D. Stark; Hangseok Choi; and Sean McCone. Journal of Geotechnical Engineering, May 2005. pp 575 - 588

**Purpose:**

Estimate effective stress, or drained, shear strength parameters of cohesive soils through emperical correlations using laboratory index testing and the effective normal stress. Secant residual and secant fully softened friction angles can be estimated from charts developed by Stark et al.

**Laboratory Data**

Soil Layer: Alluvium Silt and Clay

Statistical Results from 6 Borings

| | PI* | LL* | MC | % Passing #200 Sieve (.075 mm) | Clay Sized Fraction (.002 mm) |
|---|---|---|---|---|---|
| Number in Statistical Sample | 4 | 4 | 10 | 12 | 10 |
| Minimum | 7 | 34 | 22 | 48 | 3 |
| Maximum | 15 | 38 | 38 | 96 | 28 |
| Mean | 12.5 | 36.0 | 29.0 | 76.8 | 11.0 |
| Median | 14 | 36 | 28.5 | 76.5 | 6.5 |
| Mode | 15 | #N/A | 26 | 91 | 5 |
| Std Dev | 3.8 | 1.8 | 5.4 | 15.9 | 8.5 |

*Does not include results from 'Non-Plastic' samples.

| | | | | | |
|---|---|---|---|---|---|
| *Design Value* | *15* | 36 | - | - | 10.0 |

**Adjustment Factor for ASTM Derived Values**

$$\frac{\text{ball-milled derived LL}}{\text{ASTM derived LL}} = .003\ (\text{ASTM derived LL}) + 1.23$$

$LL_{ASTM}$ = 36
$LL_{BM}$ = 48.2

$$\frac{\text{ball-milled derived CF}}{\text{ASTM derived CF}} = 0.0003\ (\text{ASTM derived CF})2 - 0.037(\text{ASTM derived CF}) + 2.254$$

$CF_{ASTM}$ = 10.0
$CF_{BM}$ = 19.1

where: LL = Liquid Limit
CF = Clay-sized Fraction

**PLATE 23**

BBCM SOLUTIONS TO BUILD ON

## DRAINED SHEAR STRENGTH PARAMETER CORRELATION

Soil Layer: Alluvium Silt and Clay

$LL_{BM}$ = 48.2

$CF_{BM}$ = 19.1

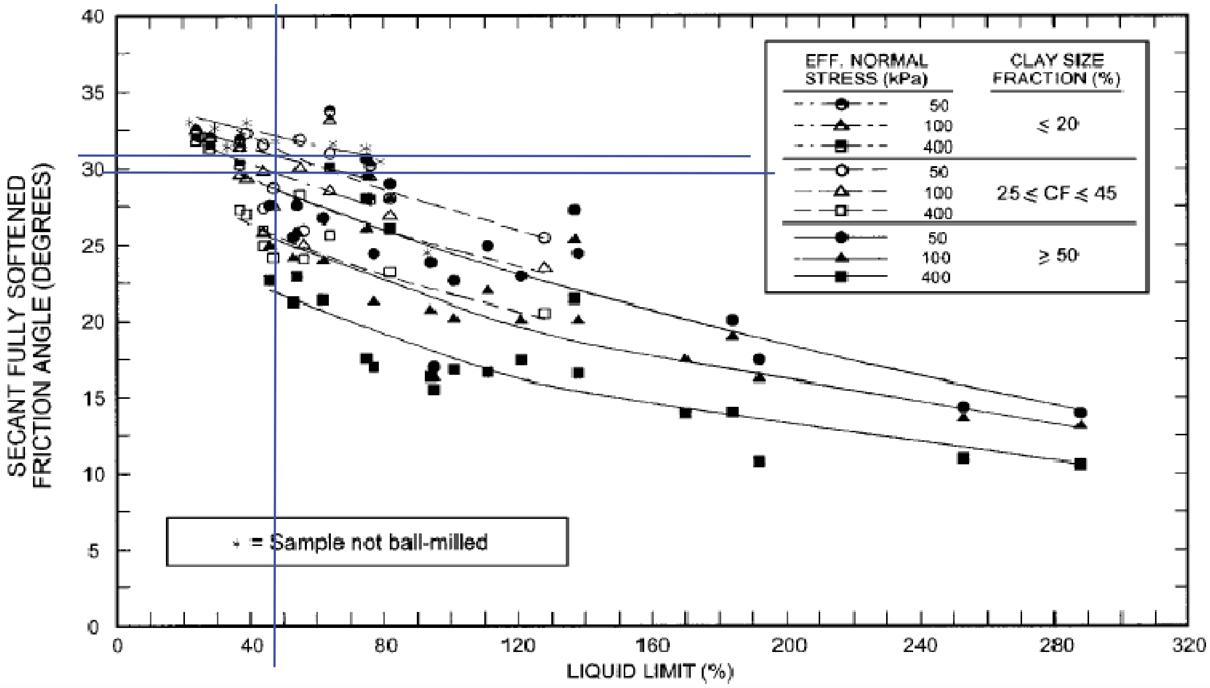


**Fig. 5.** Secant fully softened friction angle relationships with liquid limit, clay-size fraction, and effective normal stress

### Secant Fully Softened Friction Angle

| Clay Sized Fraction, % | | Effective Normal Stress<br>100 kPa | <br>400 kPa |
|---|---|---|---|
| | *CF ≤ 20* | 31° | 29.5° |
| | *25 ≤ CF ≤ 45* | - | - |

| **Design Friction Angle Value** | 30° |
|---|---|

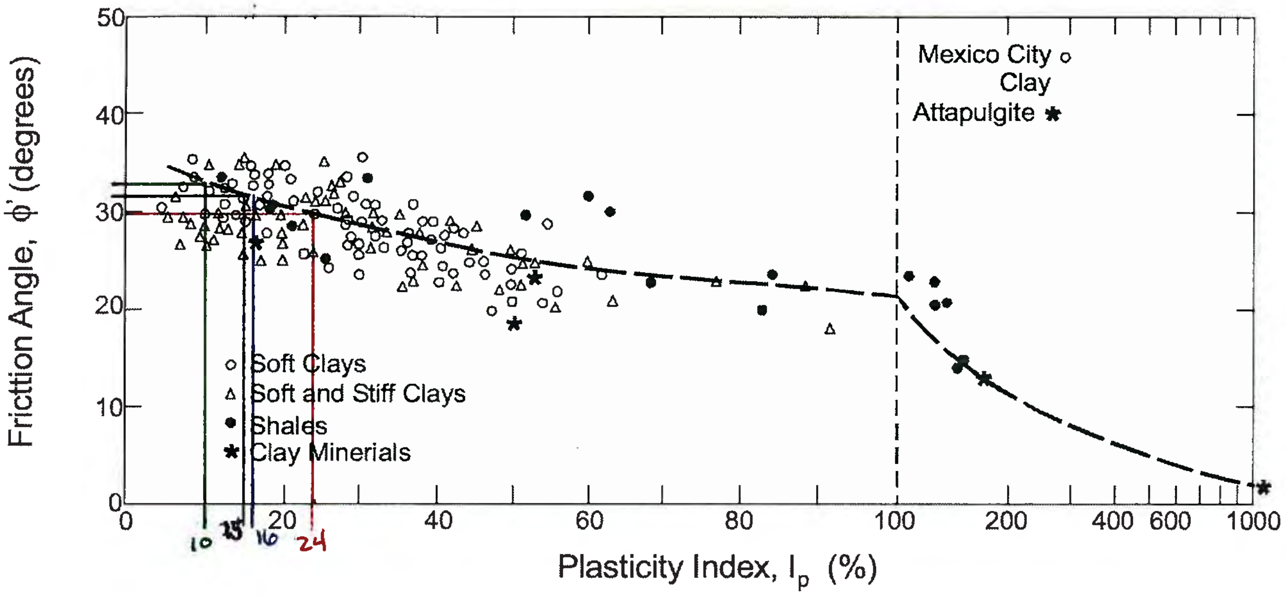


Figure 74. Relationship between ϕ′ and PI (Terzaghi, Peck, and Mesri, 1996).

Report No. FHWA-IF-02-034
Geotechnical Engineering Circular No. 5
Evaluation of Soil and Rock Properties
April, 2002

| | LAYER | P.I. | ϕ' |
|---|---|---|---|
| — | EMBANKMENT EXPANSION FILL | 10 | 33° |
| — | ORIGINAL EMBANKMENT FILL | 24 | 30° |
| — | ALLUVIUM SILT AND CLAY | 15 | 31.5° |
| — | ORGANIC CLAYEY SILT | 16 | 31° |

## TABLE 3.28
## COMMON PROPERTIES OF COHESIONLESS SOILS

$1\ g/cm^3 = \frac{pcf}{62.427}$

| Material | Compactness | $D_R$, % | N* | $\gamma$ dry,† g/cm³ | $\gamma_{dry}$ (pcf) | Void ratio e | $\gamma_{SAT}$ (pcf) | Strength‡ $\phi$ |
|---|---|---|---|---|---|---|---|---|
| GW: well-graded gravels, gravel-sand mixtures | Dense | 75 | 90 | 2.21 | 138 | 0.22 | 149 | 40 |
| | Medium dense | 50 | 55 | 2.08 | 129.8 | 0.28 | 143.5 | 36 |
| | Loose | 25 | <28 | 1.97 | 123 | 0.36 | 139.5 | 32 |
| GP: poorly graded gravels, gravel-sand mixtures | Dense | 75 | 70 | 2.04 | 127.4 | 0.33 | 143 | 38 |
| | Medium dense | 50 | 50 | 1.92 | 120 | 0.39 | 137.5 | 35 |
| | Loose | 25 | <20 | 1.83 | 114.2 | 0.47 | 134 | 32 |
| SW: well-graded sands, gravelly sands | Dense | 75 | 65 | 1.89 | 118 | 0.43 | 136.8 | 37 |
| | Medium dense | 50 | 35 | 1.79 | 111.7 | 0.49 | 132.2 | 34 |
| | Loose | 25 | <15 | 1.70 | 106.1 | 0.57 | 128.8 | 30 |
| SP: poorly graded sands, gravelly sands | Dense | 75 | 50 | 1.76 | 109.9 | 0.52 | 131.3 | 36 |
| | Medium dense | 50 | 30 | 1.67 | 104.2 | 0.60 | 127.6 | 33 |
| | Loose | 25 | <10 | 1.59 | 99.3 | 0.65 | 124 | 29 |
| SM: silty sands | Dense | 75 | 45 | 1.65 | 103 | 0.62 | 127 | 35 |
| | Medium dense | 50 | 25 | 1.55 | 97 | 0.74 | 123.5 | 32 |
| | Loose | 25 | <8 | 1.49 | 93 | 0.80 | 120.7 | 29 |
| ML: inorganic silts, very fine sands | Dense | 75 | 35 | 1.49 | 93 | 0.80 | 120.7 | 33 |
| | Medium dense | 50 | 20 | 1.41 | 88 | 0.90 | 117.6 | 31 |
| | Loose | 25 | <4 | 1.35 | 84.3 | 1.0 | 115.5 | 27 |

*N is blows per foot of penetration in the SPT. Adjustments for gradation are after Burmister (1962).[13] See Table 3.23 for general relationships of $D_R$ vs. N.

†Density given is for $G_s$ = 2.65 (quartz grains).

‡Friction angle $\phi$ depends on mineral type, normal stress, and grain angularity as well as $D_R$ and gradation (see Fig. 3.63).

$1\ g/cm^3 = 9.81\ kN/m^3$

$$\gamma_{SAT} = \frac{(G_s + e)\gamma_w}{1 + e}$$

$$\gamma_{SAT} \cdot \gamma_d + \frac{e\gamma_w}{(1 + e)}$$

## Newer Embankment Fill: Permeability

$D_{15}$ Range = 0.002 - 0.080

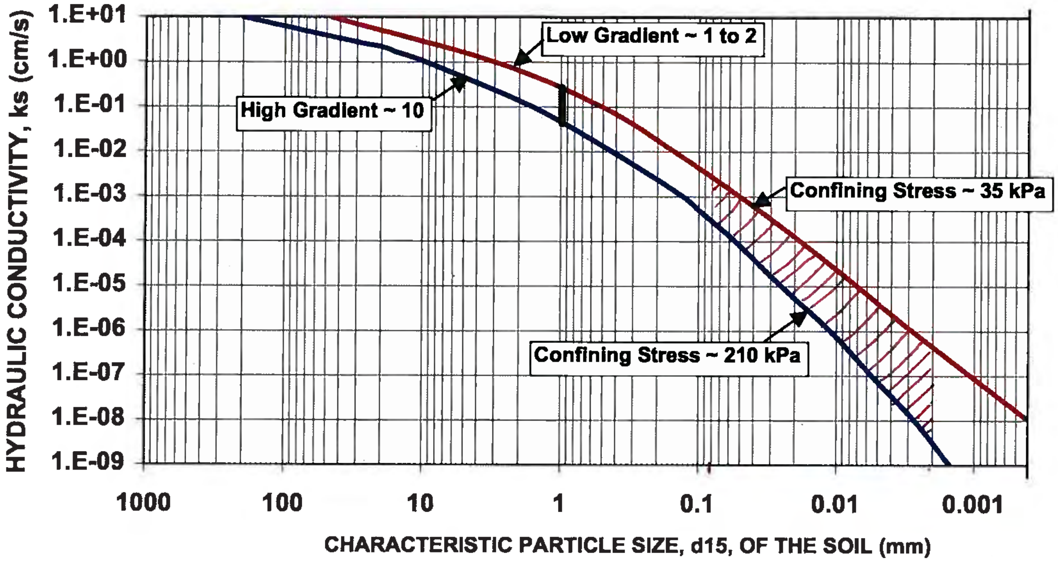


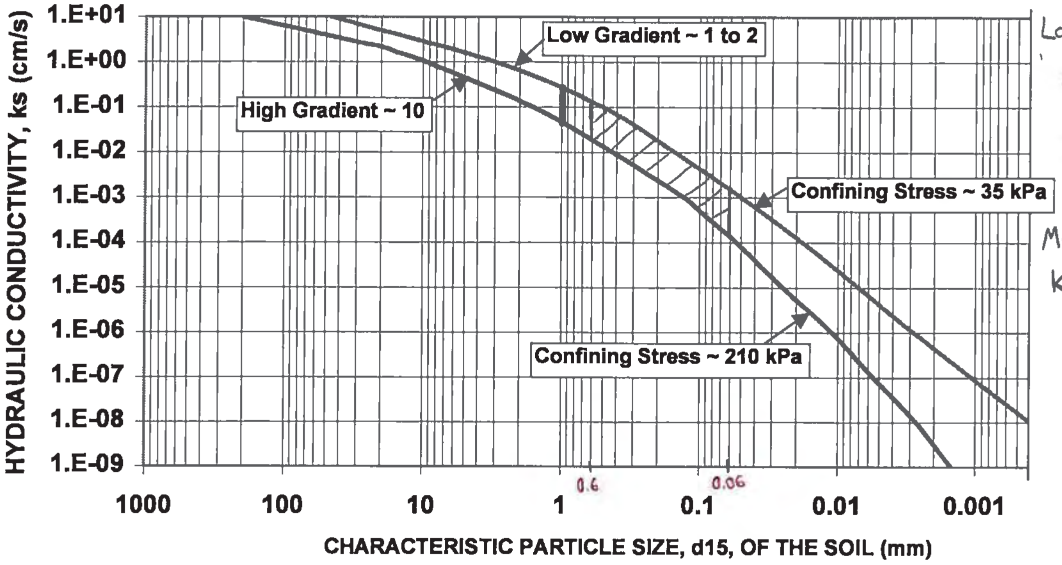
Figure 91. Range of hydraulic conductivity based on grain size (after GeoSyntec, 1991).

Considering the site geology, the laboratory and field data should be tabulated with other known data for the sample/test location and with depth, soil/rock type, grain size distribution, Atterberg limits, and water content. This table should also include important test information such as: stress conditions, gradients, and test method. Once this table is constructed it will be much easier to group like soil types and k values, to delineate distinct areas within the site, and to eliminate potentially erroneous data. Once these values have been grouped together and potentially erroneous values eliminated, it may be useful to compute an average value for each grouping. When averaging, the log of the hydraulic conductivity value must be taken before performing an arithmetic mean or incorrect results will be produced. First, the logarithm of each value should be taken. Second, an average value should be calculated from these logarithmic values. Finally, the antilog of this average value should be taken to calculate the average hydraulic conductivity value. Table 35 illustrates how to calculate the mean of the log of k data and compares this value with an incorrect direct arithmetic mean.

$K_s$ range: $1\times10^{-8} - 1\times10^{-3}$ cm/s

Geotechnical Engineering Circular No. 5
Evaluation of Soil and Rock Properties.

Glacial outwash sand and gravel.



Loose: $k_v = 1 \times 10^{-2}$ cm/s

Medium-dense: $k_v = 1 \times 10^{-3}$ cm/s

Figure 91. Range of hydraulic conductivity based on grain size (after GeoSyntec, 1991).

Considering the site geology, the laboratory and field data should be tabulated with other known data for the sample/test location and with depth, soil/rock type, grain size distribution, Atterberg limits, and water content. This table should also include important test information such as: stress conditions, gradients, and test method. Once this table is constructed it will be much easier to group like soil types and k values, to delineate distinct areas within the site, and to eliminate potentially erroneous data. Once these values have been grouped together and potentially erroneous values eliminated, it may be useful to compute an average value for each grouping. When averaging, the log of the hydraulic conductivity value must be taken before performing an arithmetic mean or incorrect results will be produced. First, the logarithm of each value should be taken. Second, an average value should be calculated from these logarithmic values. Finally, the antilog of this average value should be taken to calculate the average hydraulic conductivity value. Table 35 illustrates how to calculate the mean of the log of k data and compares this value with an incorrect direct arithmetic mean.

Geotechnical Engineering Circular No. 5
Evaluation of Soil and Rock Properties.

Method: Geosyntec
Source: FHWA GEC No 5: pg 184

Equation: Graphic

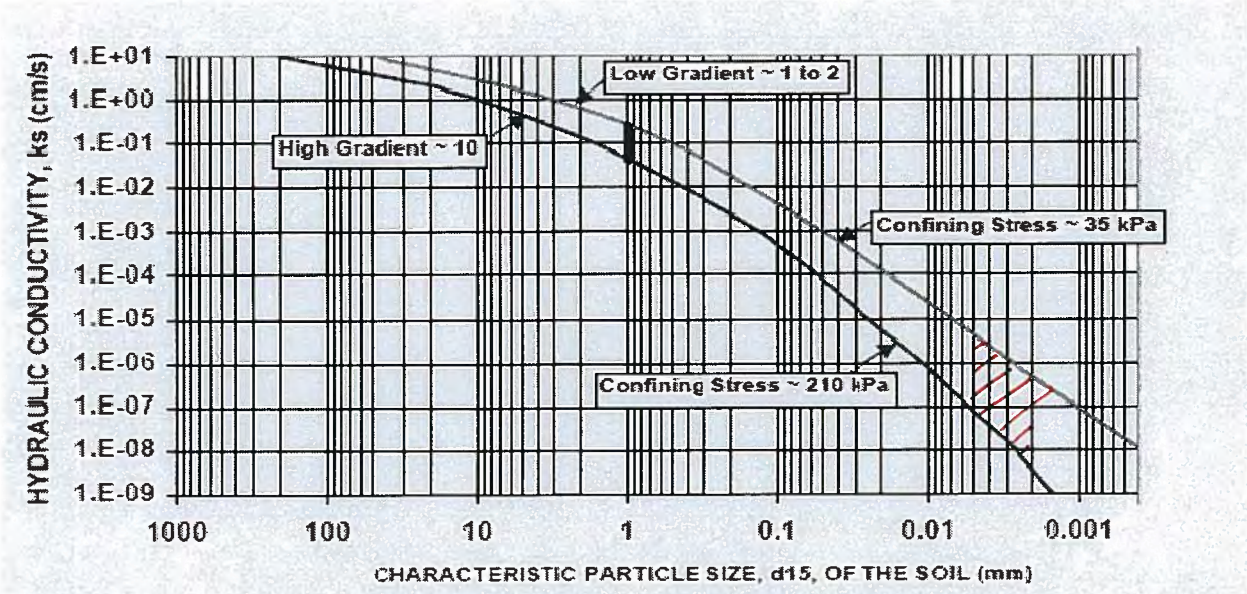


Figure 91. Range of hydraulic conductivity based on grain size after GeoSyntec, 1991).

LAYER: ORGANIC CLAYEY SILT

$d_{15}$ RANGE = 0.0015 mm - 0.005 mm

AVG $d_{15}$ = 0.002 mm

USE $K_v = 5 \times 10^{-6}$ cm/SEC BASED ON INCLUSION OF SILT SEAMS

# PERMEABILITY TEST DATA AND COMPUTATION SHEET

## ((ASTM D-5084) FALLING HEAD, METHOD C)

Job Number: **011.11497.013**
Project Name: **Cardinal Ash Pond Investigation**
Project Location: **Brilliant, Ohio**
Tested By: **PJM**
Remarks:
Material: **FILL : Hard brown, gray and dark-gray silty clay inter-mixed with organic silt, trace fine to coarse sand.**

Date: **5/6-7/2009**
Boring: **CD-PZ-BAP-0907**
Sample: **ST-6A Sec. II**
Depth: **8.5' to 9.9'**

Maximum Dry Density:
Optimum Moisture Content:
% Compaction.:
Optimum +/-:
Natural: X
Remolded:

*Sample:*

Initial Length: 5.5945 in = 14.210 cm
Final Ave. Length (L): 5.6042 in = 14.235 cm
Diameter: 2.8765 in = 7.31 cm
Area (A): 6.499 sq in = 41.93 sq cm
Volume (V): 36.356 cu in = 595.77 cu cm
Wet Wt.: 1144.17 grams
Unit Wet Wt.: 119.90 pcf
Unit Dry Wt.: 93.99 pcf

*Test Conditions:*

Chamber Pressure: 62 psi
Back Pressure: 58 psi
Confining Pressure: 4 psi
Temp. @ Start: 22.5 °C
Temp. @ End: 22.5 °C
Average Temp.: 22.5 °C
*B* Parameter: 0.96

| *Moisture Content:* | Before Test | After Test |
|---|---|---|
| Pan No. = | D | D |
| Wet Wt. + Pan = | 1144.17 | 1157.03 |
| Dry Wt. + Pan = | 896.92 | 896.92 |
| Wt. of Pan = | 0.00 | 0.00 |
| Wt. of Dry Soil = | 896.92 | 896.92 |
| Wt. of Water = | 247.25 | 260.11 |
| % Moisture = | 27.57 | 29.00 |
| **% SATURATION** | **93.80** | **98.30** |

S.G.(est) = 2.7000

*Pipette Pressures During Test:*

Top Pipette: 60 psi = 4220.3 cm
Bottom Pipette: 58 psi = 4079.6 cm

*Pipette:*

Area (a): 0.3435 sq in = 0.8725 sq cm

*Calculations:*

$$\boxed{k = \frac{a \cdot L}{2 \cdot A \cdot \Delta t} \ln\left(\frac{h_1}{h_2}\right)}$$

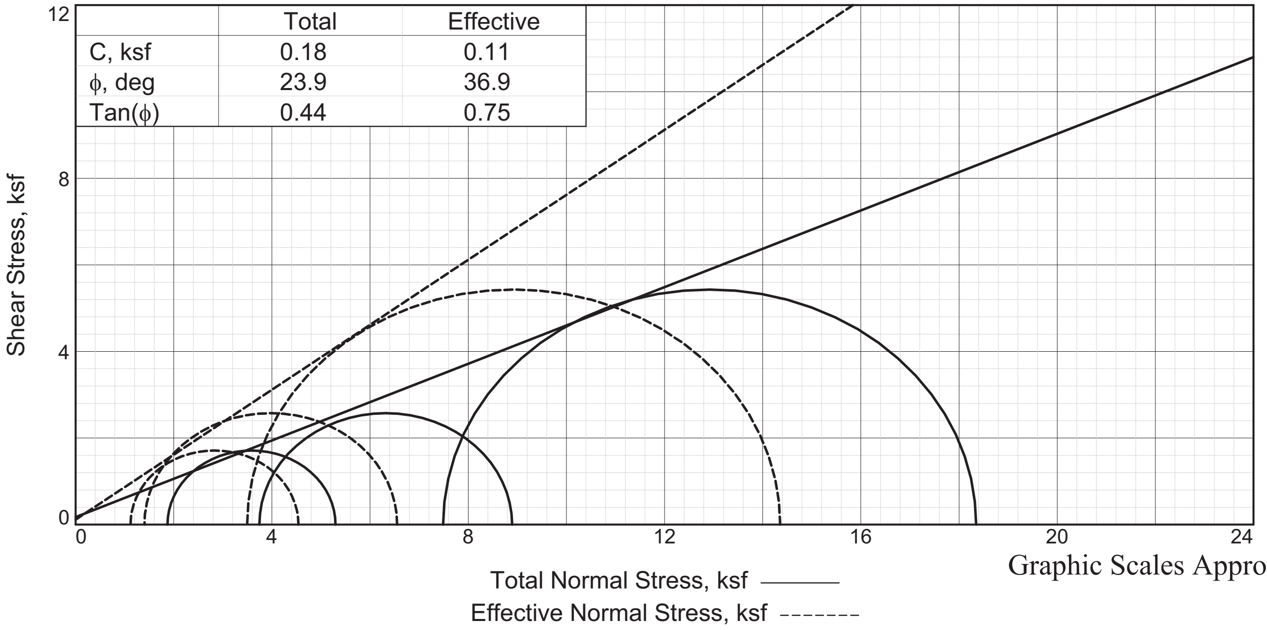
where:

k = Hydraulic Conductivity
a = Pipette Cross-Sectional Area
L = Length of Sample
A = Sample Cross-Sectional Area

Δt = Time Interval ($t_2$ - $t_1$)
$h_1$ = Head Loss Across Permeameter/Specimen at $t_1$
$h_2$ = Head Loss Across Permeameter/Specimen at $t_2$
ln = Natural Logarithm (Base e = 2.71828)

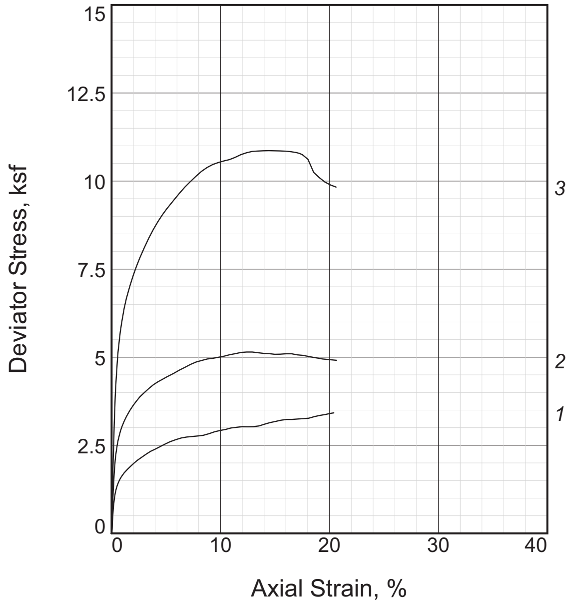
| Date | Time Readings | Time Interval Δt Seconds | Top Pipette cc | Hydraulic Head Headwater $H_1$ cm | Bottom Pipette cc | Hydraulic Head Tailwater $H_2$ cm | Head Loss h = $H_1$-$H_2$ cm | ℓn ($h_1$/$h_2$) | Temp. Corr. Permeability k cm/sec |
|---|---|---|---|---|---|---|---|---|---|
| 5/6/2009 | 9:45 AM | 0.00 | 48.45 | 4092.08 | 14.20 | 4272.01 | -179.93 | – | – |
| 5/6/2009 | 10:51 AM | 3,960 | 48.40 | 4092.14 | 14.45 | 4271.73 | -179.59 | 0.00191 | 6.740E-08 |
| 5/6/2009 | 12:15 PM | 5,040 | 48.20 | 4092.36 | 14.65 | 4271.50 | -179.13 | 0.00256 | 7.077E-08 |
| 5/6/2009 | 1:45 PM | 5,400 | 48.05 | 4092.54 | 15.00 | 4271.09 | -178.56 | 0.00320 | 8.280E-08 |
| 5/6/2009 | 3:17 PM | 5,520 | 47.85 | 4092.77 | 15.25 | 4270.81 | -178.04 | 0.00289 | 7.312E-08 |
| 5/7/2009 | 8:21 AM | 61,440 | 45.60 | 4095.34 | 18.00 | 4267.66 | -172.31 | 0.03272 | 7.431E-08 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

**Time Weighted Average, k** [cm/sec] = **7.423E-08**



| | Total | Effective |
|---|---|---|
| C, ksf | 0.18 | 0.11 |
| ϕ, deg | 23.9 | 36.9 |
| Tan(ϕ) | 0.44 | 0.75 |

Graphic Scales Approximate



| Sample No. | | 1 | 2 | 3 |
|---|---|---|---|---|
| Initial | Water Content, % | 35.1 | 43.8 | 31.9 |
| | Dry Density, pcf | 83.0 | 76.2 | 85.0 |
| | Saturation, % | 92.2 | 97.7 | 87.6 |
| | Void Ratio | 1.0297 | 1.2123 | 0.9833 |
| | Diameter, in. | 2.90 | 2.85 | 2.90 |
| | Height, in. | 5.59 | 5.59 | 5.59 |
| At Test | Water Content, % | 33.3 | 38.9 | 31.0 |
| | Dry Density, pcf | 86.9 | 82.6 | 90.3 |
| | Saturation, % | 95.6 | 101.0 | 96.5 |
| | Void Ratio | 0.9402 | 1.0401 | 0.8674 |
| | Diameter, in. | 2.86 | 2.78 | 2.85 |
| | Height, in. | 5.49 | 5.42 | 5.43 |
| Strain rate, in./min. | | 0.00 | 0.00 | 0.00 |
| Back Pressure, psi | | 40.00 | 40.00 | 40.00 |
| Cell Pressure, psi | | 53.00 | 66.00 | 92.00 |
| Fail. Stress, ksf | | 3.4 | 5.1 | 10.9 |
| Total Pore Pr., ksf | | 6.5 | 8.1 | 9.8 |
| Ult. Stress, ksf | | 3.4 | 4.9 | 9.8 |
| Total Pore Pr., ksf | | 6.5 | 8.0 | 9.9 |
| $\bar{\sigma}_1$ Failure, ksf | | 4.5 | 6.6 | 14.4 |
| $\bar{\sigma}_3$ Failure, ksf | | 1.1 | 1.4 | 3.5 |

**Type of Test:**
CU with Pore Pressures

**Sample Type:** Shelby Tube

**Description:** Gray mottled with dark-gray and brown clayey silt, some fine sand, trace medium to

**LL=** 35 **PL=** 28 **PI=** 7

**Assumed Specific Gravity=** 2.7

**Remarks:**

1

**Client:**

**Project:** Cardinal Plant Ash Pond Investigation
Brilliant, Ohio

**Location:** CD-PZ-BAP-0901

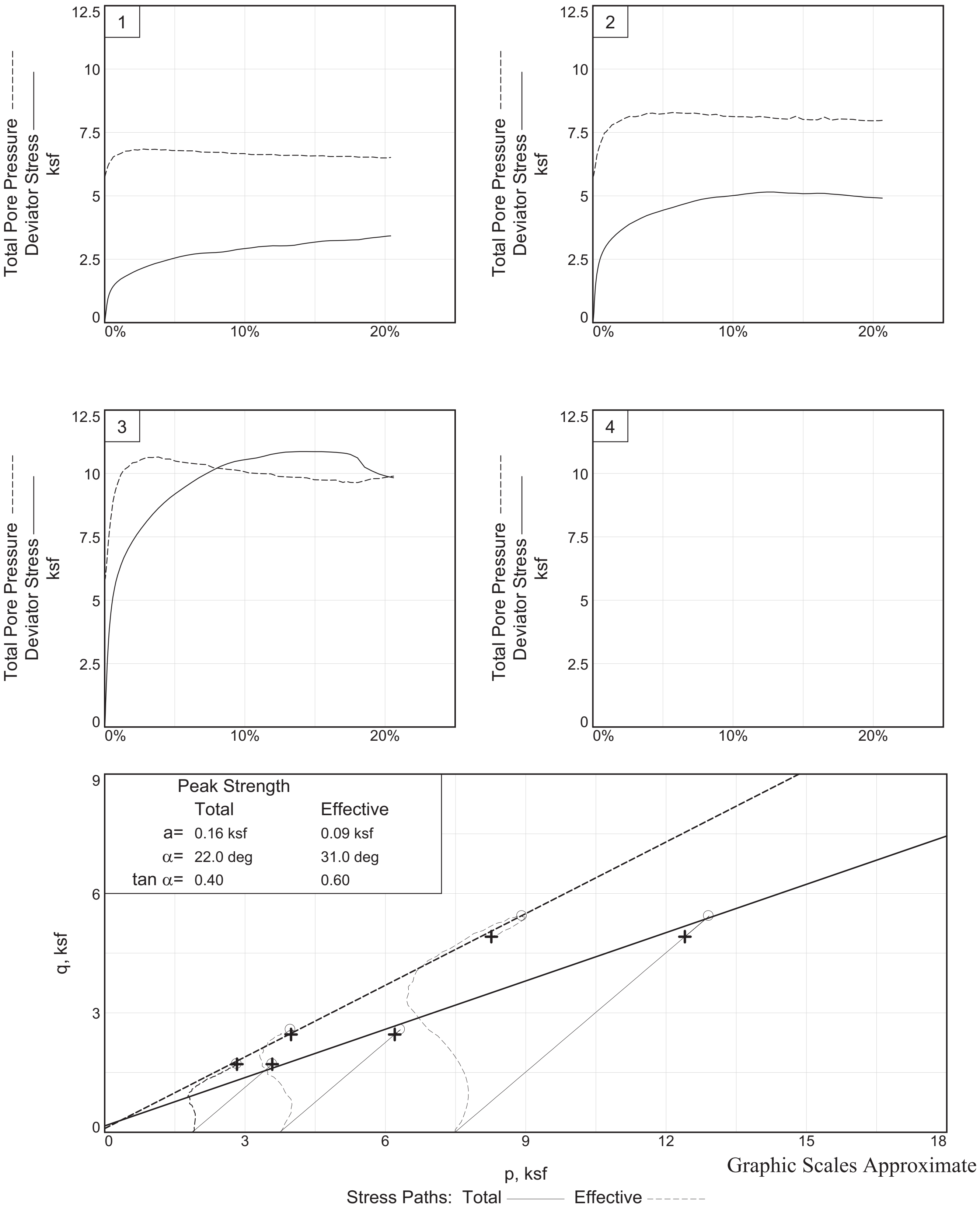
**Sample Number:** ST-19A **Depth:** 31.0' to 32.8'

**Proj. No.:** 011.11497.013 **Date Sampled:** 5/1/09

TRIAXIAL SHEAR TEST REPORT

# BBC&M Engineering, Inc.

**Tested By:** PJM **Checked By:** JJ **PLATE 31**



Peak Strength

| | Total | Effective |
|---|---|---|
| a= | 0.16 ksf | 0.09 ksf |
| α= | 22.0 deg | 31.0 deg |
| tan α= | 0.40 | 0.60 |

Graphic Scales Approximate

**Client:**

**Project:** Cardinal Plant Ash Pond Investigation

**Location:** CD-PZ-BAP-0901 **Depth:** 31.0' to 32.8' **Sample Number:** ST-19A

2

**Project No.:** 011.11497.013

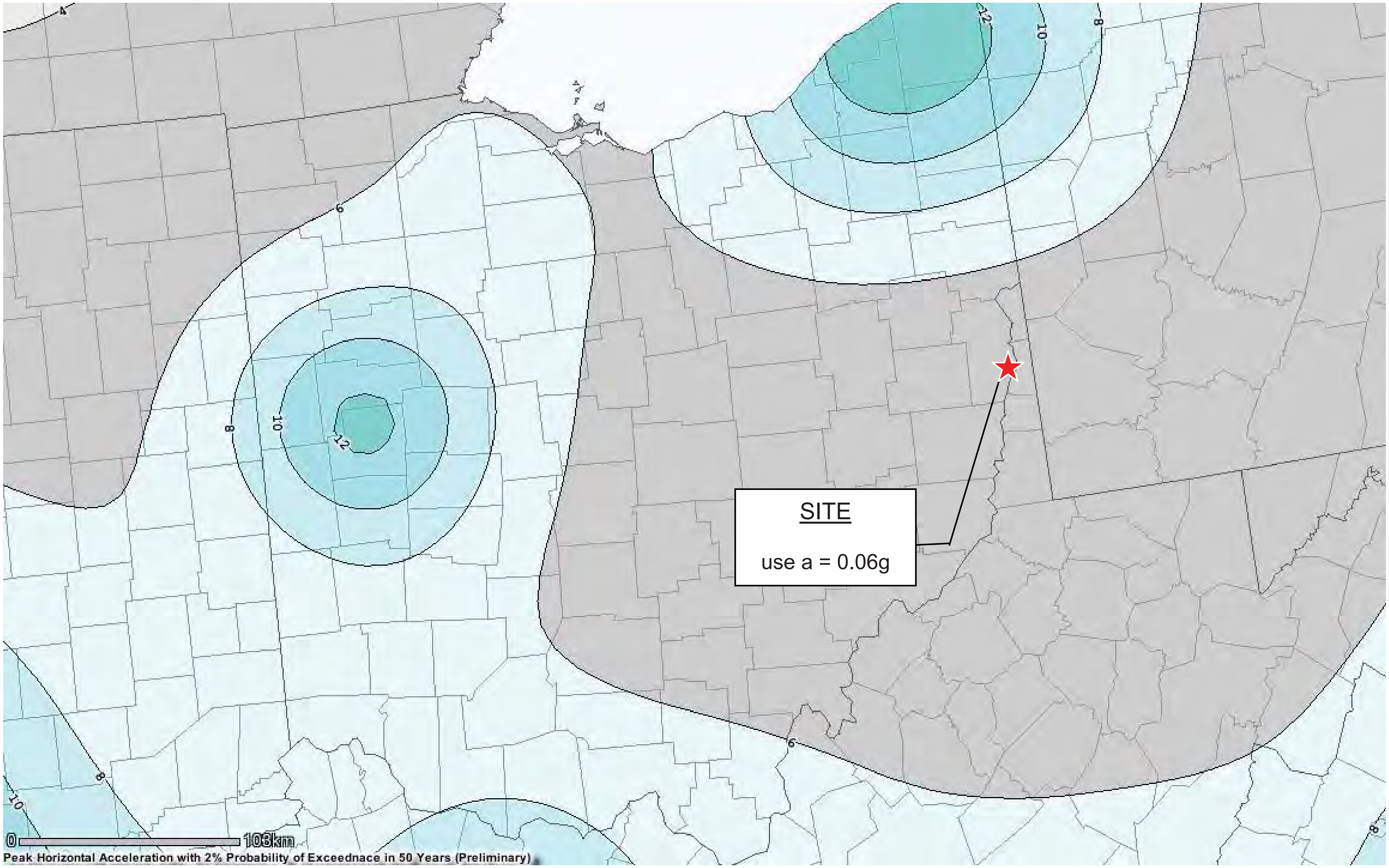
**BBC&M Engineering, Inc.**

**Tested By:** PJM **Checked By:** JJ

**PLATE 32**

## USGS National Seismic Hazard Maps - 2008

Peak Horizontal Acceleration with 2% Probability of Exceedence in 50 Years



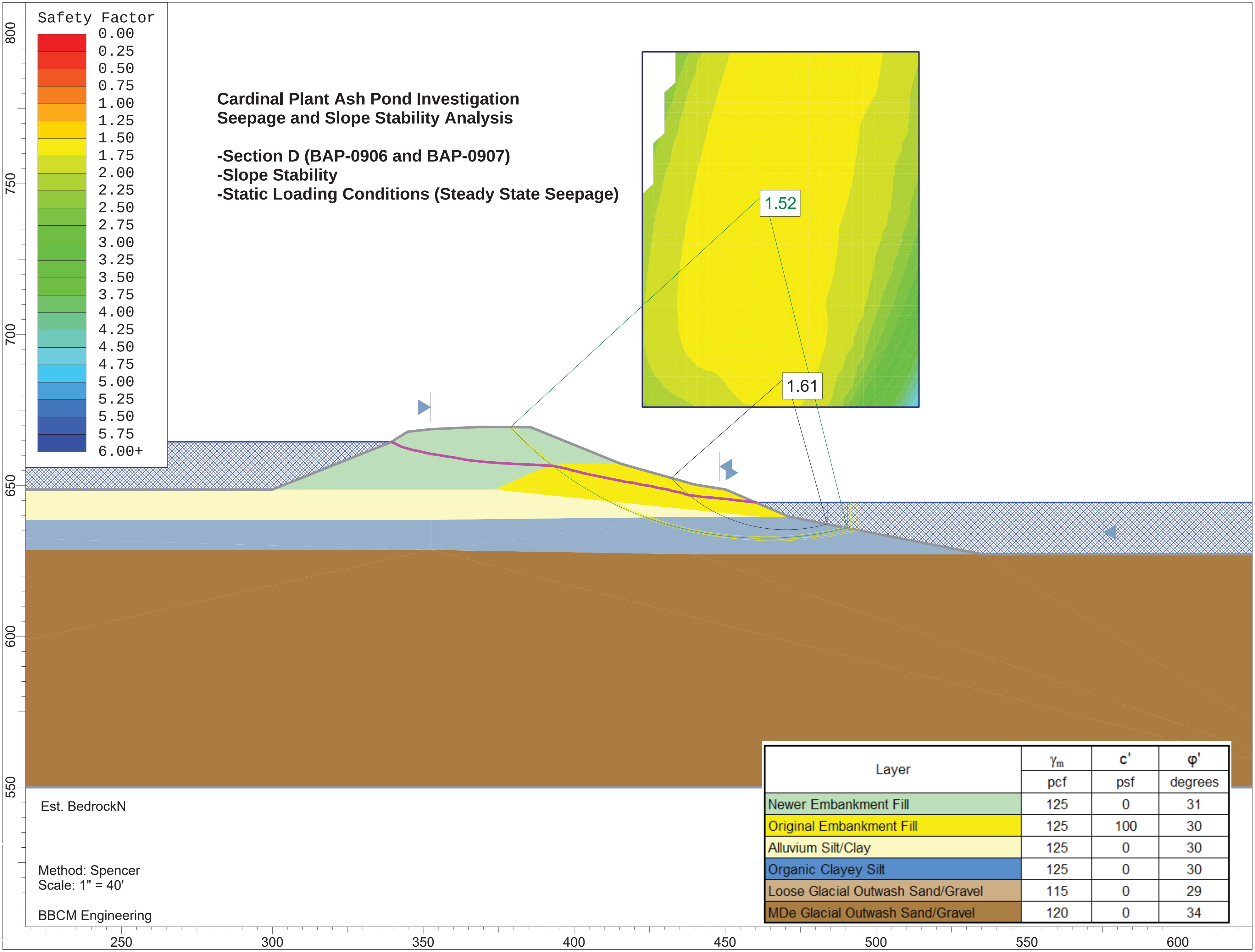
SITE

use a = 0.06g

Peak Horizontal Acceleration with 2% Probability of Exceednace in 50 Years (Preliminary)

PLATE 33

# Appendix IV – Limit Equilibrium Analysis



**Cardinal Plant Ash Pond Investigation**
**Seepage and Slope Stability Analysis**

**-Section D (BAP-0906 and BAP-0907)**
**-Slope Stability**
**-Static Loading Conditions (Steady State Seepage)**

| Layer | $\gamma_m$ | c' | φ' |
|---|---|---|---|
| | pcf | psf | degrees |
| Newer Embankment Fill | 125 | 0 | 31 |
| Original Embankment Fill | 125 | 100 | 30 |
| Alluvium Silt/Clay | 125 | 0 | 30 |
| Organic Clayey Silt | 125 | 0 | 30 |
| Loose Glacial Outwash Sand/Gravel | 115 | 0 | 29 |
| MDe Glacial Outwash Sand/Gravel | 120 | 0 | 34 |

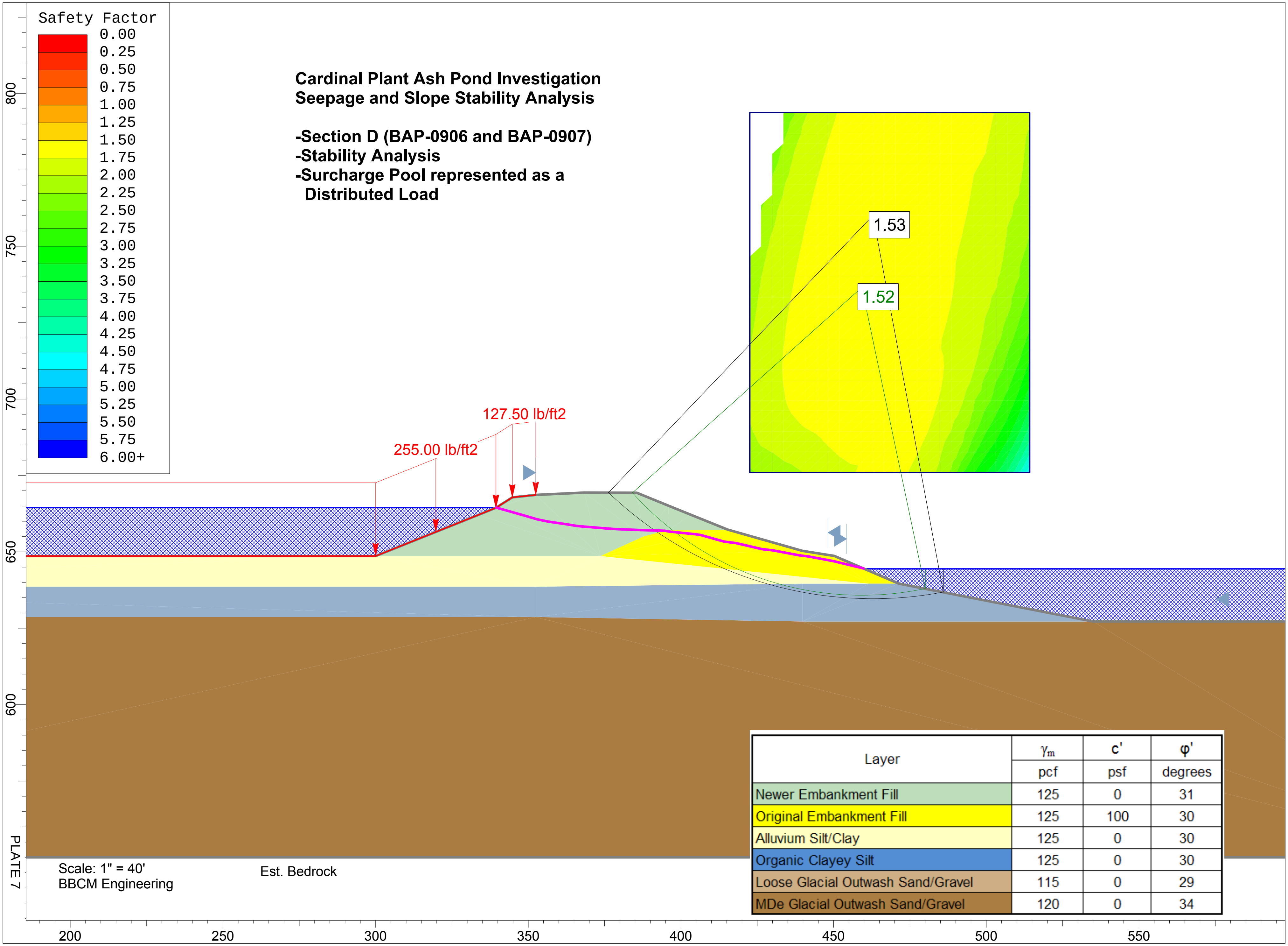
Method: Spencer
Scale: 1" = 40'

BBCM Engineering

PLATE 10

**Cardinal Plant Ash Pond Investigation**
**Seepage and Slope Stability Analysis**

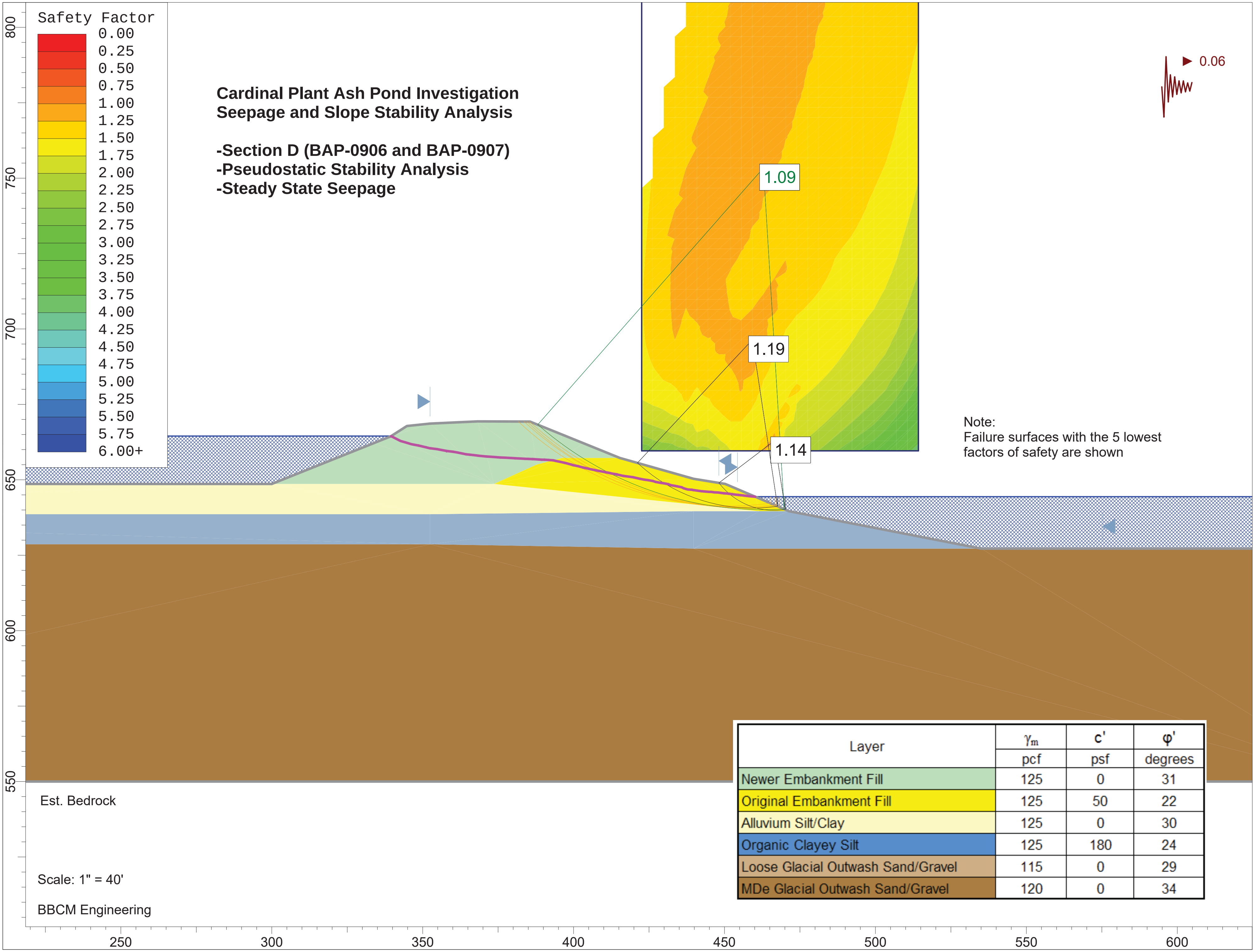
**-Section D (BAP-0906 and BAP-0907)**
**-Stability Analysis**
**-Surcharge Pool represented as a**
**Distributed Load**



| Layer | $\gamma_m$ | c' | φ' |
|---|---|---|---|
| | pcf | psf | degrees |
| Newer Embankment Fill | 125 | 0 | 31 |
| Original Embankment Fill | 125 | 100 | 30 |
| Alluvium Silt/Clay | 125 | 0 | 30 |
| Organic Clayey Silt | 125 | 0 | 30 |
| Loose Glacial Outwash Sand/Gravel | 115 | 0 | 29 |
| MDe Glacial Outwash Sand/Gravel | 120 | 0 | 34 |

Scale: 1" = 40'
BBCM Engineering

PLATE 7



**Cardinal Plant Ash Pond Investigation**
**Seepage and Slope Stability Analysis**

**-Section D (BAP-0906 and BAP-0907)**
**-Pseudostatic Stability Analysis**
**-Steady State Seepage**

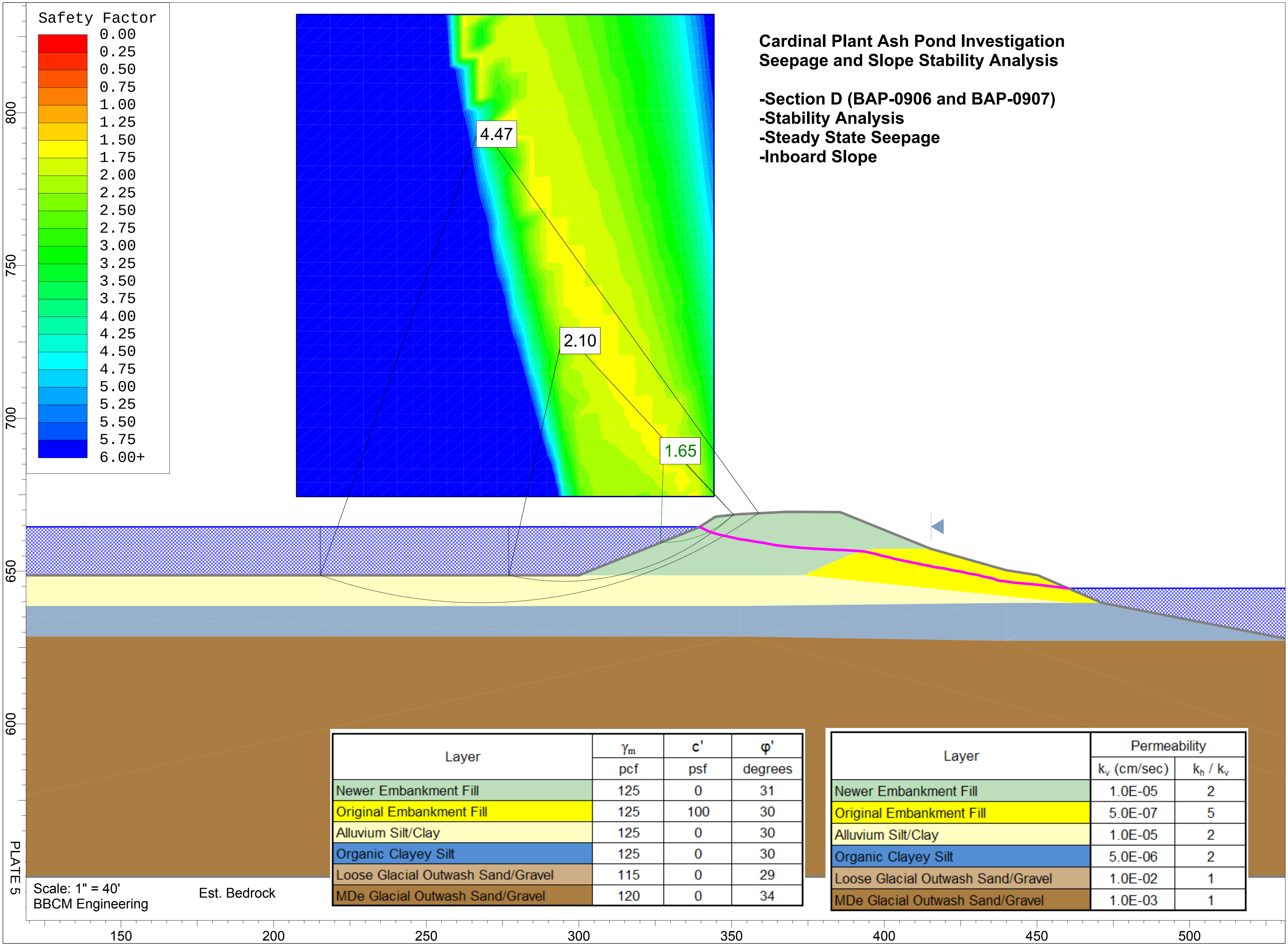
Note:
Failure surfaces with the 5 lowest
factors of safety are shown

| Layer | $\gamma_m$ | c' | φ' |
|---|---|---|---|
| | pcf | psf | degrees |
| Newer Embankment Fill | 125 | 0 | 31 |
| Original Embankment Fill | 125 | 50 | 22 |
| Alluvium Silt/Clay | 125 | 0 | 30 |
| Organic Clayey Silt | 125 | 180 | 24 |
| Loose Glacial Outwash Sand/Gravel | 115 | 0 | 29 |
| MDe Glacial Outwash Sand/Gravel | 120 | 0 | 34 |

Scale: 1" = 40'

BBCM Engineering

PLATE 11



## Cardinal Plant Ash Pond Investigation
## Seepage and Slope Stability Analysis

**-Section D (BAP-0906 and BAP-0907)**
**-Stability Analysis**
**-Steady State Seepage**
**-Inboard Slope**

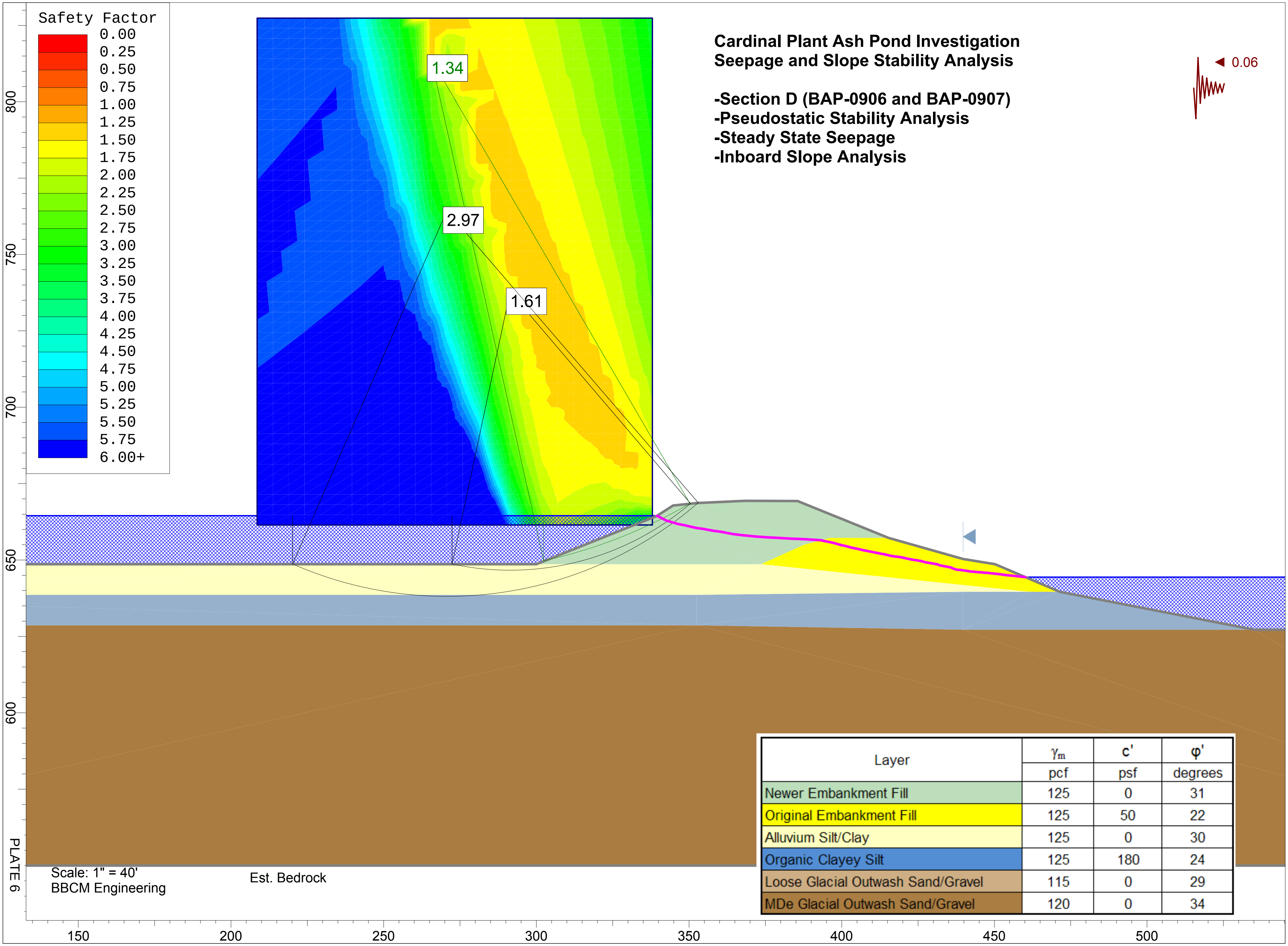
| Layer | $\gamma_m$ | c' | φ' |
|---|---|---|---|
| | pcf | psf | degrees |
| Newer Embankment Fill | 125 | 0 | 31 |
| Original Embankment Fill | 125 | 100 | 30 |
| Alluvium Silt/Clay | 125 | 0 | 30 |
| Organic Clayey Silt | 125 | 0 | 30 |
| Loose Glacial Outwash Sand/Gravel | 115 | 0 | 29 |
| MDe Glacial Outwash Sand/Gravel | 120 | 0 | 34 |

| Layer | Permeability | |
|---|---|---|
| | $k_v$ (cm/sec) | $k_h$ / $k_v$ |
| Newer Embankment Fill | 1.0E-05 | 2 |
| Original Embankment Fill | 5.0E-07 | 5 |
| Alluvium Silt/Clay | 1.0E-05 | 2 |
| Organic Clayey Silt | 5.0E-06 | 2 |
| Loose Glacial Outwash Sand/Gravel | 1.0E-02 | 1 |
| MDe Glacial Outwash Sand/Gravel | 1.0E-03 | 1 |

Scale: 1" = 40'
BBCM Engineering

## Cardinal Plant Ash Pond Investigation Seepage and Slope Stability Analysis

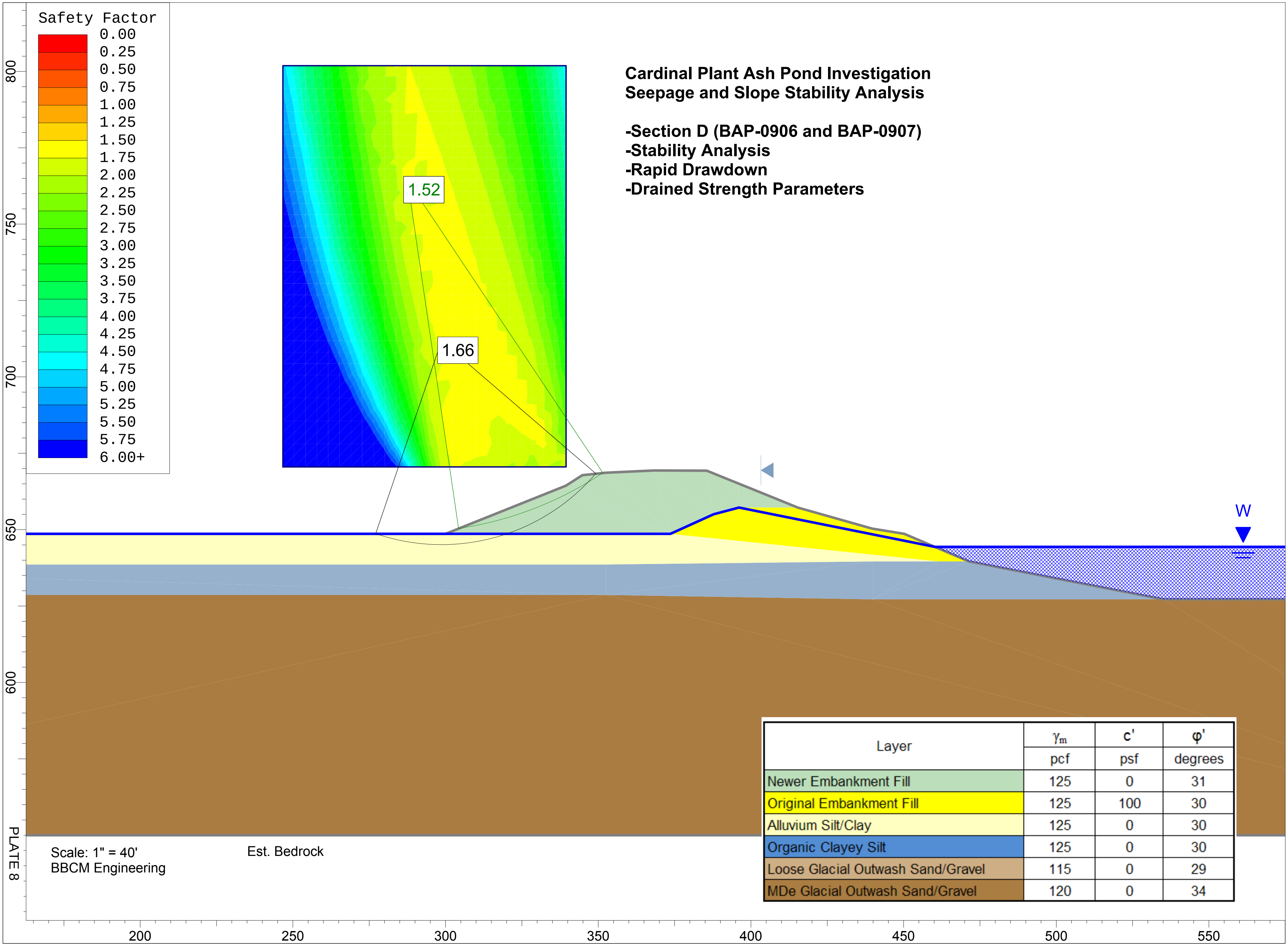
-Section D (BAP-0906 and BAP-0907)
-Pseudostatic Stability Analysis
-Steady State Seepage
-Inboard Slope Analysis



| Layer | $\gamma_m$ | c' | φ' |
|---|---|---|---|
| | pcf | psf | degrees |
| Newer Embankment Fill | 125 | 0 | 31 |
| Original Embankment Fill | 125 | 50 | 22 |
| Alluvium Silt/Clay | 125 | 0 | 30 |
| Organic Clayey Silt | 125 | 180 | 24 |
| Loose Glacial Outwash Sand/Gravel | 115 | 0 | 29 |
| MDe Glacial Outwash Sand/Gravel | 120 | 0 | 34 |

Scale: 1" = 40'
BBCM Engineering

PLATE 6



**Cardinal Plant Ash Pond Investigation**
**Seepage and Slope Stability Analysis**

**-Section D (BAP-0906 and BAP-0907)**
**-Stability Analysis**
**-Rapid Drawdown**
**-Drained Strength Parameters**

| Layer | $\gamma_m$ | c' | φ' |
|---|---|---|---|
| | pcf | psf | degrees |
| Newer Embankment Fill | 125 | 0 | 31 |
| Original Embankment Fill | 125 | 100 | 30 |
| Alluvium Silt/Clay | 125 | 0 | 30 |
| Organic Clayey Silt | 125 | 0 | 30 |
| Loose Glacial Outwash Sand/Gravel | 115 | 0 | 29 |
| MDe Glacial Outwash Sand/Gravel | 120 | 0 | 34 |

Scale: 1" = 40'
BBCM Engineering

INDEX TESTING SUMMARY
LIQUEFACTION SCREENING

**Fine Grained Soil Liquefaction Screening**
**Cardinal Bottom Ash Pond**

**Layer: NEWER EMBANKMENT FILL**

| BORING NUMBER | SAMPLE NUMBER | SAMPLE DEPTH | NATURAL MOISTURE CONTENT | LIQUID LIMIT % | PLASTIC LIMIT % | PLASTIC INDEX % | GRAVEL % | SAND % | SILT % | CLAY .005 mm % | CLAY .002 mm % | SILT/CLAY % | USCS CLASSIFICATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BAP-0901 | S-5 | 7.75 | 16 | 28 | 18 | 10 | | | | | | | |
| BAP-0901 | S-9 | 13.75 | 13 | 27 | 17 | 10 | | | | | | | |
| BAP-0901 | S-12 | 18.25 | 14 | 37 | 24 | 13 | 7 | 32 | 49 | 23 | 12 | 61 | SANDY LEAN CLAY CL |
| BAP-0902 | S-11 | 16.75 | 24 | 37 | 19 | 18 | | | | | | | |
| BAP-0902 | S-12 | 18.25 | 21 | 35 | 17 | 18 | 8 | 37 | 33 | 28 | 21 | 54 | SANDY LEAN CLAY CL |
| BAP-0902 | S-13 | 19.75 | 31 | 29 | 17 | 12 | 1 | 20 | 62 | 28 | 17 | 79 | LEAN CLAY with SAND CL |
| BAP-0904 | S-9 | 13.75 | 16 | 35 | 21 | 14 | | | | | | | |
| BAP-0906 | S-3 | 4.75 | 15 | 27 | 17 | 10 | | | | | | | |
| BAP-0906 | S-8 | 12.75 | | | | | 30 | 40 | 22 | 13 | 9 | 31 | |
| BAP-0906 | S-11 | 17.25 | 14 | 31 | 19 | 12 | 18 | 44 | 26 | 18 | 12 | 38 | CLAYEY SAND with GRAVEL SC |

| Fines Content and Plasticity Index Screening | | | Is Soil Sample Liquefiable (meets all three criteria) |
|---|---|---|---|
| | % Passing | | |
| LL < 35 | 0.005 < 15 | WC < 0.9LL | |
| Yes | - | Yes | - |
| Yes | - | Yes | - |
| No | No | Yes | No |
| No | - | Yes | No |
| No | No | Yes | No |
| Yes | No | No | No |
| No | - | Yes | No |
| Yes | - | Yes | - |
| - | Yes | - | - |
| Yes | No | Yes | No |

**Layer: ORIGINAL EMBANKMENT FILL**

| BORING NUMBER | SAMPLE NUMBER | SAMPLE DEPTH | NATURAL MOISTURE CONTENT | LIQUID LIMIT % | PLASTIC LIMIT % | PLASTIC INDEX % | GRAVEL % | SAND % | SILT % | CLAY .005 mm % | CLAY .002 mm % | SILT/CLAY % | USCS CLASSIFICATION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BAP-0903 | S-2 | 3.25 | 24 | 48 | 24 | 24 | 0 | 8 | 60 | 45 | 32 | 92 | LEAN CLAY CL |
| BAP-0903 | S-5 | 7.75 | 20 | 36 | 20 | 16 | 0 | 14 | 58 | 38 | 28 | 86 | LEAN CLAY CL |
| BAP-0905 | S-3 | 4.75 | 17 | 32 | 18 | 14 | 0 | 25 | 53 | 30 | 23 | 76 | LEAN CLAY with SAND CL |
| BAP-0905 | S-5 | 7.75 | 22 | 48 | 24 | 24 | | | | | | | |
| BAP-0907 | S-5 | 7.75 | 23 | 49 | 26 | 23 | | | | | | | |
| BAP-0907 | S-6A | 9.25 | 28 | 47 | 29 | 18 | 0 | 5 | 67 | 43 | 29 | 96 | SILT ML |

| Fines Content and Plasticity Index Screening | | | Is Soil Sample Liquefiable (meets all three criteria) |
|---|---|---|---|
| | % Passing | | |
| LL < 35 | 0.005 < 15 | WC < 0.9LL | |
| No | No | Yes | No |
| No | No | Yes | No |
| Yes | No | Yes | No |
| No | - | Yes | No |
| No | - | Yes | No |
| No | No | Yes | No |

# Appendix V – 2009 Investigation Report Text

August 4, 2009
011-11497-013

BBCM
SOLUTIONS TO BUILD ON

Mr. Pedro Amaya, P.E.
American Electric Power
1 Riverside Plaza
Columbus, OH 43215

Re: Subsurface Investigation and Analysis
Bottom Ash Pond Embankments
AEP Cardinal Plant
Brilliant, Ohio

Dear Mr. Amaya:

In accordance with our proposal dated March 23, 2009, and our signed contract dated March 25, 2009, BBC&M Engineering, Inc. (BBCM) has completed a geotechnical assessment of the embankment separating the Bottom Ash Complex from the Ohio River at the Cardinal Generating Plant in Brilliant, Ohio.

BBCM's scope of work, as developed by AEP, consisted of obtaining subsurface data at a total of four cross-sections through the bottom ash pond an recirculation pond embankments, and performing seepage and slope stability analyses to provide an indication as to the level of safety provided by the embankments. The following report is a summary of our investigation.

We appreciate having been given the opportunity to be of service on this project. If you have any questions, please do not hesitate to contact this office.

Respectfully submitted,

**BBC&M ENGINEERING, INC.**
Columbus, Ohio

Michael T. Romanello, E.I.
Staff Engineer

Michael G. Rowland, P.E.
Senior Engineer

Submitted: 4 bound copies
1 electronic copy on CDROM

6190 Enterprise Court • Dublin, OH 43016 - 3293 • Phone 614.793.2226 • Fax 614.793.2410

# Cardinal Generating Plant
# Bottom Ash Pond Investigation

Brilliant, Ohio

Report to

American Electric Power Service Corp.
Columbus, Ohio

Prepared by

BBCM Engineering, Inc.
Dublin, Ohio

August, 2009

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## APPENDIX D

## INTRODUCTION

The Cardinal Generating Plant is located along the Ohio river between Brilliant, Ohio and Tiltonsville, Ohio, as shown on the Vicinity Map, included as Plate 1 of Appendix A. The Bottom Ash Pond Complex is located along the west bank of the river just to the south of the main plant area. The Bottom Ash Complex consists of two components: the Bottom Ash Pond and the Recirculation Pond. The Bottom Ash Pond is located north of the Recirculation Pond and they are separated by an earthen embankment. The crest elevation for all of the embankments is approximately the same, but vary in Elevation from 668.6' to 669.4' at the surveyed cross sections. The total length of the exterior embankment along the Ohio River is approximately 2,000 feet. For comparison, the normal pool for this stretch of the Ohio River is El. 644. Both ponds are isolated from exterior surface water inflow.

## SCOPE OF WORK

The purpose of this Geotechnical Assessment was to provide an indication as to the level of safety provided by the dam separating the ponds from the Ohio River. The work which was performed as part of the limited subsurface investigation consisted of 1) review of the original plans; 2) the performance of two soil borings each at four different locations (one at the crest and one at the toe); 3) conversion of four soil borings into observation wells; 4) the completion of laboratory testing on the recovered samples; and, 5) engineering analyses of the existing embankments with consideration to seepage, steady-state slope stability and seismic slope stability.

## REVIEW OF HISTORICAL PLANS

The Site Development Plan for the Ash Storage Area and the corresponding Sections Plan (drawings numbers 3-3017-5 and 3-3027-3, respectively) from the ash pond vertical expansion in the 1970s were made available for review. The plans were developed in 1973 and include 'Record Drawing' information through 1978. The ash pond complex is believed to have been originally constructed in the 1960s when the plant was first brought online. BBCM also received an electronic drawing file of the plant, including topographic data, as depicted in the Plan of Borings presented as Plate 2 in Appendix A. The aerial survey used to develop the drawing file was performed in 1994.

Based on the historical cross-sections extending through both the Bottom Ash Pond and the Recirculation Pond from the vertical expansion, the original ash pond embankments along the Ohio River ranged in height from 4 to 6 feet above the bottom of the ash pond. Historical Sections 'A-A' and 'C-C' detail the vertical expansion plans for the embankment which was assessed during this investigation. These cross-sections are presented as Plates 1 and 2 of Appendix C. Based on the sections, the original embankment was raised by approximately 10 to 12 feet by constructing an earthen embankment on the inboard slope of the original embankments. The construction was intended to raise the crest from an approximate elevation of 658.0 feet to Elevation 670.0 feet. The approximate boundary of the original ash pond embankment is depicted on the historical cross-sections as well as the seepage and stability analysis graphic output.

## GEOLOGY

The natural soils at the site generally consist of a layer of alluvium silt, clay and fine sand over glacial outwash deposits of variable thickness overlying the bedrock surface. The alluvium clays and silts were deposited in the backwater of the Ohio River, while the outwash materials typically consist of sand, gravel and silt deposits deposited during the last ice age. Based on geological literature, the glacial outwash extends to the bedrock surface, estimated to be roughly 60 feet below the natural ground surface at the pond. The upper most bedrock most likely consists of shale and/or sandstone belonging to the Conemaugh Group of Pennsylvanian Age.

## FIELD WORK

### Site Reconnaissance

On March 20, 2009, a Senior Engineer and a Project Engineer from our office performed a Dam and Dike Condition Survey and results were presented in the 2009 Inspection Report for the Ash Impoundment. During the condition survey, the locations of the critical cross sections determined by AEP were observed, and the proposed borings were staked in these areas. Additional information concerning the visual condition of the dam may be found in this report.

### Soil Borings

During the period of April 6 through April 10, 2009, BBCM was on site and performed a total of seven (7) soil borings, designated CD-BAP-0901 through CD-BAP-0907, that were extended to depths ranging from 30.0 to 60.5 feet below existing grade. A 'PZ' designation was added to Borings CD-PZ-BAP-0902, 0904, and 0905 to indicate an observation well was installed within the borehole. For simplicity throughout this report, the borings are typically referred to with the 'BAP' (Bottom Ash Pond) designation only. Borings BAP-0901, 0902, 0904 and 0906 were located at the crest of the pond embankments and Borings BAP-0903, 0905, and 0907 were located at the outboard toe of the embankment slopes, and were placed to correspond with the crest borings. The boring location areas were selected by AEP and field located by BBCM. The boring locations are shown on the 'Plan of Borings' presented on a full size drawing as Plate 2 in Appendix A. All boring locations and elevations, as well as additional ground surface points near the borings were surveyed by AEP personnel to create surface profiles.

All borings were performed with either a truck-mounted drill rig or an all-terrain-vehicle (ATV) mounted drill rig and were advanced between sampling attempts using 3¼-inch or 4¼-inch I.D. hollow-stem augers. Disturbed, but representative samples were obtained by lowering a 2-inch O.D. split-barrel sampler to the bottom of the hole and driving it into the soil by blows from a 140-pound automatic hammer freely falling 30 inches (Standard Penetration Test, ASTM D1586). The automatic hammer used to advance the SPT sampler had previously been calibrated for energy transmission using dynamic pile monitoring methods. The energy calibration factor is included on the boring logs. SPT sampling was performed continuously through the embankment fill and at 2½-foot intervals once the native soil was encountered. Split barrel samples were examined immediately after recovery and representative portions of each sample were placed in air tight jars and retained for subsequent laboratory testing.

### Undisturbed Soil Samples

In addition to the disturbed samples, thin-walled press tube samples (“Shelby” tubes) were also attempted at various depths in order to obtain relatively undisturbed soil samples for strength testing. The samples were collected by hydraulically pressing a 3-inch diameter thin-walled steel (Shelby) tube at the end of the drill rod stem into the soil at a uniform rate. The samples were preserved inside the Shelby tube sampler and sealed with wax. The sample collection was completed in accordance with ASTM D 1587 Method for Thin-Walled Tube Geotechnical Sampling of Soils. Two Shelby tube samples were obtained in Boring BAP-0901 and one Shelby tube sample was obtained in each of borings BAP-0903 and BAP-0906. It should be noted that several other attempts were made to obtain additional undisturbed samples but resulted in crushing the tube or no recovery.

### Borehole Backfilling and Observation Wells

During and at the completion of drilling, groundwater readings were measured and recorded in each boring. In Borings CD-PZ-BAP-0902, 0904, and 0905, wells were installed to permit future groundwater readings. The wells consist of 2-inch diameter PVC, well casings and screens. Screens are nominal 10-foot lengths with 10-slotted openings. Quartz sand was used as a filter (where the surrounding soil does not consist of sand and gravel) and was placed to a level approximately 2 feet above the top of the well screen. A well seal consisting of approximately 2 feet of granular bentonite (3/8-inch hole plug) was set above the filter pack and the remainder of the annular space was filled with a bentonite slurry (benseal). A lockable steel cover was installed over the well and a 3 foot by 3 foot concrete pad was constructed to protect the exposed portion of the well which extends above the ground surface. Three to four steel bollards were installed around each concrete pad to protect the well.

During the installation of the wells, a surge block was used to densify the sand pack. Upon completion, each well was developed. Well development includes an attempt to hand bail 10 well volumes of groundwater from each well. Well Completion Diagrams are presented as Plates 23 though 25 of Appendix A. BBCM understands that all follow up groundwater level measurements will be obtained by AEP personnel. It is also understood that AEP will formally survey in the top of pipe for the three wells.

### Recording of Field Data

In the field, the following procedures and specific duties were performed by a Staff Engineer or a Field Geologist from our office:

- examined all samples recovered from the borings;
- cleaned soil samples of cuttings and preserved representative portions in airtight glass jars;
- made seepage observations and measured the water levels in the borings;
- prepared a log of each boring;
- made hand-penetrometer measurements in soil samples exhibiting cohesion; and,
- provided liaison between the field personnel and the Project Manager so that the field investigation could be modified in the event that unexpected subsurface conditions were encountered.

At the completion of drilling, all samples were transported to the BBCM laboratory for further examination and testing.

## LABORATORY TESTING

### Index Testing

Laboratory testing was performed on selected representative soil samples obtained during the field investigations to determine natural moisture content (ASTM D2216), liquid and plastic limits (BBCM adjustment to ASTM D4318), and grain size analyses (ASTM D422). The results of these and other tests permit an evaluation of the strength, compressibility and permeability characteristics of the soils encountered at this site.

The results of the moisture content testing and of the liquid and plastic limits are graphically displayed on the individual boring logs presented in Appendix A. The results of all grain size analyses are also displayed graphically and presented as Plates 10 through 66 in Appendix B. All laboratory test results and a summary of laboratory test results are presented in Appendix B.

Table 1 summarizes the results of the index testing for the each layer except for the glacial outwash sand and gravel, where only a limited number of index testing was performed. For a comprehensive summary of all index testing performed, see Plates 3 through 7 of Appendix C.

*Table 1. Summary of index values*

Newer Embankment Fill

| *Statistic* | *MC* | *LL* | *PL* | *PI* | *CF* |
|---|---|---|---|---|---|
| Sample Size | 16 | 12 | 12 | 12 | 8 |
| Minimum | 10 | 25 | 16 | 9 | 8 |
| Maximum | 31 | 37 | 24 | 18 | 21 |
| Mean | 16.3 | 30.3 | 18.3 | 12.1 | 12.1 |
| Median | 15 | 29 | 17 | 11 | 11 |
| Mode | 16 | 27 | 17 | 10 | 12 |
| Standard Deviation | 5.4 | 4.5 | 2.3 | 3.2 | 4.6 |

Original Embankment Fill

| *Statistic* | *MC* | *LL* | *PL* | *PI* | *CF* |
|---|---|---|---|---|---|
| Sample Size | 10 | 6 | 6 | 6 | 4 |
| Minimum | 15 | 32 | 18 | 14 | 23 |
| Maximum | 33 | 49 | 29 | 24 | 32 |
| Mean | 22.5 | 43.3 | 23.5 | 19.8 | 28.0 |
| Median | 22 | 48 | 24 | 21 | 29 |
| Mode | 22 | 48 | 24 | 24 | N/A |
| Standard Deviation | 5.1 | 7.4 | 4.0 | 4.4 | 3.7 |

Alluvium Silt and Clay

| *Statistic* | *MC* | *LL* | *PL* | *PI* | *CF* |
|---|---|---|---|---|---|
| Sample Size | 10 | 4 | 4 | 4 | 10 |
| Minimum | 22 | 34 | 21 | 7 | 3 |
| Maximum | 38 | 38 | 28 | 15 | 28 |
| Mean | 29.0 | 36.0 | 23.5 | 12.5 | 11.0 |
| Median | 29 | 36 | 23 | 14 | 7 |
| Mode | 26 | N/A | N/A | 15 | 5 |
| Standard Deviation | 5.4 | 1.8 | 3.1 | 3.8 | 8.5 |

Organic Clayey Silt

| *Statistic* | *MC* | *LL* | *PL* | *PI* | *CF* |
|---|---|---|---|---|---|
| Sample Size | 22 | 18 | 18 | 18 | 21 |
| Minimum | 28 | 30 | 22 | 3 | 5 |
| Maximum | 54 | 50 | 38 | 20 | 44 |
| Mean | 41.8 | 40.2 | 27.1 | 13.2 | 18.9 |
| Median | 43 | 41 | 27 | 15 | 17 |
| Mode | 43 | 45 | 24 | 16 | 16 |
| Standard Deviation | 5.2 | 5.4 | 3.7 | 4.7 | 7.4 |

MC = Moisture Content; LL = Liquid Limit; PL = Plastic Limit; PI = Plasticity Index;
CF = Clay-sized Fraction (% finer than 0.002 mm)

### Specialty Testing

In addition to the above index tests, a three-point isotropically consolidated-undrained (CU) triaxial shear test (ASTM D4767) and a flex wall permeability test was performed on undisturbed soil samples obtained from Shelby Tube sampling. Results of all laboratory testing are included in Appendix B. Difficulties were encountered in obtaining undisturbed samples within the newer embankment fill due to the granular nature of the material. The CU triaxial test and permeability test were performed on undisturbed samples obtained within the alluvium and original embankment fill layers, respectively.

## GENERAL SUBSURFACE CONDITIONS

### Stratigraphy

Based on the descriptions of the samples recovered in the borings and laboratory testing, the subsurface stratigraphy for each section can generally be described in descending order from the top of the embankment as follows:

- The four borings which were performed from the crest of the embankments encountered 1.0 to 3.0 feet of roadway base consisting of bottom ash/boiler slab at the ground surface overlying 18.0 to 22.0 feet of embankment fill consisting of very stiff to hard silty clay and medium-dense to dense fine to coarse sand and gravel. Hand penetrometer measurements on samples exhibiting cohesion within this layer ranged from 2.5 to 4.5+ tons per square foot (tsf), while SPT N-values (corrected for 60% energy) ranged from 6 to 50 with an average of 26. Index testing results, including liquid limit and plasticity index of samples tested within this stratum are summarized in Table 1 of the previous section. The material was predominantly classified as Lean Clay (CL) to Clayey Gravel with Sand (GC) under the Unified Soil Classification System. Boring CD-PZ-BAP-0901 encountered a 4.5 foot thick zone of very-soft to very-stiff silty clay at the bottom of the fill. Hand penetrometer measurements within this zone ranged from 0.0 to 2.25 tsf.

- The three borings which were performed from the outboard toe of the embankments encountered 8.5 to 11.5 feet of embankment fill consisting of very-stiff to hard brown mottled with gray silty clay. The fill encountered in these borings is believed to be associated with the original pond embankments, and is denoted throughout this report as the 'Original Embankment Fill'. Hand penetrometer measurements on samples within this layer ranged from 1.6 to 4.5+ tons per square foot (tsf), while SPT N-values (corrected for 60% energy) ranged from 11 to 48 with an average of 22. Index testing results, including liquid limit and plasticity index of samples tested within this stratum are summarized in Table 1 of the previous section. The material was predominantly classified as Lean Clay (CL) under the Unified Soil Classification System.

- Underlying the embankments, the borings encountered 4.5 to 10.5 feet of alluvium consisting of very-loose to loose silt with few zones of stiff to hard silty clay and thin seams of very loose to loose fine to coarse sand. Hand penetrometer measurements on samples exhibiting cohesion within this layer ranged from 1.6 to 4.5+ tons per square foot (tsf), while SPT N-values (corrected for 60% energy) ranged from 0 to 33, with an average of 8. Index testing results, including liquid limit and plasticity index of samples tested within this stratum are summarized in Table 1 of the previous section.

- Beneath the alluvium silt and clay, the borings encountered 3.5 to 14.5 feet of very-soft to stiff organic clayey silt. Hand penetrometer measurements on samples exhibiting cohesion within this layer ranged from 0.0 to 1.25 tons per square foot (tsf), while SPT N-values (corrected for 60% energy) ranged from 0 to 20, with an average of 5. Index testing results, including liquid limit and plasticity index of samples tested within this stratum are summarized in Table 1 of the previous section. Loss on Ignition (LOI) values ranged from 7.9 to 10.4%. The material is predominantly classified as organic clay with sand (OL) under the Unified Soil Classification System. Throughout the report, this layer was identified as a clayey silt based on its consistency even though the PI often indicated the material would be classified as a silty clay

- All borings were terminated after penetrating 7.0 to 30.0 into feet very-loose to loose fine to coarse sand and/or medium-dense to dense brown fine to coarse sand and gravel. SPT $N_{60}$-values in the very-loose to loose sand ranged from 4 to 29 bpf with an average of 12. SPT $N_{60}$-values in the medium-dense to dense sand and gravel ranged from 14 to 69 bpf with an average of 32. The percent passing the 200 sieve ranged between 6 and 24, with an average of 12.2.

The newer embankment fill consisted of silty clay, sand, and gravel and was considered as a uniform stratum although the main descriptor varied based on the small variations in the percent by weight of each material. Strength parameters associated with this layer are discussed in the **Seepage and Stability Analysis** section. For a more detailed description of the stratigraphy, including the presence of minor variations and inclusions, the logs of the individual borings should be examined in conjunction with the summary above.

### Groundwater

Groundwater observations were made as each boring was being advanced and measurements were made at the completion of drilling. The groundwater observations are graphically displayed on the boring logs and also noted at the bottom of the log. All water level readings indicated on the borings logs are referenced from the ground surface, as the top of pipes have not yet been formally surveyed. Extended groundwater measurements were made in the observation wells while on site and are summarized in Table 2.

*Table 2: Extended Groundwater Measurements.*

| *Boring* | *Elevation During Drilling* | *Elevation at Completion* | *Elevation on 4-7/8-09* | *Elevation on 4-10-09* |
|---|---|---|---|---|
| CD-BAP-0901 | 635.2 | 654.9 | | - |
| CD-PZ-BAP-0902 | 655.0 | 657.3 | 657.3 | 659.6 |
| CD-BAP-0903 | 627.6 | 633.6 | | - |
| CD-PZ-BAP-0904 | 652.1 | 652.1 | | 652.2 |
| CD-PZ-BAP-0905 | 632.1 | 642.1 | 642.1 | 644.7 |
| CD-BAP-0906 | 648.6 | 658.3 | | - |
| CD-BAP-0907 | 627.3 | 634.0 | | - |

Elevation Datum: NAD 27 / NGVD 29

## SEEPAGE AND STABILITY ANALYSIS

Embankment dams must exhibit adequate factors of safety against a slope stability failure for static and seismic conditions. As part of this project, BBCM considered four areas of the ash pond embankment along the river as deemed critical by AEP to analyze for stability. Each section was developed by performing one boring through the crest of the embankment and one boring at the outboard toe, with the exception of the southernmost section through the recirculation pond embankment, where the location of the proposed boring at the toe was inaccessible. The following sections of this report discuss the analyses that were performed, explain the rational supporting parameter selection and present the results.

Based on visual observations, the Recirculation Pond embankments appeared to be in 'Fair' condition while the Bottom Ash Pond appeared to be in "Good' Condition. The principal item which came out of this inspection relative to this report is that no evidence of slope failure or seepage was observed on the embankment slope between the pond and the river. It should be noted however, that the toe of the slope is inundated by the ordinary high water level of the Ohio River. The 2009 Inspection Report should be consulted for the complete assessment of the visual observations made for the Bottom Ash Complex.

### Methodology

The seepage and stability analyses were performed with the aid of the computer program Slide (Version 5.0) developed by Rocscience, Inc. The program performs 2-D limit equilibrium slope stability analyses and steady-state unsaturated seepage analysis; the latter using the finite element method. Pore pressure values produced from the seepage analysis are used in the slope stability computations for each model.

Static and seismic slope stability analyses were performed on the outboard embankment slopes for Cross-Sections B and D using Spencer's method (Spencer, 1973) with a deterministic approach. Both methods provide solutions for given cross sections based on limit equilibrium theory. The five critical slip surfaces corresponding to the lowest factor-of-safety are shown in the graphical output. Seismic slope stability analyses were performed based on a pseudo-static slope stability approach. Stability calculations were performed in general accordance with the US Army Corps of Engineer's Engineering Manual 1110-2-1902 entitled *Slope Stability*.

### Cross Sections

Cross-sections showing the general subsurface conditions encountered in the borings were developed based on the survey data provided by AEP. Table 3 summarizes the borings used to develop the four cross sections, which are shown individually on the Subsurface Cross Sections shown on a full size plan sheet as Plate 3 of Appendix A. Two cross-sections were chosen to carry out the seepage and stability analysis, and are considered representative of the cross-sections not used. It should be noted that no bathymetric data was available. As such, the portion of the slope located below the Ohio River normal pool was estimated. If bathymetric information becomes available in the future, it is recommended that the analysis cross-sections be reviewed.

*Table 3: Cross Section Data*

| *Cross-Section* | *Location* | *Crest Boring* | *Toe Boring* |
|---|---|---|---|
| Section A | Recirculation Pond | CD-BAP-0901 | - |
| Section B | Recirculation Pond | CD-PZ-BAP-0902 | CD-BAP-0903 |
| Section C | Bottom Ash Pond | CD-PZ-BAP-0904 | CD-PZ-BAP-0905 |
| Section D | Bottom Ash Pond | CD-BAP-0906 | CD-BAP-0907 |

Although four separate cross-sections were examined, the parameters selected to represent the permeability and strength of both the original and newer embankment fill layers were kept the same between sections. Although there are minor differences when comparing the two layers between borings, it is believed that there is insufficient evidence to support delineating the parameters from section to section. Therefore, for the purposes of the seepage and slope stability analyses, the permeability and shear strength parameters used to represent the fill layers were based on the totality of test data available for the embankment across the entire site.

The natural alluvium soils underlying the pond embankments are somewhat variable, consistent with the depositional environment of such soils. As with the embankment fill, it is difficult to justify developing specific parameters for an individual cross-section, as the properties of this stratum may vary over short distances. As such, the parameters used to represent the alluvium, and similarly the organic clayey silt and glacial outwash layers, were based on the totality of test data available for these layers across the entire site.

At the time of the survey performed March 27, 2009, the pool levels in the recirculation pond and bottom ash pond were at EL. 663.1, and EL. 664.4, respectively. The resulting freeboard from the surveyed pool levels range from 4.3 - 5.1 feet and 5.6 - 5.8 feet for the recirculation and bottom ash ponds, respectively. It is understood that these levels represent the approximate normal operating pool level. The pool level in the Ohio River was recorded as Elevation 644.4 feet. The ordinary high water level of the river is believed to be EL. 644 at the site.

## Seepage Analysis

The location of the groundwater table within the embankments was estimated based on extended groundwater readings taken from the observations wells and conditions encountered during drilling. Groundwater conditions used in the finite element model were then calibrated to match the observed conditions. Results from the seepage analysis provided pore pressure values within the model to be used in the Stability Analysis.

### Hydraulic Properties

As previously indicated, the same modeled permeability values for the various soil layers were taken for both cross-sections based on the totality of information available for the site. A flex wall permeability test was performed on an undisturbed sample obtained within the original embankment fill layer yielding a vertical permeability of $7.4 \times 10^{-8}$ cm/sec. The design value for permeability was increased to $5 \times 10^{-7}$ cm/sec as a result of the calibration of the seepage models. Permeability values for the other strata were estimated from typical published values based on material description or correlations to grain size. Permeability values and anisotropic ratios were then adjusted during the seepage analysis to best match the observed groundwater conditions. Supporting calculations for the development of the permeability values are included in the *Slope Stability Shear Strength and Permeability Parameter Justification* section of Appendix C.

Permeability values assigned to the model layers are shown in the table below. Several layers were modeled with anisotropic permeability functions. The horizontal permeability ($k_h$) of the original embankment fill soils were estimated as 10 times the vertical permeability ($h_v$), to best model the stratification of the soil as a result of compacting the fill in horizontal lifts (Casagrande, 1937), but was adjusted to a ratio of 5 times during the analysis. Similarly, a $k_h/k_v$ ratio of 2 was used for the newer embankment fill soils. The alluvium and organic clayey silt foundation layer were modeled with a horizontal permeability twice the vertical permeability to simulate the natural stratification and inclusion of fine sand seams. The remaining soil layers were defined as a granular material and were assigned isotropic permeability functions.

*Table 4: Permeability Values*

| Material Description | Permeability | | Reference |
|---|---|---|---|
| | $k_v$ (cm/sec) | $k_h$ / $k_v$ | |
| Newer Embankment Fill | $1 \times 10^{-5}$ | 2 | Grain Size Correlation |
| Original Embankment Fill | $5 \times 10^{-7}$ | 5 | Permeability Test |
| Alluvium Silt and Clay | $1 \times 10^{-5}$ | 2 | Typical Published Values |
| Organic Clayey Silt | $5 \times 10^{-6}$ | 2 | Typical Published Values |
| Loose to Med Dense Glacial Outwash Sand and Gravel | $1 \times 10^{-2}$ | 1 | Grain Size Correlation |
| Med Dense - Dense Glacial Outwash Sand and Gravel | $1 \times 10^{-3}$ | 1 | Grain Size Correlation |

### Hydraulic Boundary Conditions

Topographic contours from the most recent survey as well as from historical construction drawings were used to expand the surface profile created from the AEP survey in order to develop a full scale model. The following boundary conditions were assigned to the finite element based models.

- A 'Constant Head' boundaries of 663.0 and 664.5' were used to represent the level of water in the recirculation pond and ash pond, respectively.
- The model was extended on the downstream side to the approximate middle of the Ohio River, and a 'Constant Head' boundary of 644.4' was used to represent the normal flow level of the river at this point (water level recorded by AEP).
- A 'No-Flow' boundary was placed on the upstream end of the model, as flow should become predominantly downward near the middle of the pond.
- A ‘No-Flow’ boundary was placed on the bottom of the model at Elevation 550' representing the approximate bedrock surface, which is assumed impermeable for this analysis.
- 'Unknown' boundary conditions were set on the remainder of the model to allow the program freedom to calculate values at these locations. These locations include the downstream slope face and the downstream ground surface.
- For Section D, the Constant Head Boundary of 644.4' was extended up the downstream slope to the location of the toe boring in an effort to model the observed groundwater conditions within the original embankment fill.

### Finite Element Discretization and Mesh

The following steps were performed during the development of the seepage model:

- 6 Noded Triangles were used to generate the finite element mesh for the models (see Plates 2 and 7 of Appendix D).
- The density of nodes was manually increased to minimize the number of ‘Poor Quality Elements’ based on the Mesh Quality function available in Slide.
- Poor quality elements were defined as elements with one of the following characteristics:
    1. Maximum side length to minimum side length ratio greater than 10.
    2. Minimum interior angle less than 20 degrees.
    3. Maximum interior angle greater than 120 degrees.
- Prior to final computational runs, a sensitivity analysis was performed to determine if an adequate number of total finite element nodes were used in the analysis.
- A sensitivity analysis was performed on the tolerance of the computational iteration.

### Seepage Analysis Models and General Results

Graphical output from the seepage analyses for Sections B and D are presented in Appendix D as Plates 3 and 4 for Section and B and Plates 8 and 9 for Section D. The calibrated seepage models produced phreatic surface shapes close to what was expected based on the water levels measured in the observation wells.

Although a typical phreatic surface extending from the ash pond level to the Ohio River was generated, much of the seepage emanating from the ponds is moving downward through the newer embankment fill and thin stratum of alluvium soils and into the glacial outwash sand and gravel stratum.

## Stability Analyses

### Shear Strength Parameters

In order to perform slope stability analyses, it was necessary to estimate appropriate parameters to represent the existing soils. The shear strength and unit weight values used for the slope stability analyses were based on a combination of the laboratory index test results, triaxial shear tests, published values and judgment, and are intended to be representative of long-term conditions. Table 5 lists the strength parameters used in both static and seismic analyses for each stratum. Supporting calculations for the development of these strength values are presented in the *Slope Stability Shear Strength Parameter Justification* section of Appendix C.

The percent of organic content in the Organic Clayey Silt layer was determined by performing Loss on Ignition (LOI) tests; results ranged from 7.9 to 10.4 percent. For LOI-values of less than 20 percent, the soil properties are controlled by the non-organic portion of the soil (FHWA, 2002).

*Table 5: Strength Values for Static Conditions*

| Material Description | $\gamma_{wet}$ (pcf) | Strength | | Reference |
|---|---|---|---|---|
| | | $\phi'$ | c' (psf) | |
| Newer Embankment Fill | 125 | 31° | 0 | SPT and Index Testing Correlations |
| Original Embankment Fill | 125 | 30° | 100 | Index Testing Correlations |
| Alluvium Silt and Clay | 125 | 30° | 0 | Index Testing Correlations |
| Organic Clayey Silt | 125 | 30° | 0 | Index Testing Correlations and CU Triaxial Test (BBCM 2009) |
| Very Loose to Loose Glacial Outwash Sand and Gravel | 115 | 29° | 0 | SPT and Grain Size Correlations |
| Medium Dense Glacial Outwash Sand and Gravel | 120 | 34° | 0 | SPT and Grain Size Correlations |

In addition to the static steady-state stability analyses, strength parameters were developed for use with the pseudo-static seismic analyses. With respect to seismic loading, it is believed that the newer embankment fill soil is sufficiently granular that drained strengths values will be exhibited during seismic loading. However, as the original embankment fill is more cohesive in nature, it will likely exhibit an undrained response. As the embankment fill has come to equilibrium under the present steady-state seepage conditions, the shear strength envelope used in the analysis was based on the "R" test, as recommended in the Army Corps of Engineer's Manual 1110-2-1906 "Laboratory Soils Testing," and suggested by Duncan and Wright in their 2005 publication. This is essentially the slope and y intercept of the CU strength envelope. Unfortunately, CU triaxial tests were not performed in the newer embankment fill layer as all Shelby tubes attempted in this layer failed to recover an adequate sample size (however, a permeability test was performed). The seismic strength values for the newer embankment fill layer has been estimated based on values given by Duncan and Wright (2005) for soils with similar index properties (See Plate 16 of Appendix D). CU Triaxial test data was available for the Organic Clayey Silt layer, and the corresponding R envelope was used to model the shear strength. As there is a significant amount of sand within the alluvium strata, drained strength values were used for seismic loading.

*Table 6: Strength Values for Seismic Conditions*

| Material Description | $\gamma_{wet}$ (pcf) | Strength | | Reference |
|---|---|---|---|---|
| | | $\phi$ | c (psf) | |
| Newer Embankment Fill | 125 | 31° | 0 | SPT and Index Testing Correlations |
| Original Embankment Fill | 125 | 22° | 50 | Duncan and Wright (2005) |
| Alluvium Silt and Clay | 125 | 30° | 0 | Index Testing Correlations |
| Organic Clayey Silt | 125 | 24° | 180 | CU Triaxial Test (BBCM 2009) |
| Very Loose to Loose Glacial Outwash Sand and Gravel | 115 | 29° | 0 | SPT and Grain Size Correlations |
| Medium Dense Glacial Outwash Sand and Gravel | 120 | 34° | 0 | SPT and Grain Size Correlations |

### Analysis and Results

Static and seismic analyses were performed on Sections B and D to determine the factor of safety against rotational failure for the outboard slopes using drained soil strength parameters. The graphical computer outputs for these analyses have been included with this report in Appendix D.

Seismic analyses were performed using a pseudo-static analysis with a horizontal seismic coefficient of 0.06g. This coefficient was determined from the 2008 USGS National Seismic Hazard Maps for the "Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years". This chart is provided as Plate 33 of Appendix C.

Graphical results of the slope stability analysis for static and seismic conditions are shown in Appendix D. Table 7 summarizes the lowest factors of safety determined for each analysis case.

*Table 7: Stability Analysis Summary*

| Analysis Case | Required Minimum Factor of Safety | Computed FS | |
|---|---|---|---|
| | | Section B | Section D |
| Static (Steady-State Seepage) | 1.50 | 1.57 | 1.52 |
| Pseudo-Static | 1.00 | 1.05 | 1.09 |

The critical failure surfaces were located through a deterministic search, with no limitations on failure depth. The failure surface locations were restricted to find only surfaces associated with a global failure through the composite embankment (original plus newer embankment fill) or through the original embankment only. Shallow sloughing failures along the river bank were not considered for this analysis. The results are based on the pool level recorded at the time of the survey, extrapolated bathymetric data, and the groundwater measurements recorded from the observation wells.

## CONCLUSIONS

As part of this report, BBCM examined the stability of the outboard embankment slopes at 4 locations under steady-state seepage and seismic loading conditions using the results of 7 soil borings. The analyses suggest that at the four cross sections examined, the embankments exhibit adequate factors of safety relative to those recommended by the US Army Corps of Engineers (COE).

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# Appendix VI – Excerpt from 2010 Follow-Up Investigation Report

## INTRODUCTION

BBCM previously performed a limited subsurface investigation and slope stability analyses of the Cardinal Bottom Ash Pond Complex, the report of which was dated August 4, 2009. This report consisted of obtaining subsurface data at a total of four cross-sections through the bottom ash pond and recirculation pond embankments, and performing seepage and slope stability analyses to provide an indication as to the level of safety provided by the embankments.

The purpose of this follow-up work was to supplement the analyses performed as part of the original work in an attempt to fulfill the AEP action plan requirements in response to the USEPA inspection report. The follow-up slope stability analyses are solely based on existing subsurface data, as no additional field or laboratory work was performed as part of this project. Also as part of this follow-up work, hydraulic and hydrologic (H&H) analyses were performed to determine the capacity and freeboard of the Bottom Ash Pond related to current requirements. A summary of the work performed is contained in this report. This report should be considered an addendum to our August 4, 2009 Bottom Ash Pond Complex report.

## SLOPE STABILITY ANALYSIS

### Follow-Up Embankment Stability Analysis

Additional slope stability analyses were performed on Sections B and D to determine the factor of safety against rotational failure for the following conditions:

1.) Inboard slopes under steady-state seepage conditions;
2.) Pseudo-static seismic analyses under steady-state seepage conditions for the inboard slopes;
3.) Surcharge pool conditions (outboard slopes); and,
4.) Rapid drawdown analyses for the inboard slope.

The previously developed cross-section (B and D) geometry, permeability values, and shear strength parameters were used in the follow-up analysis. Please refer to the '*Subsurface Investigation and Analysis – Bottom Ash Pond Embankments'* report by BBCM dated August, 2009 for a complete discussion of these parameters.

Seismic analyses for the inboard slopes were performed using a pseudo-static analysis with a horizontal seismic coefficient of 0.06g, consistent with the original report. The surcharge pool was modeled using a distributed line surcharge load, as it is not expected that the phreatic surface within the embankment will change during this temporary loading condition.

A rapid drawdown analysis was also completed for the bottom ash pond inboard embankment slopes utilizing the previously developed cross-sections. It is the understanding of BBCM that the ponds are typically filled with ash which would tend to support the inboard slopes. However, on an occasional basis, during times of ash removal and subsequent re-filling, a full pool of water could be established and a rapid drawdown scenario could occur if the pond were suddenly emptied. While not impossible, a large scale rapid drawdown event with unsupported interior slopes is unlikely. Notwithstanding, a rapid drawdown analysis was completed using the conventional method whereby the phreatic surface is positioned at the ground surface (inside the pond) and extended up into the slowly-draining embankment layers to the normal pool elevation. Drained strength parameters are used in this scenario. The drawdown level for the analysis was considered to occur from the normal operating pool El. 664.4 down to the natural ground surface on the inboard side of the embankment. During the subsurface investigation it was determined that there are two types of fill present in the embankments, identified as *newer embankment fill* and *original embankment fill*. The *newer embankment fill* contains a high percentage of sand and gravel (58%), as determined from previous laboratory testing. While pockets of this layer are cohesive and will exhibit a slowly-draining response during a rapid drawdown event, the layer as a whole likely will not maintain a consistent phreatic surface on the inboard slope. As a result, the phreatic surface was modeled to maintain its elevated level only within the *original embankment fill* and not within the *newer embankment fill*. Please see the analysis of the *newer embankment fill* layer submitted in Appendix B.

Graphical results of the slope stability analysis for static and seismic conditions are shown in Appendix A. Table 1 summarizes the lowest factors of safety determined for each analysis case.

*Table 1: Stability Analysis Summary*

| Analysis Case | Required Minimum Factor of Safety | Computed FS | |
|---|---|---|---|
| | | Section B | Section D |
| Static (Steady-State Seepage) – Inboard Slope | 1.50 | 1.70 | 1.65 |
| Pseudo-Static – Inboard Slope | 1.00 | 1.39 | 1.34 |
| Maximum Surcharge Pool – Outboard Slope | 1.40 | 1.55 | 1.52 |
| Rapid Drawdown – Inboard Slope | 1.30 | 1.55 | 1.52 |

The critical failure surfaces were located through a deterministic search, with no limitations on failure depth. The failure surface locations were restricted to find only surfaces associated with a global failure through the embankment. Shallow sloughing failures along the river bank were not considered for these analyses.

Liquefaction of Foundation Alluvium

A liquefaction screening analysis was performed for the soft alluvium soils underlying the embankments. There is concern that areas of this layer could potentially liquefy during seismic excitation and ultimately cause a failure of the embankments. The screening analysis was performed using the five techniques listed in the Federal Highway GEC No. 3:

1.) Geologic Age and Origin,
2.) Fines Content and Plasticity Index,
3.) Saturation,
4.) Depth Below Ground Surface, and
5.) Soil Penetration Resistance.

The five screening techniques are described in detail in the hand calculations provided in Appendix B. Due to the fines content and plasticity index, as well as the geologic age and origin, the screening analysis suggests that liquefaction will not occur for the alluvium silt and clay layer.