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November 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 – Bottom Ash Pond Alternative Closure Demonstration, Revision 1

Dear Administrator Wheeler:

Cardinal Operating Company hereby submits a revised demonstration 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.

Cardinal's original demonstration was submitted electronically to US EPA on October 30, 2020. The revised demonstration includes additional descriptions, clarifications and details to better describe Cardinal's CCR program compliance.

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,

TM 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 1

November 30, 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. A figure of the Cardinal facility and associated CCR units is presented in Figure 1.

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. The water balance diagram associated with Cardinal's NPDES Permit 0IB00009*XD is presented in Figure 2.

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 (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 (1.60)
Coal Pile Run-Off Pond Overflow	Waste water collected by the station's Coal Pile Run-Off Pond. Includes storm water from: • Coal pile, • Coal truck unloading area, • Unit 1, 2, and 3 FGD areas (including gypsum pile, limestone pile, and marine area run-off), and • Unit 1 and 2 power block sumps and drains.	0.23 (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: • JBR process water, • Reagent feed tank, • FGD reclaim water, and • Byproduct storage tank.	0.00 (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. Additionally, if the BAP Complex was forced to initiate closure, Cardinal would be subject to NPDES violations; the LVW streams not associated with power generation that go into the BAP Complex (storm water, coal pile runoff, gypsum, limestone pile runoff, ancillary process water associated with FGD wastewater treatment plant) would have no permitted outfall.

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.

While Cardinal has two, small coal pile runoff ponds, these ponds are not an alternative to the BAP Complex. The ponds are less than an acre in size and are designed to receive various runoffs and facility sumps. They do not have capacity to handle additional waste streams. Additionally, these ponds drain to the BAP Complex. A new conveyance system and NPDES-permitted outfall would be required.

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, one indicated that the facility could not accept external waste streams and two had a combined capacity of less than 10 MGD. These facilities treat water from other sources and are unable to guarantee the ability to treat Cardinal's waste streams on regular basis, while meeting their permit obligations. This would put Cardinal at risk for NPDES violations. Additionally, the WWTPs are not equipped to handle the additional truck traffic required to receive Cardinal's waste streams. Off-site WWTPs are not a viable treatment option for Cardinal's waste streams.

Even if one or more WWTPs had sufficient capacity, the Cardinal Operating Company would need to identify a means of transporting the waste water from Cardinal. 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. The nearest alternative water source would be the Ohio River. However, Cardinal does not have infrastructure to use this water. Utilizing this option would require regulatory approvals from Ohio EPA (permit to install, NPDES modification) and Ohio Department of Natural Resources. Additionally, there may be 316(b) implications associated with this withdrawal. Given regulatory uncertainty and time required to obtain these permits, Cardinal did not proceed with this option.

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 1×10^{-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 1×10^{-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 1×10^{-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 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). In addition, the tanks would need to be taken out of service periodically to clean out the solids deposited. With the number of tanks and piping connections, Cardinal would be at an increased risk for leaks and spills. The associated releases could be considered a bypass of treatment and would be subject to NPDES violations.

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 trailers 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:

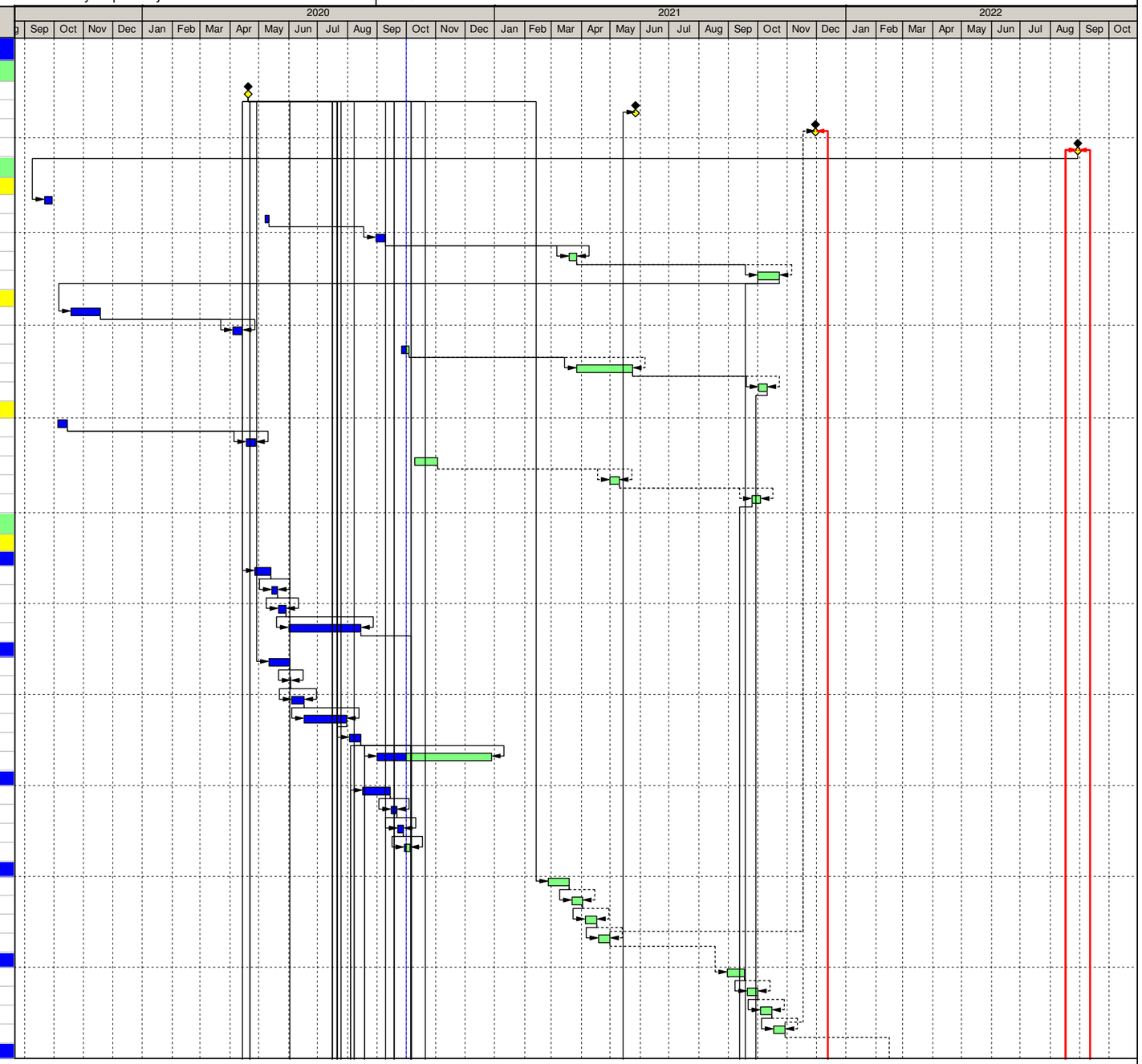
- How each phase and the steps within that phase interact with or are dependent on each other and the other phases,
- All of the steps and phases that can be completed concurrently,
- The total time needed to retrofit the South Pond and to repurpose the North Pond as a non-CCR waste basin.

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

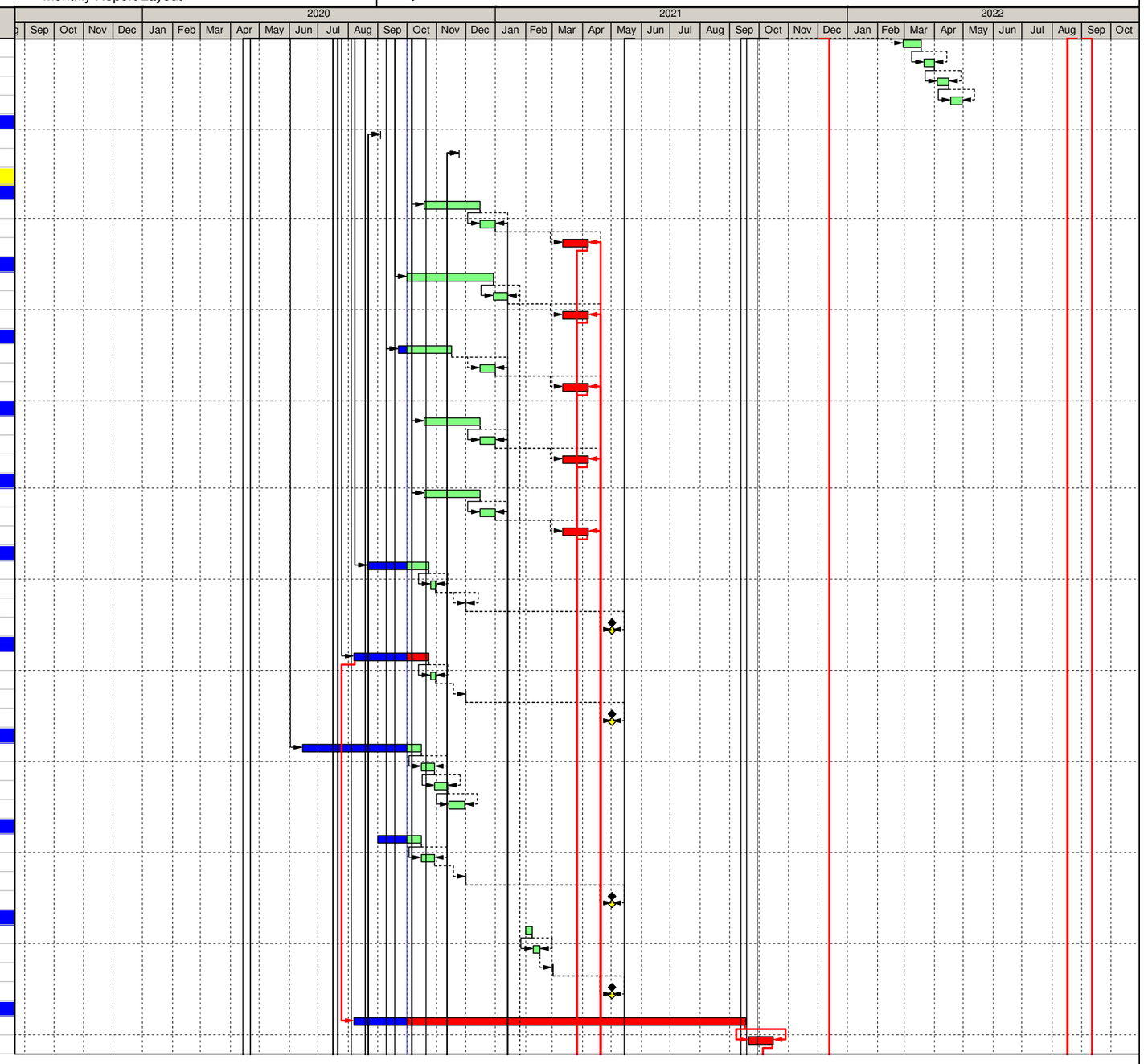


Remaining Level of Effort ◆ ◆ Milestone
Actual Work
Remaining Work
Critical Remaining Work
◇ ◇ Baseline Milestone

Engineering, Procurement & Construction Schedule by WBS

Sargent & Lundy

WBS	Activity ID	Activity Name	Rem Duration	Activity % Complete	Start	Finish
	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-Dec-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 Complaince 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

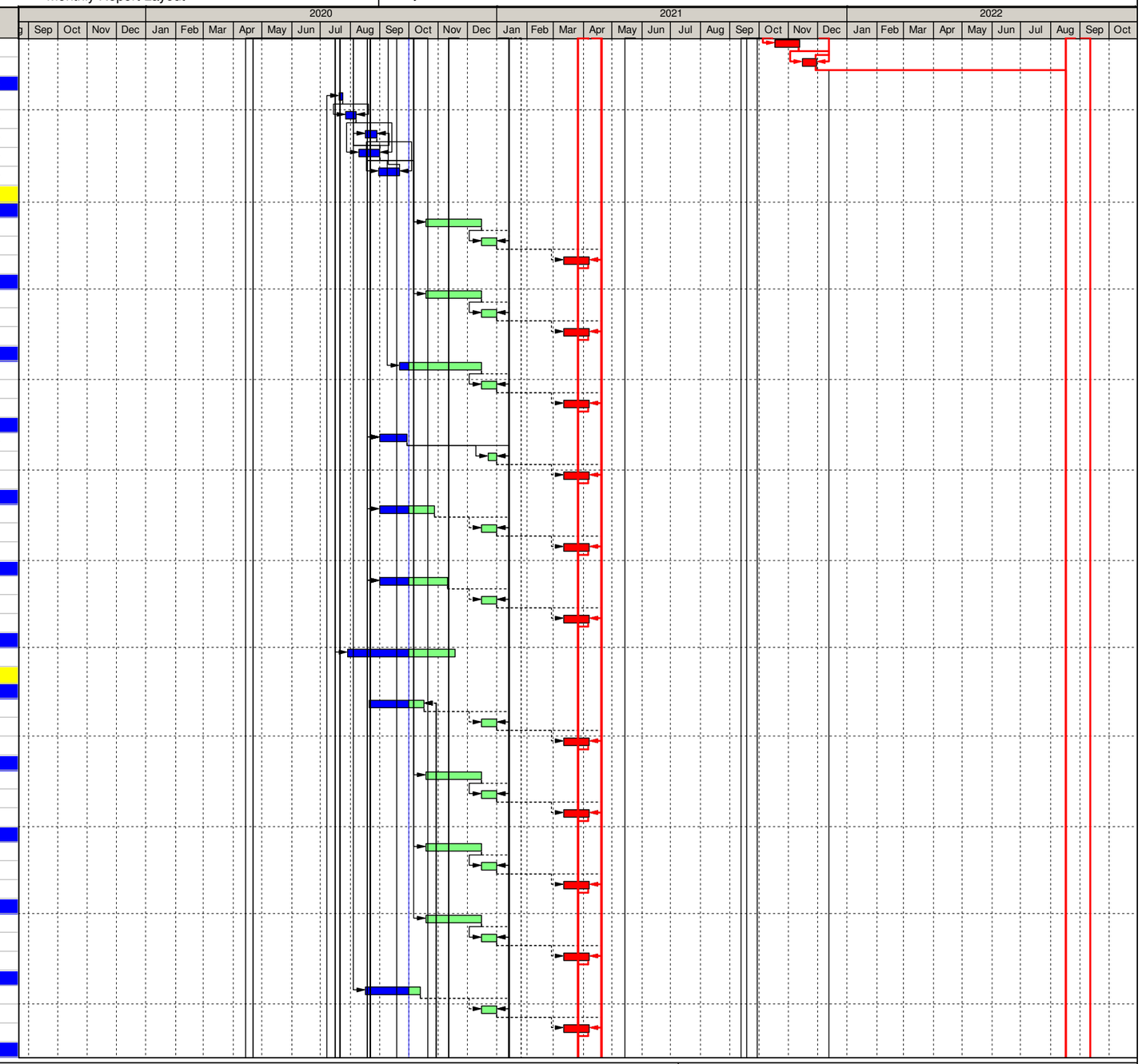


Remaining Level of Effort ◆ ◆ Milestone
Actual Work
Remaining Work
Critical Remaining Work
◇ ◇ Baseline Milestone

Engineering, Procurement & Construction Schedule by WBS

Sargent & Lundy

WBS	Activity ID	Activity Name	Rem Duration	Activity % Complete	Start	Finish
	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

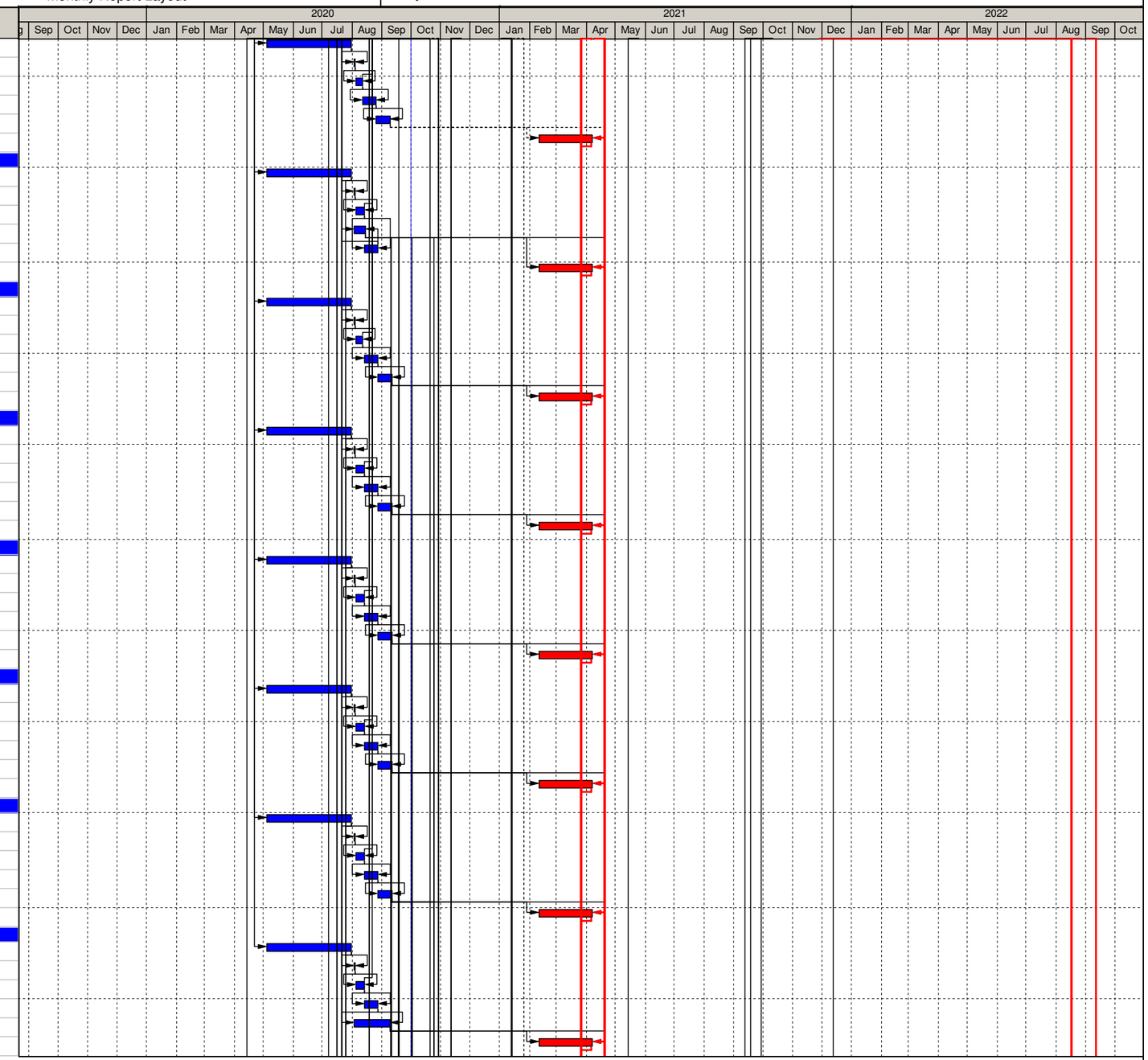


Remaining Level of Effort ◆ ◆ Milestone
Actual Work
Remaining Work
Critical Remaining Work
◇ ◇ Baseline Milestone

Engineering, Procurement & Construction Schedule by WBS

Sargent & Lundy

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

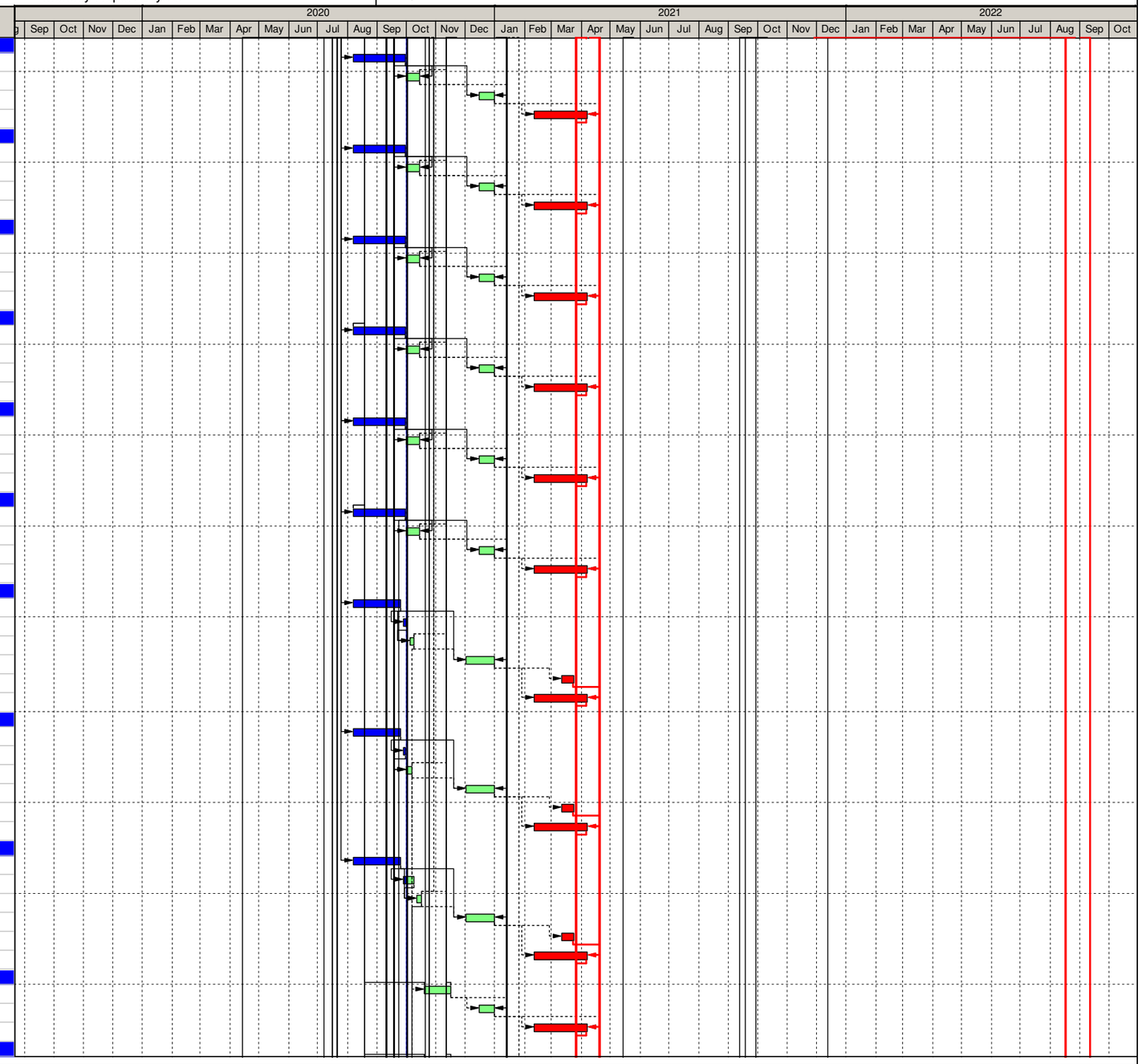


Remaining Level of Effort ◆ ◆ Milestone
Actual Work
Remaining Work
Critical Remaining Work
◇ ◇ Baseline Milestone

Engineering, Procurement & Construction Schedule by WBS

Sargent & Lundy

WBS	Activity ID	Activity Name	Rem Duration	Activity % Complete	Start	Finish
	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**

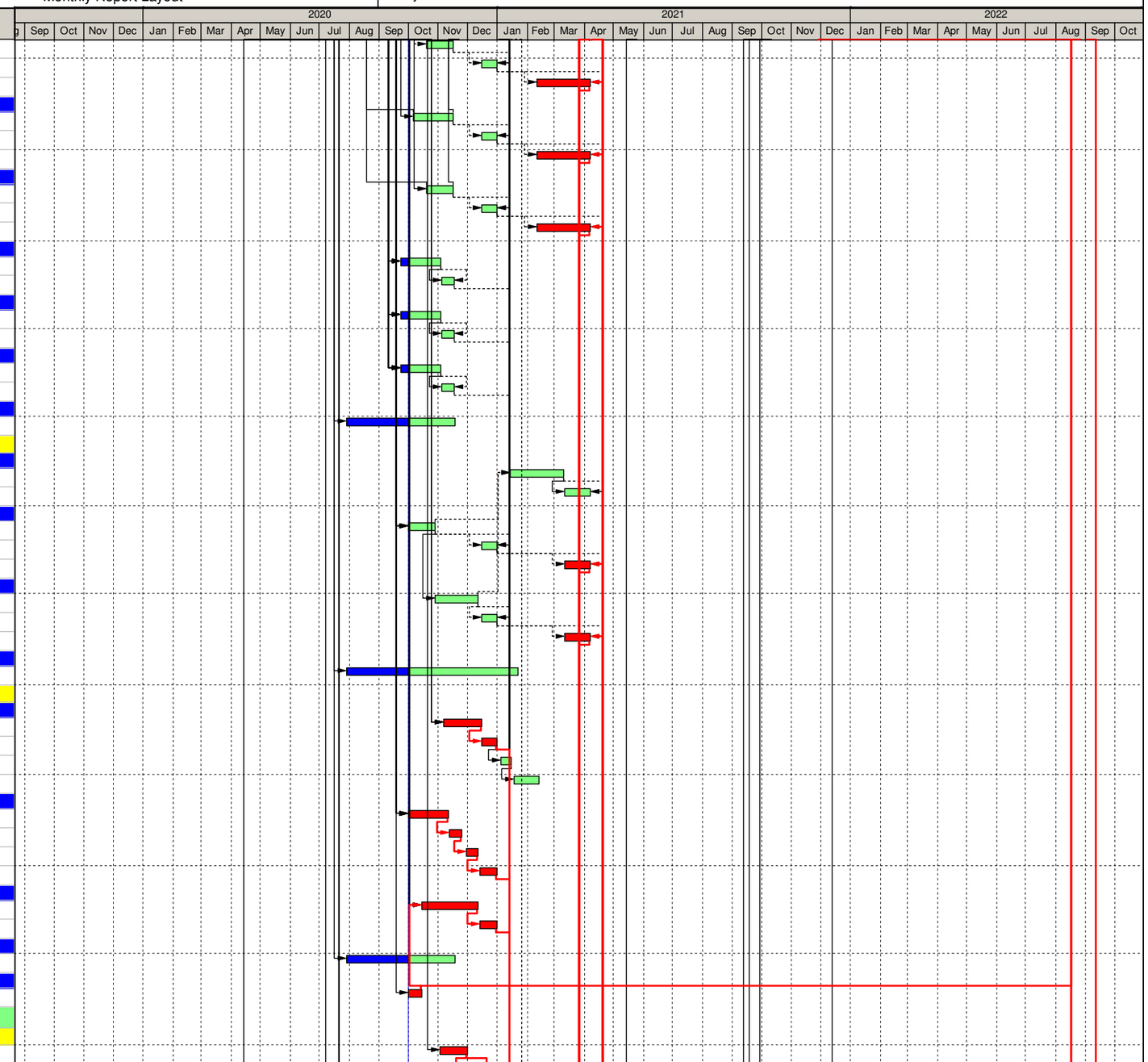


Remaining Level of Effort ◆ ◆ Milestone
Actual Work
Remaining Work
Critical Remaining Work
◇ ◇ Baseline Milestone

Engineering, Procurement & Construction Schedule by WBS

Sargent & Lundy

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
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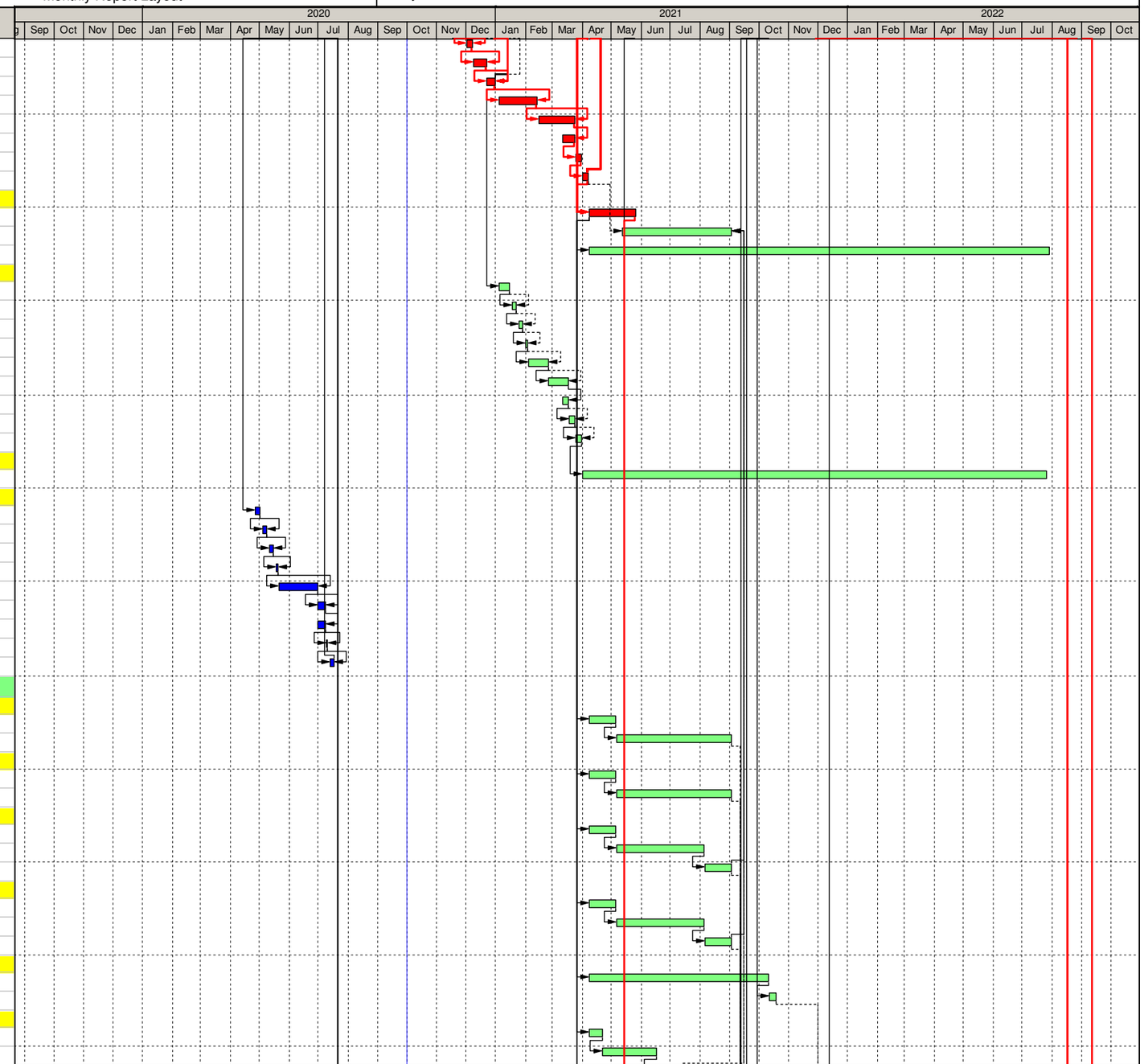
◇ ◇ Baseline Milestone

Engineering, Procurement & Construction Schedule by WBS

Sargent & Lundy

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

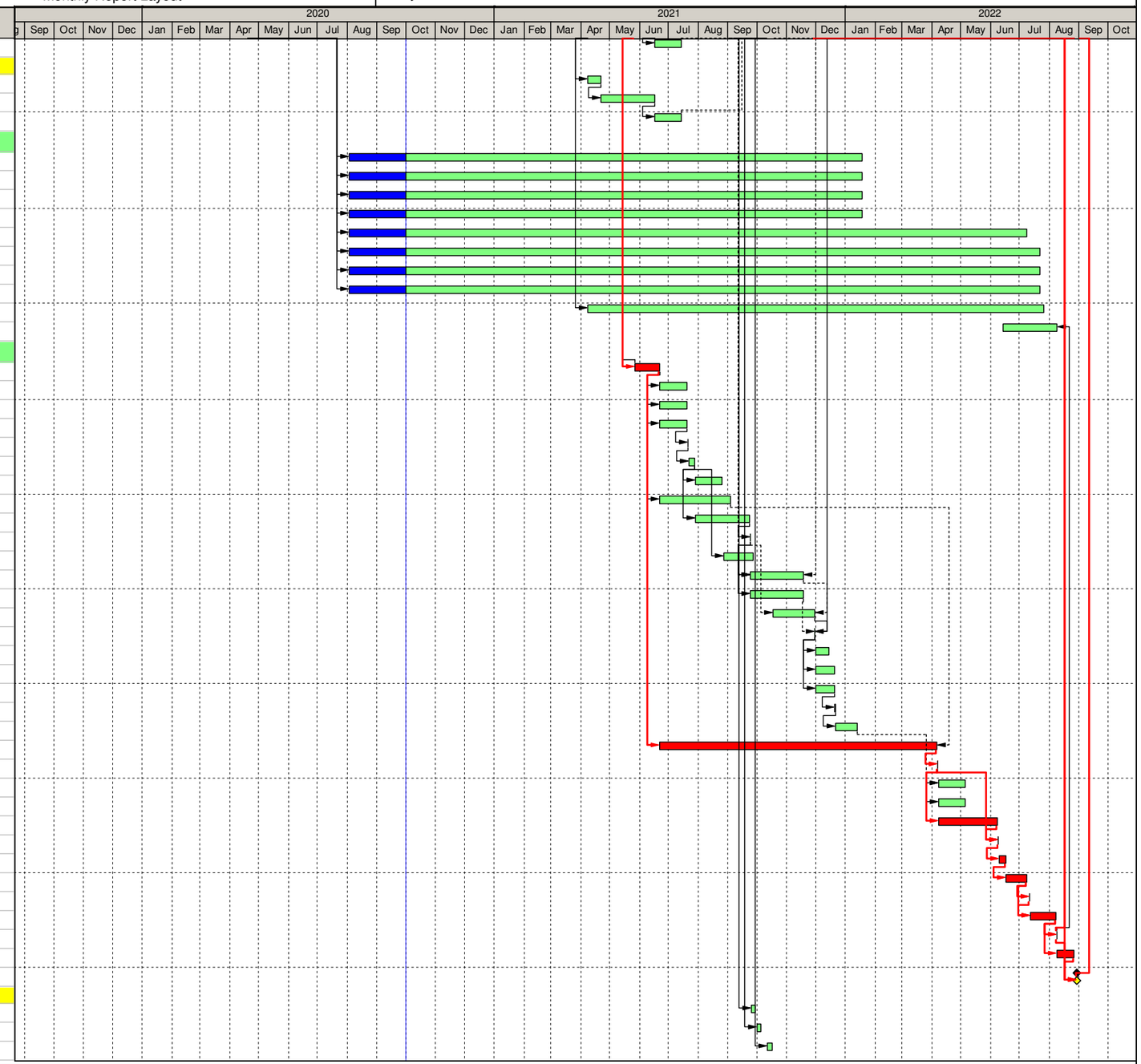


Remaining Level of Effort ◆ ◆ Milestone
Actual Work
Remaining Work
Critical Remaining Work
◇ ◇ Baseline Milestone

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



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 1×10^{-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).

The Cardinal Operating Company anticipates it will take approximately 200 workdays to excavate and transport the estimated 310,000 cubic yards of CCR currently stored in the North Pond plus any CCR-impacted soils to FAR I Landfill. This estimate was determined to be the fastest feasible timeframe in which the General Work Contractor could reasonably haul this quantity of material up to the landfill, which can only be accessed from the plant via the existing narrow, steep, two-lane private road from Riddles Run Road up to FAR I Landfill. The time estimated for this activity is primarily based on the average number of haul trucks that the General Work Contractor will feasibly and effectively be able to utilize when accounting for the loading rate of the excavator removing the material from the North Pond, reduced productivity during the winter, and plant traffic using these haul roads for other purposes, including the haul trucks that will be regularly transporting FGD waste, fly ash from Cardinal's new fly ash storage silos to FAR I Landfill, and materials to support construction activities associated with installing the final cover system for FAR II.

Given that the landfill is approximately three miles from the North Pond, it will take each truck approximately 30 minutes to complete one trip to FAR I Landfill and back to the North Pond. Depending on factors such as the bucket size, excavation conditions, and operator efficiency, it is estimated that the excavator will take between 4 and 8 minutes to load each truck. Therefore, it is expected to take about 30 to 40 minutes for one truck to complete one transportation cycle of being loaded, traveling to the landfill, unloading, and traveling back to the North Pond. Accordingly, it is expected that the General Work Contractor will utilize approximately 10 trucks per day to keep the excavator operating at maximum efficiency. Based on an average of 10 trucks hauling CCR and CCR-impacted soils excavated from the North Pond to FAR I Landfill per 10-hour workday, an average of approximately 1,800 cubic yards of CCR and CCR-impacted soils can be hauled to FAR I Landfill for final disposal. Thus, the General Work Contractor will need at least 170 workdays to transport the quantity of CCR currently stored in the North Pond to FAR I Landfill in normal construction season conditions. When accounting for lost days due to winter weather, reduced productivity in the winter, and potential quantities of CCR-impacted soils that will need to be excavated from the North Pond, the Cardinal Operating Company estimates the General Work Contractor will need the 200 workdays shown in the visual timeline representation of the project schedule in Section 2.0 to complete this task.

In conclusion, it is expected that the southern portion of the North Pond will be clean-closed by early April 2022 based on approximately 10 highway-compliant haul trucks transporting excavated CCR and CCR-impacted soils from the North Pond to FAR I Landfill each workday. This is the fastest feasible timeframe in which this activity can be completed as this number of trucks keeps the excavator used to remove material from the North Pond operating at maximum efficiency and limits disruptions to other trucks using the only access road to the landfill. Given the narrow two-lane roads that provide the only means of accessing the landfill from the station, the distance to the landfill, and the trucks required to support other station operations during this construction phase (*e.g.*, trucks hauling fly ash from the new fly ash storage silos and FGD waste to the landfill), the General Work Contractor will not be able to effectively utilize more than the 10 haul trucks estimated in this demonstration.

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.

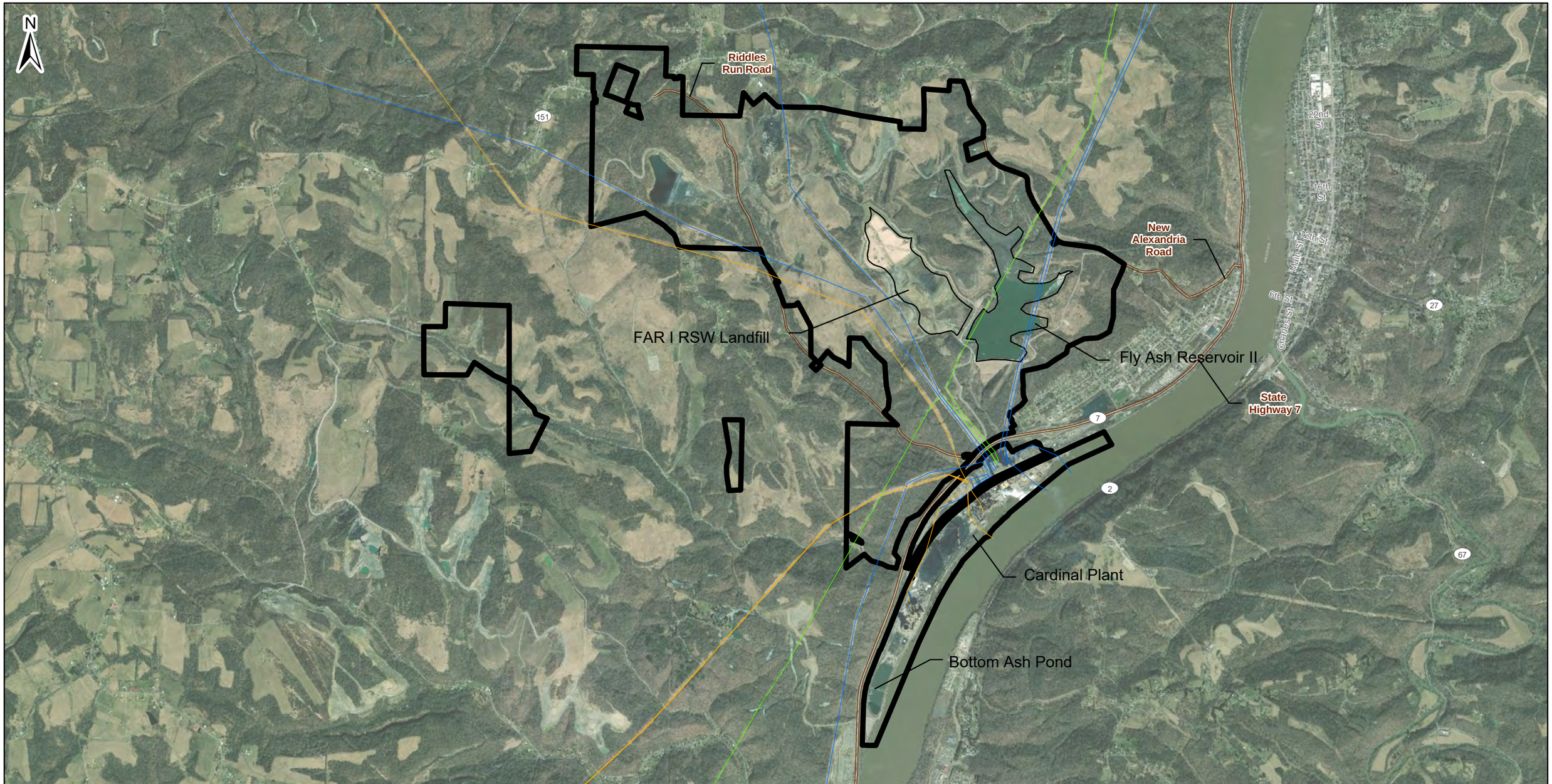
8. Environmental Protection Agency, "Steam Electric Reconsideration Rule," 85 Fed. Reg. 198, pp. 64650–64723, 10/13/2020.

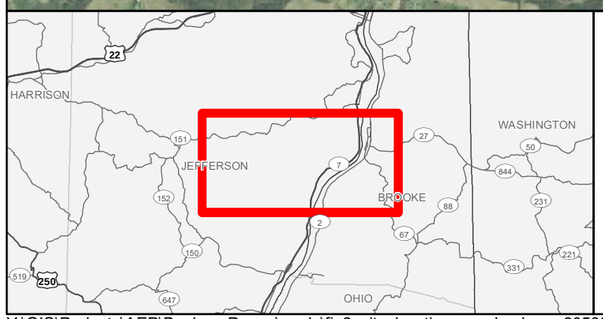
9. Environmental Protection Agency, "Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category," 80 Fed. Reg. 212, pp. 67838– 67903, 11/03/2015.

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.

Section 6.0 Figures





Notes
1. Coordinate System: NAD 1983 StatePlane Ohio North FIPS 3401 Feet
2. Projection: Lambert Conformal Conic
3. Data Sources: AECOM, Cardinal Operating Company, Tele Atlas
4. Background: Esri World Imagary, DigitalGlobe, 03/2015, Accessed 01/2019

0 1,500 3,000 6,000 Feet
1 in = 3,000 feet

Legend

- Parcel Boundary
- 69 kV Trasmission Line
- 138 kV Trasmission Line
- 345 kV Trasmission Line
- Public Road

Figure No.
1- Aerial Site Location

Cardinal Site Location

Jefferson County, OH and Brooke County, WV

Cardindal Operating Company
Brilliant, OH

Prepared by: HD	Date: 1/31/2019
Reviewed by: RDO	Job No.: 60583548

Sheet 1 of 1

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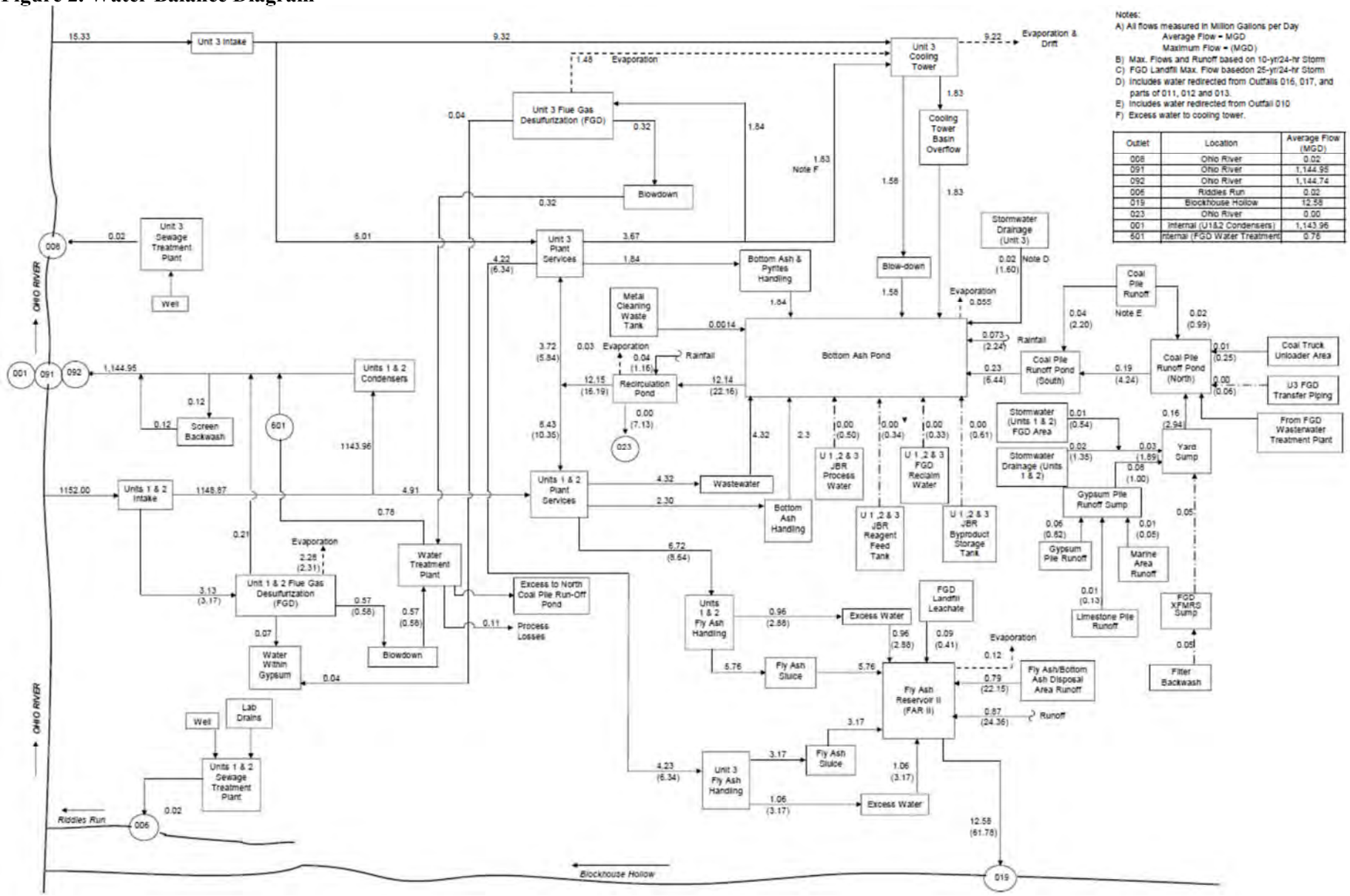
Figure 2- Water Balance from Cardinal NPDES Permit

Figure 2. Water Balance Diagram



Outlet	Location	Average Flow (MGD)
008	Ohio River	0.02
091	Ohio River	1,144.95
092	Ohio River	1,144.74
006	Riddles Run	0.02
019	Blockhouse Hollow	12.58
023	Ohio River	0.00
001	Internal (U1&2 Condensers)	1,143.96
601	Internal (FGD Water Treatment	0.76

CARDINAL
OPERATING COMPANY

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Columbus, OH 43229
614.846.5757

7.0 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 Facility is in compliance with the CCR Rule.

7.1 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 Facility CCR Units are in compliance with all requirements contained in 40 CFR § 257 Subpart D.

TC M. Alban CS PMJ NK

Thomas M. Alban
Vice President
November 30, 2020

7.2 Compliance Documents

Compliance documentation is outlined below for Cardinal's three CCR Units, Fly Ash Reservoir II, Bottom Ash Pond and FAR I RSW Landfill.

Fly Ash Reservoir II

In accordance with 40 CFR§ 257.103(f)(1)(iv)(B)(2) through (B)(8), the following documents are provided below in Attachment 1 for Fly Ash Reservoir II:

§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 – Completed in July 2019 and subsequent public meeting was held on September 4th, 2019.

§257.103(f)(1)(iv)(B)(6) – Remedy Selection Report – Provided are two corrective measure selection progress reports (March & September 2020) and completed Remedy Selection Report, uploaded to Operating Record on October 27, 2020.

§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.

Bottom Ash Pond

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

§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, 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.

FAR I RSW Landfill

In accordance with 40 CFR§ 257.103(f)(1)(iv)(B)(2) through (B)(8), the following documents are provided below in Attachment 3 for the FAR I RSW Landfill:

§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.

§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 FAR I RSW Landfill is currently in Detection Monitoring and does not exceed Groundwater Protection Standards.

§257.103(f)(1)(iv)(B)(6) – Remedy Selection Report – Not applicable, the FAR I RSW Landfill is currently in Detection Monitoring and no remedy selection report is required.

§257.103(f)(1)(iv)(B)(7) – Not applicable, The CCR Unit is a Landfill and Structural Stability Assessments pursuant to §257.73(d) do not apply.

§257.103(f)(1)(iv)(B)(8) – Not applicable, The CCR Unit is a Landfill and Safety Factor Assessments pursuant to §257.73(e) do not apply.

Fly Ash Reservoir II

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
- Corrective Measures Delineation Well
- Jules Verne Seep

Fly Ash Reservoir (FAR) II

Notes
- Monitoring well coordinates provided by Buckeye Power.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Fly Ash Reservoir II (Geosyntec, 2017) provided by Buckeye Power.

1,000 500 0 1,000 Feet

Site Layout
Fly Ash Reservoir II

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2020/01/14

Figure 2

P:\Projects\Buckeye Power\GIS\MXDs\FAR II\AEP-Cardinal_FAR-II_Site_Layout.mxd. ARevezzo. 1/14/2020. CHA8423/01/08.

Fly Ash Reservoir II

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

Well construction diagrams and drilling logs for all groundwater monitoring wells

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-21

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 830,426.7 E 2,516,358.1**

GROUND ELEVATION **1016.2** SYSTEM

Water Level, ft			
TIME			
DATE			

BORING NO. **CA-0620** DATE **7/17/15** SHEET **1** OF **12**

BORING START **8/25/06** BORING FINISH **6/1/06**

PIEZOMETER TYPE WELL TYPE

HGT. RISER ABOVE GROUND **2.45** DIA **6"**

DEPTH TO TOP OF WELL SCREEN **170.0** BOTTOM **260.0**

WELL DEVELOPMENT **YES** BACKFILL **N/A**

FIELD PARTY **GEOSYNTEC CONSULTING** RIG

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
1	SS	0.0	2.0							Loose, grayish brown, gravelly **SAND** (SP); dry; non-plastic; coarse to fine sand with approx. 20% fine gravel to cobbles.		
2	SS	2.0										
3	SS	4.0					5					
4	SS	6.0										
5	SS	8.0					10					
6	SS	10.0								Loose, black, **COAL**; dry.		
7	SS	12.0								Loose, orange, silty **SAND** (SM); dry, fine grained; over 6" of grayish brown, clayey silt.		
8	SS	14.0					15			Loose, grayish brown to orange, silty **SAND** (SM); dry; non-plastic; micaceous.		
9	SS	16.0										
10	SS	18.0								Moderately hard, greenish gray, **SANDSTONE**;		

TYPE OF CASING USED

	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
X	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-21

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0620** DATE **7/17/15** SHEET **2** OF **12**

PROJECT **CARDINAL LANDFILL** BORING START **8/25/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
11	SS	20.0								fine grained; rust color along fractures; massive.		
1	RC	22.0	30.0									
										Hard, light gray, **LIMESTONE**; fine grained; rust color along fractures; vertical fracture at 24.0 ft.; massive.		
							25					
										Soft, greenish gray (GLEY1-6/1-5GY), **SANDSTONE**; micaceous; massive.		
2	RC	30.0	40.0				30					
										Soft, gray, **SAND and SHALE**; micaceous.		
										Soft, gray to greenish gray, **SANDSTONE**; medium grained; slight shale like foliations; 3" sandy shale at 33 ft.; 5 horizontal and vertical fractures.		
							35					
										Very soft, gray to greenish gray, **CLAYSHALE**; massive.		
										Hard, gray to greenish gray, **SANDSTONE**.		
3	RC	40.0	50.0				40					
										Very soft, gray to greenish gray, **CLAYSHALE**; high sand content; massive to foliated.		
							45					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-21

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0620** DATE **7/17/15** SHEET **3** OF **12**

PROJECT **CARDINAL LANDFILL** BORING START **8/25/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										Moderately hard, greenish gray, **SANDSTONE**; fine grained, rust color along cracks; massive.		
4	RC	50.0	60.0				50					
							55			2 horizontal fractures near 55.0 ft.		
										Soft, gray to black, **CLAYSHALE**; massive to foliated.		
5	RC	60.0	70.0				60			Hard, light gray (GLEY2-7/1-10B), **LIMESTONE**; massive.		
										Soft, gray to black; **CLAYSHALE**; massive.		
							65					
6	RC	70.0	80.0				70					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-21

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0620** DATE **7/17/15** SHEET **4** OF **12**

PROJECT **CARDINAL LANDFILL** BORING START **8/25/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										Moderately hard, greenish gray, **SANDSTONE**; fine grained; massive. Vertical fracture at 73.0 ft. Horizontal fracture at 74.5 ft.		
							75			Soft, dark gray, **CLAYSHALE**; massive.		
7	RC	80.0	90.0				80					
										Light gray, **LIMESTONE**; iron staining.		
										Soft, dark gray, **CLAYSHALE**; massive.		
							85					
8	RC	90.0	100.0				90			Light gray, **LIMESTONE**.		
										Soft, dark gray, **CLAYSHALE**; massive.		
							95			Hard, gray (GLEY1-6/2-N), **LIMESTONE**; massive.		
										Soft, dark gray, **CLAYSHALE**; massive.		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-21

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0620** DATE **7/17/15** SHEET **5** OF **12**

PROJECT **CARDINAL LANDFILL** BORING START **8/25/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							100					
9	RC	100.0	110.0							Hard, gray, **LIMESTONE**; massive.		
										Soft, gray (GLEY1-4/1-N), **CLAYSTONE**; massive.		
							105					
							110					
10	RC	110.0	120.0									
							115					
							120					
11	RC	120.0	130.0									
										Light gray, **LIMESTONE**.		
										Dark gray, **CLAYSHALE**.		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-21

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0620** DATE **7/17/15** SHEET **6** OF **12**

PROJECT **CARDINAL LANDFILL** BORING START **8/25/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							125			Light gray, **LIMESTONE**.		
										Dark gray to black to red brown (10R-3/2-/2), **CLAYSHALE**; dry; massive.		
12	RC	130.0	140.0				130					
							135					
13	RC	140.0	150.0				140			Hard, dark gray (GLEY2-3/1-5PB), **CLAYSTONE**; vertical fractures refilled with calcite; massive.		
							145					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well M-21

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0620** DATE **7/17/15** SHEET **7** OF **12**

PROJECT **CARDINAL LANDFILL** BORING START **8/25/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
14	RC	150.0	160.0									
										Hard, gray, **SANDSTONE**; medium grained.		
										Hard, grayish brown (10YR 5/3), **SANDSTONE**; medium grained.		
							155					
							160					
15	RC	160.0	170.0									
							165					
										Hard, gray (GLEY2-5/1-10B), **SANDSTONE**; medium grained.		
							170					
16	RC	170.0	180.0									
										Vertical fracture at 172.0 ft.		
							175					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-21

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0620** DATE **7/17/15** SHEET **8** OF **12**

PROJECT **CARDINAL LANDFILL** BORING START **8/25/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
17	RC	180.0	190.0				180					
							185			Thin (1mm) clay hair line seams between 185.5 and 187.0 ft. and through sandstone to 225.5 ft.		
18	RC	190.0	200.0				190					
										Pebbly subrounded limestone clasts.		
							195					
19	RC	200.0	210.0				200					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-21

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0620** DATE **7/17/15** SHEET **9** OF **12**

PROJECT **CARDINAL LANDFILL** BORING START **8/25/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							205					
							210					
20	RC	210.0	220.0							Sandstone conglomerate between 210.0 and 211.0 ft.		
										Sandstone conglomerate between 212.0 and 213.5 ft.		
										Sandstone conglomerate between 214.0 and 215.0 ft.		
							215					
							220					
21	RC	220.0	230.0							Sandstone conglomerae between 221.5 and 221.7 ft.		
							225			Sandstone conglomerate between 225.0 and 225.5 ft.		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-21

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0620** DATE **7/17/15** SHEET **10** OF **12**

PROJECT **CARDINAL LANDFILL** BORING START **8/25/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										Hard, dark gray, **SANDSTONE**; fine grained.		
22	RC	230.0	240.0				230			Moderately hard to hard, dark gray to black, **CLAYSHALE**; contains brown, angular, coarse to fine gravel inclusions (>5%); massive.		
										Sandstone conglomerate between 233.0 and 233.3 ft.		
							235					
										Sandstone conglomerate between 237.6 and 238.0 ft.		
23	RC	240.0	250.0				240					
							245					
										Hard, light gray, **SANDSTONE**; medium grained; thin coal streaks (1mm) throughout.		
24	RC	250.0	260.0				250			Dark gray claystone between 250.0 and 250.5 ft.		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-21

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0620** DATE **7/17/15** SHEET **11** OF **12**

PROJECT **CARDINAL LANDFILL** BORING START **8/25/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							255					
										Gray, **SANDSTONE**; conglomerate.		
25	RC	260.0	270.0				260					
										Soft to moderately hard, greenish gray (GLEY2-4/1-5B), **CLAYSHALE**; slightly foliated.		
										Hard, gray (GLEY1-4/1-5B), **LIMESTONE**; contains fossils, fractured and broken glass at 273.0 ft.		
26	RC	270.0	280.0									
										Dark gray to black, **CLAYSHALE**; slicken slides throughout.		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-21

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0620** DATE **7/17/15** SHEET **12** OF **12**

PROJECT **CARDINAL LANDFILL** BORING START **8/25/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
27	RC	280.0	290.0									
28	RC	290.0	300.0									

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-22

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 830,925.1 E 2,519,495.8**

GROUND ELEVATION **1005.7** SYSTEM

Water Level, ft			
TIME			
DATE			

BORING NO. **CA-0702** DATE **7/17/15** SHEET **1** OF **9**

BORING START **5/1/07** BORING FINISH **5/21/07**

PIEZOMETER TYPE **N/A** WELL TYPE **OW**

HGT. RISER ABOVE GROUND **2.359** DIA **2"**

DEPTH TO TOP OF WELL SCREEN **152.9** BOTTOM **214.4**

WELL DEVELOPMENT **YES** BACKFILL **QUICK GROUT**

FIELD PARTY **MCR / ZLR** RIG **D-120**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							5					
							10					
							15					
1	NQ	15.5	17.9		1.2	0				**HARD N4 MEDIUM GRAY LIMESTONE**		
										SOFT N4 MEDIUM GRAY CLAY		
										HARD N4 MEDIUM GRAY LIMESTONE		
2	NQ	17.9	24.2		4.0	55				**HARD N4 MEDIUM GRAY LIMESTONE** all fractured		
										HARD 5B 7/1 MEDIUM LIGHT BLUISH GRAY LIMEY FINE-GRAIN SANDSTONE		

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
X	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-22

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0702** DATE **7/17/15** SHEET **2** OF **9**

PROJECT **CARDINAL LANDFILL** BORING START **5/1/07** BORING FINISH **5/21/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
3	NQ	24.2	34.2		9.2	54	25			**HARD 5B 7/1 MEDIUM LIGHT BLUISH GRAY LIMEY FINE-GRAIN SANDSTONE**		
										SOFT N5 MEDIUM GRAY CLAY SHALE		
										HARD LIMESTONE		
										SOFT N5 MEDIUM GRAY CLAY SHALE		
							30			**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE / LIMESTONE NODULE**		
4	NQ	34.2	40.7		6.4	0	35			**SOFT 5YR 4/1 BROWNISH GRAY CLAY SHALE** w/5G 6/1 greenish gray clay shale, w/high angle fracture		
							40					
5	NQ	40.7	49.2		8.2	28				**HARD TO MEDIUM 5G 6/1 GREENISH GRAY CLAY SHALE**		
							45					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-22

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0702** DATE **7/17/15** SHEET **3** OF **9**

PROJECT **CARDINAL LANDFILL** BORING START **5/1/07** BORING FINISH **5/21/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
6	NQ	49.2	59.2		10.0	42	50					
							55			**HARD 5G 6/1 GREENISH GRAY CLAY SHALE**		
7	NQ	59.2	69.2		7.7	43	60			**SOFT 5G 6/1 GEEENISH GRAY CLAY SHALE** **HARD 5G 6/1 GREENISH GRAY CLAY SHALE** w/traces of limestone **HARD 5G 6/1 GREENISH GRAY LIMESTONE** **HARD 5G 6/1 GREENISH GRAY CLAY SHALE** w/fracture 64.0' and 65.0 high angles		
8	NQ	69.2	75.2		6.0	33	65 70			**HARD 5G 6/1 GREENISH GRAY CLAY SHALE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-22

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0702** DATE **7/17/15** SHEET **4** OF **9**

PROJECT **CARDINAL LANDFILL** BORING START **5/1/07** BORING FINISH **5/21/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							75			**HARD N5 MEDIUM GRAY LIMESTONE** broken up		
9	NQ	75.2	84.2		8.4	49				**HARD N7 LIGHT GRAY LIMESTONE**		
										HARD 5G 6/1 GREENISH GRAY CLAY SHALE		
							80					
10	NQ	84.2	90.7		4.7	0				**HARD 5G 6/1 GREENISH GRAY CLAY SHALE** w/limestone nodules		
							85					
							90					
11	NQ	90.7	97.7		5.4	61				**HARD 5G 6/1 GREENISH GRAY CLAY SHALE** w/limestone nodules		
							95					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-22

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0702** DATE **7/17/15** SHEET **5** OF **9**

PROJECT **CARDINAL LANDFILL** BORING START **5/1/07** BORING FINISH **5/21/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
12	NQ	97.7	104.2		6.4	44				**HARD 5G 6/1 GREENISH GRAY CLAY SHALE**		
										HARD 5G 6/1 GREENISH GRAY LIMESTONE		
							100			**HARD 5G 6/1 GREENISH GRAY CLAY SHALE** w/limestone nodules		
										HARD 5G 6/1 GREENISH GRAY LIMESTONE		
13	NQ	104.2	114.2		8.8	70				**MEDIUM TO HARD 5G 6/1 GREENISH GRAY CLAY SHALE**		
							105					
							110					
14	NQ	114.2	121.2		6.2	19				**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
							115			**HARD 5B 5/1 MEDIUM BLUISH GRAY LIMESTONE** w/fracture throughout		
										HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE		
										HARD 5B 5/1 MEDIUM BLUISH GRAY LIMESTONE w/fracture throughout		
							120			**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
15	NQ	121.2	129.2		8.3	51				**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-22

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0702** DATE **7/17/15** SHEET **6** OF **9**

PROJECT **CARDINAL LANDFILL** BORING START **5/1/07** BORING FINISH **5/21/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							125					
16	NQ	129.2	139.2		10.0	33	130			**HARD N5 MEDIUM GRAY CLAY SHALE** w/fractures		
							135					
17	NQ	139.2	149.2		10.0	41	140			**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
							145					
										COAL		
										HARD N3 DARK GRAY SHALE		
										N5 MEDIUM GRAY WELL CEMENTED MEDIUM GRAIN SANDSTONE		148.0' - 215.0' MORGANTOWN SANDSTONE / SHALLOW WELL?
18	NQ	149.2	159.2		10.0	87				**N5 MEDIUM GRAY WELL CEMENTED**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-22

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0702** DATE **7/17/15** SHEET **7** OF **9**

PROJECT **CARDINAL LANDFILL** BORING START **5/1/07** BORING FINISH **5/21/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										MEDIUM GRAIN SANDSTONE		
							155					
19	NQ	159.2	169.2		10.0	93				**N5 MEDIUM GRAY WELL CEMENTED MEDIUM GRAIN SANDSTONE**		
							160					
							165					
20	NQ	169.2	179.2		10.0	71				**N5 MEDIUM GRAY WELL CEMENTED MEDIUM GRAIN SANDSTONE**		
							170					
							175					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-22

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0702** DATE **7/17/15** SHEET **8** OF **9**

PROJECT **CARDINAL LANDFILL** BORING START **5/1/07** BORING FINISH **5/21/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
21	NQ	179.2	189.2		10.0	52	180			**N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE**		SWL 117.8' 05/21/07; NQ HOLE TO 179.2'; THIS IS A 408 HR READING
										N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE w/coal		
							185			**N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE**		
										N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE w/coal		
										N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE		
22	NQ	189.2	199.2		10.0	85	190			**N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE** w/coal seams		
										N5 MEDIUM GRAY WELL CEMENTED MEDIUM GRAIN SANDSTONE		
							195					
23	NQ	199.2	209.2		9.2	87	200			**N5 MEDIUM GRAY WELL CEMENTED MEDIUM GRAIN SANDSTONE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-22

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0702** DATE **7/17/15** SHEET **9** OF **9**

PROJECT **CARDINAL LANDFILL** BORING START **5/1/07** BORING FINISH **5/21/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										COAL SEAM		
										N5 MEDIUM GRAY SANDY COARSE STONE		
							205					
										N5 MEDIUM GRAY MEDIUM GRAIN WELL CEMENTED SANDSTONE		
24	NQ	209.2	219.2		10.0	95				**N5 MEDIUM GRAY WELL CEMENTED MEDIUM GRAIN SANDSTONE**		
							210					
							215					
										HARD N5 MEDIUM GRAY SILTY SHALE		
												STOPPED BORING @ 219.2' 05/21/07; INSTALLED 2" PVC MONITORING WELL; SWL 90.8' 05/22/07; NQ HOLE TO 219.2' ; 14 HR READING

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-16

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 835,565.0 E 2,516,519.0**

GROUND ELEVATION **1065.8** SYSTEM

Water Level, ft			
TIME			
DATE			

BORING NO. **CA-0616** DATE **7/17/15** SHEET **1** OF **11**

BORING START **1/18/07** BORING FINISH **1/24/07**

PIEZOMETER TYPE **N/A** WELL TYPE **OW**

HGT. RISER ABOVE GROUND **2.798** DIA **2"**

DEPTH TO TOP OF WELL SCREEN **201.3** BOTTOM **250.3**

WELL DEVELOPMENT **YES** BACKFILL **QUICK GROUT**

FIELD PARTY **MCR / ZLR** RIG **D-120**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							5					GROUNDING PROCEDURES NOT IN USE; DECONNED TOOLS 01/08/07; WATER TO DRILL AND DECON FROM FIRE PROTECTION SYSTEM @ CARDINAL PLANT; BLIND DRILL HW 4" CASING FROM GRADE TO BEDROCK @ 78' THROUGH MINE SPOIL; BLIND DRILLED 4" ROLLER BIT FROM 78' TO 82.8'
							10					
							15					

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-16

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0616** DATE **7/17/15** SHEET **2** OF **11**

PROJECT **CARDINAL LANDFILL** BORING START **1/18/07** BORING FINISH **1/24/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							25					
							30					
							35					
							40					
							45					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitorign Well: M-16

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0616** DATE **7/17/15** SHEET **3** OF **11**

PROJECT **CARDINAL LANDFILL** BORING START **1/18/07** BORING FINISH **1/24/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							50					
							55					
							60					
							65					
							70					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-16

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0616** DATE **7/17/15** SHEET **4** OF **11**

PROJECT **CARDINAL LANDFILL** BORING START **1/18/07** BORING FINISH **1/24/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							75					
							80					
1	NQ	82.8	89.6		6.6	12				**MEDIUM HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		STARTED CORING @ 82.8'
							85					
2	NQ	89.6	97.6		7.4	36	90			**MEDIUM HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
							95					
3	NQ	97.6	104.6		6.8	56				**SOFT 5YR 3/4 MODERATE BROWN SHALE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-16

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0616** DATE **7/17/15** SHEET **5** OF **11**

PROJECT **CARDINAL LANDFILL** BORING START **1/18/07** BORING FINISH **1/24/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							100			**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
4	NQ	104.6	114.6		10.0	67	105			**SOFT 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
							110			**HARD SILTY FINE 5B 5/1 MEDIUM BLUISH GRAY SANDSTONE** w/limestone nodules		
										HARD 5B 5/1 MEDIUM BLUISH GRAY FINE TO MEDIUM GRAIN SANDSTONE		
5	NQ	114.6	124.6		10.0	82	115			**HARD 5B 5/1 MEDIUM BLUISH GRAY FINE TO MEDIUM GRAIN SANDSTONE**		
							120					LOST ALL DRILL RETURN WTAER @

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-16

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0616** DATE **7/17/15** SHEET **6** OF **11**

PROJECT **CARDINAL LANDFILL** BORING START **1/18/07** BORING FINISH **1/24/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
												123.0'; NO VISABLE SIGNS OF FRACTURES OR IRON STAINING
6	NQ	124.6	129.6		4.6	13	125			**SOFT TO HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
										HARD N5 MEDIUM GRAY SHALEY LIMESTONE		
7	NQ	129.6	139.6		9.6	39	130			**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE** w/limestone nodules throughout		SWL 1,122' ON 01/22/07 (80 HR READING) NQ HOLE TO 129.6'
							135			**HARD N5 MEDIUM GRAY LIMESTONE**		
										HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE		
8	NQ	139.6	146.1		5.7	32	140			**SOFT TO HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
										HARD N5 MEDIUM GRAY LIMEY SHALE		
							145			**HARD N5 MEDIUM GRAY LIMESTONE**		
9	NQ	146.1	154.6		8.4	31				**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-16

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0616** DATE **7/17/15** SHEET **7** OF **11**

PROJECT **CARDINAL LANDFILL** BORING START **1/18/07** BORING FINISH **1/24/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										SOFT 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE		
10	NQ	154.6	159.6		5.0	22	155			**SOFT TO HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		SWL 109.4' ON 01/23/07 (~15 HR READING) NQ HOLE TO 159.6'
										HARD N5 MEDIUM GRAY LIMESTONE		
11	NQ	159.6	169.6		5.8	72	160			**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE** w/limestone nodules throughout		FROM 159.6' - 169.6' INNER TUBE DID NOT LATCH IN CORE BARREL; PULLED TOOLS & RECOVERED 5.8' OF CORE FROM INSIDE CORE BARREL; CURE COULD BE MISPLACED IN BOX; RESET TOOLS & STARTED CORING @ 169.6', CORED 5.0' - 174.6'; PICKED UP 2.1' OF CORE FROM RUN #11
							165					
12	NQ	169.6	174.6		7.1	75	170			**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE** w/limestone nodules		
										HARD 5B 7/1 LIGHT BLUISH GRAY SILTY FINE GRAIN WELL CEMENTED SANDSTONE		
13	NQ	174.6	184.6		10.0	64	175			**HARD 5B 5/1 MEDIUM BLUISH GRAY SILTY FINE GRAIN WELL CEMENTED SANDSTONE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-16

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0616** DATE **7/17/15** SHEET **8** OF **11**

PROJECT **CARDINAL LANDFILL** BORING START **1/18/07** BORING FINISH **1/24/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							180					
										HARD N4 MEDIUM DARK GRAY SILTY SILTSTONE		
14	NQ	184.6	194.6		10.0	25	185			**HARD 5B 7/1 LIGHT BLUISH GRAY MEDIUM SANDSTONE**		
										HARD 5B 5/1 MEDIUM BLUISH GRAY SILTY FINE SANDSTONE		
							190					
										HARD N7 LIGHT GRAY MEDIUM SANDSTONE		
										HARD 5B 5/1 MEDIUM BLUISH GRAY SILTY FINE SANDSTONE		
										HARD N7 LIGHT GRAY MEDIUM SANDSTONE		
15	NQ	194.6	199.6		5.1	90	195			**HARD N7 LIGHT GRAY MEDIUM TO COARSE SANDSTONE**		SWL 117.6' ON 01/24/07 (18 HR READING) NQ HOLE TO 199.6'
16	NQ	199.6	209.6		10.1	94	200			**HARD N6 MEDIUM LIGHT GRAY WELL CEMENTED MEDIUM TO COARSE SANDSTONE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-16

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0616** DATE **7/17/15** SHEET **9** OF **11**

PROJECT **CARDINAL LANDFILL** BORING START **1/18/07** BORING FINISH **1/24/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							205					
17	NQ	209.6	219.6		9.9	97	210			**HARD N6 MEDIUM LIGHT GRAY WELL CEMENTED MEDIUM TO COARSE SANDSTONE** w/small 1" seams of coal		
							215					
18	NQ	219.6	229.6		10.0	86	220			**HARD N6 MEDIUM LIGHT GRAY WELL CEMENTED MEDIUM TO COARSE SANDSTONE**		
							225			**HARD N4 MEDIUM DARK GREY SILTSTONE**		
										HARD N6 MEDIUM LIGHT GRAY WELL CEMENTED MEDIUM TO COARSE SANDSTONE		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-16

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0616** DATE **7/17/15** SHEET **10** OF **11**

PROJECT **CARDINAL LANDFILL** BORING START **1/18/07** BORING FINISH **1/24/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
19	NQ	229.6	239.6		10.0	84	230			**HARD N6 MEDIUM LIGHT GRAY WELL CEMENTED MEDIUM TO COARSE SANDSTONE**		
							235			**HARD N4 MEDIUM DARK GRAY SILTSTONE**		
										HARD N6 MEDIUM LIGHT GRAY WELL CEMENTED MEDIATE TO COARSE SANDSTONE		
										HARD N4 MEDIUM DARK GRAY SILTSTONE		
20	NQ	239.6	249.6		9.9	72	240			**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE** w/limestone nodules		
										HARD N6 MEDIUM LIGHT GRAY WELL CEMENTED MEDIUM TO COARSE SANDSTONE		
										COAL SEAM		
										HARD N6 MEDIUM LIGHT GRAY WELL CEMENTED MEDIUM TO COARSE SANDSTONE		
							245					
										HARD N4 MEDIUM DARK GRAY SILTSTONE		
21	NQ	249.6	254.6		5.1	41	250			**HARD N5 MEDIUM GRAY WELL CEMENTED MEDIUM TO COARSE SANDSTONE** w/siltstone crossbedded throughout		
										HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE w/limestone nodules		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-16

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0616** DATE **7/17/15** SHEET **11** OF **11**

PROJECT **CARDINAL LANDFILL** BORING START **1/18/07** BORING FINISH **1/24/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
												STOPPED BORING @ 254.6 ON 01/24/07; BUILD 2" MONITORING WELL; 111.0' - 130.0' IS CONNELLSVILLE; 194.6' - 249.7' IS MORGANTOWN

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-15

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 833,569.0 E 2,518,172.3**

GROUND ELEVATION **1071.8** SYSTEM

Water Level, ft			
TIME			
DATE			

BORING NO. **CA-0614** DATE **7/17/15** SHEET **1** OF **11**

BORING START **7/18/07** BORING FINISH **7/25/07**

PIEZOMETER TYPE **N/A** WELL TYPE **OW**

HGT. RISER ABOVE GROUND **2.45** DIA **2"**

DEPTH TO TOP OF WELL SCREEN **214.0** BOTTOM **274.3**

WELL DEVELOPMENT **YES** BACKFILL **QUICK GROUT**

FIELD PARTY **MCR/ZLR/RMP** RIG **D-120**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
												GROUNDING PROCEDURES NOT IN USE ON THIS BORING; DRILL AND DECON WATER USED FROM CARDINAL FIRE PROTECTION SYSTEM; DECONNED TOOLS & DRILL 07/18/07; BLIND DRILLED 4" HW CASING TO START CORING @ 8.6'
							5					
1	NQ	8.6	14.4		3.7	11				**SOFT N6 MEDIUM LIGHT GRAY BROKEN SILTY CLAYSHALE**		
							10					
2	NQ	14.4	24.4		6.3	30				**N5 MEDIUM GRAY BROKEN SILTSTONE**		
							15					
										HARD N8 VERY LIGHT GRAY LIMESTONE w/heavy iron staining throughout		

TYPE OF CASING USED

	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-15

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0614** DATE **7/17/15** SHEET **2** OF **11**

PROJECT **CARDINAL LANDFILL** BORING START **7/18/07** BORING FINISH **7/25/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
3	NQ	24.4	29.9		4.3	47	25			**HARD N7 LIGHT GRAY SILTY CLAYSHALE** w/iron staining		
4	NQ	29.9	39.4		9.1	31	30 35			**HARD N5 MEDIUM GRAY WELL CEMENTED FINE SANDY SILTSTONE** w/iron staining throughout; high angle fracture @ 35.2'		
5	NQ	39.4	49.9		10	22	40 45			**HARD N3 DARK GRAY FINE SANDY SILTSTONE** Well Cemented		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-15

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0614** DATE **7/17/15** SHEET **3** OF **11**

PROJECT **CARDINAL LANDFILL** BORING START **7/18/07** BORING FINISH **7/25/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										N1 BLACK COAL		
6	NQ	49.9	54.9		3.7	68	50			**N6 MEDIUM LIGHT GRAY LIMESTONE**		
										N5 MEDIUM GRAY LIMEY SILTSTONE		
7	NQ	54.9	59.9		4.6	43	55			**N5 MEDIUM GRAY BROKEN LIMEY SILTSTONE**		
										HARD 5Y 6/4 DUSKY YELLOW FINE GRAIN WELL CEMENTED SANDSTONE w/heavy iron staining; vertical fracture @ 56.5'		
8	NQ	59.9	69.9		7.1	61	60			**HARD N5 MEDIUM GRAY WELL CEMENTED LIMESTONE**		
							65			**N5 MEDIUM GRAY BROKEN CLAYSHALE** w/fractures @ 61' and 64.0'		
9	NQ	69.9	79.9		5.4	43	70			**HARD N5 MEDIUM GRAY LIMESTONE** **SOFT N7 LIGHT GRAY CLAYSHALE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-15

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0614** DATE **7/17/15** SHEET **4** OF **11**

PROJECT **CARDINAL LANDFILL** BORING START **7/18/07** BORING FINISH **7/25/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							75					
10	NQ	79.9	89.9		6.6	23	80			**N1 BLACK COAL**		
							85			**N5 MEDIUM GRAY SILTSTONE** w/high angle fracture		
11	NQ	89.9	99.9		10	12	90			**N6 MEDIUM LIGHT GRAY FINE GRAIN WELL CEMENTED SANDY CLAYSHALE**		
							95					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

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JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0614** DATE **7/17/15** SHEET **5** OF **11**

PROJECT **CARDINAL LANDFILL** BORING START **7/18/07** BORING FINISH **7/25/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
12	NQ	99.9	106.9		5.8	53	100			**N6 MEDIUM LIGHT GRAY FINE GRAIN SANDY CLAYSHALE**		
13	NQ	106.9	114.9		5.6	0	105			**N6 MEDIUM LIGHT GRAY WELL CEMENTED FINE GRAIN SANDSTONE** w/high angle fracture throughout whole piece		
										N6 MEDIUM LIGHT GRAY WELL CEMENTED FINE GRAIN SANDSTONE		
										HARD N4 MEDIUM GRAY SHALE w/machine break		
							110			**SOFT N4 MEDIUM GRAY CLAYSHALE**		
14	NQ	114.9	120.9		5.2	8	115			**HARD N5 MEDIUM GRAY CLAYSHALE**		
										N6 MEDIUM LIGHT GRAY LIMESTONE w/ high angle fracture from 117' - 118.4'		
							120			**SOFT N5 MEDIUM GRAY CLAYSHALE**		
15	NQ	120.9	129.9		4.8	38				**HARD N5 MEDIUM GRAY CLAYSHALE**		
										N6 MEDIUM LIGHT GRAY LIMESTONE		

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AEP CIVIL ENGINEERING LABORATORY

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JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0614** DATE **7/17/15** SHEET **6** OF **11**

PROJECT **CARDINAL LANDFILL** BORING START **7/18/07** BORING FINISH **7/25/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							125			**HARD N5 MEDIUM GRAY CLAYSHALE**		
16	NQ	129.9	134.9		3.9	10	130			**HARD N6 MEDIUM LIGHT GRAY SILTSTONE** w/high angle fracture @ 130.9'		SWL 74.4' 07/23/07 - 50 HR READING / NQ HOLE TO 129.9'
										SOFT N6 MEDIUM LIGHT GRAY CLAYSHALE		
17	NQ	134.9	138.4		2.3	17	135			**HARD N5 MEDIUM GRAY LIMESTONE**		
										N5 MEDIUM GRAY SILTSTONE		
										HARD N5 MEDIUM GRAY CLAYSHALE		
18	NQ	138.4	143.9		6.5	0						
										HARD N5 MEDIUM GRAY CLAYSHALE		
							140					
19	NQ	144.4	149.4		4.0	18						
							145					
										SOFT N4 MEDIUM DARK GRAY CLAYSHALE		
										N5 MEDIUM GRAY LIMEY SILTSTONE		
										SOFT N5 MEDIUM GRAY CLAYSHALE		
20	NQ	149.4	154.4		3.9	0				**N4 MEDIUM DARK GRAY CLAYSHALE**		

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AEP CIVIL ENGINEERING LABORATORY

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COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0614** DATE **7/17/15** SHEET **7** OF **11**

PROJECT **CARDINAL LANDFILL** BORING START **7/18/07** BORING FINISH **7/25/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
21	NQ	154.4	158.4		3.5	11	155			**HARD N6 MEDIUM LIGHT GRAY SILTSTONE**		
22	NQ	158.4	164.9		5.7	16	160			**HARD N5 MEDIUM GRAY CLAYSHALE**		
23	NQ	164.9	168.9		3.4	0	165			**SOFT N6 MEDIUM LIGHT GRAY CLAYSHALE** w/high angle fracture @ 168.7'		
24	NQ	168.9	174.9		5.7	0	170			**HARD N5 MEDIUM GRAY CLAYSHALE**		
25	NQ	174.9	179.9		5	10	175			**HARD N5 MEDIUM GRAY SILTSTONE**		

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COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0614** DATE **7/17/15** SHEET **8** OF **11**

PROJECT **CARDINAL LANDFILL** BORING START **7/18/07** BORING FINISH **7/25/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
26	NQ	179.9	182.4		1.9	0	180			**HARD N4 MEDIUM DARK GRAY LIMESTONE**		
										N4 MEDIUM DARK GRAY SILTSTONE		
27	NQ	182.4	183.9		1	0				**N4 MEDIUM DARK GRAY SILTY LIMESTONE**		SWL 67.4' - 14 HR READING / NQ HOLE TO 182.9'
28	NQ	183.9	187.9		3.4	50	185			**HARD N5 MEDIUM GRAY LIMEY SILTSTONE**		
										SOFT N5 MEDIUM GRAY SILTSTONE w/high angle fracture @ 186.7'		
										SOFT N5 MEDIUM GRAY LIMEY SILTSTONE		
29	NQ	187.9	189.9		2.4	0				**HARD N5 MEDIUM GRAY LIMEY SILTSTONE**		
30	NQ	189.9	194.9		4.9	0	190			**HARD N6 MEDIUM LIGHT GRAY LIMEY SILTSTONE**		
										SOFT N6 MEDIUM LIGHT GRAY CLAYSHALE		
31	NQ	194.9	199.9		5	32	195			**N5 MEDIUM GRAY CLAYSHALE**		
										N5 MEDIUM GRAY FINE GRAIN WELL CEMENTED SANDSTONE		
										N6 MEDIUM LIGHT GRAY SILTSTONE		
32	NQ	199.9	204.9		5	36	200			**N6 MEDIUM LIGHT GRAY SANDY FINE GRAIN WELL CEMENTED SILTSTONE** w/crossbeddings in sandstone		

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COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0614** DATE **7/17/15** SHEET **9** OF **11**

PROJECT **CARDINAL LANDFILL** BORING START **7/18/07** BORING FINISH **7/25/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										N6 MEDIUM LIGHT GRAY FINE GRAIN WELL CEMENTED SANDSTONE badly broken by machine		
33	NQ	204.9	214.9		10.2	28	205			**N6 MEDIUM LIGHT GRAY FINE GRAIN SANDSTONE**		
										N4 MEDIUM DARK SANDY CLAYSHALE		
										N6 MEDIUM LIGHT GRAY SILTY SANDSTONE w/crossbeddings		
							210			**SOFT N4 MEDIUM DARK GRAY SANDY CLAYSHALE**		
										N6 MEDIUM LIGHT GRAY WELL CEMENTED FINE GRAIN SANDSTONE		
										N4 LIGHT GRAY WELL CEMENTED FINE SANDY SILTSTONE w/sandstone lenses		
34	NQ	214.9	224.9		10	76	215			**N5 MEDIUM GRAY FINE GRAIN SILTSTONE** w/sandstone lenses		
										N5 MEDIUM GRAY FINE SANDSTONE w/crossbedding throughout		
										N5 MEDIUM GRAY FINE GRAIN SILTSTONE w/sandstone lenses		
							220					
										N5 MEDIUM GRAY COARSE SANDSTONE well cemented throughout		
35	NQ	224.9	229.9		5	86	225			**N6 MEDIUM LIGHT GRAY COARSE SANDSTONE** crossbedded w/siltstone		
										N5 MEDIUM GRAY SILTSTONE		
										N6 MEDIUM LIGHT GRAY COARSE SANDSTONE		

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COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0614** DATE **7/17/15** SHEET **10** OF **11**

PROJECT **CARDINAL LANDFILL** BORING START **7/18/07** BORING FINISH **7/25/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										N5 MEDIUM GRAY SILTSTONE		
										N6 MEDIUM LIGHT GRAY COARSE SANDSTONE w/coal lenses		
36	NQ	229.9	234.9		5	90	230			**HARD N7 LIGHT GRAY COARSE SANDSTONE**		
										COAL PARTINGS		
										HARD WELL CEMENTED COAL LENSES		
37	NQ	234.9	244.9		10	90	235			**N7 LIGHT GRAY MEDIUM GRAIN SANDSTONE** w/1" cross of clayshale		
							240			**HARD WELL CEMENTED CLAYSHALE** crossbedded w/fine grain sandstone		
38	NQ	244.9	254.9		9.2	91	245			**N6 MEDIUM LIGHT GRAY MEDIUM GRAIN SANDSTONE** w/clayshale crossbedding		
										N2 GRAYISH BLACK CLAYSHALE crossbedded w/fine grain sandstone		
							250			**N6 MEDIUM LIGHT GRAY MEDIUM GRAIN SANDSTONE** w/clayshale crossbedding		
										N2 GRAYISH BLACK CLAYSHALE crossbedded w/fine grain sandstone		
										HARD N7 MEDIUM LIGHT GRAY MEDIUM GRAIN WELL CEMENTED SANDSTONE		

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COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0614** DATE **7/17/15** SHEET **11** OF **11**

PROJECT **CARDINAL LANDFILL** BORING START **7/18/07** BORING FINISH **7/25/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										crossbedded w/clayshale		
39	NQ	254.9	264.1		9.2	100	255			**N7 LIGHT GRAY COURSE GRAIN SANDSTONE** w/lenses		
							260					
40	NQ	264.1	269.6		6.2	89	265			**HARD N6 MEDIUM LIGHT GRAY WELL CEMENTED COARSE SANDSTONE** w/coal parting @ 266.0'		
41	NQ	269.9	277.4		7.5	65	270			**HARD N6 MEDIUM LIGHT GRAY WELL CEMENTED COARSE SANDSTONE** w/limestone nodules @ 273.9' - 274.9'		
							275			**HARD N5 MEDIUM GRAY WELL CEMENTED SILTSTONE**		
												STOPPED BORING @ 277.4' 07/25/07

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

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COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 832,901.9 E 2,519,661.8**

GROUND ELEVATION **984.9** SYSTEM

Water Level, ft			
TIME			
DATE			

BORING NO. **CA-0612** DATE **7/17/15** SHEET **1** OF **8**

BORING START **3/6/07** BORING FINISH **3/21/07**

PIEZOMETER TYPE WELL TYPE **OW**

HGT. RISER ABOVE GROUND **3.301** DIA **2"**

DEPTH TO TOP OF WELL SCREEN **127.3** BOTTOM **184.3**

WELL DEVELOPMENT **YES** BACKFILL **QUICK GROUT**

FIELD PARTY **MCR / ZLR** RIG **D-120**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
												GROUNDING PROCEDURES NOT IN USE; DECONNED TOOLS & DRILL 03/01/07; DRILL WATER USED COMING FROM FIRE PROTECTION SYSTEM @ CARDINAL; BLIND DRILLED 325 HSA'S TO TOP OF BEDROCK @ 14.0'; STARTED CORING AT 14.0'
							5					
							10					
1	NQ	14.0	19.3		2.2	18				**HARD N6 LIGHT GRAY CLAY SHALE**		
							15			**SOFT 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
2	NQ	19.3	24.7		2.7	30				**SOFT 5B 5/1 MEDIUM BLUISH GRAY CLAY**		

TYPE OF CASING USED

	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **ZLR**

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COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0612** DATE **7/17/15** SHEET **2** OF **8**

PROJECT **CARDINAL LANDFILL** BORING START **3/6/07** BORING FINISH **3/21/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										SHALE		
3	NQ	24.7	34.7		9.9	23	25			**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE** w/vertical fractures		
							30					
4	NQ	34.7	41.7		4.6	0	35			**HARD N5 MEDIUM GRAY CLAY SHALE** w/limestone nodules throughout, w/fractures		
							40					
5	NQ	41.7	44.7		1.5	27				**HARD N5 MEDIUM GRAY CLAY SHALE** w/limestone nodules throughout		
6	NQ	44.7	54.7		10.0	69	45			**SOFT 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		

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COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0612** DATE **7/17/15** SHEET **3** OF **8**

PROJECT **CARDINAL LANDFILL** BORING START **3/6/07** BORING FINISH **3/21/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE		
							50					
										SOFT 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE		
7	NQ	54.7	64.7		9.6	49	55			**SOFT N7 LIGHT GRAY CLAY SHALE**		
										HARD N7 LIGHT GRAY CLAY SHALE		
							60					
										SOFT N7 LIGHT GRAY CLAY SHALE		
8	NQ	64.7	72.7		7.9	28	65			**SOFT 5G 6/1 GREENISH GRAY CLAY SHALE**		
							70			**HARD 5G 6/1 GREENISH GRAY CLAY SHALE** w/limestone nodules		

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COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0612** DATE **7/17/15** SHEET **4** OF **8**

PROJECT **CARDINAL LANDFILL** BORING START **3/6/07** BORING FINISH **3/21/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
9	NQ	72.7	79.7		7.0	27				**HARD 5G 6/1 GREENISH GRAY CLAY SHALE** w/limestone nodules		
							75					
										SOFT 5G 6/1 GREENISH GRAY CLAY SHALE		
10	NQ	79.7	89.7		10.0	67	80			**HARD 5G 6/1 GREENISH GRAY LIMESTONE**		
										HARD WELL CEMENTED SILTSTONE w/limestone nodules		
							85					
11	NQ	89.7	99.7		10.0	40	90			**HARD 5G 6/1 GREENISH GRAY WELL CEMENTED SILTSTONE**		
										SOFT 5G 6/1 GREENISH GRAY SHALE		
							95					
										HARD N7 LIGHT GRAY LIMESTONE		
										SOFT N7 LIGHT GRAY SHALE		

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COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0612** DATE **7/17/15** SHEET **5** OF **8**

PROJECT **CARDINAL LANDFILL** BORING START **3/6/07** BORING FINISH **3/21/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										HARD N7 LIGHT GRAY LIMESTONE		
12	NQ	99.7	109.7		10.0	60	100			**HARD 5G 6/1 GREENISH GRAY CLAY SHALE**		
							105			**HARD 5G 6/1 GREENISH GRAY WELL CEMENTED SILTSTONE**		
										HARD 5G 6/1 GREENISH GRAY CLAY SHALE		
13	NQ	109.7	119.7		9.6	66	110			**HARD 5G 6/1 GREENISH GRAY CLAY SHALE**		
							115					
										HARD 5G 6/1 GREENISH GRAY WELL CEMENTED SILTSTONE		
14	NQ	119.7	129.7		10.0	82	120			**HARD 5G 6/1 GREENISH GRAY CLAY SHALE**		
										N3 DARK GRAY COAL		
										HARD N5 MEDIUM GRAY CLAY SHALE		

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COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0612** DATE **7/17/15** SHEET **6** OF **8**

PROJECT **CARDINAL LANDFILL** BORING START **3/6/07** BORING FINISH **3/21/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										w/traces of sandstone		
							125			**HARD N7 LIGHT GRAY WELL CEMENTED MEDIUM TO COARSE SANDSTONE** w/cross bedding throughout		
15	NQ	129.7	139.7		10.0	96	130			**MEDIUM TO COARSE N6 MEDIUM LIGHT GRAY WELL CEMENTED SANDSTONE**		
							135					
16	NQ	139.7	149.7		10.0	90	140			**MEDIUM TO COARSE N6 MEDIUM LIGHT GRAY WELL CEMENTED SANDSTONE**		
							145					
										HARD 5G 6/1 GREENISH GRAY SILTSTONE		

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COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0612** DATE **7/17/15** SHEET **7** OF **8**

PROJECT **CARDINAL LANDFILL** BORING START **3/6/07** BORING FINISH **3/21/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
17	NQ	149.7	159.7		10.0	56				**MEDIUM TO COARSE N6 MEDIUM LIGHT GRAY WELL CEMENTED SANDSTONE**		
										MEDIUM TO COARSE N6 MEDIUM LIGHT GRAY WELL CEMENTED SILTSTONE		
										FINE TO MEDIUM N6 MEDIUM LIGHT GRAY WELL CEMENTED SANDSTONE w/cross bedding silt stone		
							155					
18	NQ	159.7	169.7		10.0	86	160			**FINE TO MEDIUM N6 MEDIUM LIGHT GRAY WELL CEMENTED SANDSTONE** w/trace siltstone		
							165					
19	NQ	169.7	179.7		9.8	83	170			**FINE TO MEDIUM N7 LIGHT GRAY WELL CEMENTED SANDSTONE**		
							175					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-14

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0612** DATE **7/17/15** SHEET **8** OF **8**

PROJECT **CARDINAL LANDFILL** BORING START **3/6/07** BORING FINISH **3/21/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
20	NQ	179.7	189.7		9.8	93	180			**FINE TO MEDIUM N7 LIGHT GRAY WELL CEMENTED SANDSTONE** w/limestone nodules **MEDIUM TO COARSE N7 LIGHT GRAY WELL CEMENTED SANDSTONE** w/limestone nodules		
							185			**5G 6/1 GREENISH GRAY WELL CEMENTED SILSTONE**		
21	NQ	189.7	194.7		4.6	93	190			**5G 6/1 GREENISH GRAY WELL CEMENTED SILTSTONE**		
												STOPPED BORING @ 194.7'; SWL @ 44.2' 03/23/07; NQ HOLE TO 194.7'

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M1309

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL FLY ASH DAM**

COORDINATES **N 835,558.0 E 2,517,396.3**

GROUND ELEVATION **1170.2** SYSTEM **State Plane using NAD27/29**

Water Level, ft			
TIME			
DATE			

BORING NO. **B-1309D** DATE **7/17/15** SHEET **1** OF **15**

BORING START **5/2/13** BORING FINISH **5/30/13**

PIEZOMETER TYPE WELL TYPE

HGT. RISER ABOVE GROUND **1.85** DIA **2.0**

DEPTH TO TOP OF WELL SCREEN **307.9** BOTTOM **347.5**

WELL DEVELOPMENT **YES** BACKFILL **QUICK GROUT & HC**

FIELD PARTY **ZLR / TAS** RIG **D-120**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
1	SPT	0.0	1.5							STONE PAD		STONE PAD
2	SPT	1.5	3.0	4-7-11	.9					VERY STIFF MODERATE YELLOWISH BROWN 10YR 6/2 CLAY tsf 2.0		
3	SPT	3.0	4.5	8-11-16	1.0					VERY STIFF DARK YELLOWISH BROWN 10YR 4/2 CLAY AND SHALE tsf 2.0		
4	SPT	4.5	4.7	50/.2	.9		5			HARD PALE BROWN 5YR 5/2 SHALEY CLAY tsf 4.5		
5	SPT	6.0	6.4	50/.4	.4					HARD PALE BROWN 5YR 5/2 SHALEY CLAY tsf 0		
1	NQ	8.2	14.1		5.9	22				HARD LIGHT OLIVE GRAY 5Y 5/2 CLAYSHALE		STOPPED SAMPLING / AUGER REFUSAL @ 7.0' / SET 4" CASING
							10					
2	NQ	14.1	24.1		10.0	9						
							15					

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
X	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **TAS**

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M1309

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1309D** DATE **7/17/15** SHEET **2** OF **15**

PROJECT **CARDINAL FLY ASH DAM** BORING START **5/2/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
3	NQ	24.1	26.6		2.5	0	25					
4	NQ	26.6	34.1		7.5	17	30					
5	NQ	34.1	39.1		5.0	40	35					
6	NQ	39.1	44.1		5	53	40			HARD GREENISH GRAY 5G 6/1 CLAYSHALE		
										HARD DARK GRAY N3 CLAYSHALE		
7	NQ	44.1	54.1		10	36	45			HARD BROWNISH GRAY 5YR 4/1 CLAYSHALE w/high angle fractures @ 1.8', 6.0', & 7.3'		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M1309

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1309D** DATE **7/17/15** SHEET **3** OF **15**

PROJECT **CARDINAL FLY ASH DAM** BORING START **5/2/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							50					
8	NQ	54.1	64.1		10	46	55			VERY HARD MEDIUM LIGHT GRAY N6 LIMEY SHALE w/limestone nodules @ 4.5'		
							60					
9	NQ	64.1	69.1		5	16	65			VERY HARD MEDIUM LIGHT GRAY N6 LIMEY SHALE		
10	NQ	69.1	74.1		5	20	70			HARD MEDIUM DARK GRAY N4 CLAYSHALE		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M1309

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1309D** DATE **7/17/15** SHEET **4** OF **15**

PROJECT **CARDINAL FLY ASH DAM** BORING START **5/2/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
11	NQ	74.1	84.1		10	52	75			VERY HARD LIGHT OLIVE GRAY 5Y 5/2 LIMESTONE w/high angle fractures @ .8', 1.3', 3.0', & 4.0'		
							80			HARD MEDIUM BLUISH GRAY 5B 5/1 CLAYSHALE		
12	NQ	84.1	94.1		10	98	85					
							90					
13	NQ	94.1	104.1		10	72	95			HARD MEDIUM DARK GRAY N4 CLAYSHALE		
										HARD LIGHT GRAY N7 CLAYSHALE w/limestone nodules, high angle fractures @ 4.9' & 5.4' of recovery		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M1309

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1309D** DATE **7/17/15** SHEET **5** OF **15**

PROJECT **CARDINAL FLY ASH DAM** BORING START **5/2/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							100			HARD MEDIUM BLUISH GRAY 5B 5/1 CLAYSHALE w/limestone nodules throughout		
14	NQ	104.1	114.1		10	79	105					
							110					
15	NQ	114.1	124.1		10	76	115			HARD MEDIUM DARK GRAY N4 SILTSTONE		
							120			HARD BLACK N1 COAL		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M1309

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1309D** DATE **7/17/15** SHEET **6** OF **15**

PROJECT **CARDINAL FLY ASH DAM** BORING START **5/2/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
16	NQ	124.1	134.1		10	65	125					
										VERY HARD VERY LIGHT GRAY N8 LIMESTONE w/high angle fracture @ 6.8'		
							130					
17	NQ	134.1	144.1		10	67				HARD VERY LIGHT GRAY N8 LIMESTONE w/ high angle fracture @ 1.1'		
							135					
							140					
										HARD GREENISH GRAY 5G 6/1 LIMEY CLAYSHALE		
18	NQ	144.1	154.1		10	26				HARD GREENISH GRAY 5G 6/1 CLAYSHALE		
							145					
										MEDIUM HARD BLACK N1 COAL		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M1309

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1309D** DATE **7/17/15** SHEET **7** OF **15**

PROJECT **CARDINAL FLY ASH DAM** BORING START **5/2/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
19	NQ	154.1	164.1		10	69	155					
										HARD MEDIUM LIGHT GRAY N6 CLAYSHALE		
							160					
20	NQ	164.1	174.1		10	89						
							165					
							170					
21	NQ	174.1	184.1		10	77				HARD LIGHT BLUISH GRAY 5B 7/1 CLAYSHALE w/limestone nodules @ 3.1' to 3.5'		
							175					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M1309

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1309D** DATE **7/17/15** SHEET **8** OF **15**

PROJECT **CARDINAL FLY ASH DAM** BORING START **5/2/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							180					
22	NQ	184.1	194.1		10	95				HARD MEDIUM BLUISH GRAY 5B 5/1 CLAYSHALE		
							185					
							190					
23	NQ	194.1	204.1		10	62						
							195					
							200					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M1309

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1309D** DATE **7/17/15** SHEET **9** OF **15**

PROJECT **CARDINAL FLY ASH DAM** BORING START **5/2/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										HARD DARK REDDISH BROWN 10R 3/4 MULTICOLORED CLAYSHALE		
24	NQ	204.1	214.1		10	75				HARD MEDIUM BLUISH GRAY 5B 5/1 CLAYSHALE		
							205					
							210					
										HARD DARK REDDISH BROWN 10R 3/4 CLAYSHALE		
25	NQ	214.1	224.1		10	90				HARD MEDIUM BLUISH GRAY 5B 5/1 SHALE w/limestone nodules		
							215					
										HARD MEDIUM BLUISH GRAY 5B 5/1 FINE SANDY SHALE		
							220					
26	NQ	224.1	234.1		10	76						
							225					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M1309

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1309D** DATE **7/17/15** SHEET **10** OF **15**

PROJECT **CARDINAL FLY ASH DAM** BORING START **5/2/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							230					
										HARD DARK GREENISH GRAY 5G 4/1 CLAYSHALE		
										HARD LIGHT BLUISH GRAY 5B 7/1 CLAYSHALE w/limestone nodules		
27	NQ	234.1	244.1		10	88	235					
							240					
28	NQ	244.1	254.1		10	54	245					
							250					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M1309

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1309D** DATE **7/17/15** SHEET **11** OF **15**

PROJECT **CARDINAL FLY ASH DAM** BORING START **5/2/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
29	NQ	254.1	264.1		10	65	255					
							260					
30	NQ	264.1	274.1		10	77	265			HARD GREENISH GRAY 5G 6/1 CLAYSHALE		
										HARD DARK REDDISH BROWN 10R 3/4 MULTICOLORED CLAYSHALE		
							270			HARD GREENISH GRAY 5G 6/1 CLAYSHALE w/limestone nodules throughout		
31	NQ	274.1	284.1		10	89				HARD GREENISH GRAY 5G 6/1 SHALE		
							275			HARD DARK REDDISH BROWN 10R 3/4 SHALE		
										HARD GREENISH GRAY 5G 6/1 SHALE w/limestone nodules		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M1309

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1309D** DATE **7/17/15** SHEET **12** OF **15**

PROJECT **CARDINAL FLY ASH DAM** BORING START **5/2/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										HARD GREENISH GRAY 5G 6/1 SANDY SHALE		
32	NQ	284.1	294.1		10	88				HARD MEDIUM LIGHT GRAY N6 SANDY SHALE		
							285					
							290					
33	NQ	294.1	304.1		10	97				HARD MEDIUM DARK GRAY N4 WELL CEMENTED FINE SANDSTONE		
							295					
							300					
34	NQ	304.1	314.1		10	100				HARD MEDIUM LIGHT GRAY N6 WELL CEMENTED FINE SANDSTONE		
							305					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M1309

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1309D** DATE **7/17/15** SHEET **13** OF **15**

PROJECT **CARDINAL FLY ASH DAM** BORING START **5/2/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							310					
35	NQ	314.1	324.1		10	100						
							315					
							320					
										MEDIUM HARD BLACK N1 COAL		
										HARD MEDIUM LIGHT GRAY N6 WELL CEMENTED FINE SANDSTONE		
36	NQ	324.1	334.1		10	97						
							325					
							330			HARD MEDIUM LIGHT GRAY N6 WELL CEMENTED FINE SANDSTONE w/limestone fragments		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M1309

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1309D** DATE **7/17/15** SHEET **14** OF **15**

PROJECT **CARDINAL FLY ASH DAM** BORING START **5/2/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
37	NQ	334.1	344.1		10	93	335			HARD MEDIUM GRAY N5 SHALEY SANDSTONE		
							340			HARD MEDIUM LIGHT GRAY N6 WELL CEMENTED MEDIUM SANDSTONE		
38	NQ	344.1	354.1		10	95	345					
							350			HARD LIGHT BLUISH GRAY 5B 7/1 CLAYSHALE w/limestone nodules		
39	NQ	354.1	364.1		10	100	355					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M1309

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1309D** DATE **7/17/15** SHEET **15** OF **15**

PROJECT **CARDINAL FLY ASH DAM** BORING START **5/2/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							360					

AEP CD_FA_DAM.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1302

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL FLY ASH DAM**

COORDINATES **N 836,201.9 E 2,515,432.0**

GROUND ELEVATION **1028.9** SYSTEM **State Plane using NAD27/29**

Water Level, ft			
TIME			
DATE			

BORING NO. **B-1302M** DATE **7/17/15** SHEET **1** OF **9**

BORING START **3/7/13** BORING FINISH **5/30/13**

PIEZOMETER TYPE **SS** WELL TYPE **OW**

HGT. RISER ABOVE GROUND **1.8** DIA **2.0**

DEPTH TO TOP OF WELL SCREEN **168.4** BOTTOM **208.0**

WELL DEVELOPMENT **YES** BACKFILL **HOLE PLUG**

FIELD PARTY **ZLR / TAS** RIG **D-120**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
1	SPT	0.0	1.5							STONE PAD #4 LIMESTONE		STONE PAD OFF HAUL ROAD
2	SPT	1.5	3.0	5-13-13	1.3					VERY STIFF DUSKY BROWN 5YR 2/2 MINE SPOIL		
3	SPT	3.0	4.5	22-20-10	1.2					VERY STIFF MEDIUM LIGHT GRAY N6 SHALE		
4	SPT	4.5	6.0	4-5-7	1.2		5			STIFF DUSKY BROWN 5YR 2/2 MINE SPOIL		
5	SPT	6.0	7.5	4-5-7	.7					STIFF GRAYISH BROWN 5YR 3/2 MINE SPOIL		
6	SPT	7.5	9.0	7-4-4	1.1					STIFF DARK YELLOWISH BROWN 10YR 5/4 MINE SPOIL tsf 1.5		
7	SPT	9.0	10.5	9-6-6	.6		10			STIFF DARK YELLOWISH BROWN 10YR 4/2 MINE SPOIL		
8	SPT	10.5	12.0	6-8-8	.1					VERY STIFF LIGHT GRAY N7 MINE SPOIL		
9	SPT	12.0	13.5	7-5-5	.5					STIFF MODERATE YELLOWISH BROWN 10YR 5/4 MINE SPOIL		
10	SPT	13.5	15.0	6-5-4	.7					STIFF MODERATE YELLOWISH BROWN 10YR 5/4 MINE SPOIL tsf 2.0		
11	SPT	15.0	16.5	4-5-7	.8		15			STIFF MODERATE YELLOWISH BROWN 10YR 5/4 MINE SPOIL		
12	SPT	16.5	18.0	5-5-9	1.5							
13	SPT	18.0	19.5	27-7-6	.6					STIFF LIGHT BROWN 5YR 5/6 MINE SPOIL		
14	SPT	19.5	21.0	23-12-15	.2					VERY STIFF LIGHT GRAY N7 MINE SPOIL		

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
X	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1302

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1302M** DATE **7/17/15** SHEET **2** OF **9**

PROJECT **CARDINAL FLY ASH DAM** BORING START **3/7/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
15	SPT	21.0	21.1	50/.1	.1					HARD LIGHT GRAY N7 LIMESTONE		
16	SPT	22.5	22.8	50/.3	1.5					HARD LIGHT GRAY N7 LIMEY CLAYSHALE		
17	SPT	24.0	24.3	50/.3	.2					HARD DUSKY BROWN 5YR 2/2 LIMEY CLAYSHALE		
1	NQ	25.5	34.0		8.5	27	25			MEDIUM HARD MEDIUM BLUISH GRAY 5B 5/1 SANDY CLAYSHALE		
2	NQ	34.0	44.0		5.3	28	30			MEDIUM HARD MEDIUM GRAY N5 CLAYSHALE		
							35			HARD MEDIUM GRAY N5 LIMESTONE		
										MEDIUM HARD MEDIUM GRAY N5 CLAYSHALE badly broken w/iron stains throughout		Lost water return @ 36.0'
3	NQ	44.0	54.0		3.9	51	40			MEDIUM HARD LIGHT BLUISH GRAY 5B 7/1 SANDY CLAYSHALE w/iron stains throughout		
							45					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1302

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1302M** DATE **7/17/15** SHEET **3** OF **9**

PROJECT **CARDINAL FLY ASH DAM** BORING START **3/7/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							50					
4	NQ	54.0	64.0		6.4	80				MEDIUM HARD LIGHT BLUISH GRAY 5B 7/1 TO GRAYISH PURPLE 5P 4/2 CLAYSHALE		
							55					
							60					
5	NQ	64.0	74.0		7.7	62				HARD LIGHT BLUISH 5B 7/1 WELL CEMENTED FINE GRAIN SANDSTONE		
							65					
							70					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1302

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1302M** DATE **7/17/15** SHEET **4** OF **9**

PROJECT **CARDINAL FLY ASH DAM** BORING START **3/7/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
6	NQ	74.0	84.0		9.3	63						
							75					
							80					
7	NQ	84.0	94.0		9.8	68						
							85					
							90					
										MEDIUM HARD MEDIUM BLUISH GRAY 5B 5/1 CLAYSHALE		
8	NQ	94.0	104.0		1.3	0						
							95					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1302

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1302M** DATE **7/17/15** SHEET **5** OF **9**

PROJECT **CARDINAL FLY ASH DAM** BORING START **3/7/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							100					
9	NQ	104.0	114.0		3.5	23				MEDIUM HARD LIGHT BLUISH GRAY 5B 7/1 CLAYSHALE		
							105					
							110					
10	NQ	114.0	124.0		6.5	48				HARD MEDIUM BLUISH GRAY 5B 5/1 CLAYSHALE		
							115					
							120			HARD MEDIUM GRAY N5 LIMESTONE		
										HARD MEDIUM GRAY N5 CLAYSHALE		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1302

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1302M** DATE **7/17/15** SHEET **6** OF **9**

PROJECT **CARDINAL FLY ASH DAM** BORING START **3/7/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
11	NQ	124.0	134.0		10	73	125			HARD MEDIUM GRAY 5B 5/1 CLAYSHALE w/limestone nodules, high angle fracture @ 2.8' (126.8')		
							130					
12	NQ	134.0	144.0		10	46	135			HARD MEDIUM GRAY N5 CLAYSHALE		
							140					
13	NQ	144.0	154.0		7.85	38	145			HARD MEDIUM GRAY N5 CLAYSHALE w/limestone nodules		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1302

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1302M** DATE **7/17/15** SHEET **7** OF **9**

PROJECT **CARDINAL FLY ASH DAM** BORING START **3/7/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
14	NQ	154.0	159.0		5.1	59	155			HARD MEDIUM GRAY N5 CLAYSHALE w/high fractures @ 1.7', 3.6', & 4.1'		
15	NQ	159.0	164.0		2.25	53	160			HARD MEDIUM GRAY N5 CLAYSHALE w/high angle fracture @ .4'		
16	NQ	164.0	174.0		10		165			HARD MEDIUM GRAY N5 SANDY CLAYSHALE		
							170			HARD MEDIUM GRAY N5 WELL CEMENTED FINE SANDSTONE		
17	NQ	174.0	184.0		10.1	94	175					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1302

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1302M** DATE **7/17/15** SHEET **8** OF **9**

PROJECT **CARDINAL FLY ASH DAM** BORING START **3/7/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							180					
18	NQ	184.0	194.0		9.6	81	185			HARD MEDIUM LIGHT GRAY N6 WELL CEMENTED FINE SANDSTONE w/shale lenses, limestone nodules @ 6.8'		
							190					
19	NQ	194.0	204.0		10	69	195			HARD MEDIUM LIGHT GRAY N6 WELL CEMENTED FINE SANDSTONE w/shale lenses, pyrite and limestone nodules @ 7.8' and 8.3'		
							200					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1302

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **B-1302M** DATE **7/17/15** SHEET **9** OF **9**

PROJECT **CARDINAL FLY ASH DAM** BORING START **3/7/13** BORING FINISH **5/30/13**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
20	NQ	204.0	209.0		5.0	66	205			HARD MEDIUM LIGHT GRAY N6 WELL CEMENTED FINE GRAIN STANDSTONE		
21	NQ	209.0	219.0		10	56	210			HARD MEDIUM GRAY N5 CLAYSHALE w/limestone nodules throughout		
							215			HARD MEDIUM DARK GRAY N4 CLAYSHALE w/limestone nodules throughout		

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-13

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 831,697.9 E 2,518,374.3**

GROUND ELEVATION **988.4** SYSTEM

Water Level, ft			
TIME			
DATE			

BORING NO. **CA-0610** DATE **7/17/15** SHEET **1** OF **8**

BORING START **4/3/07** BORING FINISH **4/3/07**

PIEZOMETER TYPE WELL TYPE **OW**

HGT. RISER ABOVE GROUND **2.724** DIA **2"**

DEPTH TO TOP OF WELL SCREEN **130.3** BOTTOM **187.3**

WELL DEVELOPMENT **YES** BACKFILL **QUICK GROUT**

FIELD PARTY **MCR / ZLR** RIG **D-120**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
												GROUNDING PROCEDURES NOT IN USE ON THIS BORING; DECONNED RIG & TOOL 04/02/07; ALL WATER USED COMING FROM FIRE PROTECTION SYSTEM @ CARDINAL PLANT; BLIND DRILLED 3.25" HSA'S TO 19.0'; STARTED CORING @ 19.0'
							5					
							10					
							15					
1	NQ	19.0	24.4		5.4	20				**SOFT N7 LIGHT GRAY SANDY CLAY SHALE**		

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **RACER**

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-13

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0610** DATE **7/17/15** SHEET **2** OF **8**

PROJECT **CARDINAL LANDFILL** BORING START **4/3/07** BORING FINISH **4/3/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
												LOST ALL DRILL RETURN WATER @ +/-22.0'
										HARD FINE SANDY LIMESTONE		
2	NQ	24.4	34.4		7.3	7	25			**HARD N7 LIGHT GRAY FINE SANDY LIMESTONE**		
										HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE w/trace of iron staining throughout		
							30					
3	NQ	34.4	42.4		2.4	0	35			**SOFT 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
										HARD N7 LIGHT GRAY LIMESTONE		
							40					
4	NQ	42.4	49.4		3.4	0				**HARD N6 MEDIUM LIGHT GRAY CLAY SHALE**		
							45			**SOFT N6 MEDIUM LIGHT GRAY CLAY SHALE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-13

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0610** DATE **7/17/15** SHEET **3** OF **8**

PROJECT **CARDINAL LANDFILL** BORING START **4/3/07** BORING FINISH **4/3/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
5	NQ	49.4	57.9		6.0	0	50			**MEDIUM HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
							55					
6	NQ	57.9	64.4		6.5	17	60			**SOFT TO MEDIUM 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		SWL @ 13.8' 04/04/07; NQ HOLE TO 64.4' - 14 HOUR READING
7	NQ	64.4	69.4		1.4	0	65			**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
8	NQ	69.4	76.4		5.9	0	70			**SOFT N5 MEDIUM GRAY CLAY SHALE**		REASON FOR POOR RECOVERY - HSA'S NOT SEATED @ ROCK & SOIL INTERFACE; PULLED NQ'S RODS

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-13

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0610** DATE **7/17/15** SHEET **4** OF **8**

PROJECT **CARDINAL LANDFILL** BORING START **4/3/07** BORING FINISH **4/3/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
												AND HSA'S; DRILLED 4" CASING TO 24.0' FOR GOOD SEAL
							75					
9	NQ	76.4	79.4		3.1	39				**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		SWL @ 22.5' 04/09/07; NQ HOLE TO 79.4' - 130 HOUR READING
10	NQ	79.4	89.4		10.0	4	80			**MEDIUM TO HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE** 86.0 to 89.4 has iron staining throughout		
							85					HIGH ANGLE FRACTURE @ 88.4'
11	NQ	89.4	99.4		10.0	15	90			**SOFT 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
							95					
										HARD N5 MEDIUM GRAY LIMESTONE		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-13

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0610** DATE **7/17/15** SHEET **5** OF **8**

PROJECT **CARDINAL LANDFILL** BORING START **4/3/07** BORING FINISH **4/3/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE		
12	NQ	99.4	106.4		6.7	45	100			**HARD N5 MEDIUM GRAY LIMESTONE**		
										HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE high angle fracture @ 103.9		
13	NQ	106.4	114.4		6.5	74	105			**MEDIUM HARD 5B 5/1 MEDIUM BLUISH GRAY SILTY CLAY SHALE** broken, possibly machine breaks		
							110			**MEDIUM TO HARD N5 MEDIUM GRAY SILTY CLAY SHALE**		
14	NQ	114.4	124.4		10.0	68	115			**HARD 5YR 6/1 LIGHT BROWNISH GRAY CLAY SHALE**		
										HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE		
										SOFT 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE		
										HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE		
							120			**SOFT 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-13

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0610** DATE **7/17/15** SHEET **6** OF **8**

PROJECT **CARDINAL LANDFILL** BORING START **4/3/07** BORING FINISH **4/3/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
15	NQ	124.4	134.4		10.0	69	125			**SOFT 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
										HARD N3 DARK GRAY SILTSTONE		
										FINE TO MEDIUM N5 MEDIUM GRAY SANDSTONE well cemented		
										MEDIUM N5 MEDIUM GRAY SANDSTONE well cemented		
							130					
16	NQ	134.4	144.4		10.0	91	135			**N5 MEDIUM GRAY LARGE GRAIN WELL CEMENTED SANDSTONE**		
							140					
17	NQ	144.4	154.4		10.0	62	145			**N5 MEDIUM GRAY LARGE GRAIN WELL CEMENTED SANDSTONE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-13

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0610** DATE **7/17/15** SHEET **7** OF **8**

PROJECT **CARDINAL LANDFILL** BORING START **4/3/07** BORING FINISH **4/3/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
18	NQ	154.4	164.4		10.0	75	155			**N5 MEDIUM GRAY LARGE GRAIN WELL CEMENTED SANDSTONE**		
19	NQ	164.4	169.4		5.0	20	160			**HARD 5GY 4/1 DARK GREENISH GRAY SILTSTONE**		
							165			**HARD N5 MEDIUM GRAY SILTSTONE**		
										N5 MEDIUM GRAY LARGE GRAIN WELL CEMENTED SANDSTONE		
20	NQ	169.4	179.4		10.0	90	170			**N5 MEDIUM GRAY LARGE GRAIN WELL CEMENTED SANDSTONE**		
							175					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-13

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0610** DATE **7/17/15** SHEET **8** OF **8**

PROJECT **CARDINAL LANDFILL** BORING START **4/3/07** BORING FINISH **4/3/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
21	NQ	179.4	189.4		10.0	90	180			**N5 MEDIUM GRAY LARGE GRAIN WELL CEMENTED SANDSTONE**		
							185					
22	NQ	189.4	194.4		5.0	58	190			**HARD N5 MEDIUM GRAY SHALEY LIMESTONE** **HARD N5 MEDIUM GRAY SHALEY LIMESTONE**		SWL @ 49.8' 04/11/07; NQ HOLE FINISHED @ 194.4'; 18 HR READING; STOPPED BORING @ 194.4 04/10/07; INSTALLED 2" MONITORING WELL

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-12

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 833,112.2 E 2,516,013.2**

GROUND ELEVATION **1187.7** SYSTEM

Water Level, ft			
TIME			
DATE			

BORING NO. **CA-0608** DATE **7/17/15** SHEET **1** OF **16**

BORING START **12/13/06** BORING FINISH **12/13/06**

PIEZOMETER TYPE WELL TYPE **GM**

HGT. RISER ABOVE GROUND **3.009** DIA **1.5**

DEPTH TO TOP OF WELL SCREEN **393.0** BOTTOM **398.0**

WELL DEVELOPMENT BACKFILL

FIELD PARTY **MCR / ZLR** RIG **D-120**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
		0.0	10.0							Deconed rig & tools 08/29/06 using fire protection water from Cardinal U3. Grounding procedures not in use on this boring. Drilling water used from cardinal u3 fire protection. Blind drilled 4" roller bit from grade to 10.0'.		
							5					
1	NQ	10.0	14.5		3.1	16	10			**HARD 10YR/5/4 MODERATE YELLOWISH BROWN CLAY SHALES** w/fractured and soft areas from 10.0' to 12.0'		Started coring @ 10.0'
2	NQ	14.5	24.5		4.05	69	15			**10YR 5/4 MODERATE YELLOWISH BROWN MEDIUM CLAY SHALE** w/fractures and soft areas **HARD N6 MEDIUM LIGHT GRAY LIMESTONE** **10YR 5/4 MODERATE YELLOWISH BROWN MEDIUM CLAY SHALE** w/fractures		Poor recovery due to sand which locked core in inner tube

TYPE OF CASING USED

	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
X	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-12

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0608** DATE **7/17/15** SHEET **2** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **12/13/06** BORING FINISH **12/13/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
3	NQ	24.5	34.5		10.0	100	25			**SOFT 10Y 4/2 GRAYISH OLIVE CLAY SHALE**		
										MEDIUM HARD 10YR 6/6 DARK YELLOWISH ORANGE CLAY SHALE		
										HARD N7 LIGHT GRAY LIMESTONE		
							30					
										5G 6/1 GREENISH GRAY MEDIUM CLAY SHALE		
										HARD N7 LIGHT GRAY LIMESTONE		
										MEDIUM HARD 5G 6/1 GREENISH GRAY CLAY SHALE		
4	NQ	34.5	44.5		10.0	100	35			**MEDIUM HARD 5GY 3/2 GRAYISH OLIVE GREEN and 5GY 6/1 GREENISH GRAY CLAY SHALE** w/fractures and iron staining @ 34.5 - 35.4, 35.7 - 36.5, 36.7 - 40.0, 40.4, & 40.9 - 44.5		
							40					
5	NQ	44.5	54.5		9.8	71	45			**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALEY LIMESTONE** w/fractures and iron staining throughout		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-12

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0608** DATE **7/17/15** SHEET **3** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **12/13/06** BORING FINISH **12/13/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							50					
6	NQ	54.5	59.5		5.0	44	55			**HARD N6 MEDIUM LIGHT GRAY LIMESTONE** w/fractures and iron staining throughout		
										MEDIUM HARD 5G 6/1 GREENISH GRAY CLAY SHALE w/fractures and iron staining throughout		
7	NQ	59.5	69.5		4.5	100	60			**HARD N7 LIGHT GRAY LIMESTONE** w/fractures and iron staining throughout		Lost all drill return water @ ~61.5'
							65					
8	NQ	69.5	79.5		9.1	66	70			**MEDIUM HARD 5GY 6/1 GREENISH GRAY CLAY SHALE** w/fractures throughout		

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AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-12

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0608** DATE **7/17/15** SHEET **4** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **12/13/06** BORING FINISH **12/13/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										HARD N5 MEDIUM GRAY LIMESTONE		
							75			**MEDIUM HARD 5GY 6/1 GREENISH GRAY CLAY SHALE**		
										HARD N5 MEDIUM GRAY LIMESTONE		Air hammer to 77.0'
9	NQ	79.5	89.5		9.7	82	80			**HARD N5 MEDIUM GRAY SHALEY LIMESTONE**		
										HARD N7 LIGHT GRAY LIMESTONE		
							85			**SOFT N5 MEDIUM GRAY FRACTURED CLAY SHALE**		
										HARD N7 LIGHT GRAY LIMESTONE		
10	NQ	89.5	99.5		9.2	43	90			**HARD N5 MEDIUM GRAY CLAY SHALE** w/fracture		Pumped 70 gals quick grout into bore hole & let set all weekend to try to seal fractures in limestone. SWL DRY 09/05/06; this is 96 hr reading
										SOFT N5 MEDIUM GRAY CLAY SHALE		
							95			**N1 BLACK COAL**		All coal placed in sepatate box.
										SOFT N5 MEDIUM GRAY CLAY SHALE w/fractures & iron staining throughout		

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AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-12

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0608** DATE **7/17/15** SHEET **5** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **12/13/06** BORING FINISH **12/13/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
11	NQ	99.5	109.5		10.0	55	100			**HARD N5 MEDIUM GRAY CLAY SHALE** w/fractures and iron staining throughout		
										HARD N5 MEDIUM GRAY CLAY SHALE		
							105					
										HARD N7 LIGHT GRAY LIMESTONE w/fractures		
12	NQ	109.5	119.5		10.0	62	110			**HARD N7 LIGHT GRAY LIMESTONE** w/fractures		
										SOFT N5 MEDIUM GRAY CLAY SHALE		
										HARD 5G 6/1 GREENISH GRAY CLAY SHALE w/fractures & fine grain sandstone lenses throughout		
							115					
13	NQ	119.5	122.0		2.5	0	120			**HARD 5G 6/1 GREENISH GRAY CLAY SHALE** w/fractures throughout		
14	NQ	122.0	129.5		6.5	42				**HARD 5G 6/1 GREENISH GRAY CLAY SHALE** w/fractures throughout		9/6/06 - SWL = 123.6' (16 hr reading)

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AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

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JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0608** DATE **7/17/15** SHEET **6** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **12/13/06** BORING FINISH **12/13/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										SOFT N5 MEDIUM GRAY CLAY SHALE		w/ NQ rods @ 149.5'
							125			**HARD N4 MEDIUM DARK GRAY CLAY SHALE** w/fractures		
										HARD N7 LIGHT GRAY LIMESTONE w/fractures		
15	NQ	129.5	139.5		10.0	72	130			**HARD N7 LIGHT GRAY LIMESTONE** w/fractures & iron staining throughout		
							135			**HARD 5BG 5/2 GRAYISH BLUE GREEN CLAY SHALE** w/fractures		
										SOFT 5BG 5/2 GRAYISH BLUE GREEN CLAY SHALE		
										HARD 5BG 5/2 GRAYISH BLUE GREEN CLAY SHALE		
16	NQ	139.5	149.5		10.0	74	140			**HARD 5G 6/1 GREENISH GRAY FINE GRAIN SILTY SANDSTONE** w/crossbedding throughout		139.0' - 153.6' Possible Connellsville
							145					
17	NQ	149.5	156.5		5.5	40				**HARD 5G 6/1 GREENISH GRAY FINE GRAIN**		

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AEP CIVIL ENGINEERING LABORATORY

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JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0608** DATE **7/17/15** SHEET **7** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **12/13/06** BORING FINISH **12/13/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										SILTY SANDSTONE w/crossbedding throughout		
							155					
										COAL		
18	NQ	156.5	159.5		2.45	22				**HARD N5 MEDIUM GRAY SILTY CLAY SHALE** w/limestone modules & fractures		
19	NQ	159.5	169.5		10.0	90	160			**HARD N7 LIGHT GRAY LIMESTONE** w/fractures throughout		
							165					
20	NQ	169.5	179.5		5.4	52	170			**HARD N7 LIGHT GRAY LIMESTONE**		
										SOFT N5 MEDIUM GRAY CLAY SHALE		
										HARD N7 LIGHT GRAY LIMESTONE w/fractures		
							175			**SOFT N5 MEDIUM GRAY CLAY SHALE**		

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AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-12

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0608** DATE **7/17/15** SHEET **8** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **12/13/06** BORING FINISH **12/13/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										MINE VOID Lost water pressure @ 176.0'. Stopped rotation @ 176.5'. Using no rotation & water presssure, moved NQ rods from 176.5' to 186.0'. Mine void of abandoned mine from 176.5' to 186.0. SWL at this time - DRY		
							180					09/09/06 NQ Rods @ 179.5; SWL Dry @ 32 hr reading; Bottom of mine floor w/ air hammer 186.6' SWL @ 182.7 on 12/11/06; 80 hr reading with NQ hole to 289.8'. HW casing seated on bottom of mine floor
							185					
21	NQ	186.6	194.8		7.3	56				**MEDIUM HARD N5 MEDIUM GRAY SILTY FINE SANDSTONE**		10/6/06 Pulled air hammer & rods. Set HW casing to 186.6'; resumed NQ rock coring SWL @ 187.6 on 12/12/06; 14 hr reading with NQ hole to 312.8'. HW casing seated on bottom of mine floor
							190					
22	NQ	194.8	204.8		9.3	73	195			**HARD N7 LIGHT GRAY LIMESTONE**		
										MEDIUM HARD N5 MEDIUM GRAY SILTY CLAY SHALE		
										HARD 5G 6/1 GREENISH GRAY SILTY CLAY SHALE w/limestone nodules throughout		
							200					

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AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

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JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0608** DATE **7/17/15** SHEET **9** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **12/13/06** BORING FINISH **12/13/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
23	NQ	204.8	214.8		9.8	61	205			**HARD 5B 5/1 MEDIUM BLUISH GRAY SILTY CLAY SHALE**		
							210			**SOFT 5GY 6/1 GREENISH GRAY CLAY SHALE**		
24	NQ	214.8	224.8		10.0	53	215			**HARD 5GY 6/1 GREENISH GRAY FINE SANDY CLAY SHALE**		
							220					
25	NQ	224.8	234.8		9.9	41	225			**HARD 5GY 6/1 GREENISH GRAY FINE SANDY CLAY SHALE**		

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AEP CIVIL ENGINEERING LABORATORY

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JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0608** DATE **7/17/15** SHEET **10** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **12/13/06** BORING FINISH **12/13/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							230			**HARD N7 LIGHT GRAY LIMESTONE**		
										HARD 5GY 6/1 GREENISH GRAY CLAY SHALE w/limestone nodules throughout		
26	NQ	234.8	243.8		7.9	20	235			**SOFT 5G 6/1 GREENISH GRAY CLAY SHALE**		
							240			**HARD 5B 5/1 MEDIUM BLUISH GRAY FINE SANDY CLAY SHALE**		
27	NQ	243.8	249.8		6.0	75				**HARD 5B 5/1 MEDIUM BLUISH GRAY FINE SANDY CLAY SHALE** w/limestone nodules throughout		
							245					
28	NQ	249.8	259.8		9.8	79	250			**HARD 5B 5/1 MEDIUM BLUISH GRAY FINE GRAIN SANDY CLAY SHALE**		

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AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-12

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0608** DATE **7/17/15** SHEET **11** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **12/13/06** BORING FINISH **12/13/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							255					
29	NQ	259.8	269.8		9.3	42	260			**MEDIUM HARD 5G 6/1 GREENISH GRAY CLAY SHALE**		
										HARD 5B 7/1 LIGHT BLUISH GRAY SHALEY LIMESTONE		
										HARD 5G 6/1 GREENISH GRAY CLAY SHALE w/limestone nodules throughout		
										HARD 5B 7/1 LIGHT BLUISH GRAY SHALEY LIMESTONE		
							265			**HARD 5G 6/1 GREENISH GRAY CLAY SHALE** w/limestone nodules throughout		
30	NQ	269.8	275.8		5.1	55	270			**MEDIUM TO HARD 5G 6/1 GREENISH GRAY CLAY SHALE**		
							275					
31	NQ	275.8	284.8		9.0	60				**HARD 5G 6/1 GREENISH GRAY CLAY SHALE** w/limestone nodules throughout		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-12

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0608** DATE **7/17/15** SHEET **12** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **12/13/06** BORING FINISH **12/13/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
32	NQ	284.4	289.4		5.0	28				**HARD GRAY SHALE**		
							285			**N6 MEDIUM LIGHT GRAY HARD GRAY SHALE** w/limestone nodules		
										HARD N6 MEDIUM LIGHT GRAY SHALE		
										HARD N6 MEDIUM LIGHT GRAY SHALE w/limestone nodules		
										HARD N6 MEDIUM LIGHT GRAY SHALE		
33	NQ	289.8	299.8		10.0	63	290			**5YR 4/1 BROWNISH GRAY SHALE**		
										SOFT GRAY SHALE wet		
										HARD 5YR 4/1 BROWNISH GRAY SHALE		
										SOFT GRAY SHALE		
										5YR 4/1 BROWNISH GRAY SHALE w/brownish red shale		
							295					
										HARD GRAY / RED SHALE		
34	NQ	299.8	309.8		10.0	62	300			**RED GRAY SHALE**		
							305					

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JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0608** DATE **7/17/15** SHEET **13** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **12/13/06** BORING FINISH **12/13/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										GRAY SILTY SHALE		
										GRAY HARD LIMESTONE		
35	NQ	309.8	312.8		3.0	93	310			**HARD 5B 7/1 LIGHT BLUISH GRAY FINE GRAIN SANDY SILTSTONE** w/limestone lenses throughout		
36	NQ	312.8	319.8		7.0	93	315			**HARD N4 MEDIUM DARK GRAY FINE GRAIN STILTY SANDSTONE**		
37	NQ	319.8	329.8		10.0	100	320			**HARD N4 MEDIUM DARK GRAY FINE GRAIN SILTY SANDSTONE**		
							325					
38	NQ	329.8	339.8		10.0	80	330			**HARD N5 MEDIUM DARK GRAY FINE SILTY SANDSTONE**		Start of Morgantown Sandstone @ +/- 331'

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AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-12

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0608** DATE **7/17/15** SHEET **14** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **12/13/06** BORING FINISH **12/13/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										MEDIUM HARD N5 MEDIUM DARK GRAY SANDSTONE		
							335			**HARD N5 MEDIUM DARK GRAY FINE SILTY SANDSTONE**		
										MEDIUM HARD N5 MEDIUM DARK GRAY SANDSTONE		
39	NQ	339.8	349.8		10.0	100	340			**HARD N7 LIGHT GRAY WELL CEMENTED MEDIUM to COARSE GRAIN SANDSTONE** w/some crossbedding		
							345					
40	NQ	349.8	359.8		10.0	100	350			**HARD MEDIUM DARK GRAY WELL CEMENTED MEDIUM to COARSE GRAIN SANDSTONE** w/some crossbedding		
							355					

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AEP CIVIL ENGINEERING LABORATORY

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COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0608** DATE **7/17/15** SHEET **15** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **12/13/06** BORING FINISH **12/13/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
41	NQ	359.8	369.8		10.0	100	360			**HARD MEDIUM DARK GRAY WELL CEMENTED MEDIUM to COARSE GRAIN SANDSTONE** w/some crossbeddings		
							365					
42	NQ	369.8	379.8		10.0	97	370			**HARD MEDIUM DARK GRAY WELL CEMENTED MEDIUM to COARSE GRAIN SANDSTONE** w/some crossbeddings		
							375					
										HARD N4 MEDIUM DARK GRAY SHALE		
43	NQ	379.8	389.8		10.0	95	380			**HARD N4 MEDIUM DARK GRAY SILTY SHALE**		
										HARD N4 MEDIUM DARK GRAY WELL CEMENTED MEDIUM to COARSE GRAIN SANDSTONE w/some crossbedding		

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AEP CIVIL ENGINEERING LABORATORY

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JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0608** DATE **7/17/15** SHEET **16** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **12/13/06** BORING FINISH **12/13/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							385					
										COAL PARTING IN SANDSTONE		
										HARD N4 MEDIUM DARK GRAY WELL CEMENTED MEDIUM to COARSE GRAIN SANDSTONE w/some crossbedding		
44	NQ	389.8	399.8		10.0	88	390			**N5 MEDIUM GRAY FINE GRAIN SANDSTONE**		
										COAL LENSE		
										N5 MEDIUM GRAY FINE GRAIN SANDSTONE w/ coal lenses		
							395					
										HARD N4 MEDIUM DARK GRAY FINE GRAIN SANDY CLAY SHALE		Bottom of Morgantown Sandstone @ 398.4'
45	NQ	399.8	809.6		5.0	34	400					
										FINE GRAIN SILTY SANDSTONE w/limestone nodules		
										FINE GRAIN CLAY SHALE		Stopped boring @ 404.8' on 12/13/06. Flushed w/~700 gals water; installed 1" geomon type well w/ 5' screen.

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-11

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL FLY ASH DAM**

COORDINATES **N 830,072.4 E 2,516,465.1**

GROUND ELEVATION **977.8** SYSTEM

Water Level, ft			
TIME			
DATE			

BORING NO. **MW-5** DATE **7/20/15** SHEET **1** OF **12**

BORING START BORING FINISH **5/4/99**

PIEZOMETER TYPE **GEO-MON** WELL TYPE **GM**

HGT. RISER ABOVE GROUND **2.39** DIA **3**

DEPTH TO TOP OF WELL SCREEN **198** BOTTOM **200**

WELL DEVELOPMENT BACKFILL **100 gallons of Quick**

FIELD PARTY **TJH-REB** RIG **CME-75**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										NO SAMPLE - RUN 3"CASING TO 7.3'		Decon drill with potable water & alconox prior to setup.
							5					
1	NQ-2	7.3	9.6		2.3	22				**5GY 6/1 GREENISH GRAY SANDSTONE**		Started coring at 7.3' Note: No water return.
2	NQ-2	9.6	13.3		3.0	0	10			**5GY 6/1 GREENISH GRAY SANDY SHALE** Badly broken.		
3	NQ-2	13.3	14.6		1.1	0						
4	NQ-2	14.6	16.5		2.1	0	15					
5	NQ-2	16.5	19.6		2.3	0				**5GY 6/1 GREENISH GRAY CLAY SHALE**		
6	NQ-2	19.6	22.1		2.4	0				**N6 MEDIUM LIGHT GRAY LIMESTONE**		

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

Continued Next Page

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **REB**

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-11

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **MW-5** DATE **7/20/15** SHEET **2** OF **12**

PROJECT **CARDINAL FLY ASH DAM** BORING START BORING FINISH **5/4/99**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										With iron stain		
										N5 MEDIUM GRAY CLAY SHALE		
										N6 MEDIUM LIGHT GRAY LIMESTONE Broken up; iron stain		
7	NQ-2	22.1	24.6			0				**N5 MEDIUM GRAY CLAY SHALE** Broken up		
8	NQ-2	24.6	29.2		4.0	30	25			**N6 MEDIUM LIGHT GRAY CLAY SHALE**		
9	NQ-2	29.2	34.6		5.4	33	30					
										5GY 6/1 GREENISH GRAY SANDY SHALE		
										N6 MEDIUM LIGHT GRAY CLAY SHALE		
10	NQ-2	34.6	34.7		0.1	0	35			**5GY 6/1 GREENISH GRAY SANDSTONE**		
11	NQ-2	34.7	39.6		5.0	32				**N5 MEDIUM GRAY CLAY SHALE**		
12	NQ-2	39.6	43.8		3.0	20	40			**RED,BROWN & GRAY CLAY SHALE**		
										N6 MEDIUM LIGHT GRAY LIMESTONE Oxidized above & below		
										N5 MEDIUM GRAY CLAY SHALE		
13	NQ-2	43.8	49.1		3.8	0				**N5 MEDIUM GRAY CLAY SHALE**		
							45			**RED & GREENISH GRAY CLAY SHALE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-11

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **MW-5** DATE **7/20/15** SHEET **3** OF **12**

PROJECT **CARDINAL FLY ASH DAM** BORING START BORING FINISH **5/4/99**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
14	NQ-2	49.1	54.6		2.5	0				**N6 MEDIUM LIGHT GRAY LIMESTONE**		
							50			**N6 MEDIUM LIGHT GRAY CLAY SHALE**		
										N6 MEDIUM LIGHT GRAY LIMESTONE		
										N6 MEDIUM LIGHT GRAY CLAY SHALE Iron stain at 56.8'		
15	NQ-2	54.6	59.6		4.6	30	55					
										N6 MEDIUM LIGHT GRAY LIMESTONE Iron stain; broken up		
16	NQ-2	59.6	64.6		3.3	0	60					
										N5 MEDIUM GRAY CLAY SHALE		
										10R 4/2 GRAYISH RED CLAY SHALE		
17	NQ-2	64.6	69.3		4.7	60	65			**N6 MEDIUM LIGHT GRAY CLAY SHALE** Soft from 64.6'-67.2'		
18	NQ-2	69.3	74.6		4.6	26	70			**N5 MEDIUM GRAY CLAY SHALE**		Note: At approx. 70.0', the rock became more competent.

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-11

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **MW-5** DATE **7/20/15** SHEET **4** OF **12**

PROJECT **CARDINAL FLY ASH DAM** BORING START BORING FINISH **5/4/99**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										5GY 6/1 GREENISH GRAY CLAY SHALE Iron stain; fractures		
										N5 MEDIUM GRAY CLAY SHALE		
19	NQ-2	74.6	84.6		10.0	30	75					
										5GY 6/1 GREENISH GRAY CLAY SHALE		
							80			**N5 MEDIUM GRAY CLAY SHALE**		
										N5 MEDIUM GRAY LIMESTONE		
										N5 MEDIUM GRAY CLAY SHALE with LIMESTONE LENSES		
20	NQ-2	84.6	94.6		10.0	53	85					
										5R 4/2 GRAYISH RED CLAY SHALE		
							90					
										N5 MEDIUM GRAY CLAY SHALE		
21	NQ-2	94.6	104.6		9.9	84	95					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-11

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **MW-5** DATE **7/20/15** SHEET **5** OF **12**

PROJECT **CARDINAL FLY ASH DAM** BORING START BORING FINISH **5/4/99**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							100					
22	NQ-2	104.6	114.6		9.6	85	105					
										N5 MEDIUM GRAY SANDY CLAY SHALE		
							110			**10YR 5/4 MODERATE YELLOWISH BROWN SANDSTONE**		
23	NQ-2	114.6	124.2		10.0	96	115					
							120					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-11

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **MW-5** DATE **7/20/15** SHEET **6** OF **12**

PROJECT **CARDINAL FLY ASH DAM** BORING START BORING FINISH **5/4/99**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
24	NQ-2	124.2	129.6		5.4	100						
							125					
										N5 MEDIUM GRAY SANDSTONE		
										10YR 5/4 MODERATE YELLOWISH BROWN SANDSTONE		
										N5 MEDIUM GRAY SANDSTONE		
25	NQ-2	129.6	134.6		5.0	100	130					
26	NQ-2	134.6	144.6		10.0	100	135					
							140					0.1' limestone at 141.0'
27	NQ-2	144.6	154.6		9.6	76	145					
										10YR 5/4 MODERATE YELLOWISH BROWN SANDSTONE		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-11

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **MW-5** DATE **7/20/15** SHEET **7** OF **12**

PROJECT **CARDINAL FLY ASH DAM** BORING START BORING FINISH **5/4/99**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										N5 MEDIUM GRAY SANDSTONE		
										10YR 5/4 MODERATE YELLOWISH BROWN SANDSTONE		
28	NQ-2	154.6	164.6		10.0	80	155					Lost drill water at 155'; geared rig down from 5th to 3rd gear.
										N5 MEDIUM GRAY SANDSTONE		
										10YR 5/4 MODERATE YELLOWISH BROWN SANDSTONE		
										N5 MEDIUM GRAY SANDSTONE		
										10YR 5/4 MODERATE YELLOWISH BROWN SANDSTONE		
							160					
29	NQ-2	164.6	174.6		10.0	68	165					
										N5 MEDIUM GRAY SANDSTONE with COAL STREAKS		
										10YR 5/4 MODERATE YELLOWISH BROWN SANDSTONE		
										N5 MEDIUM GRAY SANDSTONE with COAL STREAKS		
							170			**10YR 5/4 MODERATE YELLOWISH BROWN SANDSTONE** Mud seam at 169.8'		Mud seam at 169.8'
										N5 MEDIUM GRAY SANDSTONE with COAL STREAKS		
30	NQ-2	174.6	184.6		10.0	64	175					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-11

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **MW-5** DATE **7/20/15** SHEET **8** OF **12**

PROJECT **CARDINAL FLY ASH DAM** BORING START BORING FINISH **5/4/99**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										N5 MEDIUM GRAY SANDSTONE CONGLOMERATE		
										N5 MEDIUM GRAY SANDSTONE with COAL STREAKS (Morgantown) Vertical crack at 189.3'		
							180					
31	NQ-2	184.6	194.6		10.0	90	185					
							190					
32	NQ-2	194.6	204.6		10.0	89	195					
							200			**N5 MEDIUM GRAY CLAY SHALE**		Mud seam at 200.2'

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-11

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **MW-5** DATE **7/20/15** SHEET **9** OF **12**

PROJECT **CARDINAL FLY ASH DAM** BORING START BORING FINISH **5/4/99**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
33	NQ-2	204.6	214.6		10.0	96	205			**N4 MEDIUM DARK GRAY SANDY SHALE**		
							210					Rock fracture at 209.7'
34	NQ-2	214.6	224.6		10.0	80	215					
										N6 MEDIUM LIGHT GRAY SHALEY SANDSTONE		
							220			**N6 MEDIUM LIGHT GRAY LIMESTONE** Vertical crack at 220.1'-220.7' (fossils)		
35	NQ-2	224.6	234.6		10.0	83	225			**N6 MEDIUM LIGHT GRAY SHALEY LIMESTONE**		
										N5 MEDIUM GRAY CLAY SHALE		
										N5 MEDIUM GRAY SANDY SHALE		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-11

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **MW-5** DATE **7/20/15** SHEET **10** OF **12**

PROJECT **CARDINAL FLY ASH DAM** BORING START BORING FINISH **5/4/99**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							230					Mud seam at 230.0'
										N6 MEDIUM LIGHT GRAY LIMESTONE Shale streaks.		
36	NQ-2	234.6	235.2		.6	100	235			**N5 MEDIUM GRAY SHALEY SANDSTONE** With calcite.		
37	NQ-2	235.2	237.6		2.4	0				**N5 MEDIUM GRAY CLAY SHALE** Broken up		Mud seam at 235.2'
										N3 DARK GRAY CLAY SHALE Broken up.		
38	NQ-2	237.6	244.6		6.3	33						
							240			**N5 MEDIUM GRAY SANDSTONE**		Mud seam at 239.9'
										N5 MEDIUM GRAY CLAY SHALE Broken up		
39	NQ-2	244.6	249.2			0	245					
40	NQ-2	249.2	254.6		2.3	0	250					Note: Run 3" casing to 83.6'

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-11

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **MW-5** DATE **7/20/15** SHEET **11** OF **12**

PROJECT **CARDINAL FLY ASH DAM** BORING START BORING FINISH **5/4/99**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
41	NQ-2	254.6	264.6		9.8	51	255			**N3 DARK GRAY CLAY SHALE**		
										N1 BLACK COAL		
										N4 MEDIUM DARK GRAY CLAY SHALE Limestone nodules.		
							260					
42	NQ-2	264.6	264.8		0.2	0	265					
43	NQ-2	264.8	274.6		9.8	70						
							270			**10Y 6/2 PALE OLIVE LIMESTONE**		
										N5 MEDIUM GRAY SHALEY LIMESTONE		
										N5 MEDIUM GRAY CLAY SHALE Limestone nodules		
44	NQ-2	274.6	284.6		10.0	38	275					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-11

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **MW-5** DATE **7/20/15** SHEET **12** OF **12**

PROJECT **CARDINAL FLY ASH DAM** BORING START BORING FINISH **5/4/99**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1004

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 831,215.4 E 2,519,112.4**

GROUND ELEVATION **1005.6** SYSTEM

Water Level, ft			
TIME			
DATE			

BORING NO. **M-1004D** DATE **7/17/15** SHEET **1** OF **9**

BORING START **3/23/10** BORING FINISH **3/31/10**

PIEZOMETER TYPE **N/A** WELL TYPE **OW**

HGT. RISER ABOVE GROUND **2.65** DIA **2"**

DEPTH TO TOP OF WELL SCREEN **148.4** BOTTOM **198.4**

WELL DEVELOPMENT **YES** BACKFILL **VOLCLAY**

FIELD PARTY **MCR/ZLR** RIG **D-120**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										DECONED 03/23/10 - LIQUI-NOX & HIGH PRESSURE PUMP / NO GROUNDING PROCESS IN USE / DRILL 4" CASING THEN SPLIT SPOON / DRILL & DECON WATER FROM CD FIRE PROTECTION SYSTEM / NO SPT'S TAKEN FROM 0' - 3.0' DUE TO MINE SPOIL PLACED FOR DRILL PAD		
1	SPT	3.0	5.0	7-6-5-9						**VERY HARD MEDIUM GRAY N5 LIMESTONE** dry		
							5					
2	SPT	5.0	6.2	5-23-50/.2						**VERY HARD MEDIUM GRAY N5 CLAYSHALE** moist		
3	SPT	7.0	7.1	50/1						SPOON REFUSAL @ 7.1' / HW CASING REFUSAL @ 8.1' / STARTED CORING @ 8.1' ON 03/24/10 / SWL DRY ON 03/24/10 / HW CASING TO 8.1'		
1	NQ	8.1	14.4		5.9	52				**HARD MEDIUM BLUISH GRAY 5B 5/1 SILTY FINE GRAIN SANDSTONE** w/high angle fracture @ 1.4'		
							10					
2	NQ	14.4	24.4		10	70				**HARD MEDIUM BLUISH GRAY 5B 5/1 SILTY FINE GRAIN SANDSTONE**		
							15					
										HARD MEDIUM GRAY N5 LIMEY SILTSTONE		
										HARD LIMESTONE		

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
X	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1004

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **M-1004D** DATE **7/17/15** SHEET **2** OF **9**

PROJECT **CARDINAL LANDFILL** BORING START **3/23/10** BORING FINISH **3/31/10**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										SOFT TO MEDIUM CLAYSHALE		
										HARD GREENISH GRAY 5GY 4/1 CLAYSHALE		
3	NQ	24.4	34.4		10	52	25			**MEDIUM LIGHT GRAY N6 SILTY FINE GRAIN SANDSTONE**		
										HARD MEDIUM GRAY N5 CLAYSHALE		
										HARD MEDUIM LIGHT GRAY N6 LIMESTONE		
							30			**HARD GREENISH GRAY 5GY 6/1 CLAYSHALE** w/limestone nodules throughout; w/high angle fracture @ 29.5'		
										SOFT LIGHT GRAY N7 CLAYSHALE		
										HARD LIGHT GRAY N7 LIMESTONE		
4	NQ	34.4	41.8		3.8	24	35			**HARD GREENISH GRAY 5GY 6/1 CLAYSHALE** badly broken		
							40					
5	NQ	41.8	49.4		7.5	35				**HARD MEDIUM LIGHT GRAY N6 CLAYSHALE** 45.0' - 49.4' badly broken machine break		
							45					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1004

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **M-1004D** DATE **7/17/15** SHEET **3** OF **9**

PROJECT **CARDINAL LANDFILL** BORING START **3/23/10** BORING FINISH **3/31/10**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
6	NQ	49.4	59.4		8.7	49	50			**HARD MEDIUM BLUISH GRAY 5B 5/1 CLAYSHALE**		
							55			**HARD MEDIUM LIGHT GRAY N5 SILTSTONE** w/limestone nodules throughout; slickenslide @ 5.6'		
7	NQ	59.4	67.4		5.5	9	60			**MEDIUM HARD TO SOFT DARK GREENISH GRAY 5GY 4/1 CLAYSHALE** w/limestone nodule @ 4.8' to 5.5'		
							65					
8	NQ	67.4	74.4		7.0	24				**HARD GREENISH GRAY 5G 6/1 CLAYSHALE**		
							70					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1004

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **M-1004D** DATE **7/17/15** SHEET **4** OF **9**

PROJECT **CARDINAL LANDFILL** BORING START **3/23/10** BORING FINISH **3/31/10**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										HARD MEDIUM LIGHT GRAY N6 LIMESTONE		
9	NQ	74.4	84.4		9.9	59	75			**HARD GREENISH GRAY 5G 6/1 CLAYSHALE** w/limestone nodules		
							80					
										MEDIUM TO SOFT MODERATE OLIVE BROWN 5Y 4/4 CLAYSHALE		
										HARD MEDIUM LIGHT GRAY N6 LIMESTONE		
										MEDIUM TO SOFT MODERATE OLIVE BROWN 5Y 4/4 CLAYSHALE		
										HARD MEDIUM LIGHT GRAY N6 LIMESTONE		
10	NQ	84.4	93.4		6.1	33	85			**HARD DARK GREENISH GRAY 5G 4/1 CLAYSHALE**		
							90			**HARD MEDIUM DARK GRAY N4 LIMESTONE**		
11	NQ	93.4	99.4		5.6	41				**HARD MEDIUM BLUISH GRAY 5B 5/1 CLAYSHALE** w/limestone nodules throughout		
							95					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1004

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **M-1004D** DATE **7/17/15** SHEET **5** OF **9**

PROJECT **CARDINAL LANDFILL** BORING START **3/23/10** BORING FINISH **3/31/10**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
12	NQ	99.4	109.4		9.9	98	100			**HARD MEDIUM BLUISH GRAY 5B 5/1 CLAYEY SILTSTONE** w/limestone nodules 99.4' - 99.6'		
13	NQ	109.4	119.4		9.4	66	105					
14	NQ	119.4	129.4		10	62	110			**HARD MEDIUM BLUISH GRAY 5B 5/1 CLAYEY SILTSTONE**		
							115			**HARD MEDIUM GRAY N5 LIMESTONE**		
										HARD MEDIUM BLUISH GRAY 5B 5/1 CLAYEY SILTSTONE		
										HARD MEDIUM GRAY N5 LIMESTONE		
										SOFT TO MEDIUM GREENISH GRAY 5G 6/1 CLAYSHALE		
										HARD MEDIUM BLUISH GRAY 5B 5/1 CLAYEY SILTSTONE w/limestone nodules		
							120			**HARD MEDIUM BLUISH GRAY 5B 5/1 CLAYSHALE** w/limestone nodules throughout @ 119.4' - 124.6'; Hard Very Dark Red 5R 2/6 Clayshale mixed w/Hard Medium Bluish Gray 5B 5/1 Clayshale from 125.6' - 126.6'		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1004

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **M-1004D** DATE **7/17/15** SHEET **6** OF **9**

PROJECT **CARDINAL LANDFILL** BORING START **3/23/10** BORING FINISH **3/31/10**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							125					
15	NQ	129.4	139.4		9.5	64	130			**MEDIUM HARD VERY DARK RED 5R 2/6 W/MEDIUM GRAY N4 CLAYSHALE**		
										HARD MEDIUM GRAY N4 CLAYSHALE		
							135			**VERY HARD MEDIUM BLUISH GRAY 5B 5/1 CLAYSHALE**		
16	NQ	139.4	149.4		10	57	140			**HARD MEDIUM BLUISH GRAY 5B 5/1 CLAYSHALE**		
							145			**HARD DARK GRAY N3 CLAYSHALE** w/coal seams @ 144.2' - 144.3', 145.2', & 145.4'		
										HARD MEDIUM BLUISH GRAY 5B 5/1 SILTY FINE GRAIN SANDSTONE		
										HARD MEDIUM BLUISH GRAY 5B 5/1 WELL CEMENTED FINE GRAIN SANDSTONE		
17	NQ	149.4	159.4		10	100				**HARD MEDIUM BLUISH GRAY 5B 5/1 WELL**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1004

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **M-1004D** DATE **7/17/15** SHEET **7** OF **9**

PROJECT **CARDINAL LANDFILL** BORING START **3/23/10** BORING FINISH **3/31/10**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										CEMENTED FINE GRAIN SANDSTONE		
							155					
18	NQ	159.4	169.4		9.9	92				**HARD MEDIUM BLUISH GRAY 5B 5/1 WELL CEMENTED MEDIUM TO FINE GRAIN SANDSTONE**		
							160					
							165					
19	NQ	169.4	179.4		10	98						
							170					
							175					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1004

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **M-1004D** DATE **7/17/15** SHEET **8** OF **9**

PROJECT **CARDINAL LANDFILL** BORING START **3/23/10** BORING FINISH **3/31/10**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										HARD MEDIUM LIGHT GRAY N6 FINE SANDY CLAYSHALE		
										HARD MEDIUM BLUISH GRAY 5B 5/1 WELL CEMENTED FINE GRAIN SANDSTONE		
20	NQ	179.4	189.4		9.9	95	180			**HARD MEDIUM LIGHT GRAY N6 WELL CEMENTED MEDIUM TO FINE GRAIN SANDSTONE**		
										HARD LIGHT GRAY N7 WELL CEMENTED FINE GRAIN SANDSTONE		
										HARD MEDIUM LIGHT GRAY N6 WELL CEMENTED MEDIUM GRAIN SANDSTONE w/Hard Black N1 Clayshale streaks		
							185					
21	NQ	189.4	199.4		9.9	99	190			**HARD MEDIUM LIGHT GRAY N6 WELL CEMENTED MEDIUM GRAIN SANDSTONE** w/gravel in bed @ 189.4' - 189.7'		
							195					
										HARD MEDIUM LIGHT GRAY N6 SANDY LIMESTONE		
										HARD MEDIUM LIGHT GRAY N6 FINE SANDY CLAYSHALE		
										HARD MEDIUM LIGHT GRAY N6 SILTY FINE GRAIN SANDSTONE		
22	NQ	199.4	209.4		10	99	200			**HARD MEDIUM LIGHT GRAY N6 FINE GRAIN SANDSTONE**		
										HARD MEDIUM LIGHT GRAY N6 WELL CEMENTED FINE GRAIN SANDY SILTSTONE		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1004

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **M-1004D** DATE **7/17/15** SHEET **9** OF **9**

PROJECT **CARDINAL LANDFILL** BORING START **3/23/10** BORING FINISH **3/31/10**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							205					
23	NQ	209.4	214.4		5	100	210			**HARD MEDIUM LIGHT GRAY N6 WELL CEMENTED FINE GRAIN SANDY SILTSTONE**		
										HARD MEDIUM LIGHT GRAY N6 WELL CEMENTED FINE GRAIN SANDSTONE		
										HARD MEDIUM LIGHT GRAY N6 SILTSTONE w/slickenslide @ 212.1'		
										STOPPED BORING @ 214.4' ON 03/30/10 / SWL 13.1' ON 03/31/10 - 18 HR READING / NQ HOLE TO 214.4' / BUILT 2" PVC MONITORING WELL		

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1003

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 829,139.1 E 2,516,070.9**

GROUND ELEVATION **933.6** SYSTEM

Water Level, ft			
TIME			
DATE			

BORING NO. **M-1003** DATE **7/17/15** SHEET **1** OF **7**

BORING START **4/7/10** BORING FINISH **4/7/10**

PIEZOMETER TYPE **N/A** WELL TYPE **OW**

HGT. RISER ABOVE GROUND **2.33** DIA **2"**

DEPTH TO TOP OF WELL SCREEN **59.3** BOTTOM **139.3**

WELL DEVELOPMENT **YES** BACKFILL **VOLCLAY**

FIELD PARTY **ZLR/DLF** RIG **D-120**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										BLIND DRILLED TO 3.7'		NO SPT'S TAKEN DUE TO STARTING DRILLING ON BEDROCK / ELEVATION LOWERED FOR DRILL PAD / DECONED 04/07/10 / LIQUI-NOX HIGH PRESSURE WASH / NO GROUNDING PROCEDURE IN USE / 4" CASING BLIND DRILLED TO 3.7'
1	NQ	3.7	9.0		2.0	0				**HARD LIGHT GRAY N7 LIMESTONE**		
							5			**HARD MODERATE YELLOWISH BROWN 10YR 5/4 CLAYSHALE**		
2	NQ	9.0	14.4		4.7	88				**SOFT DARK REDDISH BROWN 10R 3/4 CLAYSHALE**		
							10					
3	NQ	14.4	24.4		2.7	0				**HARD LIGHT BLUISH GRAY 5B 7/1 CLAYSHALE** badly broken		
							15					

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1003

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **M-1003** DATE **7/17/15** SHEET **2** OF **7**

PROJECT **CARDINAL LANDFILL** BORING START **4/7/10** BORING FINISH **4/7/10**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
4	NQ	24.4	29.4		3.9	46	25			**HARD TO SOFT LIGHT BLUISH GRAY 5B 7/1 CLAYSHALE**		
5	NQ	29.4	34.4		1.6	38	30			**HARD LIGHT GRAY N7 LIMESTONE** w/iron staining and badly broken		
										SOFT GREENISH GRAY 5G 6/1 CLAYSHALE		
6	NQ	34.4	39.4		4.6	33	35			**HARD GRAYISH RED 10R 4/2 CLAYSHALE**		
7	NQ	39.4	44.4		3.1	32	40			**SOFT MODERATE REDDISH BROWN 10R 4/6 CLAYSHALE**		
8	NQ	44.4	49.4		5.0	48	45			**HARD DARK GREENISH GRAY 5G 4/1 CLAYSHALE** w/limestone nodules		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1003

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **M-1003** DATE **7/17/15** SHEET **3** OF **7**

PROJECT **CARDINAL LANDFILL** BORING START **4/7/10** BORING FINISH **4/7/10**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
9	NQ	49.4	54.4		4.9	78	50			**HARD DARK GREENISH 5G 4/1 CLAYSHALE** w/limestone nodules @ 52.0' to 54.4'; w/iron staining & calcite		
10	NQ	54.4	64.4		9.9	42	55			**HARD DARK GREENISH GRAY 5G 4/1 CLAYSHALE** w/iron staining throughout		
							60			**HARD MEDIUM BLUISH GRAY 5B 5/1 WELL CEMENTED FINE TO MEDIUM GRAIN SANDSTONE** w/high angle fracture @ 58.6' and iron staining throughout		
11	NQ	64.4	74.4		10	100	65			**HARD MEDIUM BLUISH GRAY 5B 5/1 WELL CEMENTED MEDIUM GRAIN SANDSTONE**		
							70					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1003

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **M-1003** DATE **7/17/15** SHEET **4** OF **7**

PROJECT **CARDINAL LANDFILL** BORING START **4/7/10** BORING FINISH **4/7/10**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
12	NQ	74.4	84.4		10	100	75			**HARD MEDIUM BLUISH GRAY 5B 5/1 WELL CEMENTED MEDIUM TO FINE GRAIN SANDSTONE** w/black shale streak @ 99.4' and 100.2'		
13	NQ	84.4	94.4		10	100	80, 85					
14	NQ	94.4	104.4		10	100	90, 95					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1003

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **M-1003** DATE **7/17/15** SHEET **5** OF **7**

PROJECT **CARDINAL LANDFILL** BORING START **4/7/10** BORING FINISH **4/7/10**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							100					
15	NQ	104.4	114.4		9.8	94	105			**HARD LIGHT GRAY N7 WELL CEMENTED SANDSTONE** w/black shale streaks from 104.7' to 107.0', 107.3', 107.4', 109.1', & 111.0'		
							110					
16	NQ	114.4	124.4		10	83	115			**HARD LIGHT GRAY N7 WELL CEMENTED FINE TO MEDIUM GRAIN SANDSTONE** w/black N1 shale streaks @ 115.0', 115.2' - 115.8', 116.5', 117.2' - 117.6'; black N1 coal lens @ 116.8' - 116.9' & 121.6'; high angle fracture @ 119.6'		
							120					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1003

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **M-1003** DATE **7/17/15** SHEET **6** OF **7**

PROJECT **CARDINAL LANDFILL** BORING START **4/7/10** BORING FINISH **4/7/10**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
17	NQ	124.4	134.4		10	98	125			**HARD LIGHT GRAY N7 WELL CEMENTED FINE GRAIN SANDSTONE** w/gravel nodules 124.9' - 125.3'; w/black N1 shale streaks throughout		
							130					
18	NQ	134.4	144.4		10	100	135			**HARD MEDIUM BLUISH GRAY 5B 5/1 WELL CEMENTED FINE TO MEDIUM GRAIN SANDSTONE**		
							140					
19	NQ	144.4	154.4		10	86				**HARD MEDIUM BLUISH GRAY 5B 5/1 CLAYSHALE**		
										HARD MEDIUM BLUISH GRAY 5B 5/1 CLAYSHALE w/limestone nodules throughout		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-1003

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **M-1003** DATE **7/17/15** SHEET **7** OF **7**

PROJECT **CARDINAL LANDFILL** BORING START **4/7/10** BORING FINISH **4/7/10**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										HARD MEDIUM BLUISH GRAY 5B 5/1 FINE SANDY CLAYSHALE		
										HARD MEDIUM BLUISH GRAY 5B 5/1 FINE GRAIN SANDSTONE		
										STOPPED DRILLING @ 154.4' ON 04/13/10 / INSTALLED 2" PVC MONITORING WELL		

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: FA-8

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL FLY ASH DAM**

COORDINATES **N 829,635.1 E 2,516,460.0**

GROUND ELEVATION **918.2** SYSTEM **State Plane using NAD27/29**

Water Level, ft			
TIME			
DATE			

BORING NO. **FA-8** DATE **7/20/15** SHEET **1** OF **7**

BORING START **3/8/04** BORING FINISH **3/23/04**

PIEZOMETER TYPE **SS** WELL TYPE **OW**

HGT. RISER ABOVE GROUND **2.8** DIA

DEPTH TO TOP OF WELL SCREEN **40** BOTTOM **50**

WELL DEVELOPMENT BACKFILL **QUICK GROUT**

FIELD PARTY **REB / DLB** RIG **CME-75**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
	AUGER	0.0	15.8							**AUGERED TO 15.8'**		Deconned with alconox and steam ginny before drilling.
							5					
							10					
							15					
1	NQ2	15.8	20.0		1.8	23				**N6 LIGHT GRAY to 5G 6/1 GREENISH GRAY FRACTURED LIMESTONE** High angle fractures		

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
X	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
X	SW CASING	6"
	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **DLB**

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: FA-8

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **FA-8** DATE **7/20/15** SHEET **2** OF **7**

PROJECT **CARDINAL FLY ASH DAM** BORING START **3/8/04** BORING FINISH **3/23/04**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
2	NQ2	20.0	25.0		4.7	85				**10YR 4/6 DARK YELLOWISH BROWN CLAYEY SHALE**		
										5YR 5/2 REDDISH GRAY SHALE		
3	NQ2	25.0	35.0		9.4	87	25			**5YR 3/4 DARK REDDISH GRAY CLAYEY SHALE**		
										5B 5/1 MEDIUM BLUISH GRAY CLAYEY SHALE w/ angle fractures @ 27' (120 deg.), 27.5' (60 deg.), & 28.0' (140 deg.)		
										5B 5/1 MEDIUM BLUISH GRAY HARD SHALE w/ large limestone nodules and cross beds, w/ angle fractures @ 31.8' (80 deg.), & 32.2' (80 deg.)		
							30					
4	NQ2	35.0	45.0		10	89	35			**5B 5/1 MEDIUM BLUISH GRAY SANDY SHALE**		
							40					
										10YR 5/4 YELLOWISH BROWN SANDY SHALE		Lost water @ 42.5'
										10YR 5/4 YELLOWISH BROWN MEDIUM GRAIN SANDSTONE		
										5B 7/1 LIGHT BLUISH GRAY MEDIUM GRAIN SANDSTONE		
5	NQ2	45.0	55.0		10	96	45			**10YR 5/4 YELLOWISH BROWN MEDIUM GRAIN SANDSTONE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: FA-8

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **FA-8** DATE **7/20/15** SHEET **3** OF **7**

PROJECT **CARDINAL FLY ASH DAM** BORING START **3/8/04** BORING FINISH **3/23/04**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										w/ angle fractures @ 47.0' (110 deg.) and limonitic vugs @ 46.4'		
										5B 5/1 MEDIUM BLUISH GRAY SHALE w/ limestone cross beds		
							50			**10YR 4/3 BROWN MEDIUM GRAIN SANDSTONE** w/ angle fractures @ 49.0' (115 deg.)		
										5B 5/1 MEDIUM BLUISH GRAY MEDIUM GRAIN SANDSTONE Well cemented		
6	NQ2	55.0	65.0		10	100	55			**10YR 5/6 GRAYISH BROWN MEDIUM GRAIN SANDSTONE**		
										5B 5/1 MEDIUM BLUISH GRAY MEDIUM GRAIN SANDSTONE Well cemented		
							60					
7	NQ2	65.0	75.0		9.8	100	65			**5B 5/1 MEDIUM BLUISH GRAY MEDIUM GRAIN SANDSTONE** w/ black shale streaks throughout		
							70					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: FA-8

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **FA-8** DATE **7/20/15** SHEET **4** OF **7**

PROJECT **CARDINAL FLY ASH DAM** BORING START **3/8/04** BORING FINISH **3/23/04**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							75					
8	NQ2	75.0	85.0		10	100				**5B 5/1 MEDIUM BLUISH GRAY MEDIUM to COARSE GRAIN SANDSTONE** w/ coal lenses throughout		Some water return @ 75.0'
							80					
							85					
9	NQ2	85.0	95.0		10	100				**5B 5/1 MEDIUM BLUISH GRAY MEDIUM GRAIN SANDSTONE** w/ coal lenses throughout, 2" bands of 10YR 4/4 BROWN SANDSTONE in bottom 2.0'		
							90					
							95					
10	NQ2	95.0	105.0		10	100				**10YR 4/4 DARK YELLOWISH BROWN COARSE GRAIN SANDSTONE** w/ limonitic vugs throughout, well cemented		Lost water @ 95.0'

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: FA-8

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **FA-8** DATE **7/20/15** SHEET **5** OF **7**

PROJECT **CARDINAL FLY ASH DAM** BORING START **3/8/04** BORING FINISH **3/23/04**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							100					
										N5 MEDIUM GRAY MEDIUM to COARSE GRAIN SANDSTONE w/ coal streaks		
										N1 BLACK COAL		
11	NQ2	105.0	115.0		10	92	105			**N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE**		
										N5 MEDIUM GRAY MEDIUM to COARSE GRAIN SANDSTONE w/ coal streaks		
										N1 BLACK COAL		
										N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE w/ black shale streaks		
										N1 BLACK COAL		
							110			**N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE** w/ coal streaks and limestone nodules		
										5B 5/1 MEDIUM BLUISH GRAY MEDIUM GRAIN SANDSTONE w/ black coal streaks		
12	NQ2	115.0	125.0		10	100	115			**5B 5/1 MEDIUM BLUISH GRAY MEDIUM GRAIN SANDSTONE** w/ limestone nodules (1 1/2") @ 116.8' to 117.4'		
							120					
										10YR 4/4 DARK YELLOWISH BROWN MEDIUM GRAIN SANDSTONE w/ limonitic vugs		
										5B 5/1 MEDIUM BLUISH GRAY MEDIUM		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: FA-8

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **FA-8** DATE **7/20/15** SHEET **6** OF **7**

PROJECT **CARDINAL FLY ASH DAM** BORING START **3/8/04** BORING FINISH **3/23/04**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										GRAIN SANDSTONE w/ coal streaks		
13	NQ2	125.0	135.0		10	100	125			**5B 5/1 MEDIUM BLUISH GRAY MEDIUM GRAIN SANDSTONE**		
										10YR 4/4 DARK YELLOWISH BROWN MEDIUM to COARSE GRAIN SANDSTONE		
										N5 MEDIUM GRAY MEDIUM to COARSE GRAIN SANDSTONE w/ coal streaks and limestone nodules in bottom 3.0'		
							130					
14	NQ2	135.0	145.0		10	97	135			**N6 MEDIUM LIGHT GRAY COARSE to MEDIUM GRAIN SANDSTONE** w/ coal streaks and limestone nodules in bottom 1.5'		
							140					
										N4 MEDIUM DARK GRAY FINE GRAIN SHALEY SANDSTONE		
15	NQ2	145.0	155.0		10	100	145			**N5 MEDIUM GRAY SANDY SHALE**		
										N5 MEDIUM GRAY SHALEY FINE GRAIN SANDSTONE		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: FA-8

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **FA-8** DATE **7/20/15** SHEET **7** OF **7**

PROJECT **CARDINAL FLY ASH DAM** BORING START **3/8/04** BORING FINISH **3/23/04**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
												NOTE: Had to set 31.6' of 6" casing before using roller bit in hole.
										N5 MEDIUM GRAY SHALE		
							155					

AEP CD_FA_DAM.GPJ AEP.GDT 7/20/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0622

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 836,291.1 E 2,514,223.8**

GROUND ELEVATION **1159.2** SYSTEM

Water Level, ft			
TIME			
DATE			

BORING NO. **CA-0622** DATE **7/17/15** SHEET **1** OF **16**

BORING START **4/10/06** BORING FINISH **6/1/06**

PIEZOMETER TYPE WELL TYPE

HGT. RISER ABOVE GROUND **2.281** DIA

DEPTH TO TOP OF WELL SCREEN **354.9** BOTTOM **359.9**

WELL DEVELOPMENT BACKFILL

FIELD PARTY **DLB / MCR / MWJ** RIG **D-120**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
		0.0	10.0									**GROUNDING PROCEDURES NOT IN USE ON THIS BORING. BLIND DRILLED FROM GRADE TO 10' WITH 3 7/8" ROLLER BIT & SET 3" PVC CASING. STARTED CORING AT 10.0'**
							5					
1	NQ	10.0	13.9		3.3		10			**HARD N8 VERY LIGHT GRAY LIMESTONE** w/ 1/2" clay bands in bottom 0.3'		
2	NQ	13.9	18.9		5.0		15			**HARD N8 VERY LIGHT GRAY LIMESTONE**		
										SOFT 5G 6/1 GREENISH GRAY SHALE		
3	NQ	18.9	23.9		4.7					**HARD 5R 4/2 GRAYISH RED SHALE**		

TYPE OF CASING USED

	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0622

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **2** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										5G 6/1 GREENISH GRAY LIMESTONE fractured throughout		
										5GY 6/1 GREENISH GRAY SHALE		
4	NQ	23.9	33.9		9.7					**5B 5/1 MEDIUM BLUISH GRAY SHALE** fractured		
							25			**N7 LIGHT GRAY LIMESTONE**		
										5G 6/1 GREENISH GRAY SHALE		
										5G 6/1 GREENISH GRAY LIMESTONE fractured		
							30			**5G 6/1 GREENISH GRAY SHALE**		
										HARD 5B 5/1 MEDIUM BLUISH GRAY SHALEY LIMESTONE		
5	NQ	33.9	43.9		9.8					**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALEY LIMESTONE** fractured in bottom 1.5'		
							35					
							40					
6	NQ	43.9	46.9		3.0					**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALEY LIMESTONE**		
							45					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0622

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **3** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
7	NQ	46.9	53.9		7.0		50					
										5B 5/1 MEDIUM BLUISH GRAY SHALE		
8	NQ	53.9	63.9		9.6		55			**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALEY LIMESTONE**		
										HARD N5 MEDIUM GRAY SHALEY LIMESTONE		
9	NQ	63.9	73.9		10.0		60					
							65			**HARD 5B 5/1 MEDIUM BLUISH GRAY to N6 MEDIUM LIGHT GRAY SHALE**		
							70			**HARD N4 MEDIUM DARK GRAY SHALE** small coal band @ 73.8		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0622

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **4** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
10	NQ	73.9	83.9		10.0		75			**HARD N6 MEDIUM LIGHT GRAY SHALE** w/ coal band @ 74.4, angle fracture @ 75.7		
							80			**SOFT N4 MEDIUM DARK GRAY SHALE**		
										HARD N2 GRAYISH BLACK SHALE		
										COAL		
										HARD 5B 5/1 MEDIUM BLUISH GRAY SHALE		
11	NQ	83.9	93.9		10.0		85			**HARD N5 MEDIUM GRAY SHALE**		
							90			**HARD 5B 7/1 LIGHT BLUISH GRAY MIXED w/ N6 MEDIUM LIGHT GRAY SHALE** w/ limestone nodules		
12	NQ	93.9	103.9		10.0		95			**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0622

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **5** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										HARD 5B 7/1 LIGHT BLUISH GRAY SHALE w/ sandstone streaks, angle fracture @ 98.5		
							100					
13	NQ	103.9	113.9		10.0					**HARD N6 MEDIUM LIGHT GRAY SHALE** w/ sandstone streaks, bottom 0.5 carbonious		
							105					
							110					
										N8 VERY LIGHT GRAY LIMESTONE		
										HARD N3 DARK GRAY SHALE		
										N7 LIGHT GRAY LIMESTONE w/ 0.2 5B 5/1 medium bluish gray shale band @ 111.6		
14	NQ	113.9	123.9		10.0					**N7 LIGHT GRAY LIMESTONE**		
							115			**HARD 5GY 4/1 DARK GREENISH GRAY SHALE**		
										5GY 4/1 DARK GREENISH GRAY SHALE		
							120			**HARD N6 MEDIUM LIGHT GRAY SHALE** w/ sandstone streaks		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0622

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **6** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
15	NQ	123.9	133.9		10.0		125			**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALE** bottom 0.8 N3 dark gray carbonious		
							130			**N5 MEDIUM GRAY FINE GRAIN SANDSTONE** w/ shale band		
16	NQ	133.9	143.9		10.0		135			**HARD N5 MEDIUM GRAY SHALE**		
							140			**COAL** w/ hard shale bands		
										N4 MEDIUM DARK GRAY SHALE w/ 0.5 of carbonious shale at 142.0, bottom 1.9 hard		
17	NQ	143.9	153.9		10.0					**HARD N6 MEDIUM LIGHT GRAY SHALE**		
							145			**N8 VERY LIGHT GRAY LIMESTONE**		
										HARD N6 MEDIUM LIGHT GRAY SHALE		
										N8 VERY LIGHT GRAY LIMESTONE w/ 0.3 shale bands @ 147.8 & 152.4		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0622

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **7** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
18	NQ	153.9	163.9		6.2	68	155			**HARD N6 MEDIUM LIGHT GRAY LIMESTONE**		**SWL 21.4' on 04/17/06 w/ NQ HOLE TO 153.9'. USED ±4,000 GALS. WATER TO THIS POINT**
										HARD N6 MEDIUM LIGHT GRAY FRACTURED LIMESTONE		
										HARD N5 MEDIUM GRAY SHALE/LIMESTONE		
										SOFT N5 MEDIUM GRAY SHALE/LIMESTONE		**LOST ALL WATER RETURN AT 157.8'. HYD. PUSH - NO ROTATION FROM 163.9' - 165.9' (VOID)**
										HARD N5 MEDIUM GRAY SHALE/LIMESTONE		
							160					
19	NQ	163.9	168.9		1.9	84				**VOID**		
							165					
										SOFT 5B 5/1 MEDIUM BLUISH GRAY SHALE		
20	NQ	168.9	170.9		1.3	0				**SOFT N5 MEDIUM GRAY SHALE** wet		
							170					**Stopped after going through mine void. Started drilling HW casing and cleaning inside of casing w/ 4" roller bit. At 155', roller bit broke off inside casing. It was decided to abandon and grout this boring. Moved east +/- 5" and started drilling new boring w/ 6" air**
21	NQ	170.9	178.9		7.9	67				**HARD N6 MEDIUM LIGHT GRAY SHALE**		
										SOFT N4 MEDIUM DARK GRAY SHALE fractures throughout		
										HARD N6 MEDIUM LIGHT GRAY SHALE fractured		
							175					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0622

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **8** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										HARD N7 LIGHT GRAY SHALE		**hammer and inserted HW casing to bottom old mine floor @ 173.3'. This boring was drilled through mine piller; no camera work done on this boring. Coal seam estimated @ +/- 165.0'-17**
22	NQ	178.9	186.9		6.6	56				**SOFT N7 LIGHT GRAY SHALE** w/ fracture		
							180			**SOFT N6 MEDIUM LIGHT GRAY SHALE**		
										SOFT N6 MEDIUM LIGHT GRAY SHALE w/ fracture, wet		
										HARD N7 LIGHT GRAY SHALE dry		
										N7 LIGHT GRAY CLAY SHALE dry		
										HARD N7 LIGHT GRAY CLAY SHALE		
							185			**N4 MEDIUM DARK GRAY SHALE**		
23	NQ	186.9	189.4		2.5	88				**VERY HARD N6 MEDIUM LIGHT GRAY SHALE** w/ trace of fine limestone		**Resumed coring and logging core @ 186.9'**
24	NQ	189.4	194.4		5.0	40				**N5 MEDIUM GRAY SHALE** fracture, wet		
							190			**N6 MEDIUM LIGHT GRAY SHALE/LIMESTONE**		
										SOFT MEDIUM GRAY SHALE wet		
										MEDIUM LIGHT GRAY SHALE		
										SOFT N5 MEDIUM GRAY SHALE moist		
25	NQ	194.4	204.4		10.0	83				**5B 5/1 MEDIUM BLUISH GRAY SHALE**		
							195			**HARD N5 MEDIUM GRAY SHALE** fracture		
										HARD N5 MEDIUM GRAY SHALE		
							200					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0622

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **9** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										N5 MEDIUM GRAY SHALE fracture, wet		
										HARD N5 MEDIUM GRAY SHALE		
26	NQ	204.4	214.4		8.7	64				**HARD N4 MEDIUM DARK GRAY SHALE**		
							205			**5G 6/1 GREENISH GRAY SHALE** w/trace of fine imestone, wet		
										N2 GRAYISH BLACK SHALE fractured		
										SOFT N4 MEDIUM DARK GRAY SHALE		
										N2 GRAYISH BLACK SHALE fracture		
										N5 MEDIUM GRAY SHALE fracture, wet		
							210					
										5G 6/1 GREENISH GRAY SHALE		
										5G 6/1 GREENISH GRAY SHALE wet		
27	NQ	214.4	219.4		5.0	66				**5GY 6/1 GREENISH GRAY SHALE/LIMESTONE**		
							215					
										N5 MEDIUM GRAY SHALE		
										SOFT 5YR 6/1 LIGHT BROWNISH GRAY SANDY SHALE		
28	NQ	219.4	229.4		9.9	81				**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALE** w/limestone fractures		
							220					
										5B 5/1 MEDIUM BLUISH GRAY SHALE w/limestone		
							225					
										N4 MEDIUM DARK GRAY SHALE fractured, wet		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0622

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **10** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
29	NQ	229.4	238.8				230			**5B 5/1 MEDIUM BLUISH GRAY SHALE/ LIMESTONE** fracture		
										N4 MEDIUM DARK GRAY SHALE fractured		
										HARD MEDIUM DARK GRAY SHALE w/limestone		
							235			**MEDIUM DARK GRAY LIMESTONE** shale fractures		
										HARD DARK GRAY LIMESTONE		
30	NQ	238.8	244.4							**HARD N4 MEDIUM DARK GRAY SHALE**		
							240			**N2 GRAYISH BLACK COAL** fracture		
										SOFT N4 MEDIUM DARK GRAY SHALE		
										HARD N4 MEDIUM DARK GRAY SHALE/LIMESTONE		
31	NQ	244.4	254.4							**5B 5/1 MEDIUM BLUISH GRAY SHALE**		
							245			**5B 5/1 MEDIUM BLUISH GRAY SHALE** w/limestone fractures		
										SOFT 5GY 6/1 GREENISH GRAY SHALE w/limestone, wet		
							250			**N5 MEDIUM GRAY & 5YR 4/1 BROWNISH GRAY SHALE**		
										5B 5/1 MEDIUM BLUISH GRAY SHALE		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0622

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **11** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
32	NQ	254.4	264.4				255			**SOFT MEDIUM BLUISH GRAY SHALE**		
							260			**HARD 5GY 6/1 GREENISH GRAY SHALE** w/fractures of limestone		
										5YR 4/1 BROWNISH GRAY RED SHALE		
										MEDIUM BLUISH GRAY SHALE w/fractures of limestone		
33	NQ	264.4	274.4				265			**N4 MEDIUM DARK GRAY SHALE**		
							270			**SOFT N4 MEDIUM DARK GRAY SHALE** wet		
34	NQ	274.4	284.4				275			**SOFT N4 MEDIUM DARK GRAY SHALE**		
										N7 LIGHT GRAY & N4 MEDIUM DARK GRAY SHALE w/trace of limestone		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0622

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **12** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										N4 MEDIUM DARK GRAY SHALE/LIMESTONE		
										HARD SHALE		
35	NQ	284.4	294.4				285			**N4 MEDIUM DARK GRAY SHALE** w/fractures of limestone		
										HARD N3 DARK GRAY SHALE		
							290					
36	NQ	294.4	304.4							**HARD N4 MEDIUM DARK GRAY SHALE**		
							295					
							300					
37	NQ	304.4	314.4		10.0	100						
							305					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0622

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **13** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							310					
38	NQ	314.4	324.4		10.0		315			**N4 MEDIUM DARK GRAY SHALE**		
										N4 MEDIUM DARK GRAY & N6 MEDIUM LIGHT GRAY SHALE w/fine sandstone		
							320			**N4 MEDIUM DARK GRAY SHALE** w/traces of fine standstone lens		
										N5 MEDIUM GRAY SHALE w/trace of fine sandstone		
39	NQ	324.4	334.4		10.0		325			**HARD MEDIUM GRAY & MEDIUM DARK GRAY SHALE** w/trace of coarse sandstone		
							330			**N5 MEDIUM GRAY COARSE GRAIN SANDSTONE**		
										HARD N3 DARK GRAY SHALE w/trace of sandstone		
										N5 MEDIUM GRAY COARSE GRAIN		**MORGANTOWN**

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0622

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **14** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										SANDSTONE Morgantown sandstone starts @ 331.5'		**SANDSTONE STARTS @ 331.5'**
40	NQ	334.4	344.4		10.0		335			**N6 MEDIUM LIGHT GRAY SANSDSTONE**		
										HARD N3 DARK GRAY SHALE w/trace of fine sandstone		
										N2 GRAYISH BLACK SHALE		
							340					
										N5 MEDIUM GRAY COARSE GRAIN SANDSTONE		
										HARD N2 GRAYISH BLACK SHALE w/trace of fine sandstone		
41	NQ	344.4	354.4		9.8	92	345			**N5 MEDIUM GRAY COARSE GRAIN SANDSTONE** w/trace of dark shale		
										HARD N4 MEDIUM DARK GRAY SHALE w/trace of fine sandstone		
							350					
										MEDIUM GRAY SANDSTONE w/dark shale fractures		
42	NQ	354.4	364.4		9.7	91	355			**N6 MEDIUM LIGHT GRAY COARSE GRAIN SANDSTONE**		
										GRAYISH BLACK COAL fracture		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0622

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **15** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										N6 MEDIUM LIGHT GRAY COARSE GRAIN SANDSTONE		
							360			**N5 MEDIUM GRAY SHALE**		
43	NQ	364.4	373.4		10.0	90	365			**N6 MEDIUM LIGHT GRAY SILTSTONE**		
							370					
										HARD N5 MEDIUM GRAY SHALE		
44	NQ	373.4	383.4		10.0	81				**HARD N3 DARK GRAY CLAY SHALE**		
							375					
										N2 GRAYISH BLACK CLAY SHALE SEAM		
										N1 BLACK COAL SEAM		
										HARD N5 MEDIUM GRAY CLAY SHALE		
							380					
												STOPPED BORING

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0622

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **16** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
												@ 383.4'. SET 1" GEOMON WELL

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-6

JOB NUMBER

COMPANY **OHIO POWER COMPANY**

PROJECT **TIDD ASH POND SITE INVESTIGATION**

COORDINATES **N 831,918.6 E 2,156,681.5**

GROUND ELEVATION **1008.6** SYSTEM **STATE PLANE**

WATER LEVEL	52.7		
TIME			
DATE	7-30-90		

BORING NO. **90CA22** DATE SHEET **1** OF **4**

BORING START **07/23/90** BORING FINISH **08/09/90**

PIEZOMETER TYPE WELL TYPE **GM**

HGT. RISER ABOVE GROUND **1.9** DIA **1.0**

DEPTH TO TOP OF WELL SCREEN **220.6** BOTTOM **222.6**

WELL DEVELOPMENT BACKFILL **BENSEAL**

FIELD PARTY **MCR-JD** RIG **B-61**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
1	NQ	0.0	5.9									WATER RETURNED AFTER SEATING CASING.
							5					
							10					
							15					
							20			GRAY SILTY CLAYSHALE Calcareous, vertical cracks 20.8-21.1, 21.6-21.8		
							25			GRAY SHALEY LIMESTONE Hard.		
2	NQ	25.6	30.4		4.8	59				GRAY SILTY SANDSTONE V-fine grain.		
										GRAY LIMESTONE Hard, stain on joints and vertical cracks.		
3	NQ	30.4	40.4		10.0	77	30			GRAY TO BLACK CLAYSHALE		
										GRAY SILTY SANDSTONE F-fine grain.		
							35			vertical cracks		
										GRAY LIGHT GRAY CLAYSHALE Slightly sandy, calcareous.		
4	NQ	40.4	50.4		10.0	45	40			LIGHT GRAY SANDSTONE Silt crossbedding throughout, thin bedding at 43.1		
										GRAY TO LIGHT TO DARK GRAY CLAYSHALE Broken slightly calcareous.		
							45			LIGHT GRAY LIMESTONE Vertical fracture from 46.0-46.9, calcite filled.		
										GRAY SANDY CLAYSHALE Broken, silty,		

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
X	NW CASING	3"
	SW CASING	6"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **JD**

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-6

JOB NUMBER

COMPANY **OHIO POWER COMPANY**

PROJECT **TIDD ASH POND SITE INVESTIGATION**

BORING NO. **90CA22** DATE SHEET **2** OF **4**

BORING START **07/23/90** BORING FINISH **08/09/90**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
5	NQ	50.4	60.4		9.3	78				slightly calcareous.		
										DEEP MAROON PURPLE CLAYSHALE Blocky, slightly calcareous, slightly weathered.		
							55			LIGHT GREEN TO LIGHT GRAY CLAYSHALE Slightly broken.		
										LIGHT TAN TO LIGHT GRAY SANDSTONE Fine grain, silt bedding throughout.		
6	NQ	60.4	65.4		4.7	37	60					
										RUST BROWN CLAYSHALE Iron precipitate staining throughout, broken, slightly sandy to very sandy, fine grained sand.		
7	NQ	65.4	70.4		5.0	27	65					
										LIGHT GRAY SANDSTONE Very fine grain, silt partings and cross bedding throughout.		
8	NQ	70.4	75.4		5.0	27	70			LIGHT GRAY CLAYSHALE Slightly sandy, silty.		
							75			SILTY CLAYSHALE Soft, crack, appears to have been very plastic in the drill bit.		
9	NQ	75.4	80.4		4.7	25				LIGHT TO MEDIUM GRAY LIMESTONE Slightly sandy.		
										MEDIUM GRAY LIMESTONE Slightly shaley.		
10	NQ	80.4	90.4		9.9	79	80			GRAY CLAYSHALE Some silt bedding.		
							85			GRAY SILTY CLAYSHALE Limestone nodules throughout, hard.		
11	NQ	90.4	100.4		10.0	84	90			GRAY CLAYSHALE Hard, with traces of limestone throughout, fine grain sand throughout.		
							95			VERY BROKEN 97.2-97.8		
12	NQ	100.4	110.4		10.0	66	100					
							105					
13	NQ	110.4	120.4		9.5	52	110			LIGHT GRAY SANDSTONE Fine grain, silty, crossbedding.		
										LIGHT GRAY LIMESTONE Highly calcareous,		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-6

JOB NUMBER _____

COMPANY **OHIO POWER COMPANY** BORING NO. **90CA22** DATE _____ SHEET **3** OF **4**

PROJECT **TIDD ASH POND SITE INVESTIGATION** BORING START **07/23/90** BORING FINISH **08/09/90**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										very hard, some silty bedding.		
							120					
14	NQ	120.4	130.4		9.8	71				**LIGHT GRAY SLIGHTLY SANDY SHALEY LIMESTONE** SOME THIN SANDSTONE LENSES., VERY CALCAREOUS STREAKS THROUGHOUT,LIMESTONE BECOMING V=VERY SANDY WITH DEPTH, LIMESTONE IS VERY SILTY.		
							125					
							130					
15	NQ	130.4	140.4		10.0	83						
							135					135.5 TOP OF SEAL.
							140					
16	NQ	140.4	150.4		10.0	100				**GRAY LIGHT GRAY SILTY SHALE** Silt cross bedding throughout.		
							145					144.2 TOP OF SAND.
							150			**LIGHT GRAY SANDSTONE** Coarse grain, siltstone lenses at 148.4-148.6 and 151.1-151.3 some micaceous partings throughout.		
17	NQ	150.4	160.4		10.0	100						
							155					
							160					
18	NQ	160.4	170.4		10.0	100						
							165					
							170					
19	NQ	170.4	180.4		10.0	100						
							175					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-6

JOB NUMBER

COMPANY **OHIO POWER COMPANY** BORING NO. **90CA22** DATE SHEET **4** OF **4**

PROJECT **TIDD ASH POND SITE INVESTIGATION** BORING START **07/23/90** BORING FINISH **08/09/90**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
20	NQ	180.4	190.4		9.5	95						
							185					
							190			SOME MICACEOUS PARTINGS		
21	NQ	190.4	200.4		10.0	100						
							195					
							200					
23	NQ	200.4	210.4		8.7	87						
							205			THIN COAL LENSES AT 205.1-205.5 BECOMING MORE BROKEN BELOW 205.5		
							210					
24	NQ	210.4	215.4		4.6	92				BOTTOM OF MORGANTOWN SANDSTONE		
										SANDY LIMESTONE CONGLOMERATE		
							215					
25	NQ	215.7	225.7		10.0	100						
										SANDSTONE Fine grain, calcareous.		
							220					220.4 CHECL VALVE. 221.0 TOP OF SCREEN.
							225					223.0 BOTTOM OF SCREEN. 224.0 BOTTOM OF SAND.
26	NQ	225.7	230.2		4.5	100				SANDSTONE V-fine grain, calcareous, silt crossbedding throughout.		
							230					230.0 BOTTOM OF SEAL.

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-10

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL PLANT**

COORDINATES **N 829,994.0 E 2,518,683.2**

GROUND ELEVATION **1031.0** SYSTEM **STATE PLANE**

Water Level, ft	249.0'	117.0'	
TIME			
DATE	8-9-85	8-10-85	

BORING NO. **85W-3** DATE **7/20/15** SHEET **1** OF **11**

BORING START **8/9/85** BORING FINISH **8/13/85**

PIEZOMETER TYPE WELL TYPE **GM**

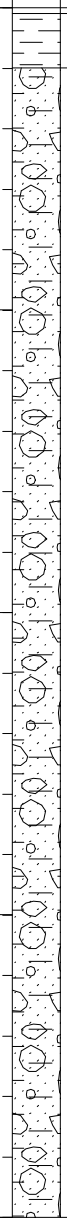
HGT. RISER ABOVE GROUND **2.42** DIA **.75**

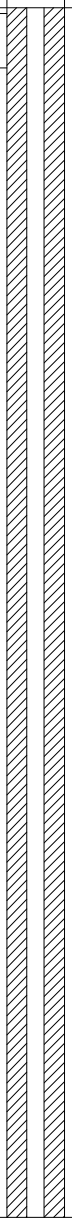
DEPTH TO TOP OF WELL SCREEN **229.5** BOTTOM **230.5**

WELL DEVELOPMENT BACKFILL **GROUT**

FIELD PARTY **B. KGOLLIHUE & TOBY** RIG **ACKER**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
1		0.0	1.0		0.0					**BROWN TOPSOIL**		
2		1.0	40.0		0.0					**COAL AND SHALE**, FILL		
							5					
							10					
							15					





TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
X	NW CASING	3"
X	SW CASING	6"
	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-10

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **85W-3** DATE **7/20/15** SHEET **2** OF **11**

PROJECT **CARDINAL PLANT** BORING START **8/9/85** BORING FINISH **8/13/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							25					
							30					
							35					
										BROWN WEATHERED SHALE		
3	NW	40.0	45.0		5.0		40			**BROWN AND GRAY SANDY SHALE**, BROKEN		
4	NW	45.0	55.0		10.0		45					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-10

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **85W-3** DATE **7/20/15** SHEET **3** OF **11**

PROJECT **CARDINAL PLANT** BORING START **8/9/85** BORING FINISH **8/13/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										GRAY FINE SANDSTONE,SHALE SEAMS, BROKEN		
							50					
										DARK GRAY SANDY SHALE, BROKEN		
5	NW	55.0	65.0		10.0		55					
							60					
										GRAY FINE SANDSTONE, BROKEN		
6	NW	65.0	75.0		10.0		65					
							70					
										GRAY SANDY SHALE, WITH SMALL CLAY SEAMS		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-10

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **85W-3** DATE **7/20/15** SHEET **4** OF **11**

PROJECT **CARDINAL PLANT** BORING START **8/9/85** BORING FINISH **8/13/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							75					
7	NW	75.0	85.0		10.0					**LIGHT GRAY FINE SANDSTONE** BROKEN		
							80			**DARK GRAY CLAYSTONE**		
8	NW	85.0	95.0		10.0		85					
							90					
9	NW	95.0	105.0		10.0		95					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-10

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **85W-3** DATE **7/20/15** SHEET **5** OF **11**

PROJECT **CARDINAL PLANT** BORING START **8/9/85** BORING FINISH **8/13/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							100					
										GRAY AND RED SILTY SHALE, BROKEN		
10	NW	105.0	115.0		10.0		105					
										GRAY SILTY SHALE		
							110					
11	NW	115.0	125.0		10.0		115			**GRAY LIMESTONE**, HARD		
							120					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-10

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **85W-3** DATE **7/20/15** SHEET **6** OF **11**

PROJECT **CARDINAL PLANT** BORING START **8/9/85** BORING FINISH **8/13/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
12	NW	125.0	135.0		10.0		125					
							130					
13	NW	135.0	145.0	.	10.0		135					
							140					
14	NW	145.0	155.0		10.0		145					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-10

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **85W-3** DATE **7/20/15** SHEET **7** OF **11**

PROJECT **CARDINAL PLANT** BORING START **8/9/85** BORING FINISH **8/13/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										GRAY AND RED SILTY SHALE		
15	NW	155.0	165.0		10.0		155					
							160					
16	NW	165.0	175.0		10.0		165					
							170			**GRAY COARSE SANDSTONE**		171.5 TOP OF SEAL.
17	NW	175.0	185.0		10.0		175					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-10

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **85W-3** DATE **7/20/15** SHEET **8** OF **11**

PROJECT **CARDINAL PLANT** BORING START **8/9/85** BORING FINISH **8/13/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
												178.0 TOP OF SAND.
							180					
							185					
18	NW	185.0	195.0		10.0							
							190					
							195					
19	NW	195.0	205.0		10.0							
							200					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-10

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **85W-3** DATE **7/20/15** SHEET **9** OF **11**

PROJECT **CARDINAL PLANT** BORING START **8/9/85** BORING FINISH **8/13/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
20	NW	205.0	215.0		10.0		205					
							210					
21	NW	215.0	225.0		10.0		215					
							220					
22	NW	225.0	235.0		10.0		225					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-10

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **85W-3** DATE **7/20/15** SHEET **10** OF **11**

PROJECT **CARDINAL PLANT** BORING START **8/9/85** BORING FINISH **8/13/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							230					228.9 CHECK VALVE. 229.5 TOP OF SCREEN. 230.5 BOTTOM OF SCREEN.
23	NW	235.0	245.0		10.0		235					237.0 BOTTOM OF SAND.
										GRAY LIMEY SHALE, VERY HARD, BROKEN		
							240					
24	NW	245.0	255.0		10.0		245					
							250					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: M-10

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **85W-3** DATE **7/20/15** SHEET **11** OF **11**

PROJECT **CARDINAL PLANT** BORING START **8/9/85** BORING FINISH **8/13/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
25	NW	255.0	265.0		10.0		255					
							260					
		265.0	265.0				265					

AEP CD SI.GPJ AEP.GDT 7/20/15

Geosyntec consultants (engineers | scientists | innovators)	**Client:** AEP-Cardinal **Project:** CHE8126L **Address:** 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No.** M-GS-1 **Page:** 1 of 10

Drilling Start Date:	**03/11/2016 14:00**	Boring Depth (ft):	**198**	Well Depth (ft):	**132**
Drilling End Date:	**03/17/2016 15:00**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**988.68**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**991.87**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 832,687.2 E 2,518,763.6**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
0									Overburden: No sample recovered with coring wireline rig.		0
5											5
10											10
15									(15') ROCK: No sample recovered with coring wireline rig.		15
20											20

NOTES:

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Drilling Start Date:	**03/11/2016 14:00**	Boring Depth (ft):	**198**	Well Depth (ft):	**132**
Drilling End Date:	**03/17/2016 15:00**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**988.68**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**991.87**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 832,687.2 E 2,518,763.6**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
20				Run 1			153/ 156	41	(20') CLAYSTONE: moderately strong to weak, greenish gray (5G 6/1), massive to slightly fissile, clay infillings in fractures, moderately to highly decomposed, slightly disintegrated, intensely fractured.		20
									(23.5') SANDSTONE: strong to very strong, medium light gray (N6), fine grained, slightly micaceous, minor cross bedding to massive, competent, fresh, unfractured, bottom 0.5 ft of sandstone - intensely fractured, moderately decomposed, clay infillings in fractures, few small limestone nodules at bottom of unit.		
25											25
									(27.4') CLAYSTONE: moderately strong to weak, greenish gray (5G 6/1), massive to slightly fissile, clay infillings in fractures, moderately decomposed, intensely disintegrated, intensely fractured.		
30											30
									(30.6') Silty SHALE: strong, greenish gray (5G 6/1), fissile, slightly decomposed, competent, moderately fractured.		
				Run 2			110/ 180	20	(33') Silty SHALE: strong, greenish gray (5G 6/1), fissile, slightly decomposed, competent, intensely fractured.		
35									(34.8') Very fissile, highly decomposed, moderately disintegrated, weak.		35
									(37') Clayey LIMESTONE: moderately strong to strong, dark greenish gray (5G 4/1), massive to nodular, moderately fractured, microcrystalline, slightly decomposed, moderately disintegrated.		
40											40

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-1** **Page: 3 of 10**

Drilling Start Date:	**03/11/2016 14:00**	Boring Depth (ft):	**198**	Well Depth (ft):	**132**
Drilling End Date:	**03/17/2016 15:00**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**988.68**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**991.87**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 832,687.2 E 2,518,763.6**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
40											40
									(41.4') Sandy CLAYSTONE: weak to very weak, dark greenish gray (5G 4/1), massive, highly decomposed, intensely fractured.		
45											45
				Run 3			65/96	15	(48') CLAYSTONE: strong, dark greenish gray (5G 4/1), massive, fissile for first 0.5 ft, slightly decomposed, slightly disintegrated, intensely fractured, very intensely fractured for frist 0.5 ft.		
50									(51.3') Highly decomposed (4 inch thick).		50
									(52.3') Highly decomposed (3 inch thick).		
									(52.9') Highly decomposed (3 inch thick).		
55											55
				Run 4			70/84	42	(56') CLAYSTONE: moderately strong to strong, variegated colors of dark reddish brown (10YR 3/4), light olive brown (5Y 5/6) and light olive gray (5Y 5/2), massive, slightly decomposed, slightly disintegrated, slightly to moderately fractured, sandy lenses occasionally.		
									(57') Color changes to dark greenish gray (5G 4/1).		
60											60

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	BORING LOG Boring/Well No. M-GS-1 Page: 4 of 10

Drilling Start Date:	03/11/2016 14:00	Boring Depth (ft):	198	Well Depth (ft):	132
Drilling End Date:	03/17/2016 15:00	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	988.68	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	991.87	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 832,687.2 E 2,518,763.6	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
60									(59.8') Changes to moderately strong, slickensides, moderately decomposed, sand grades out, intensely fractured. (61.2') 1 inch limestone band.		60
				Run 5			109/ 120	48	(63') CLAYSTONE: strong to moderately strong, dark greenish gray (5G 4/1), massive, slightly decomposed, slightly disintegrated, moderately fractured, 2 inch limestone band 0.3 ft from top of Run 5. (63-65') Small, brownish gray nodules (5YR 4/1).		
65									(64.2') Carbonaceous SHALE: strong to moderately strong, dark greenish gray (5G 4/1), with limestone nodules, massive, moderately fractured with few intensely fractured zones, slightly decomposed, slightly disintegrated. (65-73') Large, medium light gray (N6) nodules.		65
70											70
				Run 6			176/ 180	57	(73.7') Fissile, weak, intensely fractured, highly decomposed (0.5 ft layer).		
75									(74.7') CLAYSHALE: strong, dark greenish gray (5GY 4/1), massive, competent, moderately fractured, slightly disintegrated.		75
									(76.6') Carbonaceous SHALE: strong to moderately strong, dark greenish gray (5G 4/1), with less limestone nodules, with calcite veining, massive, moderately fractured with few intensely fractured zones, slightly decomposed, slightly disintegrated. (79') Becomes weak, moderately		
80											80

NOTES:

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Drilling Start Date:	03/11/2016 14:00	Boring Depth (ft):	198	Well Depth (ft):	132
Drilling End Date:	03/17/2016 15:00	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	988.68	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	991.87	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 832,687.2 E 2,518,763.6	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
80									decomposed, fissile, clay infillings in fractures, intensely fractured. (79.7') Silty CLAYSHALE: strong, dark greenish gray (5G 4/1), massive, fresh to slightly decomposed, competent, slightly fractured. (82.7') 1 ft vertical fracture.		80
85											85
				Run 7			168/ 180	34	(88') Sandy SHALE: strong, medium bluish gray (5B 5/1), fissile, fresh, competent, intensely fractured. (89') Changes to massive.		
90											90
									(92.8') LIMESTONE: strong to very strong, medium bluish gray (5B 5/1), massive, microcrystalline to fine grained, some silty parts, moderately fractured to intensely fractured, fresh, slightly disintegrated. (may be calcareous siltstone with interbedded limestone)		
95									(95.3') MUDSTONE: very weak to weak, greenish gray (5GY 6/1), moderately to highly decomposed, very intensely fractured. (96.3') Calcareous SILTSTONE: 0.5 vertical fracture 15 ft from bottom of run, massive to nodular. (see previous limestone description)		95
100											100

NOTES:

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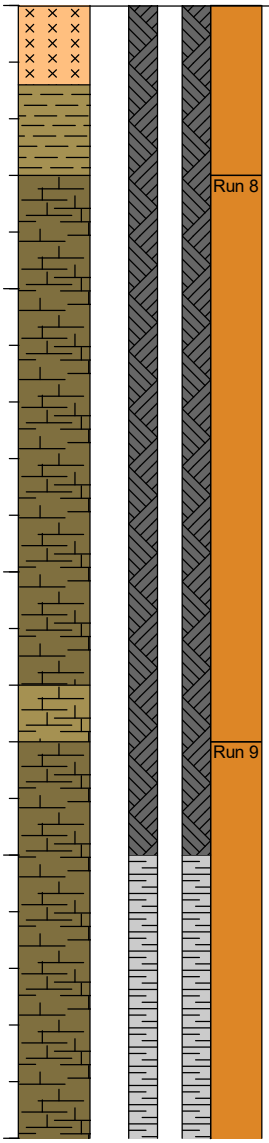
Drilling Start Date:	03/11/2016 14:00	Boring Depth (ft):	198	Well Depth (ft):	132
Drilling End Date:	03/17/2016 15:00	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	988.68	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	991.87	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 832,687.2 E 2,518,763.6	Filter Pack:	#5 Medium Coarse Sand



DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
100											100
									(101.4') MUDSTONE: very weak to weak, greenish gray (5GY 6/1), calcareous, moderately to highly decomposed, very intensely fractured.		
				Run 8			119/ 120	55	(103') CLAYSHALE: strong to moderately strong, dark greenish gray (5G 4/1), moderately fractured, slightly to moderately decomposed, slightly to moderately disintegrated, massive, small limestone nodules throughout.		
105											105
110											110
									(112') CLAYSTONE: moderately strong to weak, dark greenish gray (5G 4/1), very intensely fractured, massive, highly decomposed.		
				Run 9			176/ 180	82	(113') CLAYSHALE: limestone veining also present, locally fissile, fresh to slightly decomposed, competent, slightly to moderately fractured.		
115									(114.4') Thin coal veins occasionally appear.		115
120											120

NOTES:

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Drilling Start Date:	**03/11/2016 14:00**	Boring Depth (ft):	**198**	Well Depth (ft):	**132**
Drilling End Date:	**03/17/2016 15:00**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**988.68**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**991.87**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 832,687.2 E 2,518,763.6**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
120											120
									(120.9') Coal-bearing SHALE: very strong, grayish black (N2) to black (N1), massive, micaceous, fresh, competent, moderately fractured.		
									(122.5') SANDSTONE: strong, medium gray (N5), minor cross bedding, micaceous, competent, fresh, medium grained, slightly fractured to unfractured. [MORGANTOWN]		
125											125
				Run 10			180/ 180	96	(122.5') SANDSTONE: strong, medium gray (N5), few cross beds, micaceous, mostly massive, competent, fresh, medium grained, slightly fractured to unfractured. [MORGANTOWN]		
130											130
135											135
140											140

NOTES:

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Drilling Start Date:	**03/11/2016 14:00**	Boring Depth (ft):	**198**	Well Depth (ft):	**132**
Drilling End Date:	**03/17/2016 15:00**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**988.68**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**991.87**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 832,687.2 E 2,518,763.6**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
140											140
				Run 11			180/ 180	91	(142.5') Intensely fractured. (143') SANDSTONE: strong, medium gray (N5), few cross beds, micaceous, massive, competent, fresh, fine to medium grained, slightly fractured to unfractured. [MORGANTOWN] (144.5') Coal veins increase in appearance, moderately to intensely fractured. (146.5') Coal veins disappear, slightly fractured.		
145											145
150									(151.5') Coal veins appear again, slightly to moderately fractured for rest of Run 11. (153.4') Changes to light gray (N7).		150
155											155
				Run 12			176/ 180	88	(158') SANDSTONE: strong, medium gray (N5), few cross beds, micaceous, massive, competent, fresh, fine to medium grained, slightly to moderately fractured, coal veining		
160											160

NOTES:

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Drilling Start Date:	03/11/2016 14:00	Boring Depth (ft):	198	Well Depth (ft):	132
Drilling End Date:	03/17/2016 15:00	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	988.68	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	991.87	Seal Material(s):	Bentonite Pellets
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DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
160									for top 2 ft of Run 12. [MORGANTOWN] (160.3') Becomes unfractured.		160
165									(164.1') Sandy silty SHALE: moderately strong, medium gray (N5), fresh, competent, laminated, minor coal inclusions, micaceous, massive.		165
									(166.5') Conglomerate SANDSTONE: very light gray (N8) and medium gray (N5) with medium yellowish brown (10YR 5/4) conglomerate, medium gray (N5) clay inclusions and coal veining, fine grained, massive, slightly decomposed to fresh, competent, intensely fractured. [MORGANTOWN]		
170									(168') SANDSTONE: strong, medium dark gray (N5), massive, occasional coal veining, fresh, competent, micaceous, moderately fractured, fine to medium grained. [MORGANTOWN]		170
				Run 13			180/ 180	98	(173') SANDSTONE: strong, medium dark gray (N5), massive, occasional coal veining, fresh, competent, micaceous, slightly to moderately fractured, medium grained, 1 inch coal bed 2 ft from top of run. [MORGANTOWN] (175.5-181.5') Veining disappears. (176.5') Changes to fine grained for 7 ft.		
175											175
180											180

NOTES:

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Drilling Start Date:	03/11/2016 14:00	Boring Depth (ft):	198	Well Depth (ft):	132
Drilling End Date:	03/17/2016 15:00	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	988.68	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	991.87	Seal Material(s):	Bentonite Pellets
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DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
180									(181.5-188') Extensive coal veining.		180
185									(184') Conglomerate SANDSTONE: strong, medium light gray (N6), calcareous, medium grained, coal veins and inclusions, conglomerate (up to 2" long), slightly decomposed, competent, moderately fractured, massive. [MORGANTOWN] (186.6') Silty SHALE: strong, greenish gray (5GY 6/1), fresh, competent, massive, moderately to intensely fractured.		185
				Run 14			120/120	90	(187.8') Limestone nodules. (188') Silty SHALE: strong, greenish gray (5GY 6/1), fresh, competent, massive, slightly fractured, no limestone nodules.		
190											190
195											195
200									End of borehole at 198 ft bgs. Well installed on 04/13/2016, centralizer at 65 ft bgs.		200

NOTES:

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Drilling Start Date:	**03/22/2016 08:30**	Boring Depth (ft):	**209**	Well Depth (ft):	**140**
Drilling End Date:	**03/23/2016 09:45**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**987.62**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**990.81**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Chad Gregory**	Location (X,Y):	**N 832,174.6 E 2,519,357.6**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
0									Overburden: No Recovery with core rig.		0
5											5
									(7.5') ROCK: No Recovery - drillers use roller bit down to 15 ft.		
10											10
15				Run 1			27/36	0	(15') SILTSTONE: strong, light gray to medium dark gray (N4 to N7), moderately decomposed, intensely fractured, few yellowish gray (5Y 8/1) calcareous veins, few fine sandy lenses with minor cross bedding.		15
				Run 2			89/ 108	17	(18') CLAYSTONE: strong, medium gray to grayish black (N5 to N2), yellowish gray limestone nodules, moderately decomposed, intensely fractured.		
20											20

NOTES:

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Drilling Start Date:	03/22/2016 08:30	Boring Depth (ft):	209	Well Depth (ft):	140
Drilling End Date:	03/23/2016 09:45	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	987.62	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	990.81	Seal Material(s):	Bentonite Pellets
Logged By:	Chad Gregory	Location (X,Y):	N 832,174.6 E 2,519,357.6	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
20											20
									(21-24') Changing to medium gray, crumbled, soft, not calcareous.		
									(24-26') Changing to moderately strong, silty, white, calcareous veins.		
25											25
				Run 3			143/ 144	38	(26') SANDSTONE: moderately strong, very light to light gray (N8/N7), very fine grained, silty, massive, intensely fractured, moderately decomposed.		
									(27') SANDSTONE: moderately strong, very light to light gray (N8/N7), very fine grained, silty, massive, intensely fractured, moderately decomposed, with yellowish gray (5Y 8/1) sand inclusions.		
30											30
									(28.5') Sandy CLAYSHALE: moderately strong, medium gray to grayish black, intensely fractured, slightly decomposed.		
									(30') SANDSTONE: moderately strong, very light to light gray (N8/N7), very fine grained, silty, massive, intensely fractured, moderately decomposed, clay infillings in fractures.		
									(30.8') Silty CLAYSHALE: moderately strong, medium gray to grayish black, intensely fractured, moderately decomposed, with yellowish gray sandy inclusions.		
35											35
									(37.5') Fracture with ~1" of soft claystone infilling.		
				Run 4			74/ 120	51	(39') LIMESTONE: strong, medium light gray (N6) to dark greenish gray (5GY 4/1),		
40											40

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-2** **Page: 3 of 11**

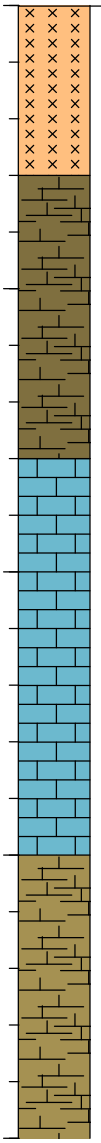
Drilling Start Date:	**03/22/2016 08:30**	Boring Depth (ft):	**209**	Well Depth (ft):	**140**
Drilling End Date:	**03/23/2016 09:45**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**987.62**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**990.81**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Chad Gregory**	Location (X,Y):	**N 832,174.6 E 2,519,357.6**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
40									massive, slightly fractured. (39.5-40') Intensely fractured, moderately decomposed. (42.5-44') Intensely fractured, moderately decomposed.		40
45											45
				Run 5			86/108	45	(48.8') CLAYSTONE: dark greenish gray, calcareous, very soft, easily crumbled. (49') LIMESTONE: strong, medium dark gray (N4), nodular, massive, slightly fractured.		
50											50
									(52') CLAYSHALE: moderately strong, dark gray (N3), moderately fractured, limestone nodules.		
55									(55') Changing to intensely fractured/crumbled.		55
				Run 6			84/84	64	(58') CLAYSTONE: strong, dark gray, yellowish gray calcareous veins. (58.5') Sandy SILTSTONE: moderately strong, medium dark gray, sandy zones light		
60											60

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-2** **Page: 4 of 11**

Drilling Start Date:	**03/22/2016 08:30**	Boring Depth (ft):	**209**	Well Depth (ft):	**140**
Drilling End Date:	**03/23/2016 09:45**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**987.62**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**990.81**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Chad Gregory**	Location (X,Y):	**N 832,174.6 E 2,519,357.6**	Filter Pack:	**#5 Medium Coarse Sand**

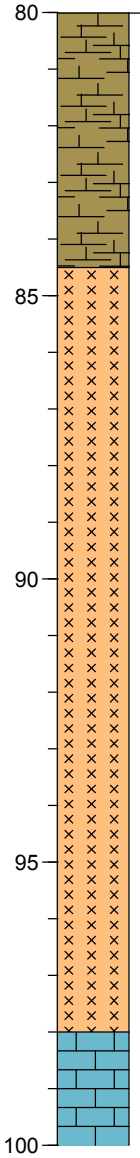


DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
60									gray, moderately fractured, yellowish gray sandy inclusions/veins.		60
									(63') Sandy CLAYSHALE: moderately strong to weak, dark gray (N3), slightly pyritic at 63 ft, intensely fractured.		
65				Run 7			86/96	21			65
									(68') LIMESTONE: strong, dark gray, large light gray nodules (~1" diameter), intensely fractured, moderately decomposed, some clayey infillings in fractures.		
70											70
				Run 8			64/72	36			
75									(75') Silty CLAYSTONE: strong, medium dark gray (N4), intensely fractured, pyritic, limestone nodules, moderately decomposed.		75
				Run 9			162/168	77			
80											80

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** Boring/Well No. M-GS-2 Page: 5 of 11

Drilling Start Date:	03/22/2016 08:30	Boring Depth (ft):	209	Well Depth (ft):	140
Drilling End Date:	03/23/2016 09:45	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	987.62	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	990.81	Seal Material(s):	Bentonite Pellets
Logged By:	Chad Gregory	Location (X,Y):	N 832,174.6 E 2,519,357.6	Filter Pack:	#5 Medium Coarse Sand



DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
80									(82-84.5') White to yellowish gray calcareous veins.		80
85									(84.5') Shaly SILTSTONE: moderately strong, medium bluish gray (5B 5/1), slightly fractured, few calcareous veins - lenses, fresh.		85
90											90
				Run 10			178/ 180	75	(93') Changing to strong.		
95									(95') Changing to moderately to intensely fractured, clay infillings, moderately decomposed 97-98 ft.		95
									(98') Shaly LIMESTONE: strong, massive, microcrystalline, nodular, medium bluish gray (5B 5/1), moderately fractured, slightly decomposed.		
100											100

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** Boring/Well No. M-GS-2 Page: 6 of 11

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Drilling Start Date:	03/22/2016 08:30	Boring Depth (ft):	209	Well Depth (ft):	140
Drilling End Date:	03/23/2016 09:45	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	987.62	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	990.81	Seal Material(s):	Bentonite Pellets
Logged By:	Chad Gregory	Location (X,Y):	N 832,174.6 E 2,519,357.6	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
100											100
									(101.5') CLAYSTONE: dark greenish gray (5G 4/1), weak, soft.		
									(102') Shaly LIMESTONE: strong, massive, microcrystalline, nodular, medium bluish gray (5B 5/1), moderately fractured, slightly decomposed.		
105											105
				Run 11			118/ 120	83			
110											110
									(113') CLAYSHALE: strong, medium dark gray (N4), calcareous, limestone nodules, moderately to intensely fractured, slightly pyritic, less calcareous towards end of run.		
115											115
									(116.5') Changing to grayish black (N2), intensely fractured/crumbled.		
				Run 12			165/ 180	93	(118') Changing to medium bluish gray (5B 5/1), yellowish gray to white calcareous veins.		
120											120

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	**Client:** AEP-Cardinal **Project:** CHE8126L **Address:** 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No.** M-GS-2 **Page:** 7 of 11

Drilling Start Date:	03/22/2016 08:30	Boring Depth (ft):	209	Well Depth (ft):	140
Drilling End Date:	03/23/2016 09:45	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	987.62	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	990.81	Seal Material(s):	Bentonite Pellets
Logged By:	Chad Gregory	Location (X,Y):	N 832,174.6 E 2,519,357.6	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
120											120
									(124') Changing to less calcareous.		
125											125
									(128.8') Coal-bearing SHALE: strong, grayish black (N2), coal lenses black (N1), slightly fractured, slightly decomposed.		
130											130
									(130.8') SANDSTONE: strong, light gray to medium dark gray, slightly fractured, fine to medium grained, thin to medium bedded, micaceous, few black carbonaceous seams. [MORGANTOWN]		
				Run 13			192/ 192	100			
135											135
140											140

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** Boring/Well No. M-GS-2 Page: 8 of 11

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Drilling Start Date:	03/22/2016 08:30	Boring Depth (ft):	209	Well Depth (ft):	140
Drilling End Date:	03/23/2016 09:45	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	987.62	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	990.81	Seal Material(s):	Bentonite Pellets
Logged By:	Chad Gregory	Location (X,Y):	N 832,174.6 E 2,519,357.6	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
140											140
145											145
				Run 14			180/ 180	98			
150											150
155									(157-159') Mud inclusions.		155
160											160

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-2** **Page: 9 of 11**

Drilling Start Date:	**03/22/2016 08:30**	Boring Depth (ft):	**209**	Well Depth (ft):	**140**
Drilling End Date:	**03/23/2016 09:45**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**987.62**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**990.81**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Chad Gregory**	Location (X,Y):	**N 832,174.6 E 2,519,357.6**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
160											160
									(161') Changing to very light gray (N8).		
				Run 15			180/ 180	96			
165											165
170									(170') Alternating between medium gray (N5), massive, and light gray with thinly interbedded black seams.		170
175											175
				Run 16			179/ 180	98			
180									(179.5') Some interbedded conglomerate, few		180

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** Boring/Well No. M-GS-2 Page: 10 of 11

Drilling Start Date:	03/22/2016 08:30	Boring Depth (ft):	209	Well Depth (ft):	140
Drilling End Date:	03/23/2016 09:45	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	987.62	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	990.81	Seal Material(s):	Bentonite Pellets
Logged By:	Chad Gregory	Location (X,Y):	N 832,174.6 E 2,519,357.6	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
180									interbedded siltstone seams, conglomerate dusky brown (5YR 2/2), grayish orange-pink (10R 8/2) to gray. Sandstone primarily massive with some black, very thin coal seams/veins.		180
185											185
									(188') Conglomerate SANDSTONE: grading into medium grained sandstone and very conglomeratic, including coal seams and pieces, few calcareous nodules.		
190									(191') Fracture with coal and pyrite.		190
				Run 17			178/ 180	93	(193.5') Changing to dark greenish gray (5G 4/1).		
195											195
									(196.3') Silty SHALE: strong, medium dark gray (N4), slightly fractured, few thin coal seams.		
200											200

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-2** **Page: 11 of 11**

Drilling Start Date:	**03/22/2016 08:30**	Boring Depth (ft):	**209**	Well Depth (ft):	**140**
Drilling End Date:	**03/23/2016 09:45**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**987.62**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**990.81**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Chad Gregory**	Location (X,Y):	**N 832,174.6 E 2,519,357.6**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
200											200
205											205
									(208') Changing to intensely fractured, claystone infillings.		
									(208.8') CLAYSTONE: moderately strong to weak, dark gray (N3), crumbled.		
210									End of borehole at 209 ft bgs.		210
									Well installed on 04/13/2016, centralizer at 70 ft bgs.		
215											215

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-3** **Page: 1 of 11**

Drilling Start Date:	**03/10/2016 10:25**	Boring Depth (ft):	**203.5**	Well Depth (ft):	**146**
Drilling End Date:	**03/11/2016 12:20**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**997.42**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,000.33**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 830,875.6 E 2,518,721.9**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
0									Overburden: No sample recovered with coring wireline rig.		0
5											5
10									(10.5') ROCK: No sample recovered with coring wireline rig.		10
15				Run 1			49/60	65	(15') SILTSTONE: moderately strong, medium gray (N5), locally fissile, slightly decomposed, moderately fractured. (15.8') SANDSTONE: strong to very strong, medium gray (N4), minor cross bedding, micaceous, medium grained, fresh, competent, slightly fractured. (17.7') CLAYSTONE to CLAYSHALE: weak, medium gray (N5), slightly decomposed, moderately fractured, bottom of unit may be coal-bearing.		15
20											20

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-3** **Page: 2 of 11**

Drilling Start Date:	**03/10/2016 10:25**	Boring Depth (ft):	**203.5**	Well Depth (ft):	**146**
Drilling End Date:	**03/11/2016 12:20**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**997.42**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,000.33**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 830,875.6 E 2,518,721.9**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
20				Run 2			106/ 168	32			20
									(20.5') MUDSTONE: very weak, medium light gray (N6), highly decomposed.		
									(21') SANDSTONE: moderately strong, medium gray (N5), locally silty, massive, unfractured, competent, fresh, fine grained, limestone nodules.		
25									(24.3') SILTSTONE: moderately strong, greenish gray (5GY 6/1), massive, fresh to slightly decomposed, competent, moderately fractured, 0.3 ft into unit - 0.8 ft vertical fracture.		25
									(26.7') CLAYSTONE: strong, very dusky purple (5RP 2/2) and dark greenish gray (5G 4/1), slightly decomposed, slightly disintegrated, intensely fractured, slickensides.		
									(28.4') SILTSTONE: moderately strong, greenish gray (5GY 6/1), massive, fresh to slightly decomposed, competent, moderately fractured.		
30											30
				Run 3			176/ 180	80	(34') CLAYSTONE: moderately strong, medium gray (N4), sandy lenses, massive, minor limestone lenses and veining, fresh, competent, slightly fractured.		
35											35
40											40

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** Boring/Well No. M-GS-3 Page: 3 of 11

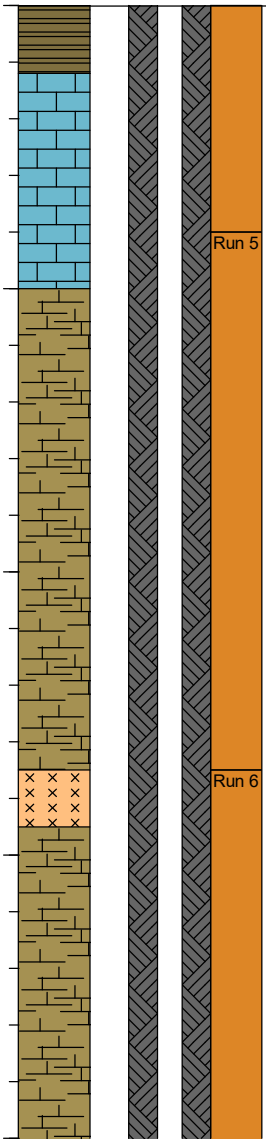
Drilling Start Date:	03/10/2016 10:25	Boring Depth (ft):	203.5	Well Depth (ft):	146
Drilling End Date:	03/11/2016 12:20	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	997.42	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,000.33	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 830,875.6 E 2,518,721.9	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
40											40
45									(45.7') Becomes moderately to intensely fractured, slightly fissile. (46') Highly decomposed MUDSTONE (0.5 ft thick). (47.2') Highly decomposed MUDSTONE for 0.5 ft, very weak, medium dark gray.		45
				Run 4			162/ 180	65	(49') LIMESTONE: very strong to strong, medium light gray (N6), microcrystalline, slightly fractured, fresh to slightly decomposed, competent.		
50											50
55									(55.5') Carbonaceous SHALE: strong, dark greenish gray (5G 4/1), calcareous veins that are very light gray (N8), slightly decomposed, competent to slightly disintegrated, slightly to moderately fractured. (56.3') Changes to moderately to highly decomposed for 0.5 ft.		55
60											60

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-3** **Page: 4 of 11**

Drilling Start Date:	**03/10/2016 10:25**	Boring Depth (ft):	**203.5**	Well Depth (ft):	**146**
Drilling End Date:	**03/11/2016 12:20**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**997.42**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,000.33**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 830,875.6 E 2,518,721.9**	Filter Pack:	**#5 Medium Coarse Sand**

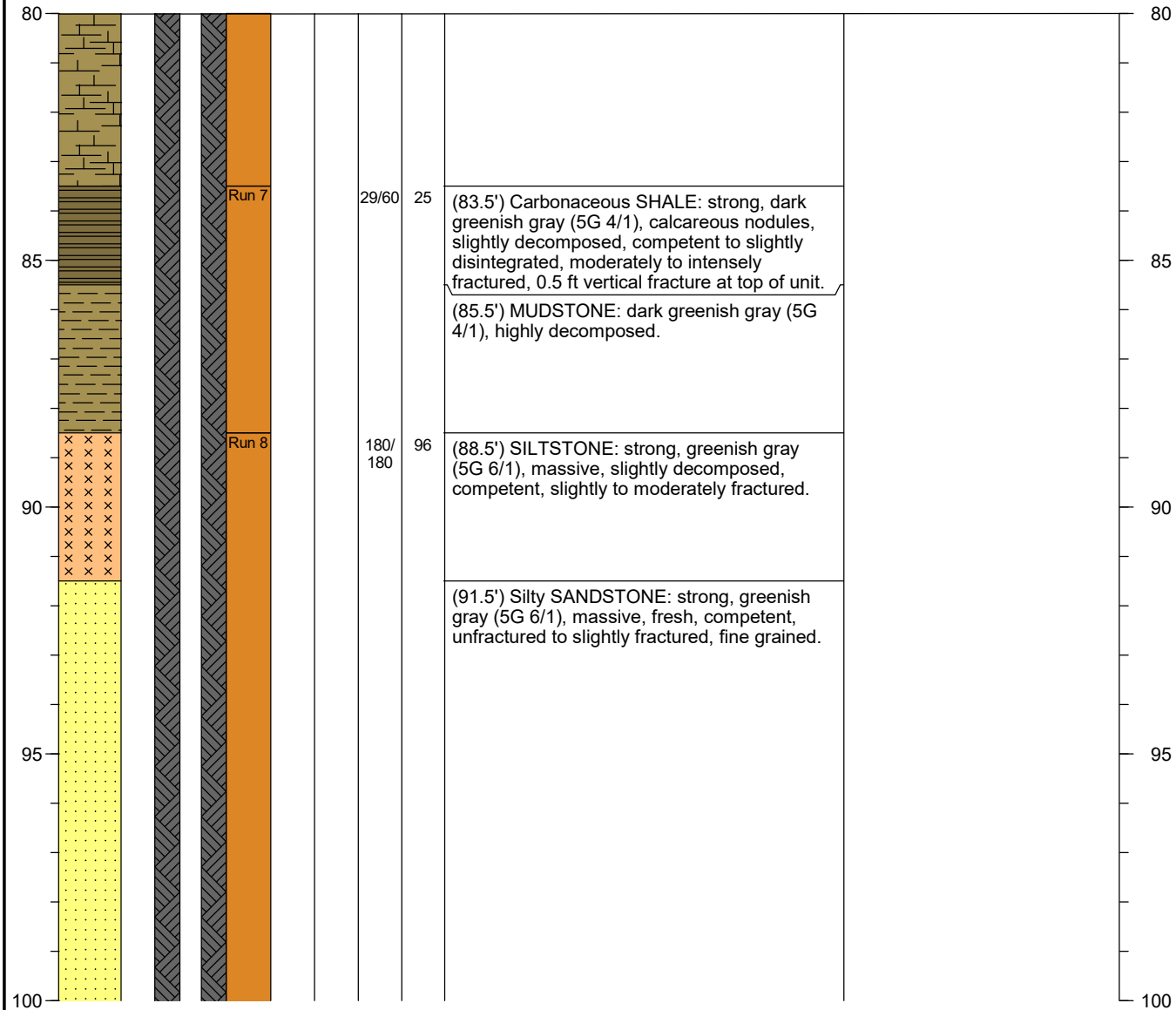


DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
60											60
									(61.2') LIMESTONE: strong, medium light gray (N6), microcrystalline, intensely fractured, moderately decomposed, competent, clay infillings in fractures.		
				Run 5			58/ 114	4	(64') LIMESTONE: strong, medium light gray (N6), microcrystalline, massive to nodular, intensely fractured, moderately decomposed, competent, clay infillings in fractures.		
65									(65') CLAYSTONE to MUDSTONE: moderately strong to weak, grayish red (5R 4/2) and dusky yellow to dark greenish gray (5G 4/1), moderately to intensely decomposed, moderately to intensely disintegrated, intensely to very intensely fractured, slickensides.		65
70											70
				Run 6			78/ 120	15	(73.5') SILTSTONE: moderately strong to strong, greenish gray (5GY 6/1), calcareous nodules, massive, intensely fractured, 80° vertical fracture (0.7 ft long) starting 0.3 ft into unit, slightly decomposed.		
75									(74.5') CLAYSTONE: dark greenish gray (5G 4/1), grades to grayish red purple (5RP 4/2) 1.7 ft into unit, back to (5G 4/1) 4.5 ft into unit, intensely fractured, slightly to moderately decomposed, slickensides.		75
									(77.6') Becomes highly decomposed, very intensely fractured.		
80											80

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	**Client:** AEP-Cardinal **Project:** CHE8126L **Address:** 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No.** M-GS-3 **Page:** 5 of 11

Drilling Start Date:	03/10/2016 10:25	Boring Depth (ft):	203.5	Well Depth (ft):	146
Drilling End Date:	03/11/2016 12:20	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	997.42	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,000.33	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 830,875.6 E 2,518,721.9	Filter Pack:	#5 Medium Coarse Sand

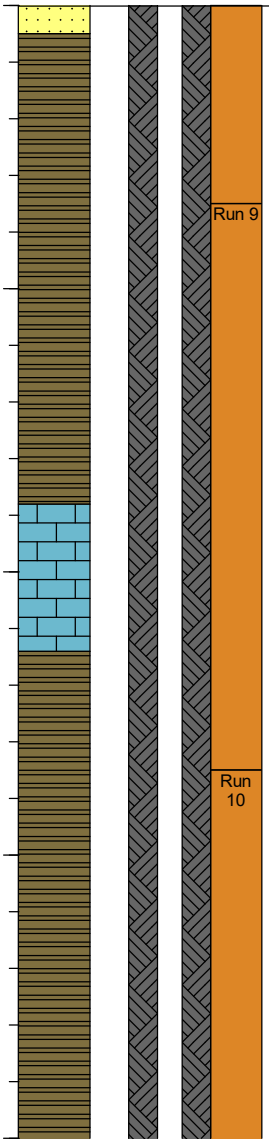


DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
80											80
				Run 7			29/60	25	(83.5') Carbonaceous SHALE: strong, dark greenish gray (5G 4/1), calcareous nodules, slightly decomposed, competent to slightly disintegrated, moderately to intensely fractured, 0.5 ft vertical fracture at top of unit.		
85									(85.5') MUDSTONE: dark greenish gray (5G 4/1), highly decomposed.		85
				Run 8			180/ 180	96	(88.5') SILTSTONE: strong, greenish gray (5G 6/1), massive, slightly decomposed, competent, slightly to moderately fractured.		
90									(91.5') Silty SANDSTONE: strong, greenish gray (5G 6/1), massive, fresh, competent, unfractured to slightly fractured, fine grained.		90
95											95
100											100

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	**Client:** AEP-Cardinal **Project:** CHE8126L **Address:** 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No.** M-GS-3 **Page:** 6 of 11

Drilling Start Date:	03/10/2016 10:25	Boring Depth (ft):	203.5	Well Depth (ft):	146
Drilling End Date:	03/11/2016 12:20	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	997.42	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,000.33	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 830,875.6 E 2,518,721.9	Filter Pack:	#5 Medium Coarse Sand



DEPTH (ft)	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS
100							
						(100.5') Sandy SHALE to SILTSTONE: strong, greenish gray (5G 6/1), massive, fresh, competent, unfractured to slightly fractured, fine grained, less sand content.	
	Run 9			91/ 120	67	(103.5') Sandy SHALE: strong, greenish gray (5G 6/1), massive, fresh, competent, unfractured to slightly fractured, fine grained, less sand content, 2-3 0.5 ft zones of fissile, intensely fractured, moderately decomposed SHALE in unit.	3 units in Run 9 (sandy shale, limestone, reddish shale)
105							
						(108.8') LIMESTONE: strong, light gray (N7), microcrystalline to fine grained, massive, competent, fresh, unfractured to slightly fractured, 1 ft vertical fracture at top of unit.	
110							
						(111.4') SHALE: grayish red (10R 4/2), dark greenish gray and dusky yellow (5Y 6/4), massive, variegated in color, limestone nodules, unfractured, fresh, competent.	
	Run 10			178/ 180	84	(113.5') SHALE: grayish red (10R 4/2), dark greenish gray and dusky yellow (5Y 6/4), massive, variegated in color, limestone nodules, unfractured, fresh, competent, 1.8 ft from top of Run 10, limestone nodules grade out.	
115							
						(119') Intensely fractured, moderately decomposed.	
120							

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-3** **Page: 7 of 11**

Drilling Start Date:	**03/10/2016 10:25**	Boring Depth (ft):	**203.5**	Well Depth (ft):	**146**
Drilling End Date:	**03/11/2016 12:20**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**997.42**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,000.33**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 830,875.6 E 2,518,721.9**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
120									(120') Silty SHALE to CLAYSHALE: strong, medium gray (N5), fresh, competent, unfractured, occasional areas with some fine grained sand, massive, limestone veins 4.7 ft from top of unit for ~0.5 ft.		120
125											125
				Run 11			180/ 180	82	(128.5') Silty SHALE to CLAYSHALE: strong, medium gray (N5), fresh, competent, unfractured, occasional areas with some fine grained sand, massive, intensely fractured for top 1.7 ft of run.		
130											130
135									(134.5') COAL: moderately strong to weak, black (N1), very intensely fractured, slightly decomposed, slightly disintegrated.		135
									(135') Coal-bearing SHALE: strong, black (N1), micaceous, massive, slightly to moderately fractured, fresh, competent.		
									(137.9') SANDSTONE: strong, medium dark gray (N4), medium grained, very micaceous, minor cross bedding, fresh, competent, unfractured. [MORGANTOWN]		
140											140

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-3** **Page: 8 of 11**

Drilling Start Date:	**03/10/2016 10:25**	Boring Depth (ft):	**203.5**	Well Depth (ft):	**146**
Drilling End Date:	**03/11/2016 12:20**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**997.42**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,000.33**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 830,875.6 E 2,518,721.9**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
140									(138.5') 1.3 ft of moderate yellowish brown (10YR 5/4) color. (141.2') Grades to slightly micaceous.		140
				Run 12			180/ 180	96	(143.5') SANDSTONE: strong, medium dark gray (N4), medium grained, very to slightly micaceous, minor cross bedding, fresh, competent, slightly fractured to unfractured. [MORGANTOWN]		
145											145
150											150
155									(157.7') Thin (1-2 cm) coal vein/seam.		155
				Run 13			180/ 180	87	(158.5') SANDSTONE: strong, medium dark gray (N4), medium grained, very to slightly micaceous, increased cross bedding, fresh,		
160											160

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-3** **Page: 9 of 11**

Drilling Start Date:	**03/10/2016 10:25**	Boring Depth (ft):	**203.5**	Well Depth (ft):	**146**
Drilling End Date:	**03/11/2016 12:20**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**997.42**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,000.33**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 830,875.6 E 2,518,721.9**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
160									competent, slightly fractured, coal veins/seams (1-2 cm). [MORGANTOWN]		160
165											165
170											170
				Run 14			179/ 180	97	(173') 0.2 ft layer of COAL. (173.5') SANDSTONE: strong, medium gray (N5), cross bedding, micaceous, fine to medium grained, fresh to slightly decomposed, slightly disintegrated, slightly fractured, coal veins (up to 1" thick), conglomerate imbedded (up to 1" thick), limestone nodules. [MORGANTOWN] (174.5') Limestone nodules disappear. (176.3') Becomes massive, coarse grained, changes to light olive gray (5Y 5/2), no coal or conglomerate, competent, fresh, unfractured.		
175											175
180											180

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** Boring/Well No. M-GS-3 Page: 10 of 11

Drilling Start Date:	03/10/2016 10:25	Boring Depth (ft):	203.5	Well Depth (ft):	146
Drilling End Date:	03/11/2016 12:20	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	997.42	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,000.33	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 830,875.6 E 2,518,721.9	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
180									(180.3') Becomes fine grained, medium light gray (N6).		180
									(183.1') Becomes very micaceous, minor cross bedding, coal veins/beds (up to 3 inch thick), slightly to moderately fractured, slightly decomposed.		
185									(186.4') 0.3 ft of imbedded conglomerate.		185
				Run 15			180/ 180	73	(188.5') SANDSTONE: strong, medium gray (N5), cross bedding, micaceous, fine to medium grained, fresh to slightly decomposed, slightly disintegrated, slightly fractured, interbedded coal veins, imbedded conglomerate, quickly grading to silty. [MORGANTOWN]		
190									(189.2') CLAYSTONE: moderately strong, dark bluish greenish gray, intensely fractured, moderately decomposed, moderately disintegrated, clay infillings in fractures, massive.		190
									(192.2') LIMESTONE: moderately strong to strong, dark greenish gray (5G 4/1), fresh, competent, slightly fractured, microcrystalline, massive.		
195									(196.5') CLAYSHALE: strong, greenish gray (5G 6/1), massive, slickensides, slightly decomposed, competent, slightly fractured, with carbonaceous prominent nodules and veins.		195
200											200

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** Boring/Well No. M-GS-3 Page: 11 of 11

Drilling Start Date:	03/10/2016 10:25	Boring Depth (ft):	203.5	Well Depth (ft):	146
Drilling End Date:	03/11/2016 12:20	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	997.42	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,000.33	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 830,875.6 E 2,518,721.9	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
200											200
									End of borehole at 203.5 ft bgs. Well installed on 04/12/2016, centralizer at 70 ft bgs.		
205											205
210											210

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** Boring/Well No. M-GS-4 Page: 1 of 12

Drilling Start Date:	03/13/2016 07:45	Boring Depth (ft):	228	Well Depth (ft):	202
Drilling End Date:	03/14/2016 12:30	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,025.65	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,028.73	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 834,146.7 E 2,517,597.8	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
0									Overburden: No sample recovered with wireline coring rig.		0
5											5
10											10
15											15
20											20

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-4** **Page: 2 of 12**

Drilling Start Date:	**03/13/2016 07:45**	Boring Depth (ft):	**228**	Well Depth (ft):	**202**
Drilling End Date:	**03/14/2016 12:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,025.65**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,028.73**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 834,146.7 E 2,517,597.8**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
20											20
25				Run 1			18/60	0	(25') CHERT: very strong, grayish black (N2), moderately red (5R 5/4) secondary staining, slightly to moderately disintegrated, competent, intensely fractured, massive, heavily pitted.	Bill thinks rods were not on rock when started coring. Rock may start ~26-28 ft.	25
									(25.3') SANDSTONE: very strong, medium light gray (N6), fine grained, massive to slightly laminated, micaceous, intensely to very intensely fractured, also light olive gray (5Y 5/2) with light brown (5YR 5/6) significant secondary staining, slightly decomposed, slightly disintegrated.		
30				Run 2			62/ 138	18			30
									(31') LIMESTONE: very strong, brownish black (5YR 2/1), microcrystalline, fresh, competent, unfractured.		
									(31.8') SANDSTONE: strong, medium gray (N5), fine grained, massive with slight laminations, moderately fractured, slightly decomposed, slightly disintegrated, clay infillings in fractures.		
35									(33.5') MUDSTONE: very weak, light gray (N7), planar structure, intensely fractured, highly decomposed, highly disintegrated.		35
40											40

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	BORING LOG Boring/Well No. M-GS-4 Page: 3 of 12

engineers | scientists | innovators

Drilling Start Date:	03/13/2016 07:45	Boring Depth (ft):	228	Well Depth (ft):	202
Drilling End Date:	03/14/2016 12:30	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,025.65	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,028.73	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 834,146.7 E 2,517,597.8	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
40											40
				Run 3			14/18	0	(41.5') SANDSTONE: very strong, medium light gray (N6), fine grained, massive to slightly laminated, micaceous, intensely to very intensely fractured, also light olive gray (5Y 5/2) with light brown (5YR 5/6) significant secondary staining, slightly decomposed, slightly disintegrated.		
				Run 4			52/ 108	0	(41.9') MUDSTONE and CHERT: very weak, light gray (N7) and light gray (N8), planar structure, very intensely fractured, highly decomposed, highly disintegrated.		
45									(43') SANDSTONE: very strong, significant olive gray (5Y 3/2) and light brown (5YR 5/6) secondary staining, massive, fine grained, well-cemented, very intensely fractured, slightly decomposed, moderately disintegrated, micaceous, pitted.		45
									(45.7') MUDSTONE: very weak, light gray (N7), planar structure, very intensely fractured, highly decomposed, highly disintegrated.		
50											50
				Run 5			75/ 132	17	(52') SANDSTONE: very strong, medium light gray (N6), fine grained, massive to slightly laminated, micaceous, intensely fractured, also light olive gray (5Y 5/2) with light brown (5YR 5/6) significant secondary staining, slightly decomposed, slightly disintegrated.		
55									(52.5') CLAYSTONE: very weak, greenish gray (5G 6/1), massive, imbedded conglomerate, unfractured, moderately decomposed, moderately disintegrated.		55
									(53.1') SANDSTONE: very strong, medium light gray (N6), fine grained, massive to slightly laminated, micaceous, intensely fractured, also light olive gray (5Y 5/2) with light brown (5YR 5/6) significant secondary staining, slightly decomposed, slightly disintegrated.		
60									(53.8') CLAYSTONE: very weak, greenish		60

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** Boring/Well No. M-GS-4 Page: 4 of 12

Drilling Start Date:	03/13/2016 07:45	Boring Depth (ft):	228	Well Depth (ft):	202
Drilling End Date:	03/14/2016 12:30	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,025.65	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,028.73	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 834,146.7 E 2,517,597.8	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
60									gray (5G 6/1), massive, imbedded conglomerate, unfractured, moderately decomposed, moderately disintegrated, becomes fissile in bottom 0.5 ft.		60
				Run 6			49/60	0	(56.7') CLAYSTONE: strong, light gray (N7), massive, significant secondary staining of medium yellow (5Y 7/6) and dark gray (N3), moderately to highly decomposed, moderately to highly disintegrated, intensely fractured, 4 inch layer of sandstone.		
65									(63') CLAYSTONE: strong, light gray (N7), massive, minimal secondary staining of medium yellow (5Y 7/6) and dark gray (N3), moderately to highly decomposed, moderately to highly disintegrated, intensely fractured, 4 inch layer of sandstone.		65
									(64') Becomes fissile, weak.		
				Run 7			51/60	19	(64.5') MUDSTONE: very weak, light gray (N7), planar structure, very intensely fractured, highly decomposed, highly disintegrated.		
									(65.7') LIMESTONE.		
70									(66.1') MUDSTONE: very weak, light gray (N7), planar structure, very intensely fractured, highly decomposed, highly disintegrated.		70
									(68') LIMESTONE: strong, olive gray (5Y 4/1), massive, microcrystalline, intensely fractured, slightly decomposed, slightly disintegrated.		
				Run 8			28/60	0	(69.5') 1 ft vertical fracture.		
									(73') LIMESTONE: strong, olive gray (5Y 4/1), massive, microcrystalline, intensely fractured, slightly decomposed, slightly disintegrated.		
75									(73.5') CLAYSHALE: very strong, dark greenish gray (5G 4/1), massive, slickensides, intensely fractured, slightly decomposed, slightly disintegrated, calcareous nodules.		75
									(74.4') CLAYSTONE: moderately strong to weak, dark greenish gray (5G 4/1) to greenish gray (5G 6/1), massive to planar structure, highly decomposed, intensely fractured.		
				Run 9			180/180	48	(78') CLAYSHALE: very strong to strong, dark greenish gray (5G 4/1), massive, fresh to slightly decomposed, competent to slightly		
80											80

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-4** **Page: 5 of 12**

Drilling Start Date:	**03/13/2016 07:45**	Boring Depth (ft):	**228**	Well Depth (ft):	**202**
Drilling End Date:	**03/14/2016 12:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,025.65**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,028.73**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 834,146.7 E 2,517,597.8**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
80									disintegrated, moderately fractured, minor calcareous veins/nodules. (79.5') 0.8 ft vertical fracture. (80.6') Grade medium dark gray (N4), fissile. (81.4') Changes to massive, dark greenish gray (5G 4/1) with brownish gray secondary staining (5YR 4/1), very intensely fractured. (82.9') Changes to moderately fractured, medium bluish gray (5B 5/1) with large limestone nodules.		80
85									(84') 2.5 ft vertical fracture, significant staining in fracture. (86.5') Changes to slightly fractured, minor limestone nodules/veins.		85
90									(91') Changes to intensely fractured, moderately decomposed.		90
				Run 10			112/ 120	49			
95									(96.1') Clayey LIMESTONE: very strong to strong, greenish black (5GY 2/1), massive, microcrystalline, alternating 2-3 inches of mudstone, moderately to intensely fractured, fresh, competent.		95
100									(98.8') CLAYSHALE: strong, dark greenish gray (5G 4/1), massive, intensely fractured,		100

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-4** **Page: 6 of 12**

Drilling Start Date:	**03/13/2016 07:45**	Boring Depth (ft):	**228**	Well Depth (ft):	**202**
Drilling End Date:	**03/14/2016 12:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,025.65**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,028.73**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 834,146.7 E 2,517,597.8**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
100									slightly decomposed, slightly disintegrated, small limestone nodules.		100
				Run 11			96/ 120	20	(103') CLAYSHALE: strong, dark greenish gray (5G 4/1), massive, very intensely fractured, slightly decomposed, slightly disintegrated, small limestone nodules. (104.6') Grades to dark gray (N3).		
105									(105.4') LIMESTONE: strong, medium gray (N5), massive, microcrystalline, slightly fractured, competent, fresh.		105
									(106.4') CLAYSHALE: strong, dark greenish gray (5G 4/1), massive, moderately fractured, slightly decomposed, slightly disintegrated, small limestone nodules. (109.4') Becomes weak, very intensely fractured, highly decomposed.		
110											110
				Run 12			180/ 180	79	(113') CLAYSHALE: strong, grayish red (5R 4/2), massive, fresh, competent, moderately fractured, slickensides, light olive gray (5Y 5/2) limestone veins. (114.2') Changes to variegated colors of grayish red (5R 4/2) and medium dark gray (N4). (116') Changes to dark greenish gray (5G 4/1), limestone veins grade out, laminated, slightly fractured.		
115											115
120											120

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-4** **Page: 7 of 12**

Drilling Start Date:	**03/13/2016 07:45**	Boring Depth (ft):	**228**	Well Depth (ft):	**202**
Drilling End Date:	**03/14/2016 12:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,025.65**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,028.73**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 834,146.7 E 2,517,597.8**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
120											120
125									(123.9') CLAYSTONE: weak to very weak, massive, planar structure, intensely fractured, dark greenish gray (5G 4/1), some limestone nodules, highly decomposed.		125
				Run 13			176/ 180	77	(126.9') LIMESTONE: very strong, brownish black (5YR 2/1), massive, microcrystalline, moderately fractured, fresh, competent.		
130									(130.5') CLAYSHALE: moderately strong to strong, dark greenish gray (5G 6/1), limestone nodules, massive, slightly to moderately fractured, fresh to slightly decomposed, competent.		130
135									(134.5-136') Changes to grayish red (5R 4/2).		135
									(136-137') Changes to dark greenish gray (5G 4/1).		
									(137-138') Changes to grayish red (5R 4/2).		
									(138-140') Changes to dark greenish gray (5G 4/1).		
140											140

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-4** **Page: 8 of 12**

Drilling Start Date:	**03/13/2016 07:45**	Boring Depth (ft):	**228**	Well Depth (ft):	**202**
Drilling End Date:	**03/14/2016 12:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,025.65**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,028.73**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 834,146.7 E 2,517,597.8**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
140									(140-143') Changes to pale brown (5YR 5/2), limestone veins also appear.		140
				Run 14			131/ 132	76	(143') CLAYSHALE: moderately strong to strong, dark greenish gray (5G 4/1), limestone nodules/veins, massive, intensely fractured, moderately decomposed, competent.		
145									(146.8') Changes to medium dark gray (N4), no limestone nodules or veins, slightly fractured, fresh.		145
150									(149.2') Sandy SHALE: strong, medium gray (N5) and grayish black (N2), massive for top 1.5 ft of unit, laminated for bottom 3.2 ft of unit, fine grained sandy areas, sand content increases towards bottom, well cemented, micaceous, slightly fractured, fresh, competent.	May be equivalent to coal-bearing shale at M-GS-1 and M-GS-3	150
				Run 15			164/ 166	90	(154') Sandy SHALE: strong, grayish black and light gray (N6), massive shale to alternating laminations of shale and sandstone, fine grained sandy areas, sand content increases towards bottom, well cemented, micaceous, slightly fractured, fresh, competent.		
155											155
160											160

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-4** **Page: 9 of 12**

Drilling Start Date:	**03/13/2016 07:45**	Boring Depth (ft):	**228**	Well Depth (ft):	**202**
Drilling End Date:	**03/14/2016 12:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,025.65**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,028.73**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 834,146.7 E 2,517,597.8**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
160											160
									(161') SANDSTONE: strong, medium light gray (N6), some grayish black laminations (shale or coal), micaceous, slightly fractured, fine grained, fresh, competent.		
									(162.7') Sandy SHALE to Shaly SANDSTONE: strong, grayish black and light gray (N6), massive shale to alternating laminations of shale and sandstone, fine grained sandy areas, sand content increases towards bottom, well cemented, micaceous, slightly fractured, fresh, competent, 2 inch layer of previous sandstone 2.8 ft from top of unit.		
165									(165.2') 0.3 ft vertical fracture.		165
				Run 16			176/ 180	97	(168') Sandy SHALE to Shaly SANDSTONE: strong, grayish black and light gray (N6), massive shale to alternating laminations of shale and sandstone, fine grained sandy areas, sand content increases towards bottom, well cemented, micaceous, slightly fractured, fresh, competent, 2 inch layer of previous sandstone 2.8 ft from top of unit, becomes fissile at bottom.		
170									(171.8') SANDSTONE: strong, medium gray (N5), fine grained, micaceous, massive, weak coal veins, slightly fractured, fresh, competent, mud inclusions.		170
175											175
180											180

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-4** **Page: 10 of 12**

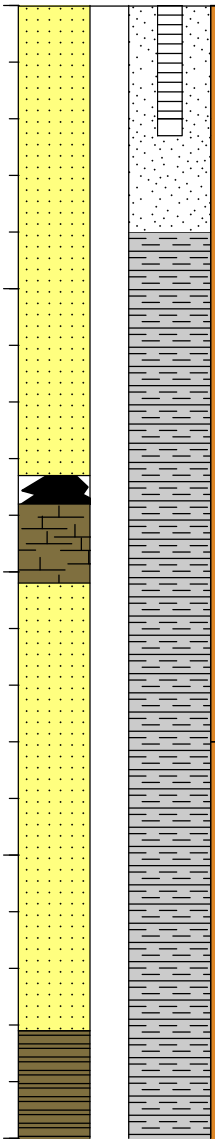
Drilling Start Date:	**03/13/2016 07:45**	Boring Depth (ft):	**228**	Well Depth (ft):	**202**
Drilling End Date:	**03/14/2016 12:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,025.65**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,028.73**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 834,146.7 E 2,517,597.8**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
180											180
				Run 17			180/ 180	93	(183') SANDSTONE: strong, medium gray (N5), fine grained, micaceous, massive, weak coal veins, slightly fractured, fresh, competent.		
185											185
									(187.4') Becomes medium grained.		
									(188.8') Becomes moderately fractured.		
190											190
									(192.5') Coal veins increase for rest of run.		
195											195
									(196.3') Mud inclusions begin to appear.		
				Run 18			179/ 180	89	(198.3') Conglomerate SANDSTONE: strong, very light gray (N6), massive, micaceous, abundant imbedded conglomerates (up to 1.5 inch thick), mud inclusions, slightly fractured,		
200											200

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	BORING LOG Boring/Well No. M-GS-4 Page: 11 of 12

Drilling Start Date:	03/13/2016 07:45	Boring Depth (ft):	228	Well Depth (ft):	202
Drilling End Date:	03/14/2016 12:30	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,025.65	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,028.73	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 834,146.7 E 2,517,597.8	Filter Pack:	#5 Medium Coarse Sand



DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
200									fresh, competent, fine grained, conglomerates are brownish gray (5YR 4/1) and very pale orange (10YR 8/2).		200
									(200.8') SANDSTONE: strong, medium gray (N5) to medium dark gray (N4), massive to minor cross bedding, occasional zones of imbedded conglomerate, fine grained, slightly fractured, fresh, competent, minor coal veins.		
205											205
									(208.3') COAL: moderately strong, black (N1), fissile to cubic structure, sandstone inclusions (up to 1.5 inch thick), moderately fractured.		
210									(208.8') Coal-bearing, sandy conglomerate CLAYSHALE: strong, medium dark gray (N4), massive, slightly fractured, fresh, competent.		210
									(210.2') SANDSTONE: strong, medium gray (N5) to medium dark gray (N4), massive to minor cross bedding, occasional zones of imbedded conglomerate, medium grained, slightly fractured, fresh, competent.		
				Run 19			180/ 180	93			
215											215
									(218') End of MORGANTOWN.		
									(218.1') Silty SHALE: strong, dark greenish gray (5G 4/1), massive, slightly to moderately fractured, fresh, competent.		
220											220

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** Boring/Well No. M-GS-4 Page: 12 of 12

Drilling Start Date:	03/13/2016 07:45	Boring Depth (ft):	228	Well Depth (ft):	202
Drilling End Date:	03/14/2016 12:30	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,025.65	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,028.73	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 834,146.7 E 2,517,597.8	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
220											220
225											225
									End of borehole at 228 ft bgs. Well installed on 04/21/2016		
230											230

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** Boring/Well No. M-GS-5 Page: 1 of 12

Drilling Start Date:	03/14/2016 14:45	Boring Depth (ft):	233	Well Depth (ft):	224
Drilling End Date:	03/16/2016 09:30	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,036.92	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,039.54	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 835,739.3 E 2,511,662.3	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
0									Overburden: No sample recovered with wireline coring rig.		0
5											5
10											10
15											15
20											20

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** Boring/Well No. M-GS-5 Page: 2 of 12

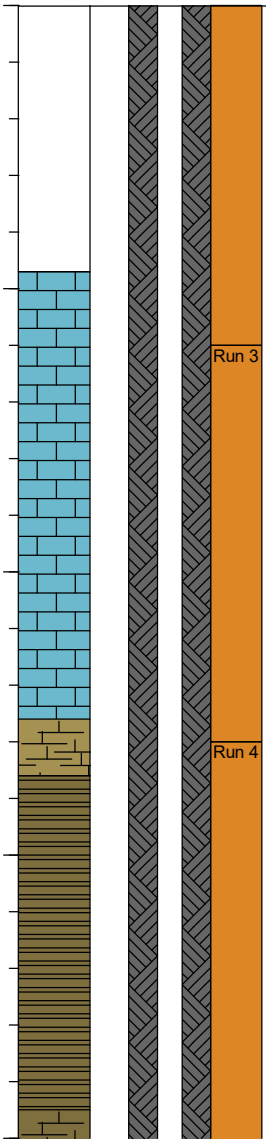
Drilling Start Date:	03/14/2016 14:45	Boring Depth (ft):	233	Well Depth (ft):	224
Drilling End Date:	03/16/2016 09:30	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,036.92	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,039.54	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 835,739.3 E 2,511,662.3	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
20				Run 1			31/ 156	13	(20') Overburden: Some limestone boulders encountered. (see remarks)	Started coring at 20 ft bgs. Overburden: Driller (B. Womack) figured this material was overburden because of change in drilling speed (faster through limestone boulders and slow through clay). Rods were violently shaking, as well, as if trying to drill through unstable rock material is boxed.	20
25											25
30									(30') Overburden: LIMESTONE encountered - strong, light gray (N7), microcrystalline, intensely fractured, slightly decomposed, slightly disintegrated.		30
				Run 2			30/ 156	4	(33') Overburden: 2.5 ft of previous LIMESTONE encountered through course of Run 2.		
35											35
40											40

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-5** **Page: 3 of 12**

Drilling Start Date:	**03/14/2016 14:45**	Boring Depth (ft):	**233**	Well Depth (ft):	**224**
Drilling End Date:	**03/16/2016 09:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,036.92**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,039.54**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 835,739.3 E 2,511,662.3**	Filter Pack:	**#5 Medium Coarse Sand**



DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
40											40
									End of overburden, begin bedrock.		
45				Run 3			84/84	69	(44.7') LIMESTONE: strong, greenish black (5GY 2/1), microcrystalline, moderately fractured, slightly decomposed, slightly disintegrated, clay in fractures.		45
50											50
				Run 4			175/ 180	78	(52.6') CLAYSTONE: very weak, medium dark gray (N4), massive, highly decomposed, highly disintegrated, intensely fractured.		
55									(53.6') Sandy silty SHALE: strong, medium light gray (N6), massive, laminated from 4-5.5 ft from top of unit, competent, fresh, slightly fractured, micaceous, sand content increases at bottom of unit.		55
60									(59.5') CLAYSHALE: strong, medium dark		60

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-5** **Page: 4 of 12**

Drilling Start Date:	**03/14/2016 14:45**	Boring Depth (ft):	**233**	Well Depth (ft):	**224**
Drilling End Date:	**03/16/2016 09:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,036.92**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,039.54**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 835,739.3 E 2,511,662.3**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
60									gray (N4), massive, slightly decomposed to fresh, competent, moderately fractured.		60
									(60.8') LIMESTONE: strong, medium light gray (N4), microcrystalline to fine grained, massive, fresh, competent, unfractured.		
									(62.6') Silty SHALE: strong, medium light gray (N6), massive, laminated from 4-5.5 ft from top of unit, competent, fresh, slightly fractured, slightly micaceous, few sandy parts.		
65									(65.1') CLAYSTONE: very weak, medium dark gray (N4), massive, highly decomposed, highly disintegrated, intensely fractured.		65
									(66.1') CLAYSHALE: strong, dark greenish gray (5G 4/1), massive, slightly decomposed to fresh, competent, moderately fractured.		
				Run 5			172/ 180	71	(68') CLAYSHALE to silty SHALE: strong, dark greenish gray (5G 4/1) to medium light gray (N5), massive, moderately to intensely fractured, slightly decomposed, competent, clay infillings in fractures, some limestone nodules, some sandy parts in silty shale.		
70									(71.5') Highly decomposed.		70
75											75
									(78.8') Sandy SHALE: laminated.		
80											80

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-5** **Page: 5 of 12**

Drilling Start Date:	**03/14/2016 14:45**	Boring Depth (ft):	**233**	Well Depth (ft):	**224**
Drilling End Date:	**03/16/2016 09:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,036.92**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,039.54**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 835,739.3 E 2,511,662.3**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
80									(81') Limestone nodules increase.		80
				Run 6			144/ 144	54	(83') CLAYSHALE: strong, dark greenish gray (5G 4/1), massive, fissile 1.5 ft from top of run, intensely fractured, slightly decomposed, competent, clay infillings in fractures.		
85									(84.5') Becomes fissile, weak, moderately to highly decomposed, moderately to highly disintegrated.		85
									(85.3') LIMESTONE: strong, olive black (5Y 2/1) with medium light gray nodules (N6), massive, fresh, competent, moderately fractured.		
									(88.3') CLAYSHALE: strong, dark greenish gray (5G 4/1), massive, fissile 1.5 ft from top of run, intensely fractured, slightly decomposed, competent, clay infillings in fractures, with limestone nodules.		
90											90
									(91.3') LIMESTONE: strong, olive black (5Y 2/1) with medium light gray nodules (N6), massive, fresh, competent, moderately fractured.		
									(92.2') CLAYSHALE to CLAYSTONE: moderately strong to very weak, dark greenish gray (5G 4/1) with yellowish gray quartz veins to olive gray (5Y 4/1), slightly to intensely decomposed, intensely fractured.		
95				Run 7			156/ 156	90	(95') CLAYSHALE: strong, dark greenish gray (5G 4/1) with yellowish gray (5Y 7/2), quartz veins, fresh, competent, moderately fractured.		95
									(98') Changes to intensely fractured, moderately decomposed.		
									(98.8') Changes to slightly fractured.		
100											100

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-5** **Page: 6 of 12**

Drilling Start Date:	**03/14/2016 14:45**	Boring Depth (ft):	**233**	Well Depth (ft):	**224**
Drilling End Date:	**03/16/2016 09:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,036.92**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,039.54**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 835,739.3 E 2,511,662.3**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
100									(100') Changes to Silty CLAYSHALE.		100
105											105
				Run 8			175/ 180	79	(108') CLAYSHALE: strong, dark greenish gray (5G 4/1) with yellowish gray (5Y 7/2), quartz veins, fresh, competent, moderately fractured.		
110											110
									(113.6') Shaly SANDSTONE: strong, medium gray (N5), interbedded sandstone with shale (possibly cross-bedding), micaceous, fine grained, competent, fresh, moderately fractured, some mud inclusions, shale is grayish black (N2).		
115											115
									(118.6') Sandy CLAYSHALE: strong, grayish black (N2), massive, sandy for top 1.7 ft of unit, fine grained, mud inclusions for top 1.7		
120											120

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** Boring/Well No. M-GS-5 Page: 7 of 12

Drilling Start Date:	03/14/2016 14:45	Boring Depth (ft):	233	Well Depth (ft):	224
Drilling End Date:	03/16/2016 09:30	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,036.92	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,039.54	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 835,739.3 E 2,511,662.3	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
120									ft, competent, fresh, moderately fractured, may be coal-bearing for top 1.7 ft.		120
				Run 9			180/ 180	93	(123') CLAYSHALE: strong, medium dark gray (N4), massive, competent, fresh, moderately fractured, no mud inclusions, coal or sandy areas, abundant limestone nodules.		
125											125
130									(131.5') 1" band of small limestone nodules.		130
135									(134.5') SANDSTONE: strong, medium gray (N5), minor cross bedding, fine grained, fresh, competent, micaceous, slightly fractured.		135
				Run 10			176/ 180	87	(136.8') Silty SHALE: strong, medium dark gray (N4), massive, competent, fresh, moderately fractured, abundant limestone nodules.		
140									(138') Silty SHALE: strong, medium dark gray (N4) to dark gray (N3), massive, competent, fresh, slightly to moderately fractured,		140

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	BORING LOG Boring/Well No. M-GS-5 Page: 8 of 12

Drilling Start Date:	03/14/2016 14:45	Boring Depth (ft):	233	Well Depth (ft):	224
Drilling End Date:	03/16/2016 09:30	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,036.92	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,039.54	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 835,739.3 E 2,511,662.3	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
140									abundant limestone nodules. (140.6') Becomes intensely fractured. (141') LIMESTONE: strong, olive gray (5Y 4/1), massive, microcrystalline, competent, fresh, unfractured. (141.6') Silty SHALE: strong, medium dark gray (N4) to dark gray (N3), massive, competent, fresh, slightly to moderately fractured, limestone nodules throughout.		140
145											145
150				Run 11			162/ 180	49	(153.3') CLAYSHALE: strong, dark greenish gray (5G 4/1), massive, moderately fractured, slightly decomposed, slightly disintegrated, 0.5 ft vertical fracture at top of unit.		150
155									(156.3') CLAYSTONE: moderately strong, medium dark gray (N4), massive, intensely fractured, clay infillings in fractures, moderately decomposed, moderately disintegrated. (157.3') LIMESTONE: strong, olive black (5Y 2/1) to dark greenish gray (5G 4/1), light gray (N7), limestone nodules, nodular to massive,		155
160											160

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-5** **Page: 9 of 12**

Drilling Start Date:	**03/14/2016 14:45**	Boring Depth (ft):	**233**	Well Depth (ft):	**224**
Drilling End Date:	**03/16/2016 09:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,036.92**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,039.54**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 835,739.3 E 2,511,662.3**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
160									microcrystalline, moderately fractured, slightly disintegrated, fresh.		160
									(162.3') CLAYSTONE: moderately strong, medium dark gray (N4), massive, intensely fractured, clay infillings in fractures, moderately decomposed, moderately disintegrated.		
165									(163.3') LIMESTONE: strong, dark greenish gray (5G 4/1), massive, microcrystalline, unfractured, fresh, competent.		165
									(163.8') CLAYSTONE: moderately strong, medium dark gray (N4), massive, intensely fractured, clay infillings in fractures, moderately decomposed, moderately disintegrated.		
				Run 12			178/ 180	97	(168') Silty SHALE: strong, dark greenish gray (5G 4/1), massive, slightly fractured, fresh, competent, minor limestone nodules.		
170									(170') Intensely fractured, moderately disintegrated.		170
									(173.4') Sandy silty SHALE: strong, grayish black (N2), massive, slightly fractured, fresh, competent, minor limestone nodules, occasional sandstone lenses, fine grained, micaceous, medium light gray.		
175											175
									(178.4') SANDSTONE: strong, medium light gray (N6), fine grained, micaceous, cross-bedded, competent, fresh, mud		
180											180

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	BORING LOG Boring/Well No. M-GS-5 Page: 10 of 12

engineers | scientists | innovators

Drilling Start Date:	03/14/2016 14:45	Boring Depth (ft):	233	Well Depth (ft):	224
Drilling End Date:	03/16/2016 09:30	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,036.92	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,039.54	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 835,739.3 E 2,511,662.3	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
180									inclusions/lenses, slightly fractured. [MORGANTOWN]		180
									(180.6') Sandy silty SHALE: strong, grayish black (N2), massive, slightly fractured, fresh, competent, occasional sandstone lenses, fine grained, micaceous, medium light gray.		
				Run 13			180/ 180	98	(183') Sandy SHALE: strong, dark gray (N3) [shale], medium dark gray (N5) [sandstone], laminations/lenses of sandstone, lenses up to 6" thick, fresh, competent, slightly fractured.		
185											185
190											190
									(191.7') SANDSTONE: strong, medium light gray (N6) to medium gray (N5), cross-bedded, fine grained, micaceous, slightly fractured, fresh, competent. [MORGANTOWN] (193.8') Shale lenses, mud inclusions/lenses appear (up to 1 inch thick).		
195									(196.7') Becomes moderately fractured.		195
				Run 14			178/ 180	90	(191.7') SANDSTONE: strong, medium light gray (N6) to medium gray (N5), cross-bedded, fine grained, micaceous to very micaceous, slightly to moderately fractured, fresh,		
200											200

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	BORING LOG Boring/Well No. M-GS-5 Page: 11 of 12

Drilling Start Date:	03/14/2016 14:45	Boring Depth (ft):	233	Well Depth (ft):	224
Drilling End Date:	03/16/2016 09:30	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,036.92	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,039.54	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 835,739.3 E 2,511,662.3	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
200									competent, some coal veining, some imbedded conglomerate, shale lenses, mud inclusions. [MORGANTOWN]		200
205											205
210											210
									(212.2') Becomes massive.		
				Run 15			152/ 156	80	(213') SANDSTONE: strong, medium light gray (N6) to medium gray (N5), cross-bedded, fine grained, micaceous to very micaceous, slightly fractured, fresh, competent, some coal veining, some imbedded conglomerate, shale lenses, mud inclusions. [MORGANTOWN]		
215											215
220											220

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. M-GS-5** **Page: 12 of 12**

Drilling Start Date:	**03/14/2016 14:45**	Boring Depth (ft):	**233**	Well Depth (ft):	**224**
Drilling End Date:	**03/16/2016 09:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,036.92**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,039.54**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 835,739.3 E 2,511,662.3**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
220											220
									(221.8') 0.4 ft thick lense of sandstone with prevalent mud inclusions, conglomerate, coal veining.		
									(222.2') COAL: strong, black (N1), massive to cubic structure, slightly fractured, slightly decomposed, competent, sandstone lense, mud inclusions.		
225											225
				Run 16			84/84	92	(222.7') SANDSTONE: strong, medium light gray (N6) to medium gray (N5), massive, cross-bedded, fine grained, micaceous to very micaceous, slightly fractured, fresh, competent, some coal veining. [MORGANTOWN]		
									(223.3') CLAYSHALE: strong, dark greenish gray (5G 4/1), massive, intensely fractured, moderately decomposed, slightly disintegrated, calcareous nodules/veining.		
230									(225.3') CLAYSTONE: weak to very weak, medium light gray (N6), massive, intensely fractured, highly decomposed, highly disintegrated.		230
									(226') CLAYSHALE: strong, dark greenish gray (5G 4/1), massive, intensely fractured, moderately decomposed, slightly disintegrated, calcareous nodules/veining.		
									(226.5') Changes to slightly fractured, fresh, competent.		
									End of borehole at 233 ft bgs.		
235									Well installed on 04/05/2016		235
240											240

NOTES:

HULL
Environment / Energy / Infrastructure

Cardinal Operating Company
306 County Road 7E
Brilliant, Ohio
BPG003

Date Started	: 3-6-2019
Date Completed	: 3-8-2019
Logged by	: Mielecki
Reviewed by	: J. Ardner
Drilling Contractor	: Terra Testing
Drilling Method	: 4.25" HSA
Sampling Method	: 4" Core Barrel
Total Depth (ft.)	: 77.0'

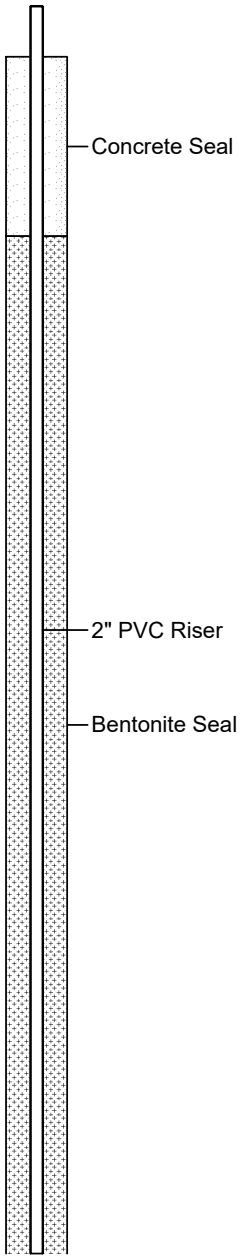
LOG OF BORING M-2000

Soil Samples
- Sample Intervals
- Sample Sent to Lab

Water Levels
- Static
- During Drilling

Depth in Feet	Sample Interval/ Sample Recovery	Sampler Type/ Sample Number	Sample	GRAPHIC	Water Level	DESCRIPTION
0						Straight drill using 4.25-inch Hollow Stem Augers to bedrock refusal.
1						Bottom Ash (0-32')
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

Well: M-2000



HULL
Environment / Energy / Infrastructure

Cardinal Operating Company
306 County Road 7E
Brilliant, Ohio
BPG003

Date Started	: 3-6-2019
Date Completed	: 3-8-2019
Logged by	: Mielecki
Reviewed by	: J. Ardner
Drilling Contractor	: Terra Testing
Drilling Method	: 4.25" HSA
Sampling Method	: 4" Core Barrel
Total Depth (ft.)	: 77.0'

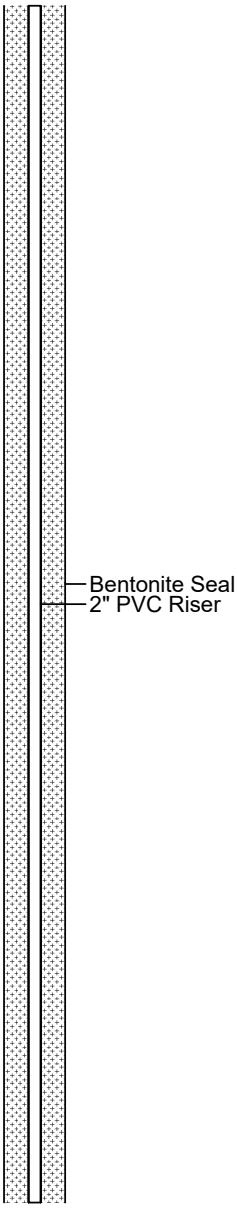
LOG OF BORING M-2000

Soil Samples
- Sample Intervals
- Sample Sent to Lab

Water Levels
- Static
- During Drilling

Well: M-2000

Depth in Feet	Sample Interval/ Sample Recovery	Sampler Type/ Sample Number	Sample	GRAPHIC	Water Level	DESCRIPTION
20–32						Bottom Ash (Continued).
32						Weathered SANDSTONE; augers set at 35.0 feet.
35	2/0.8	RC-1 35.0-37.0				Medium, reddish orange, moderately weathered, strong, SANDSTONE; fractured. Rock Quality Designation (RQD) = 0%
37	5/3.9	RC-2 37.0-42.0				Medium-grained, yellowish brown, moderately weathered, SANDSTONE; thin; fractured. RQD = 36.2%



HULL
Environment / Energy / Infrastructure

Cardinal Operating Company
306 County Road 7E
Brilliant, Ohio
BPG003

Date Started	: 3-6-2019
Date Completed	: 3-8-2019
Logged by	: Mielecki
Reviewed by	: J. Ardner
Drilling Contractor	: Terra Testing
Drilling Method	: 4.25" HSA
Sampling Method	: 4" Core Barrel
Total Depth (ft.)	: 77.0'

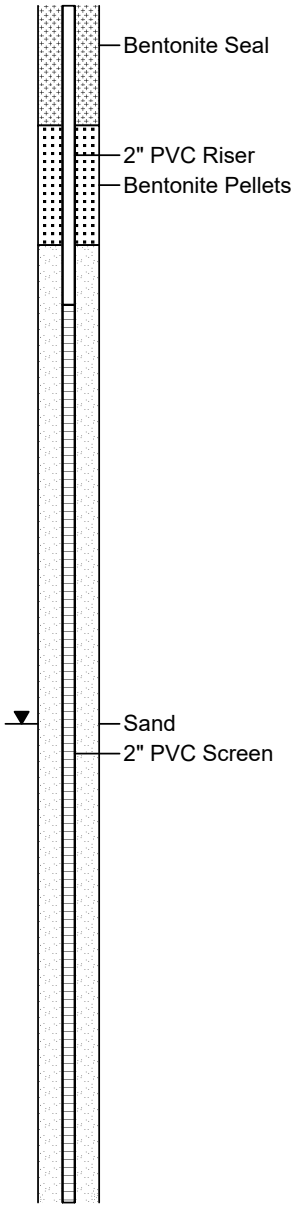
LOG OF BORING M-2000

Soil Samples
- Sample Intervals
- Sample Sent to Lab

Water Levels
- Static
- During Drilling

Well: M-2000

Depth in Feet	Sample Interval/ Sample Recovery	Sampler Type/ Sample Number	DESCRIPTION
40–41			Medium-grained, yellowish brown, moderately weathered, SANDSTONE; thin; fractured.
42	5/5	RC-3 42.0-47.0	Same as above; highly to moderately fractured. RQD = 56.7%
47	3/1.1	RC-4 47.0-50.0	Medium grained, greenish grey, moderately weathered, moderately strong, SANDSTONE; thin; fractured; becoming wet. RQD = 0%
50	2/2	RC-5 50.0-52.0	Medium grained, yellowish brown to grey, slightly weathered, moderately strong, SANDSTONE; thin; moderately fractured. RQD = 75%
52	5/4.8	RC-6 52.0-57.0	Medium grained, yellow brown to grey, moderately weathered, moderately strong, SANDSTONE; siliceous bedding; slightly rough; thin; moderately fractured. RQD = 54.4%
57	5/5	RC-7 57.0-62.0	Medium grained, very thin to medium, yellow brown to grey, moderately weathered, moderately strong; bedding fractured to moderately fractured. RQD = 56.7%



HULL
Environment / Energy / Infrastructure

Cardinal Operating Company
306 County Road 7E
Brilliant, Ohio
BPG003

Date Started	: 3-6-2019
Date Completed	: 3-8-2019
Logged by	: Mielecki
Reviewed by	: J. Ardner
Drilling Contractor	: Terra Testing
Drilling Method	: 4.25" HSA
Sampling Method	: 4" Core Barrel
Total Depth (ft.)	: 77.0'

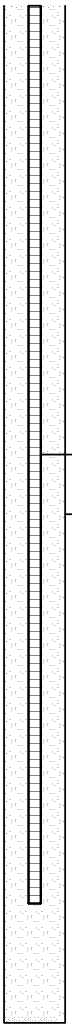
LOG OF BORING M-2000

Soil Samples
- Sample Intervals
- Sample Sent to Lab

Water Levels
- Static
- During Drilling

Well: M-2000

Depth in Feet	Sample Interval/ Sample Recovery	Sampler Type/ Sample Number	Sample	GRAPHIC	Water Level	DESCRIPTION
60						Medium, very thin to medium, yellow brown to grey, moderately weathered, moderately strong; bedding fractured to moderately fractured.
61						Same as above; some black shale streaks below 61'
62	5/4.6	RC-8 62.0-67.0				Medium, grey with black shale, moderately weathered, moderately strong, SANDSTONE; thin bedding; vertical fracture from 64-65'; some iron staining; moderately fractured. RQD = 69.1%
63						
64						
65						
66						
67	5/5	RC-9 67.0-72.0				
68						
69						Medium, grey, unweathered, medium strong SANDSTONE; slightly fractured. RQD = 60%
70						
71						
72	5/5	RC-10 72.0-77.0				RQD = 68.3%
73						
74						
75						Soft grey fine CLAY and unweathered blue grey SHALE; moderately strong; laminated; bedding; moderately fractured.
76						
77						End of Boring @ 77'
78						
79						
80						



APPENDIX D

WELL CONSTRUCTION LOGS

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

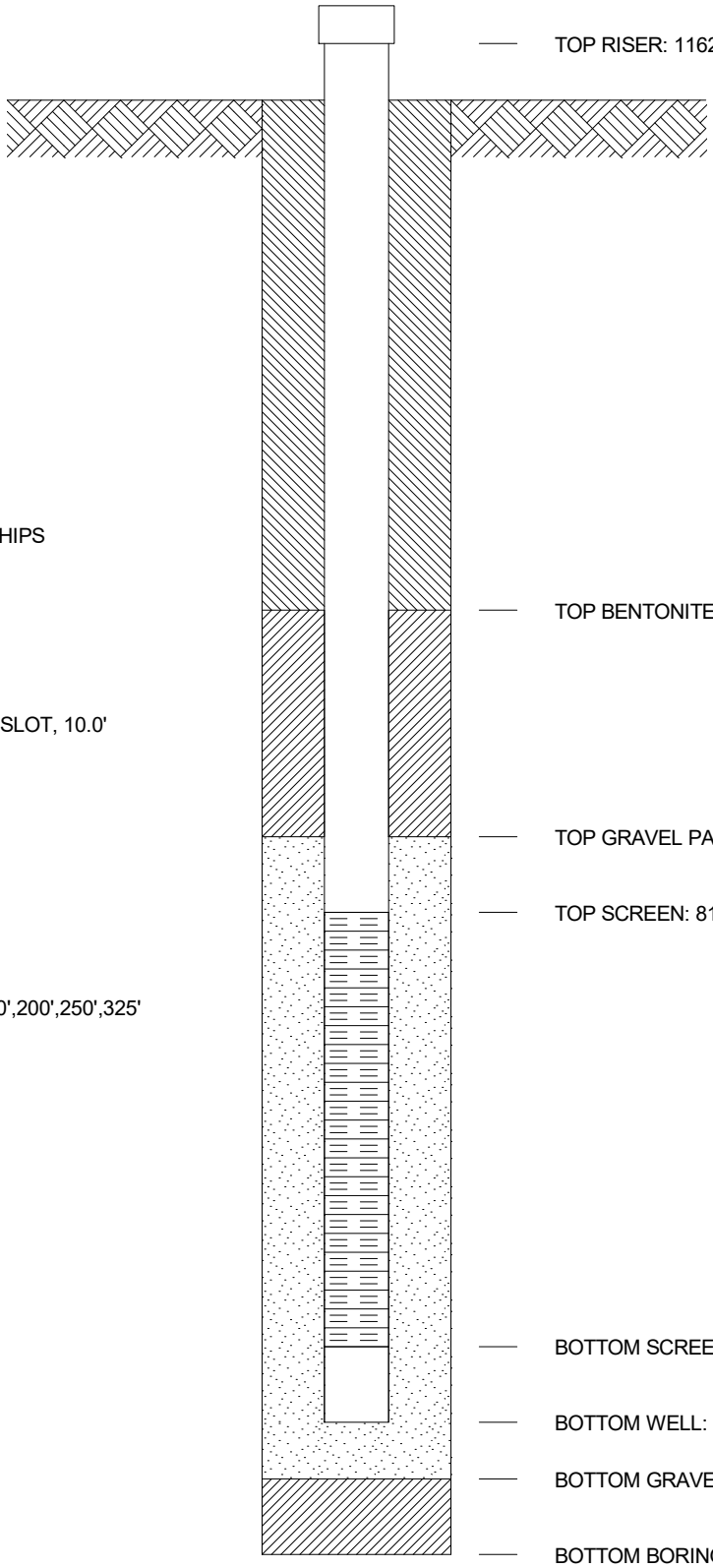
WELL No. **CA-0622A** BORING No. **CA-0622A** INSTALLED **8/16/16**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 836,291.4 E 2,514,219.5**

SYSTEM **State Plane using NAD27/29**

GROUND ELEVATION 1159.38 FT.



TOP RISER: 1162.28 FT.

TOP BENTONITE SEAL: 821.38 FT.

TOP GRAVEL PACK: 816.38 FT.

TOP SCREEN: 813.38 FT.

BOTTOM SCREEN: 803.38 FT.

BOTTOM WELL: 803.38 FT.

BOTTOM GRAVEL PACK: 803.38 FT.

BOTTOM BORING: 803.38 FT.

GROUT SEAL: BENTONITE CHIPS

BENTONITE SEAL: PELLETS

SCREEN: 2" dia., U-PACK .10 SLOT, 10.0'

GRAVEL PACK:

RISER PIPE: 2", dia., PVC

SPACERS, DEPTH: 20',80',140',200',250',325'

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

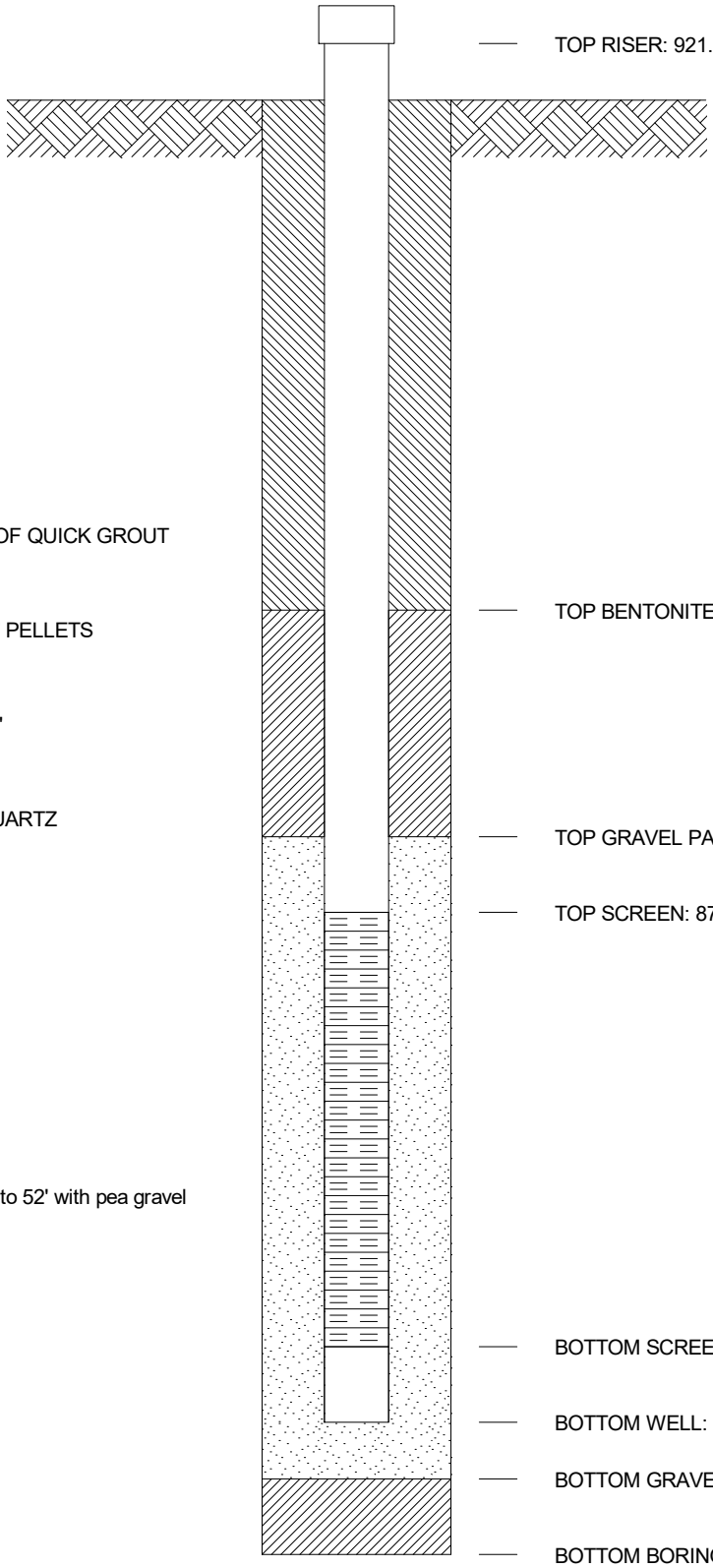
WELL No. **FA-8** BORING No. **FA-8** INSTALLED **3/23/04**

PROJECT **CARDINAL FLY ASH DAM**

COORDINATES **N 829,635.1 E 2,516,460.0**

SYSTEM **State Plane using NAD27/29**

GROUND ELEVATION 918.23 FT.



TOP RISER: 921.03 FT.

TOP BENTONITE SEAL: 883.03 FT.

TOP GRAVEL PACK: 880.43 FT.

TOP SCREEN: 878.23 FT.

BOTTOM SCREEN: 868.23 FT.

BOTTOM WELL: 867.73 FT.

BOTTOM GRAVEL PACK: 866.23 FT.

BOTTOM BORING: 763.23 FT.

GROUT SEAL: 90 GALLONS OF QUICK GROUT

BENTONITE SEAL: 50 lbs 3/8" PELLETS

SCREEN: 2" dia., 50 SLOT, 10'

GRAVEL PACK: 225 lbs #4 QUARTZ

RISER PIPE: 2", dia., PVC

SPACERS, DEPTH: None

Note: Backfilled hole from 156' to 52' with pea gravel

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

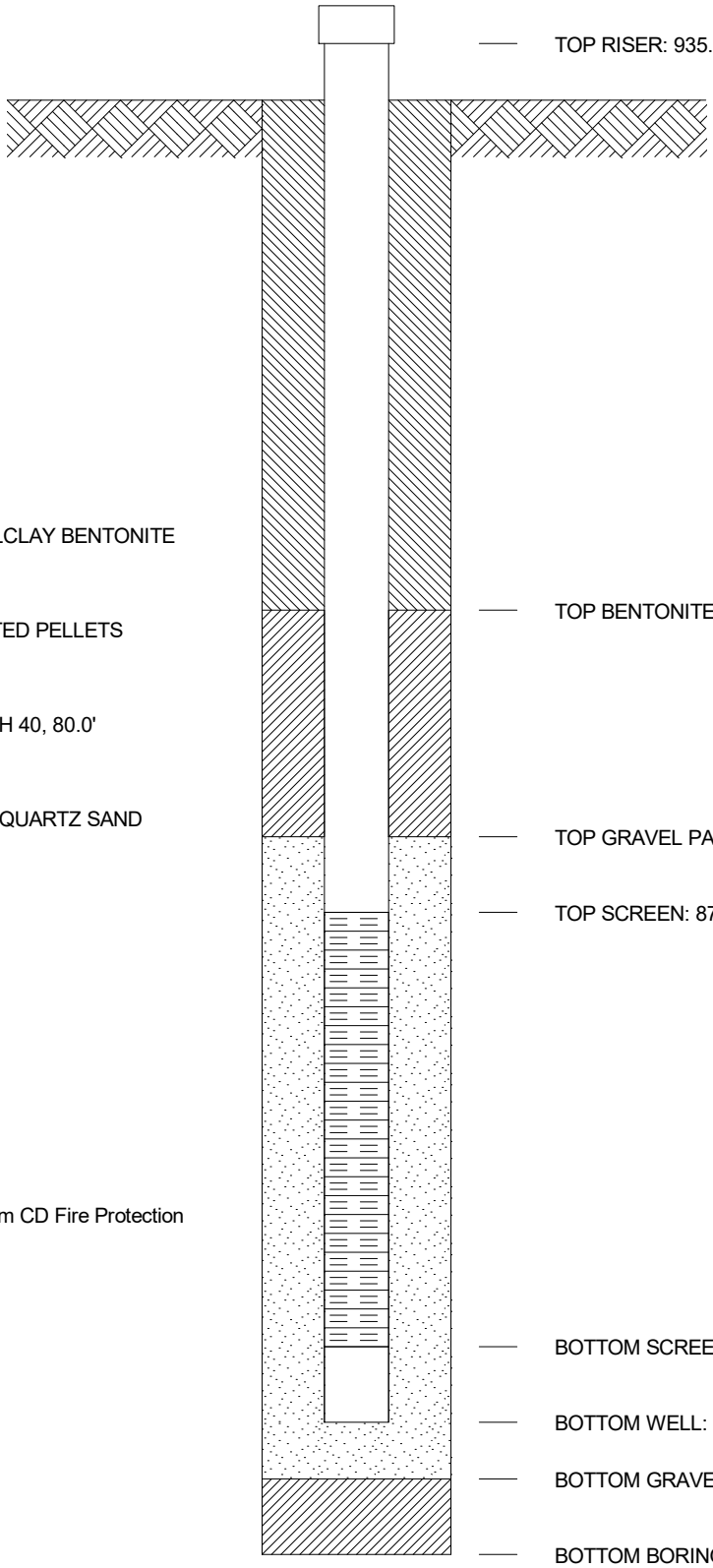
WELL No. **M-1003** BORING No. **M-1003** INSTALLED **4/7/10**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 829,139.1 E 2,516,070.9**

SYSTEM

GROUND ELEVATION 933.55 FT.



GROUT SEAL: 100 GALS VOLCLAY BENTONITE

BENTONITE SEAL: 3/8" COATED PELLETS

SCREEN: 2" dia., 20 SLOT SCH 40, 80.0'

GRAVEL PACK: 1550 LBS #4 QUARTZ SAND

RISER PIPE: 2", dia., SCH 40

SPACERS, DEPTH: 50', 10'

NOTES:
-Drill & decon water coming from CD Fire Protection System
-Decon rig & tools 04/13/10
-Drilled w/6" air hammer
-SWL @ 73.8' @ install

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

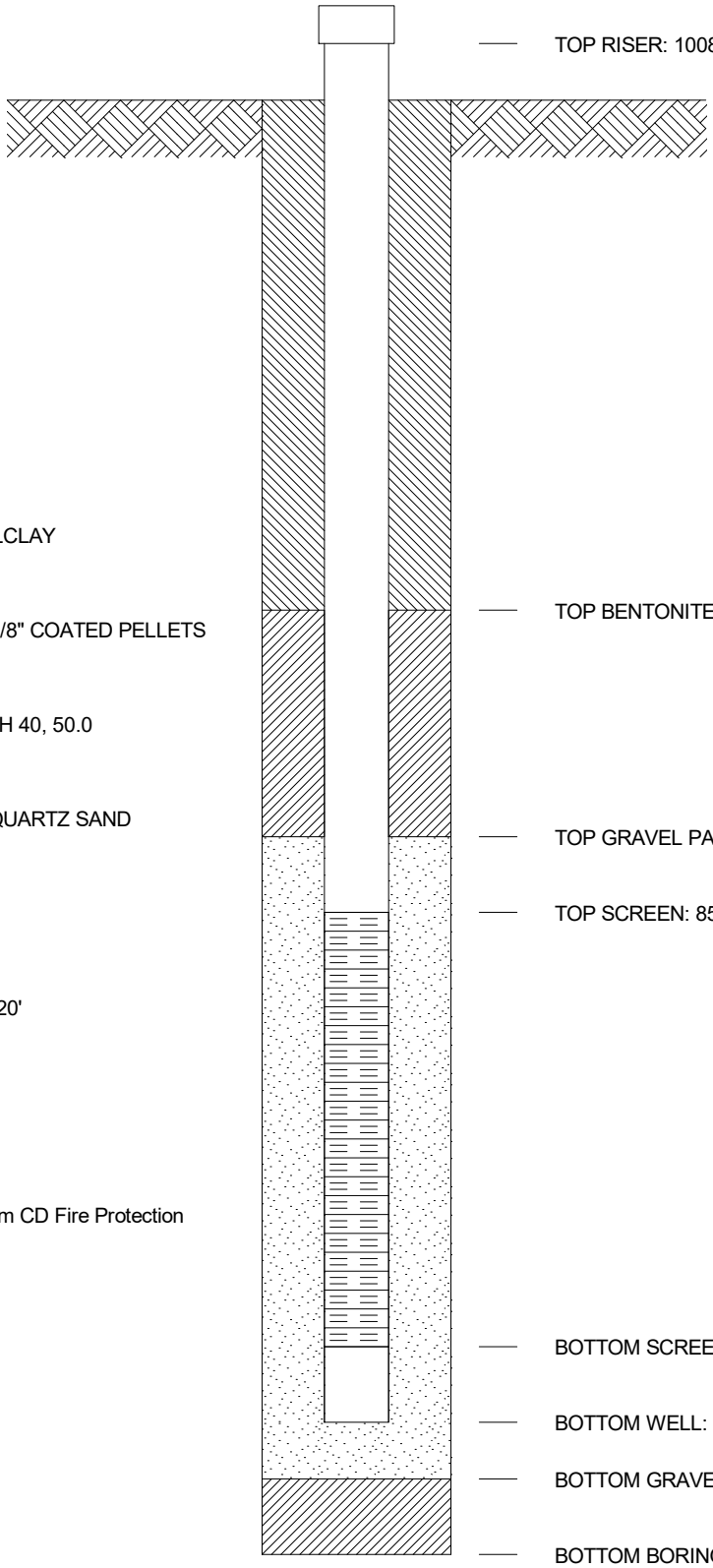
WELL No. **M-1004** BORING No. **M-1004D** INSTALLED **3/31/10**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 831,215.4 E 2,519,112.4**

SYSTEM

GROUND ELEVATION 1005.64 FT.



TOP RISER: 1008.29 FT.

TOP BENTONITE SEAL: 866.24 FT.

TOP GRAVEL PACK: 859.44 FT.

TOP SCREEN: 857.24 FT.

BOTTOM SCREEN: 807.24 FT.

BOTTOM WELL: 806.64 FT.

BOTTOM GRAVEL PACK: 805.44 FT.

BOTTOM BORING: 791.24 FT.

GROUT SEAL: 250 GALS VOLCLAY

BENTONITE SEAL: 100 LBS 3/8" COATED PELLETS

SCREEN: 2" dia., 20 SLOT SCH 40, 50.0

GRAVEL PACK: 975 LBS #4 QUARTZ SAND

RISER PIPE: 2", dia., SCH 40

SPACERS, DEPTH: 140', 80', 20'

NOTES:
-Drill & decon water coming from CD Fire Protection System
-Decon rig & tools 3/31/10
-Drilled w/6" air hammer
-SWL @ 15.1'

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

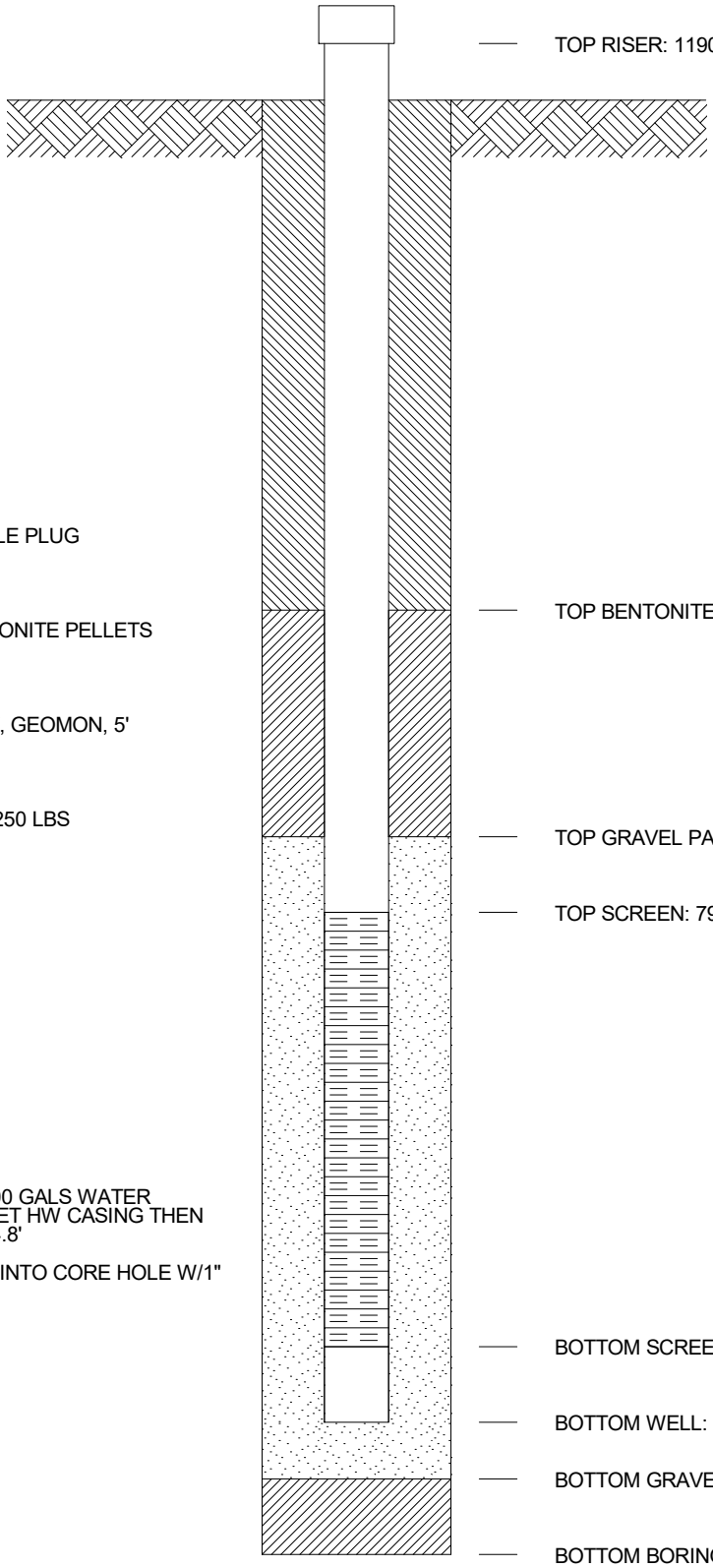
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **M-12** BORING No. **CA-0608** INSTALLED **12/13/06**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 833,112.2 E 2,516,013.2**

SYSTEM

GROUND ELEVATION 1187.65 FT.



TOP RISER: 1190.66 FT.

TOP BENTONITE SEAL: 861.25 FT.

TOP GRAVEL PACK: 855.55 FT.

TOP SCREEN: 794.65 FT.

BOTTOM SCREEN: 789.65 FT.

BOTTOM WELL: 789.65 FT.

BOTTOM GRAVEL PACK: 782.85 FT.

BOTTOM BORING: 782.85 FT.

GROUT SEAL: 3,000 LBS HOLE PLUG

BENTONITE SEAL: 30# BENTONITE PELLETS

SCREEN: 1.5" dia., 0.20 SLOT, GEOMON, 5'

GRAVEL PACK: #4 QUARTZ 250 LBS

RISER PIPE: 1", dia.,

SPACERS, DEPTH: N/A

-FLUSHED BORE HOLE W/700 GALS WATER
-6" AIR HAMMER TO 188.6' SET HW CASING THEN NQ ROCK CORE TO 404.8'
-SWL @ INSTALL 186.0'
-TREMIED SAND & PELLETS INTO CORE HOLE W/1" PIPE
-DECONNED TOOLS 11/7/06

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

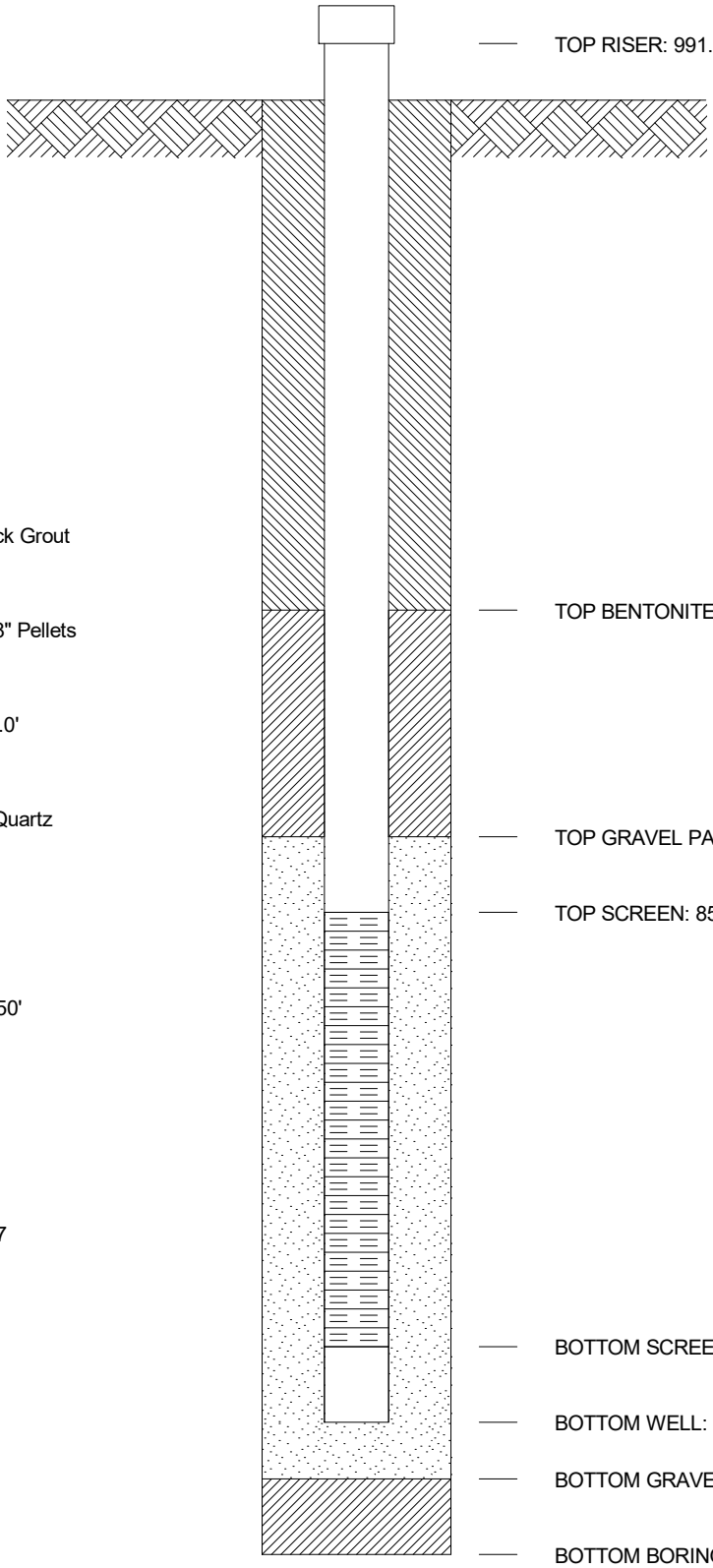
WELL No. **M-13** BORING No. **CA-0610** INSTALLED **4/3/07**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 831,697.9 E 2,518,374.3**

SYSTEM

GROUND ELEVATION 988.42 FT.



TOP RISER: 991.14 FT.

TOP BENTONITE SEAL: 871.52 FT.

TOP GRAVEL PACK: 864.12 FT.

TOP SCREEN: 858.12 FT.

BOTTOM SCREEN: 801.12 FT.

BOTTOM WELL: 800.42 FT.

BOTTOM GRAVEL PACK: 798.22 FT.

BOTTOM BORING: 794.02 FT.

GROUT SEAL: ~200 Gals Quick Grout

BENTONITE SEAL: 100 lbs 3/8" Pellets

SCREEN: 2" dia., .020 Slot, 57.0'

GRAVEL PACK: 1,050 lbs #4 Quartz

RISER PIPE: 2", dia., PVC

SPACERS, DEPTH: 150',100',50'

NOTES:
-Drilled w/6" Air Hammer
-Deconned Tolls & Rig 04/05/07
-SWL @ Install 134.2'

-3' SS Pump Type
-Pump intake @ 185'

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

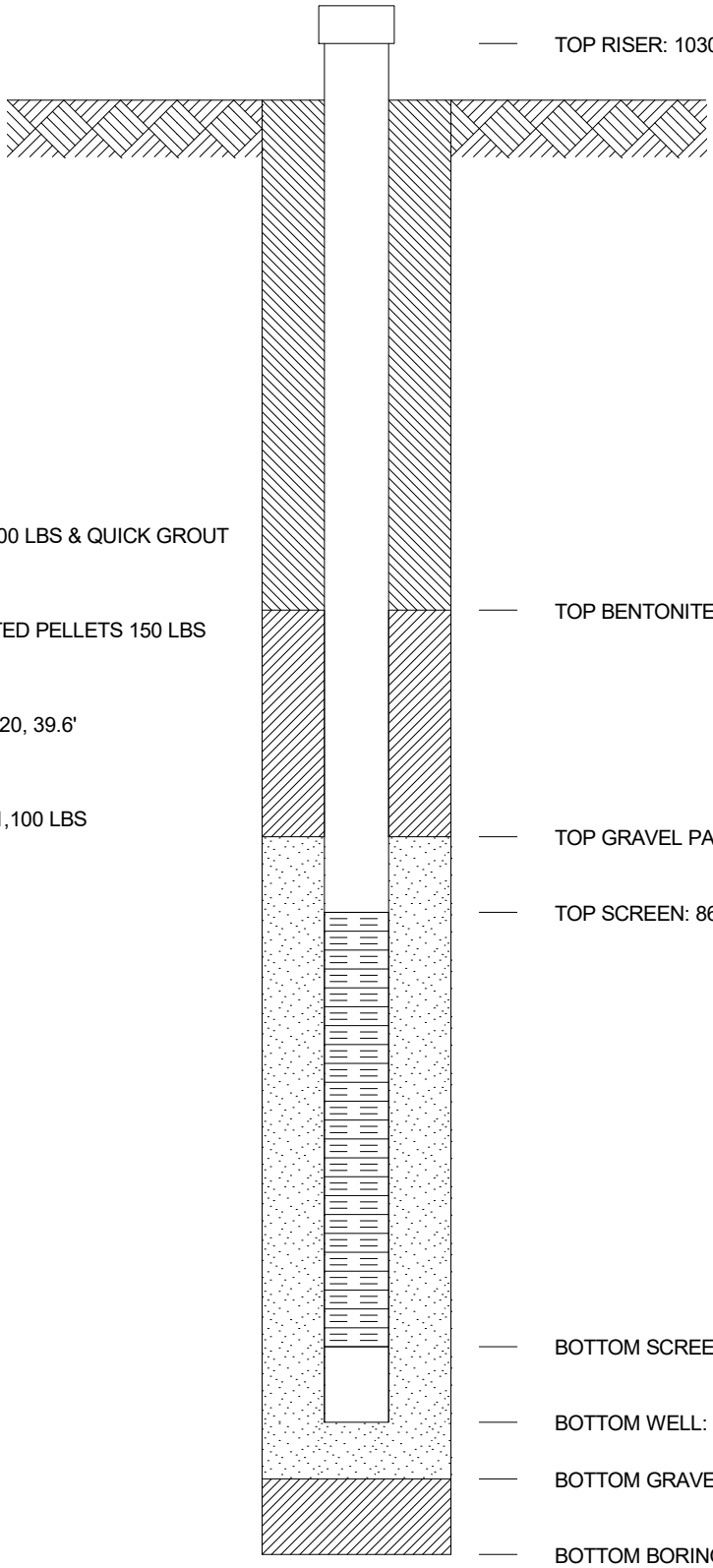
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **M-1302** BORING No. **B-1302M** INSTALLED **5/30/13**

PROJECT **CARDINAL FLY ASH DAM**

COORDINATES **N 836,201.9 E 2,515,432.0**

SYSTEM **State Plane using NAD27/29**

GROUND ELEVATION 1028.92 FT.



TOP RISER: 1030.72 FT.

TOP BENTONITE SEAL: 885.92 FT.

TOP GRAVEL PACK: 871.22 FT.

TOP SCREEN: 860.52 FT.

BOTTOM SCREEN: 820.92 FT.

BOTTOM WELL: 820.42 FT.

BOTTOM GRAVEL PACK: 819.92 FT.

BOTTOM BORING: 809.92 FT.

GROUT SEAL: HOLE PLUG 600 LBS & QUICK GROUT 50 GALS

BENTONITE SEAL: 3/8" COATED PELLETS 150 LBS

SCREEN: 2" dia., SLOTTED .020, 39.6'

GRAVEL PACK: #4 QUARTZ 1,100 LBS

RISER PIPE: 2", dia., PVC

SPACERS, DEPTH: 130 & 50

NOTES:
-Pump installed

GEOMCNST CD_FA_DAM.GPJ AEP.GDT 7/20/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

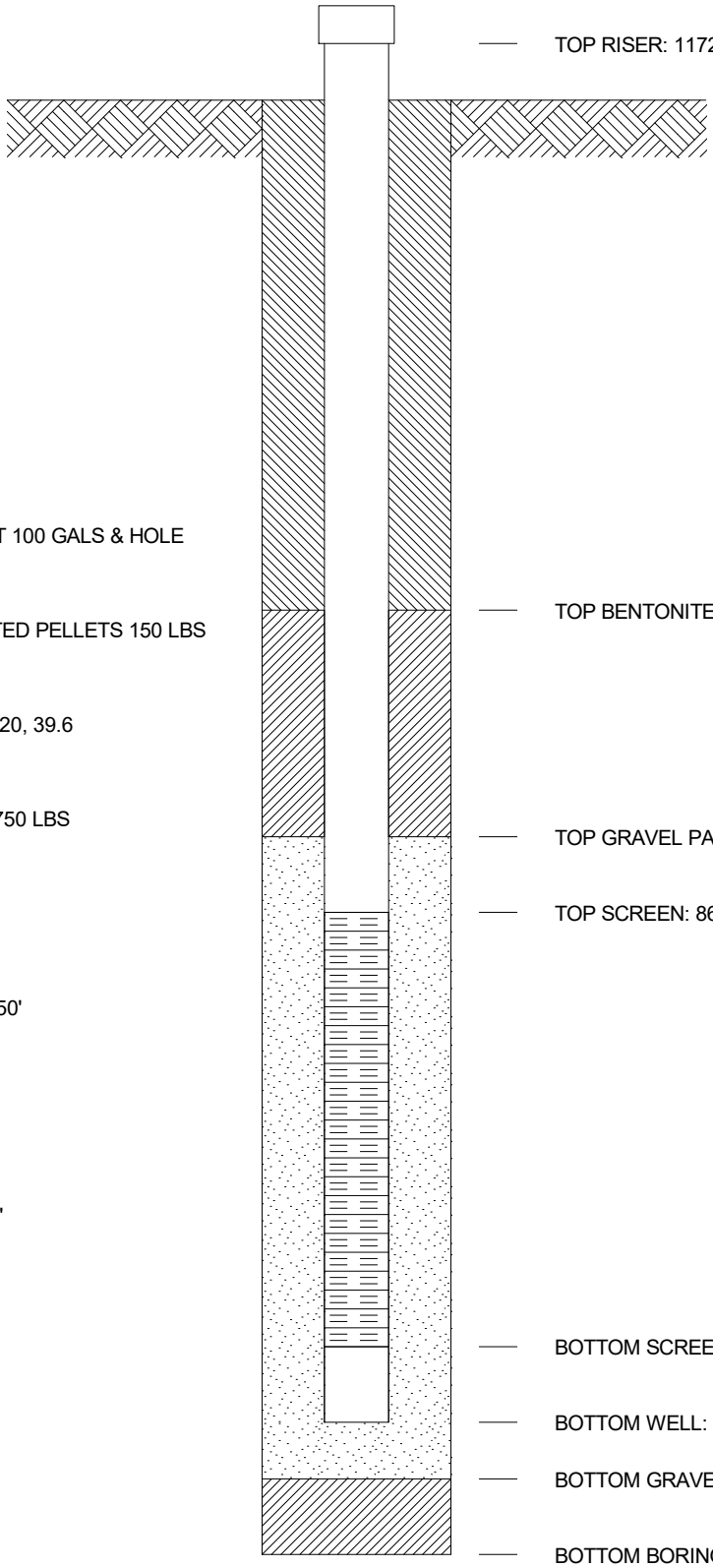
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **M-1309** BORING No. **B-1309D** INSTALLED **5/30/13**

PROJECT **CARDINAL FLY ASH DAM**

COORDINATES **N 835,558.0 E 2,517,396.3**

SYSTEM **State Plane using NAD27/29**

GROUND ELEVATION 1170.24 FT.



TOP RISER: 1172.09 FT.

TOP BENTONITE SEAL: 880.04 FT.

TOP GRAVEL PACK: 867.74 FT.

TOP SCREEN: 862.34 FT.

BOTTOM SCREEN: 822.74 FT.

BOTTOM WELL: 822.24 FT.

BOTTOM GRAVEL PACK: 821.24 FT.

BOTTOM BORING: 806.14 FT.

GROUT SEAL: QUICK GROUT 100 GALS & HOLE PLUG 500 LBS

BENTONITE SEAL: 3/8" COATED PELLETS 150 LBS

SCREEN: 2" dia., SLOTTED .020, 39.6

GRAVEL PACK: #4 QUARTZ 750 LBS

RISER PIPE: 2", dia., PVC

SPACERS, DEPTH: 250',150',50'

NOTES:
-Hole plug from 209.2' to 130.0'
-Pump installed

GEOMCNST CD_FA_DAM.GPJ AEP.GDT 7/20/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

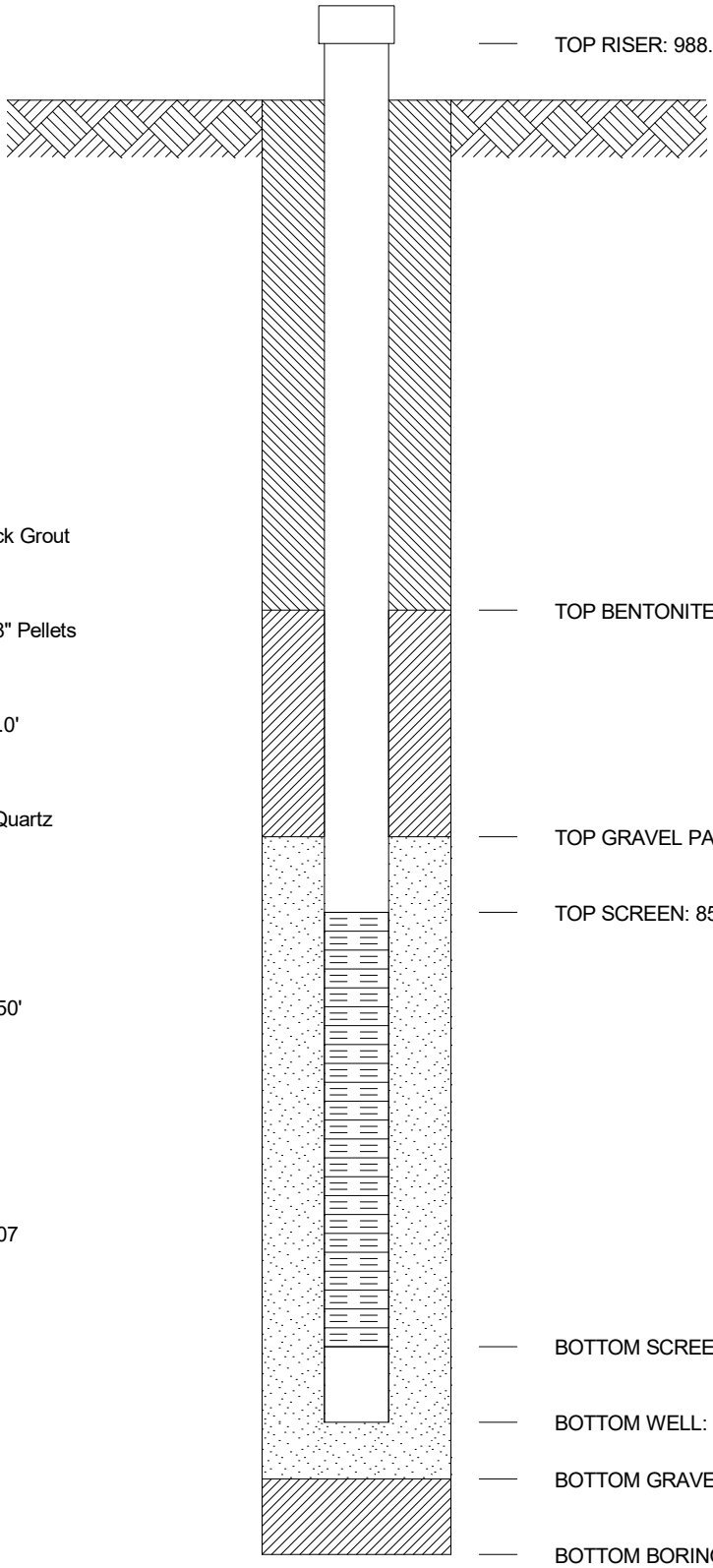
WELL No. **M-14** BORING No. **CA-0612** INSTALLED **3/21/07**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 832,901.9 E 2,519,661.8**

SYSTEM

GROUND ELEVATION 984.91 FT.



TOP RISER: 988.21 FT.

TOP BENTONITE SEAL: 866.01 FT.

TOP GRAVEL PACK: 859.11 FT.

TOP SCREEN: 857.61 FT.

BOTTOM SCREEN: 800.61 FT.

BOTTOM WELL: 799.91 FT.

BOTTOM GRAVEL PACK: 797.71 FT.

BOTTOM BORING: 790.21 FT.

GROUT SEAL: ~150 Gals Quick Grout

BENTONITE SEAL: 100 lbs 3/8" Pellets

SCREEN: 2" dia., .020 Slot, 57.0'

GRAVEL PACK: 1,150 lbs #4 Quartz

RISER PIPE: 2", dia., PVC

SPACERS, DEPTH: 150',100',50'

NOTES:
-Drilled w/6" Air Hammer
-Deconned Tools & Drill 03/21/07
-SWL @ 43.8'

-3' SS Pump Type
-Pump intake @ 182'

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

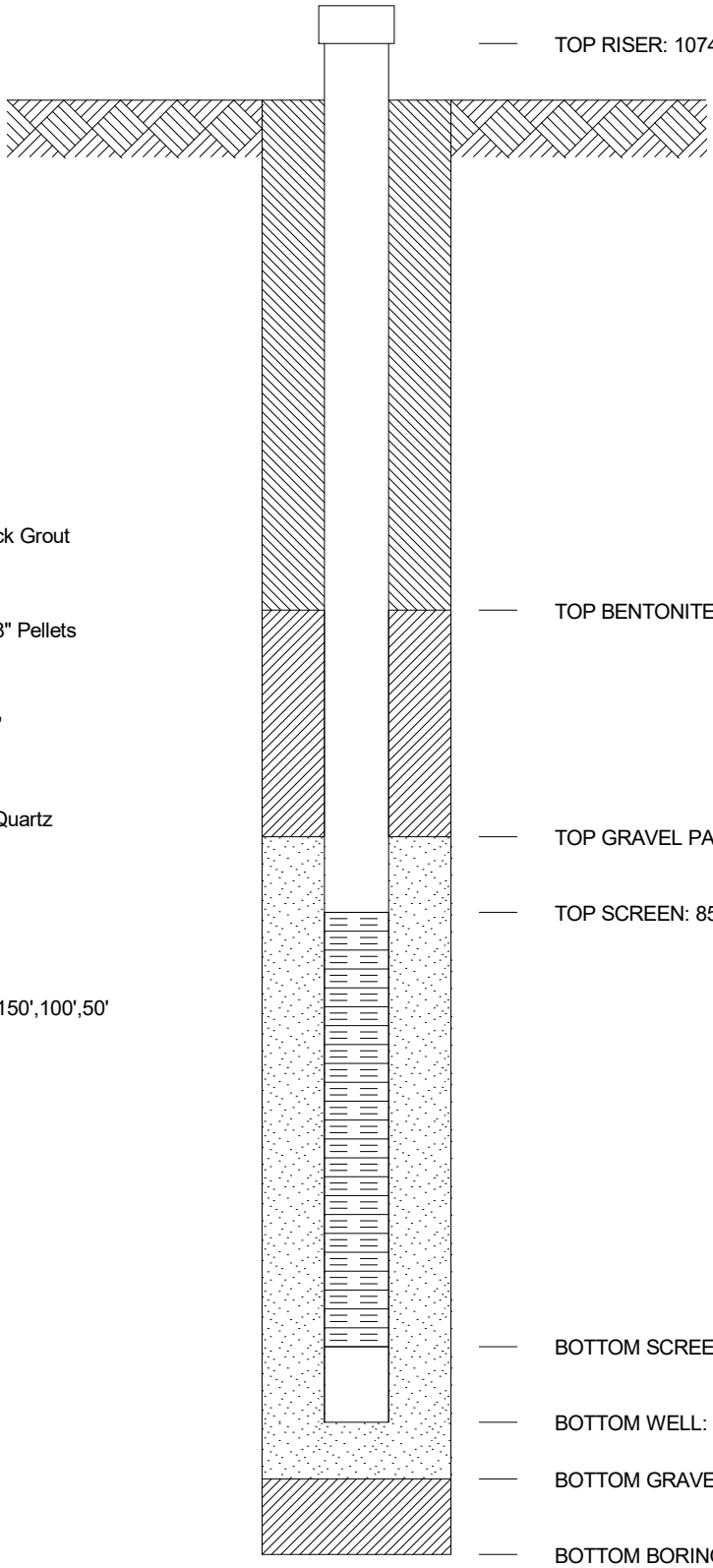
WELL No. **M-15** BORING No. **CA-0614** INSTALLED **7/25/07**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 833,569.0 E 2,518,172.3**

SYSTEM

GROUND ELEVATION 1071.83 FT.



GROUT SEAL: ~600 Gals Quick Grout

BENTONITE SEAL: 100 lbs 3/8" Pellets

SCREEN: 2" dia., .020 Slot, 60'

GRAVEL PACK: 1,275 lbs #4 Quartz

RISER PIPE: 2", dia., PVC

SPACERS, DEPTH: 250',200',150',100',50'

NOTES:
-Drilled w/6" Air Hammer
-SWL @ Install 72.5'
-Decon Tools 07/23/07

-3' SS Pump Type
-Pump intake @ 273'

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

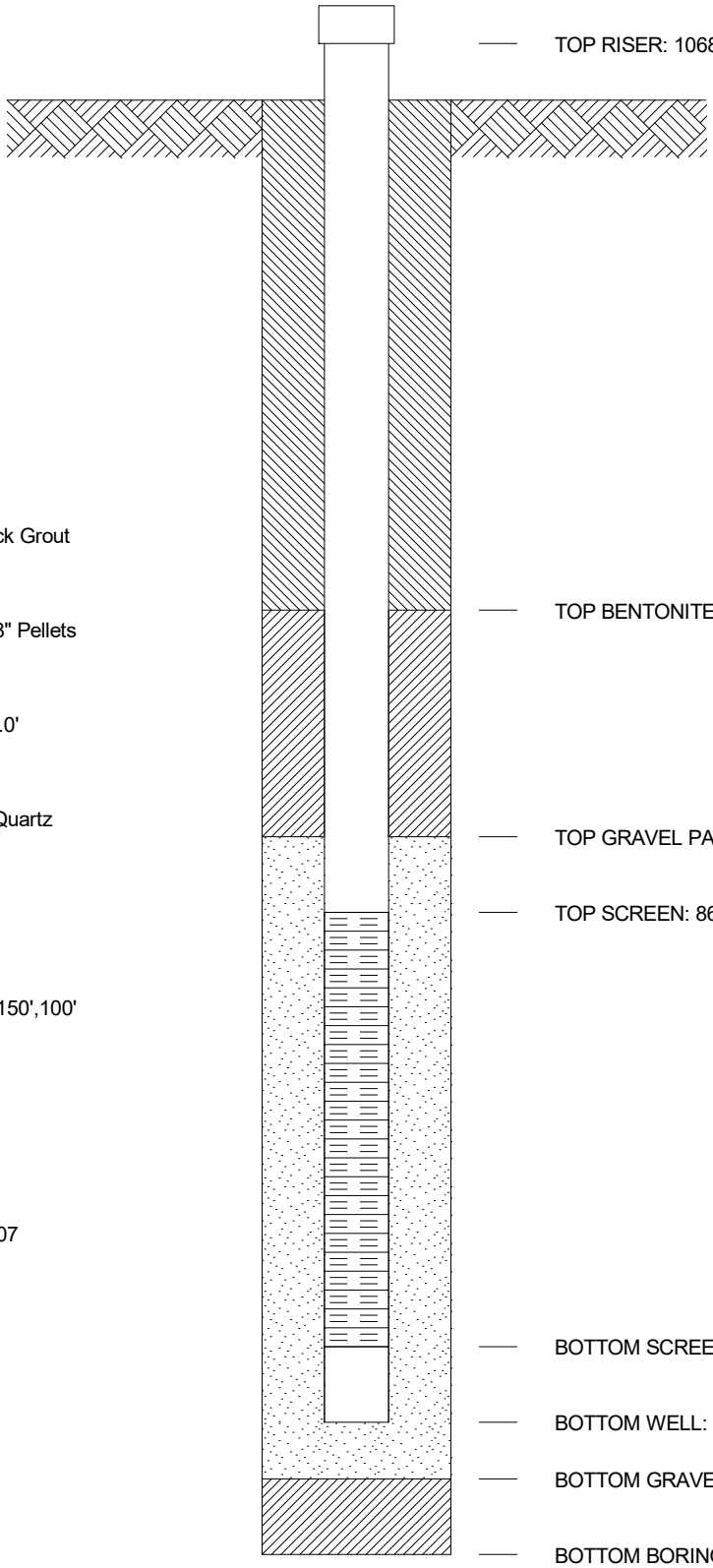
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **M-16** BORING No. **CA-0616** INSTALLED **1/24/07**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 835,565.0 E 2,516,519.0**

SYSTEM

GROUND ELEVATION 1065.75 FT.



TOP RISER: 1068.55 FT.

TOP BENTONITE SEAL: 878.25 FT.

TOP GRAVEL PACK: 871.85 FT.

TOP SCREEN: 864.45 FT.

BOTTOM SCREEN: 815.45 FT.

BOTTOM WELL: 814.75 FT.

BOTTOM GRAVEL PACK: 813.65 FT.

BOTTOM BORING: 811.15 FT.

GROUT SEAL: ~850 Gals Quick Grout

BENTONITE SEAL: 100 lbs 3/8" Pellets

SCREEN: 2" dia., .020 Slot, 49.0'

GRAVEL PACK: 1,950 lbs #4 Quartz

RISER PIPE: 2", dia., PVC

SPACERS, DEPTH: 250',200',150',100'

NOTES:
-Drilled w/6" Air Hammer
-Deconned Tools & Drill 02/01/07
-SWL @ Install 101.4'

-3' SS Pump Type
-Pump intake @ 248'

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

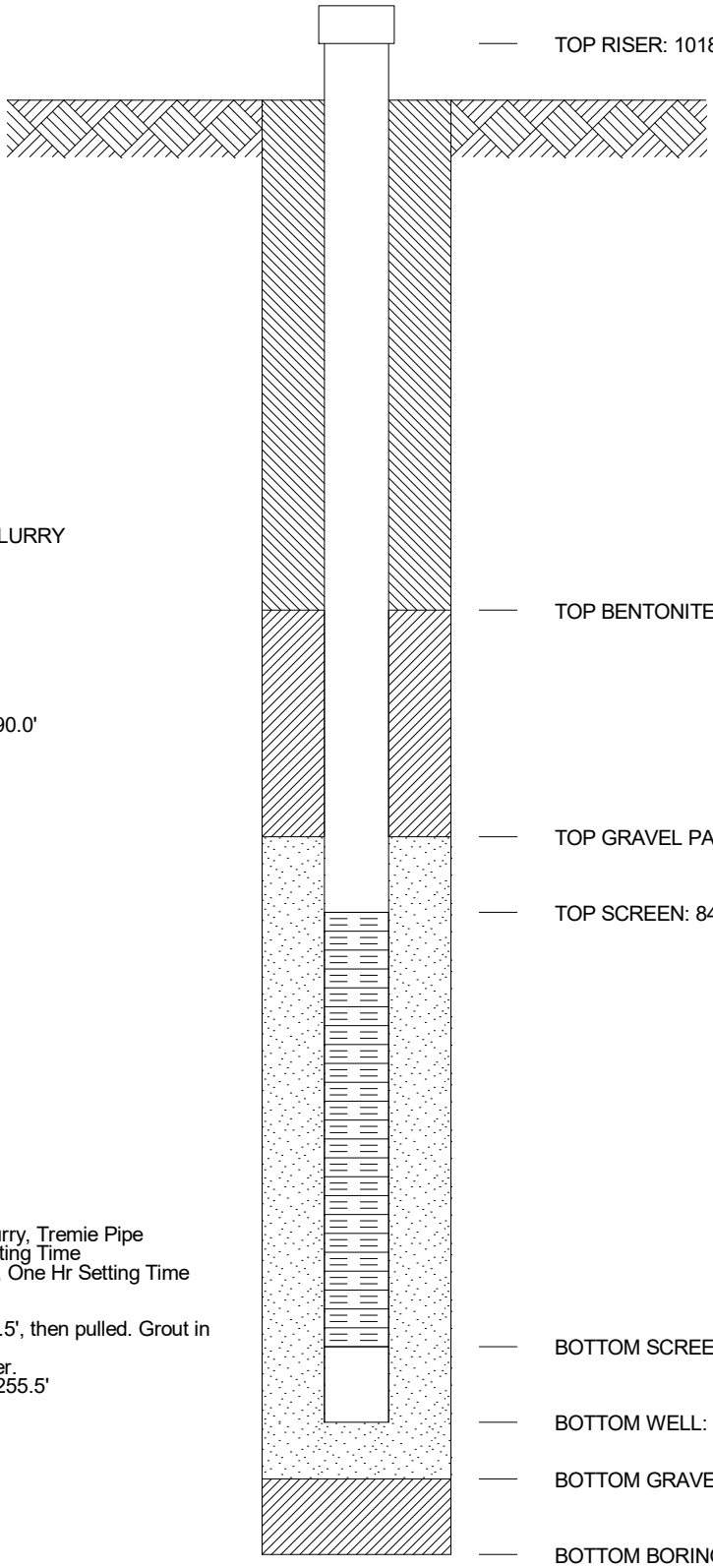
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **M-21** BORING No. **CA-0620** INSTALLED **6/1/06**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 830,426.7 E 2,516,358.1**

SYSTEM

GROUND ELEVATION 1016.16 FT.



TOP RISER: 1018.61 FT.

TOP BENTONITE SEAL: 861.66 FT.

TOP GRAVEL PACK: 856.16 FT.

TOP SCREEN: 846.16 FT.

BOTTOM SCREEN: 756.16 FT.

BOTTOM WELL: 756.16 FT.

BOTTOM GRAVEL PACK: 753.06 FT.

BOTTOM BORING: 753.06 FT.

GROUT SEAL: BENTONITE SLURRY

BENTONITE SEAL: PELLETS

SCREEN: 1" dia., .020 SLOT, 90.0'

GRAVEL PACK: FILTER PRO

RISER PIPE: 2", dia., PVC

SPACERS, DEPTH:

NOTES:
-Surface Seal: Cement
-Annular Sealant: Bentonite Slurry, Tremie Pipe Installation, Overnight Setting Time
-Bentonite Seal: Poured Slowly, One Hr Setting Time
-Sand Pack: Poured Slowly

-Original pump installed @ 258.5', then pulled. Grout in water sample.
-Well redeveloped with reclaimer.
-Pump reinstalled w/ intake @ 255.5'

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

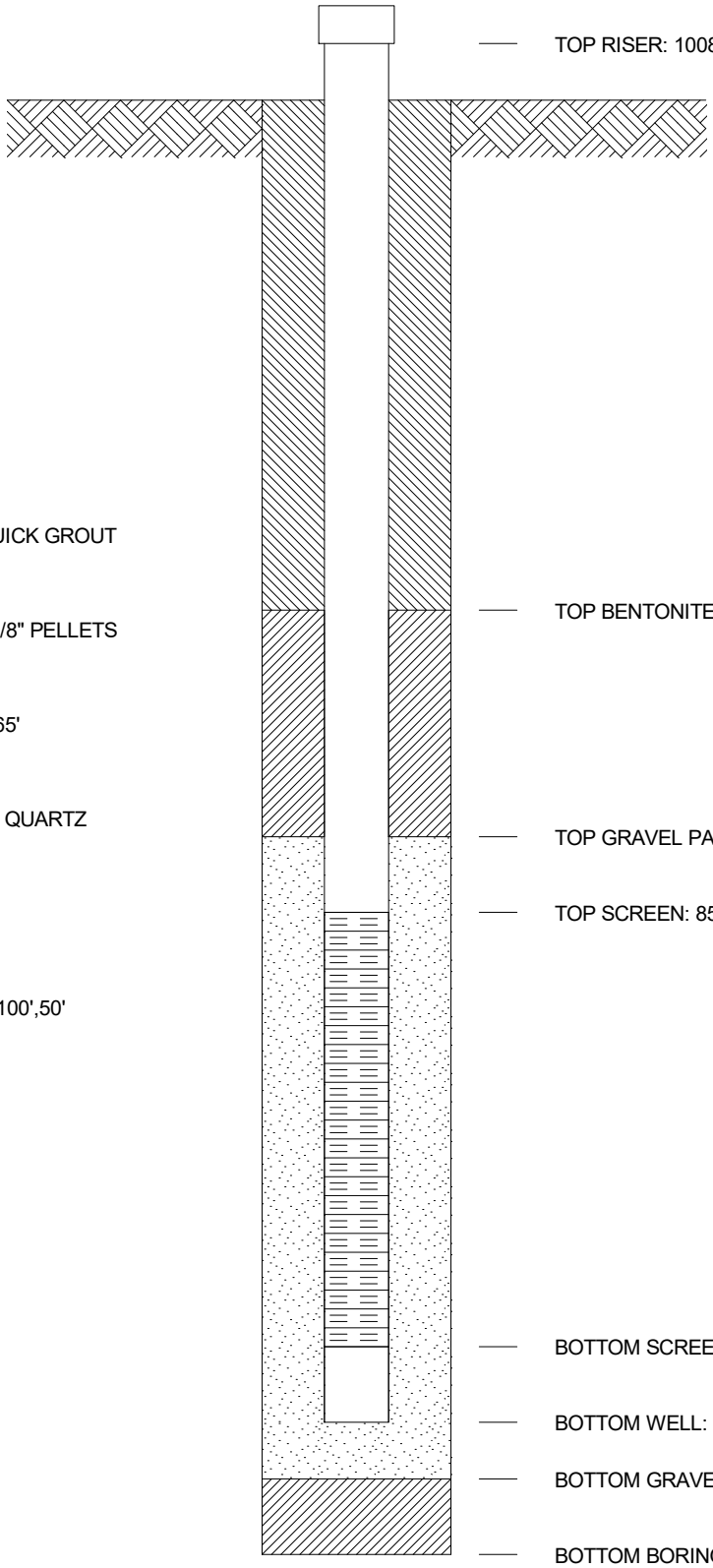
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **M-22** BORING No. **CA-0702** INSTALLED **5/21/07**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 830,925.1 E 2,519,495.8**

SYSTEM

GROUND ELEVATION 1005.68 FT.



TOP RISER: 1008.04 FT.

TOP BENTONITE SEAL: 865.28 FT.

TOP GRAVEL PACK: 859.18 FT.

TOP SCREEN: 852.78 FT.

BOTTOM SCREEN: 791.28 FT.

BOTTOM WELL: 790.58 FT.

BOTTOM GRAVEL PACK: 788.18 FT.

BOTTOM BORING: 786.48 FT.

GROUT SEAL: ~250 GALS QUICK GROUT

BENTONITE SEAL: 100 LBS 3/8" PELLETS

SCREEN: 2" dia., .020 SLOT, 65'

GRAVEL PACK: 1,100 LBS #4 QUARTZ

RISER PIPE: 2", dia., PVC

SPACERS, DEPTH: 200',150',100',50'

NOTES:
-Decon 05/22/07
-Drilled w/6" Air Hammer
-SWL @ Install 139.4'

-3' SS Pump Type
-Pump intake @ 214.5'

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

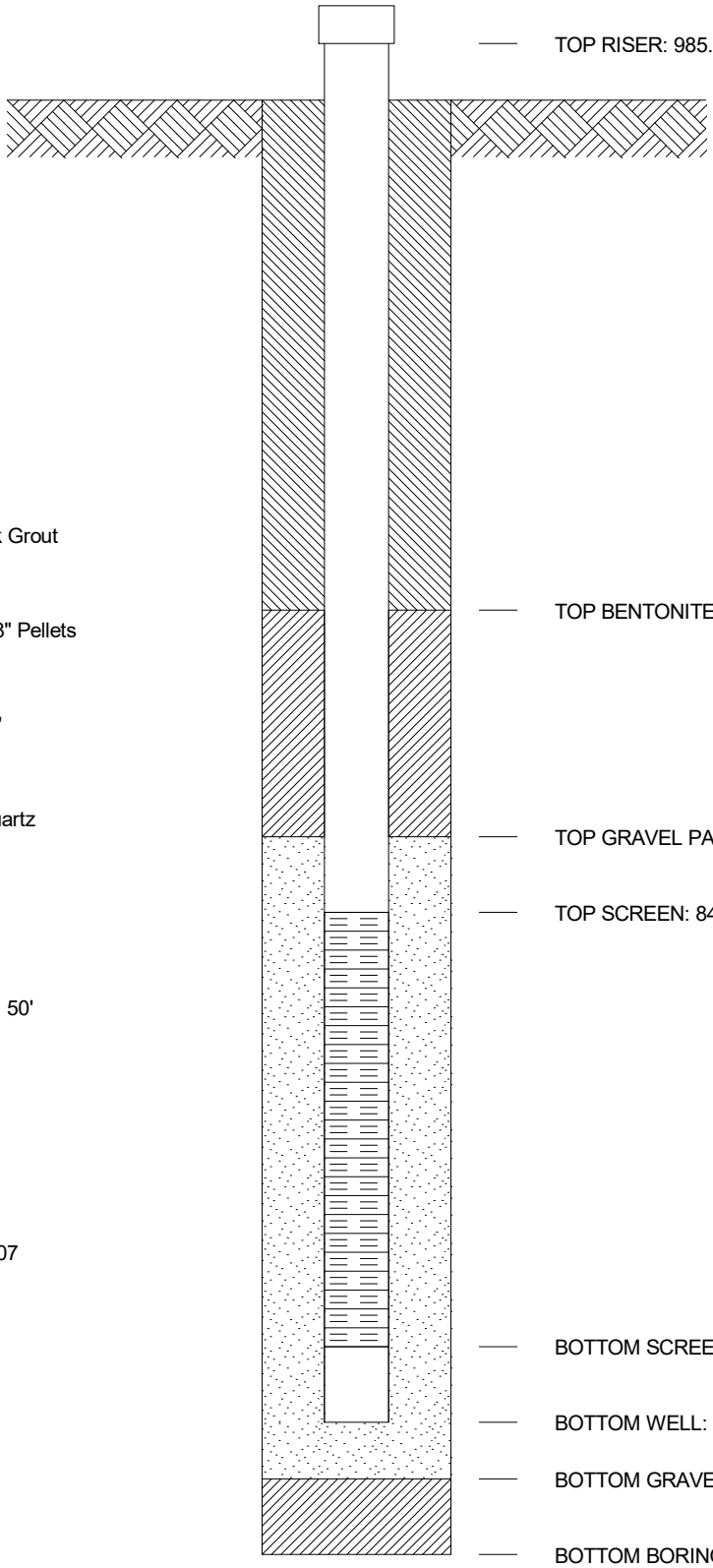
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **M-23** BORING No. **CA-0703** INSTALLED **4/23/07**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 830,051.2 E 2,518,092.0**

SYSTEM

GROUND ELEVATION 983.44 FT.



TOP RISER: 985.90 FT.

TOP BENTONITE SEAL: 858.54 FT.

TOP GRAVEL PACK: 850.74 FT.

TOP SCREEN: 847.14 FT.

BOTTOM SCREEN: 806.14 FT.

BOTTOM WELL: 805.44 FT.

BOTTOM GRAVEL PACK: 803.14 FT.

BOTTOM BORING: 803.14 FT.

GROUT SEAL: 150 Gals Quick Grout

BENTONITE SEAL: 100 lbs 3/8" Pellets

SCREEN: 2" dia., .020 Slot, 45'

GRAVEL PACK: 750 lbs #4 Quartz

RISER PIPE: 2", dia., PVC

SPACERS, DEPTH: 150', 100', 50'

NOTES:
-Replacement well for 8501/1S
-Drilled w/6" Air Hammer
-Deconned Tools & Drill 04/18/07
-SWL @ Install 98.4'

-3' SS Pump Type
-Pump intake @ 175'

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

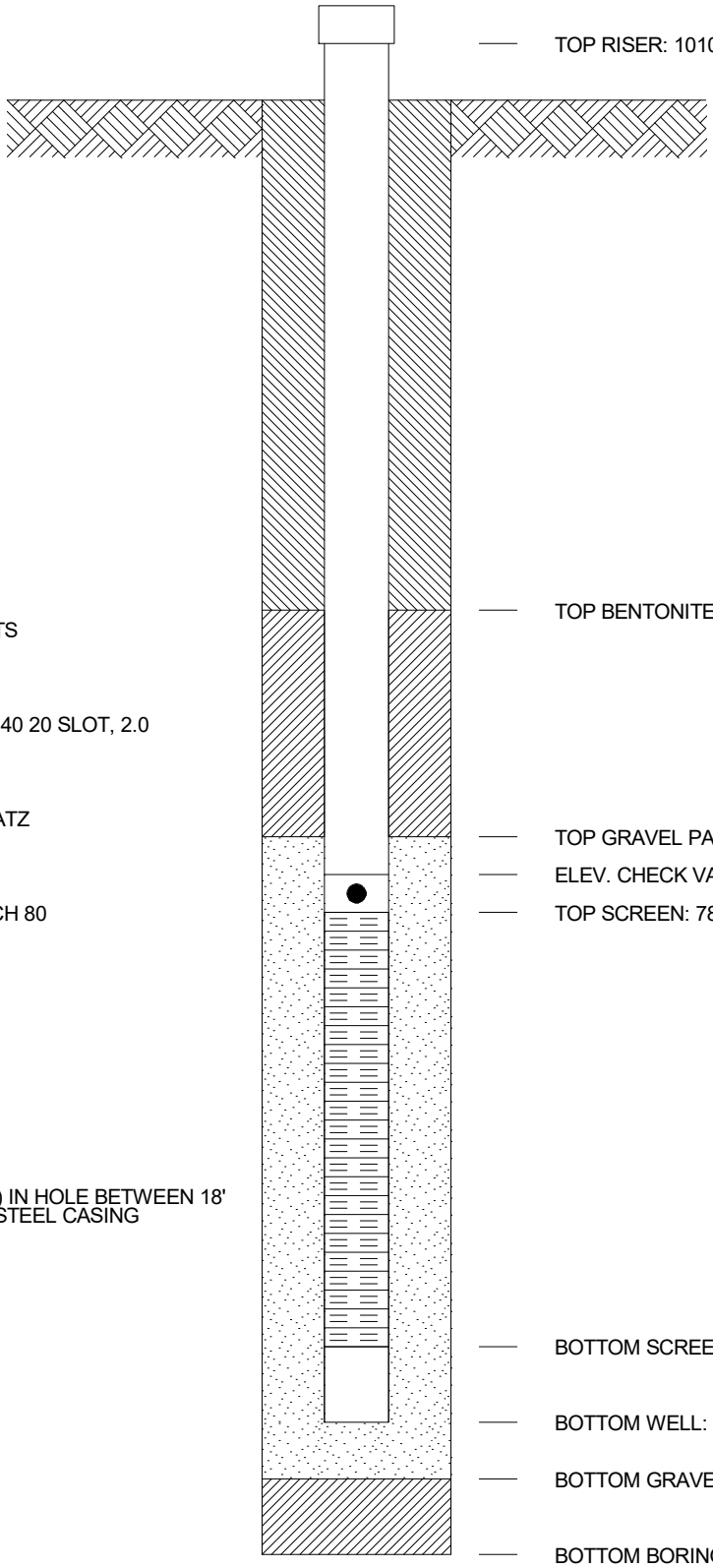
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **M-6** BORING No. **90CA22** INSTALLED **8/9/90**

PROJECT **CARDINAL PLANT**

COORDINATES **N 831,918.6 E 2,156,681.5**

SYSTEM **STATE PLANE**

GROUND ELEVATION 1008.56 FT.



TOP RISER: 1010.46 FT.

TOP BENTONITE SEAL: 873.06 FT.

TOP GRAVEL PACK: 864.36 FT.

ELEV. CHECK VALVE: 788.56 FT.

TOP SCREEN: 787.96 FT.

BOTTOM SCREEN: 785.96 FT.

BOTTOM WELL: 785.56 FT.

BOTTOM GRAVEL PACK: 784.56 FT.

BOTTOM BORING: 778.36 FT.

GROUT SEAL: BENSEAL

BENTONITE SEAL: PI PELLETS

SCREEN: 1.25 dia., PVC SCH 40 20 SLOT, 2.0

GRAVEL PACK: #4 OHIO QUATZ

RISER PIPE: 1.0, dia., PVC SCH 80

SPACERS, DEPTH:

20' OF CASING LOST (3" NW) IN HOLE BETWEEN 18' TO 50'? GEOMON A-36 STEEL CASING

GEOMCNST CD SI.GPJ AEP.GDT 7/20/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

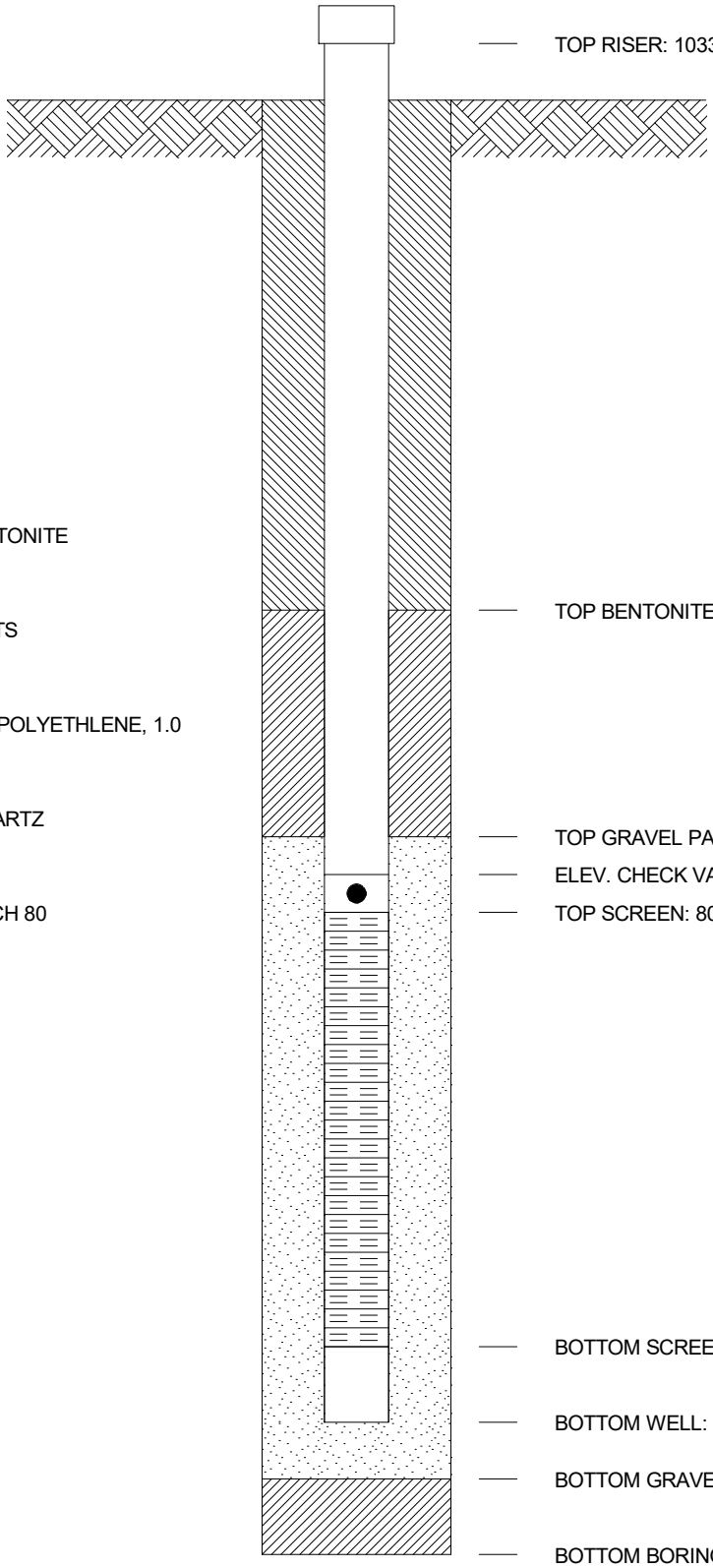
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **M-10** BORING No. **85W-3** INSTALLED **8/13/85**

PROJECT **CARDINAL PLANT**

COORDINATES **N 829,994.0 E 2,518,683.2**

SYSTEM **STATE PLANE**

GROUND ELEVATION 1031.00 FT.



TOP RISER: 1033.42 FT.

TOP BENTONITE SEAL: 859.50 FT.

TOP GRAVEL PACK: 853.00 FT.

ELEV. CHECK VALVE: 802.10 FT.

TOP SCREEN: 801.50 FT.

BOTTOM SCREEN: 800.50 FT.

BOTTOM WELL: 800.50 FT.

BOTTOM GRAVEL PACK: 794.00 FT.

BOTTOM BORING: 766.00 FT.

GROUT SEAL: CEMENT\BENTONITE

BENTONITE SEAL: PI PELLETS

SCREEN: 1.25 dia., PORPUS POLYETHLENE, 1.0

GRAVEL PACK: #4 OHIO QUARTZ

RISER PIPE: 0.8, dia., PVC SCH 80

SPACERS, DEPTH:

GEOMON 12"GEOMON

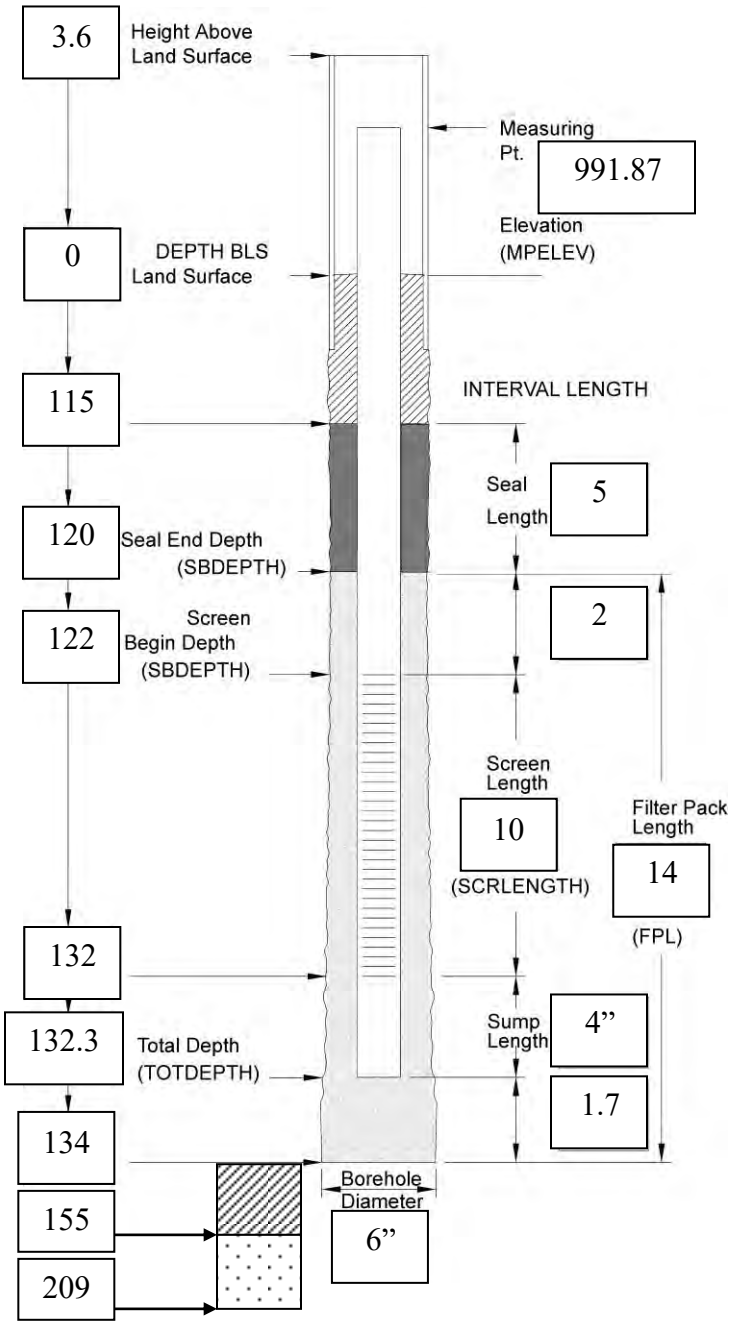
GEOMCNST CD SI.GPJ AEP.GDT 7/20/15

Geosyntec consultants

WELL CONSTRUCTION LOG
ABOVE GROUND COMPLETION

Well I.D. (LOCID): M-GS-1
Drilling Company: Layne
Drillers: Danny Allen
Geologist/Engineer: D. Mateas / M. Muenich
Signature:

Site: AEP – Cardinal Project Number: CHE8126L
Installation Method: HAS/Rotary
Casing Installation Date (INSDATE): 4/13/16
Well Type (WTCCODE): Monitoring Well
Well Completion Method (WCMCODE): Above Grade
Geologic Completion Zone (GZCODE):



Comments
Total drilled depth = 209’; backfilled with sand and chips to 134’; centralizer at 65’

Well Completion
2 Guard Posts (Y / N) Date:
Surface Pad Size: 2 ft x 2 ft x 6”
Protective Casing or Cover
Diameter/Type: 4” locking flip-top
Depth BGS: 2 Weep Hole (Y / N)
Grout
Composition/Proportions: 150 lbs Haliburton Bentonite Quick Grout / 100 gal. H_2O
Placement Method: pressure tremie

Seal Date: 4/13/16
Type: 3/8” coated bentonite pellets
Source: Pel-Plug Western Bentonite
Set-up/Hydration Time: 30 mins
Placement Method: poured gravity
Vol. Fluid Added: N/A - submerged
Filter Pack
Type: #5 med. coarse sand
Source: Flat Rock, Sparta, MI
Amount Used: 8 x 50 lb bags
Placement Method: poured gravity

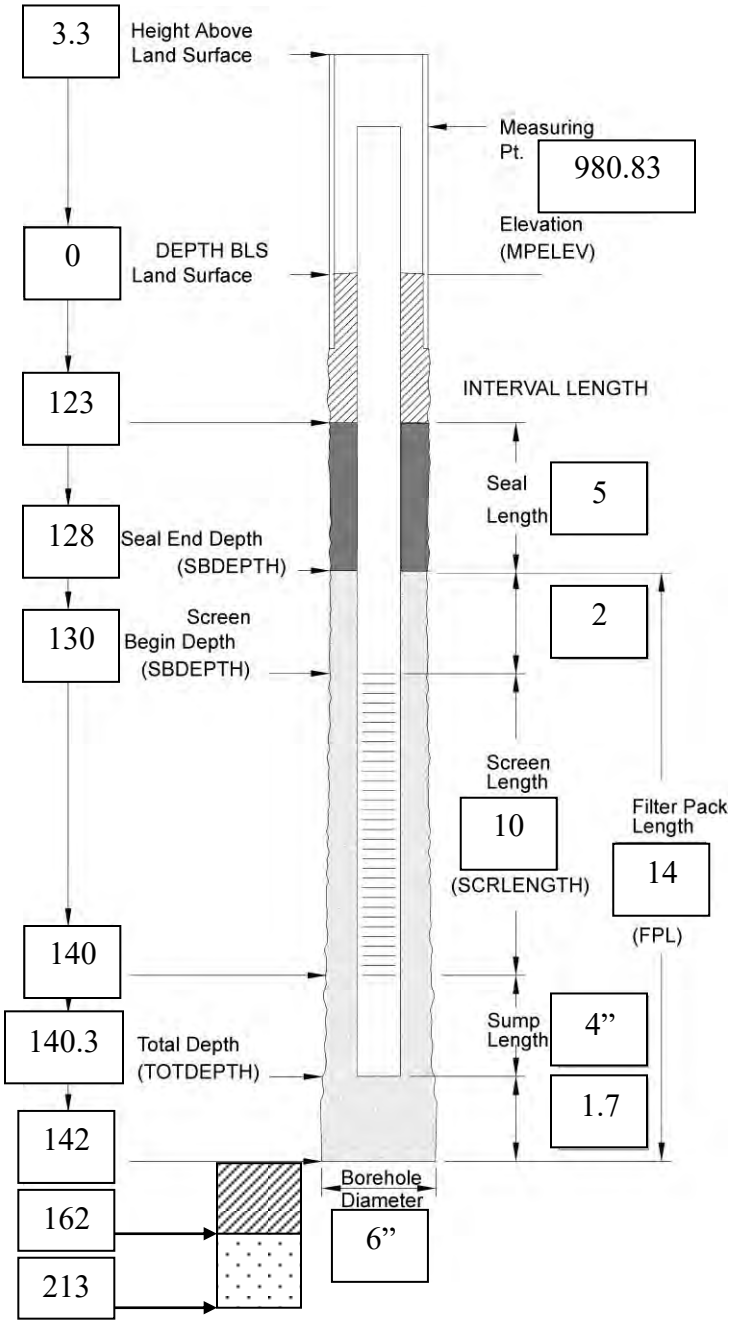
Well Riser Pipe
Casing Material (CMACODE): Sch. 40 PVC
Casing Inside Diameters (CASDIAM): 2.0 in.
Screen
Material: Pre-packed Sch. 40 PVC
Inside Diameter (SCRDIAM): 2.0 in.
Screen Slot Size: (SOUA): 0.010 10-slot in.
Percent Open Area (PCTOPEN):
Sump or Bottom Cap (Y / N)
Type/Length: 4” Sch. 40 PVC
Backfill Plug (Y / N)
Material: 3/8” med. crushed bentonite chips
Placement Method: poured gravity
Set-up/Hydration Time:
Total Water Volume During Construction
Introduced (Gal): 0 Recovered (Gal): -
Reviewed By: J. Neil Couch Date: 4/22/2016

Geosyntec consultants

WELL CONSTRUCTION LOG
ABOVE GROUND COMPLETION

Well I.D. (LOCID): M-GS-2
Drilling Company: Layne
Drillers: Danny Allen
Geologist/Engineer: D. Mateas / M. Muenich
Signature:

Site: AEP – Cardinal Project Number: CHE8126L
Installation Method: HSA
Casing Installation Date (INSDATE): 4/13/16
Well Type (WTCCODE): Monitoring Well
Well Completion Method (WCMCODE): Above Grade
Geologic Completion Zone (GZCODE):



Comments
Total drilled depth = 213’; backfilled to 142’ with sand and chips (20’ seal); 1 centralizer used at 70’

Well Completion
2 Guard Posts (Y / N) Date:
Surface Pad Size: 2 ft x 2 ft x 6”
Protective Casing or Cover
Diameter/Type: 4” locking flip-top
Depth BGS: 2 Weep Hole (Y / N)
Grout
Composition/Proportions: 150 lbs Haliburton Bentonite Quick Grout / 100 gal. H_2O
Placement Method: pressure tremie

Seal Date: 4/13/16
Type: 3/8” coated bentonite pellets
Source: Pel-Plug Western Bentonite
Set-up/Hydration Time: 30 mins
Placement Method: poured gravity
Vol. Fluid Added: N/A - submerged
Filter Pack
Type: #5 med. coarse sand
Source: Flat Rock, Sparta, MI
Amount Used: 6 x 50 lb bags
Placement Method: poured gravity

Well Riser Pipe
Casing Material (CMACODE): Sch. 40 PVC
Casing Inside Diameters (CASDIAM): 2.0 in.
Screen
Material: Pre-packed Sch. 40 PVC
Inside Diameter (SCRDIAM): 2.0 in.
Screen Slot Size: (SOUA): 0.010 10-slot in.
Percent Open Area (PCTOPEN):
Sump or Bottom Cap (Y / N)
Type/Length: 4” Sch. 40 PVC
Backfill Plug (Y / N)
Material: 3/8” med. crushed bentonite chips
Placement Method: poured gravity
Set-up/Hydration Time:
Total Water Volume During Construction
Introduced (Gal): 0 Recovered (Gal): -
Reviewed By: J. Neil Couch Date: 4/22/2016

Geosyntec consultants

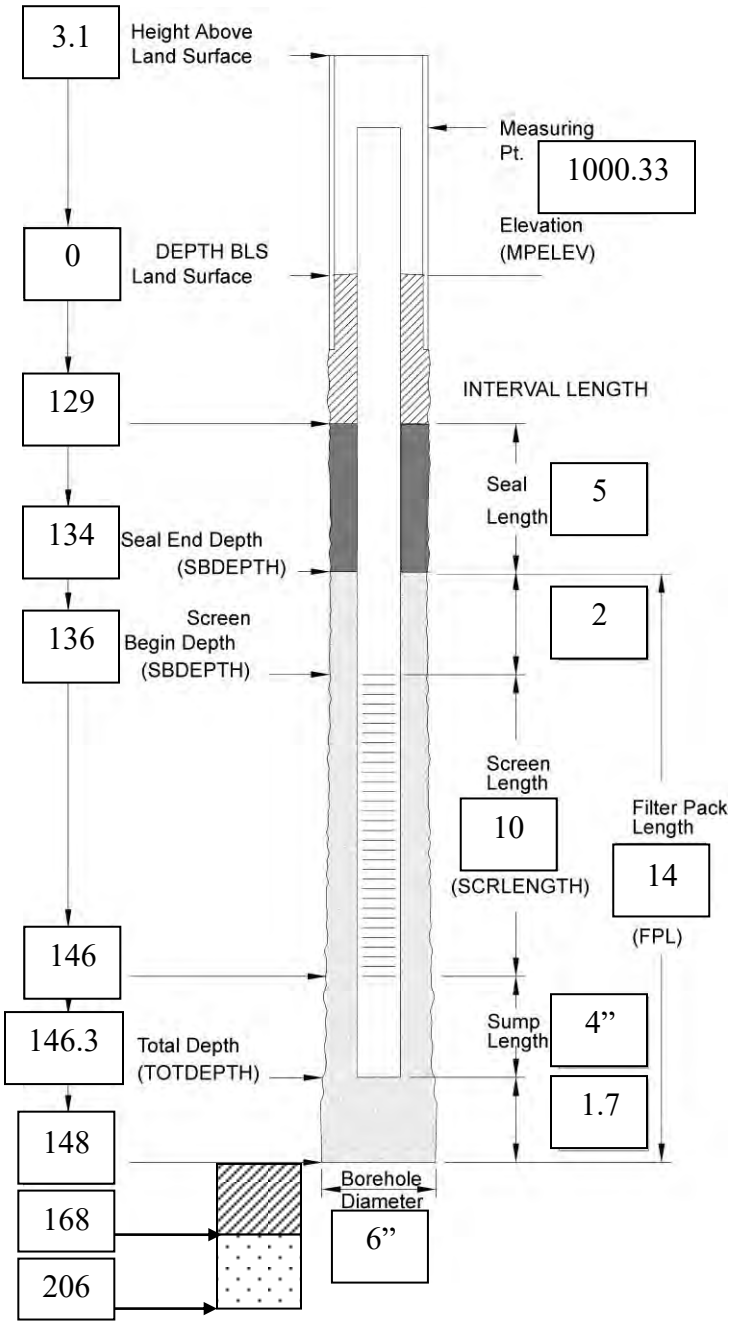
WELL CONSTRUCTION LOG
ABOVE GROUND COMPLETION

Well I.D. (LOCID): M-GS-3
Drilling Company: Layne

Drillers: Danny Allen
Geologist/Engineer: D. Mateas / M. Muenich
Signature:

Site: AEP – Cardinal Project Number: CHE8126L
Installation Method: HSA/Rotary

Casing Installation Date (INSDATE): 4/12/16
Well Type (WTCCODE): Monitoring Well
Well Completion Method (WCMCODE): Above Grade
Geologic Completion Zone (GZCODE):



Comments
Total boring depth = 206'; backfilled with sand then chips To 148'; centralizer used at 70'

Well Completion
2 Guard Posts (Y / N) Date:
Surface Pad Size: 2 ft x 2 ft x 6"
Protective Casing or Cover
Diameter/Type: 4" locking flip-top
Depth BGS: 2 Weep Hole (Y / N)
Grout
Composition/Proportions: 150 lbs Haliburton Bentonite Quick Grout / 100 gal. H_2O
Placement Method: pressure tremie

Seal Date: 4/12/16
Type: 3/8" coated bentonite pellets
Source: Pel-Plug Western Bentonite
Set-up/Hydration Time: 30 mins
Placement Method: poured gravity
Vol. Fluid Added: N/A - submerged
Filter Pack
Type: #5 med. filter pack
Source: Flat Rock Bagging, Sparta, MI
Amount Used:
Placement Method: poured gravity

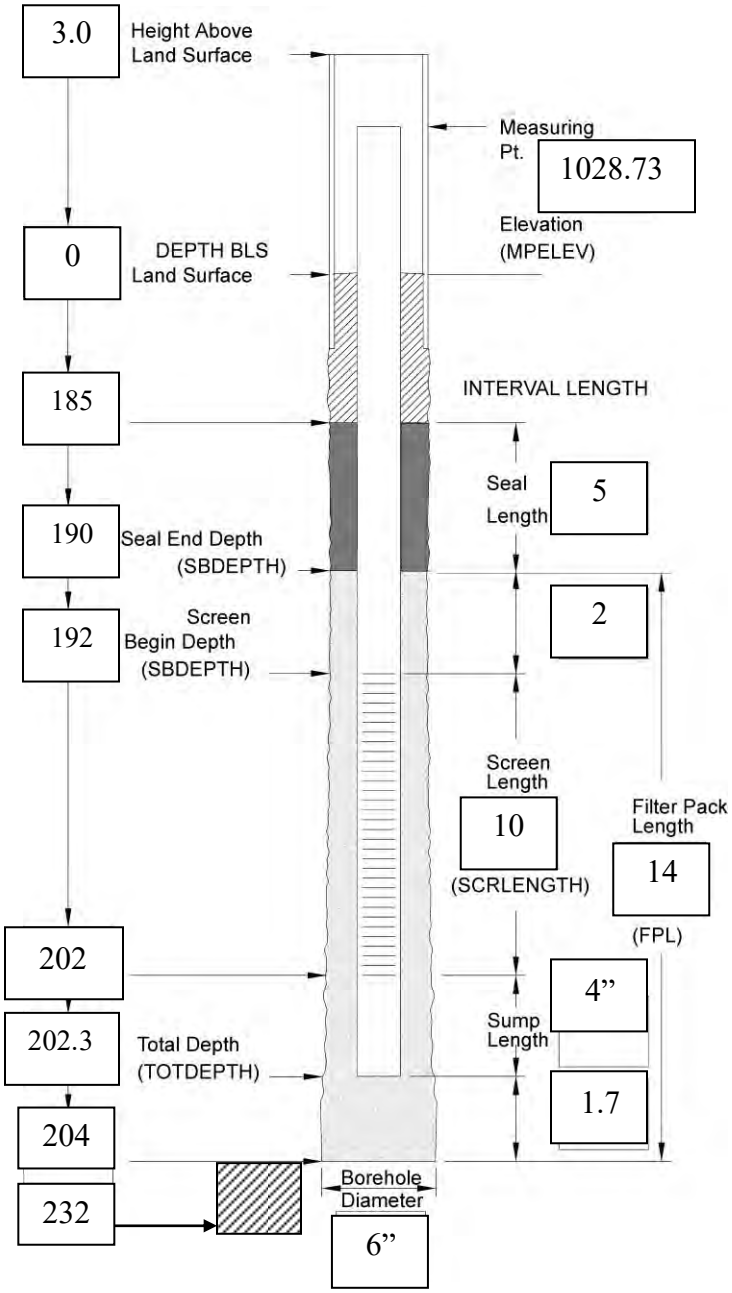
Well Riser Pipe
Casing Material (CMACODE): Sch. 40 PVC
Casing Inside Diameters (CASDIAM): 2.0 in.
Screen
Material: Pre-packed Sch. 40 PVC
Inside Diameter (SCRDIAM): 2.0 in.
Screen Slot Size: (SOUA): 0.010 10-slot in.
Percent Open Area (PCTOPEN):
Sump or Bottom Cap (Y / N)
Type/Length: 4" Sch. 40 PVC
Backfill Plug (Y / N)
Material: 3/8" crushed bentonite hole plug
Placement Method: poured gravity
Set-up/Hydration Time:
Total Water Volume During Construction
Introduced (Gal): 0 Recovered (Gal): -
Reviewed By: J. Neil Couch Date: 4/22/2016

Geosyntec consultants

WELL CONSTRUCTION LOG
ABOVE GROUND COMPLETION

Well I.D. (LOCID): M-GS-4
Drilling Company: Layne
Drillers: Danny Allen
Geologist/Engineer: D. Mateas
Signature: _____

Site: AEP – Cardinal Project Number: CHE8126L
Installation Method: HAS/Rotary
Casing Installation Date (INSDATE): 04/21/2016
Well Type (WTCCODE): Monitoring Well
Well Completion Method (WCMCODE): Above Grade
Geologic Completion Zone (GZCODE): _____



Well Completion
2 Guard Posts (Y / N) Date: _____
Surface Pad Size: 2 ft x 2 ft
Protective Casing or Cover
Diameter/Type: 4" steel
Depth BGS: _____ Weep Hole (Y / N)
Grout
Composition/Proportions: 15 bags Bentonite grout
Placement Method: pressure tremie

Seal Date: 04/21/16
Type: 3/8" coated bentonite pellets
Source: Pel-Plug Western Bentonite
Set-up/Hydration Time: 30 mins
Placement Method: poured gravity
Vol. Fluid Added: N/A - submerged
Filter Pack
Type: #5 medium coarse sand
Source: Flat Rock, Sparta, MI
Amount Used: 14 x 50 lb bags
Placement Method: poured gravity
Well Riser Pipe
Casing Material (CMACODE): Sch. 40 PVC
Casing Inside Diameters (CASDIAM): 2.0 in.
Screen
Material: Pre-packed Sch. 40 PVC
Inside Diameter (SCRDIAM): 2.0 in.
Screen Slot Size: (SOUA): 0.010 10-slot in.
Percent Open Area (PCTOPEN): _____
Sump or Bottom Cap (Y / N)
Type/Length: 4" Sch. 40 PVC
Backfill Plug (Y / N)
Material: 3/8" medium crushed bentonite chips
Placement Method: poured gravity
Set-up/Hydration Time: _____

Comments
Total drilled depth = 232'; backfilled with chips to 204'.

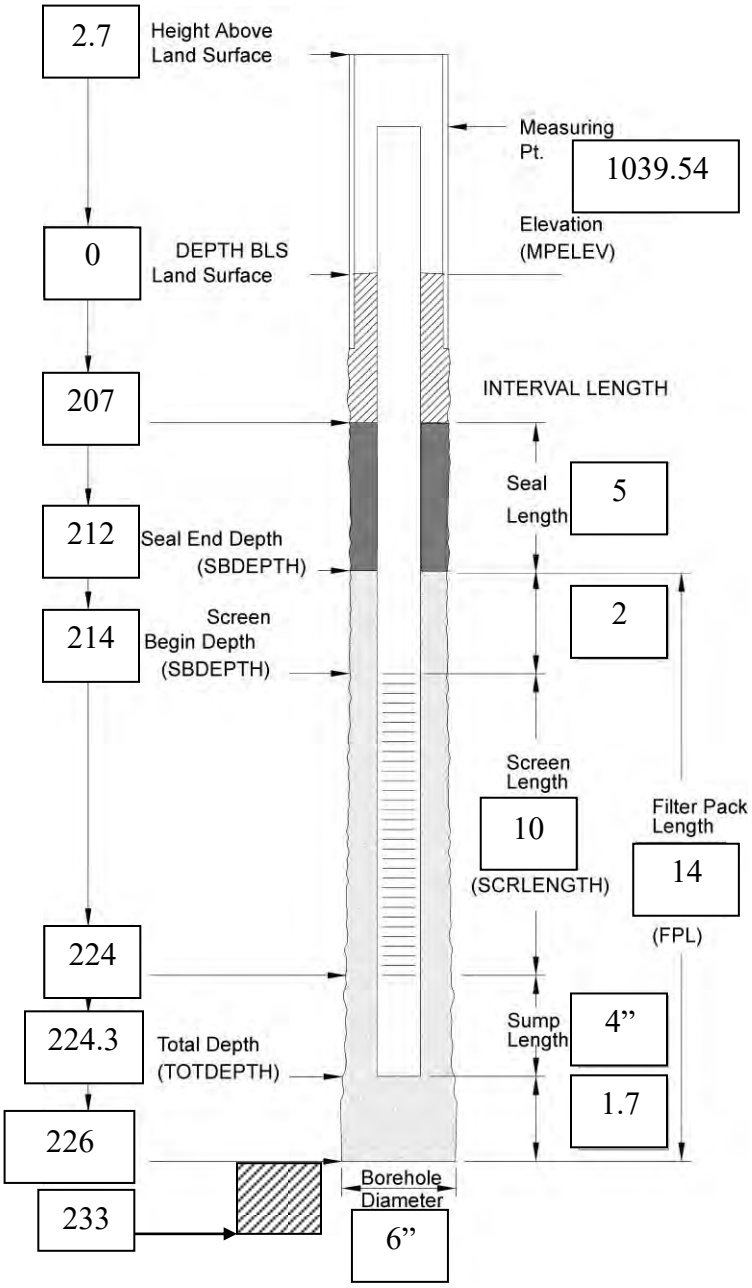
Total Water Volume During Construction
Introduced (Gal): _____ Recovered (Gal): _____
Reviewed By: J. Neil Couch Date: 5/03/2016

Geosyntec consultants

WELL CONSTRUCTION LOG
ABOVE GROUND COMPLETION

Well I.D. (LOCID): M-GS-5
Drilling Company: Layne
Drillers: Danny Allen
Geologist/Engineer: J. Bannantine
Signature:

Site: AEP – Cardinal Project Number: CHE8126L
Installation Method: HSA/Rotary
Casing Installation Date (INSDATE): 4/5/16
Well Type (WTCCODE): Monitoring Well
Well Completion Method (WCMCODE): Above Grade
Geologic Completion Zone (GZCODE):



Well Completion
2 Guard Posts (Y / N) Date:
Surface Pad Size: 2 ft x 2 ft x 6”
Protective Casing or Cover
Diameter/Type: 4” locking flip-top
Depth BGS: 2 Weep Hole (Y / N)
Grout
Composition/Proportions: 150 lbs Haliburton Bentonite Quick Grout / 100 gal. H_2O
Placement Method: pressure tremie

Seal Date: 4/5/16
Type: 3/8” coated bentonite pellets
Source: Pel-Plug Western Bentonite
Set-up/Hydration Time: 30 mins
Placement Method: poured gravity
Vol. Fluid Added: N/A - submerged
Filter Pack
Type: #5 med. coarse sand
Source: Flat Rock, Sparta, MI
Amount Used: 8 x 50 lb bags
Placement Method: poured gravity

Well Riser Pipe
Casing Material (CMACODE): Sch. 40 PVC
Casing Inside Diameters (CASDIAM): 2.0 in.
Screen
Material: Pre-packed Sch. 40 PVC
Inside Diameter (SCRDIAM): 2.0 in.
Screen Slot Size: (SOUA): 0.010 10-slot in.
Percent Open Area (PCTOPEN):
Sump or Bottom Cap (Y / N)
Type/Length: 4” Sch. 40 PVC
Backfill Plug (Y / N)
Material: 3/8” med. crushed bentonite chips
Placement Method: poured gravity
Set-up/Hydration Time:
Total Water Volume During Construction
Introduced (Gal): 0 Recovered (Gal): -
Reviewed By: J. Neil Couch Date: 5/3/2016

Comments
Total drilled depth = 233.3’; backfilled with chips to 226’

HULL
Environment / Energy / Infrastructure

Cardinal Operating Company
306 County Road 7E
Brilliant, Ohio
BPG003

Date Started	: 3-6-2019
Date Completed	: 3-8-2019
Logged by	: Mielecki
Reviewed by	: J. Ardner
Drilling Contractor	: Terra Testing
Drilling Method	: 4.25" HSA
Sampling Method	: 4" Core Barrel
Total Depth (ft.)	: 77.0'

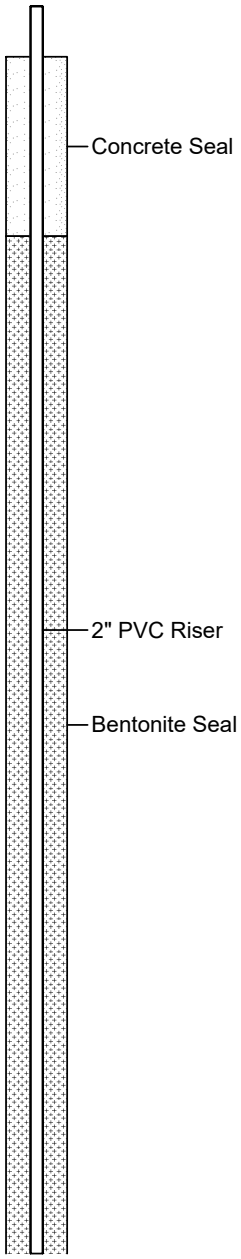
LOG OF BORING M-2000

Soil Samples
- Sample Intervals
- Sample Sent to Lab

Water Levels
- Static
- During Drilling

Depth in Feet	Sample Interval/ Sample Recovery	Sampler Type/ Sample Number	Sample	GRAPHIC	Water Level	DESCRIPTION
0						Straight drill using 4.25-inch Hollow Stem Augers to bedrock refusal.
1						Bottom Ash (0-32')
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

Well: M-2000



HULL
Environment / Energy / Infrastructure

Cardinal Operating Company
306 County Road 7E
Brilliant, Ohio
BPG003

Date Started	: 3-6-2019
Date Completed	: 3-8-2019
Logged by	: Mielecki
Reviewed by	: J. Ardner
Drilling Contractor	: Terra Testing
Drilling Method	: 4.25" HSA
Sampling Method	: 4" Core Barrel
Total Depth (ft.)	: 77.0'

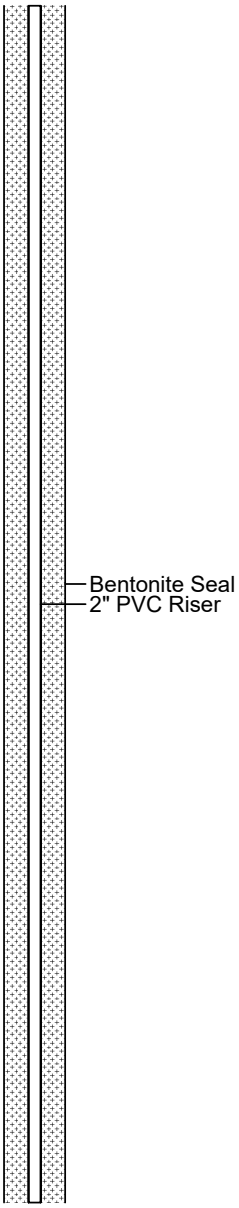
LOG OF BORING M-2000

Soil Samples
- Sample Intervals
- Sample Sent to Lab

Water Levels
- Static
- During Drilling

Well: M-2000

Depth in Feet	Sample Interval/ Sample Recovery	Sampler Type/ Sample Number	Sample	GRAPHIC	Water Level	DESCRIPTION
20–32						Bottom Ash (Continued).
32						Weathered SANDSTONE; augers set at 35.0 feet.
35	2/0.8	RC-1 35.0-37.0				Medium, reddish orange, moderately weathered, strong, SANDSTONE; fractured. Rock Quality Designation (RQD) = 0%
37	5/3.9	RC-2 37.0-42.0				Medium-grained, yellowish brown, moderately weathered, SANDSTONE; thin; fractured. RQD = 36.2%



HULL
Environment / Energy / Infrastructure

Cardinal Operating Company
306 County Road 7E
Brilliant, Ohio
BPG003

Date Started	: 3-6-2019
Date Completed	: 3-8-2019
Logged by	: Mielecki
Reviewed by	: J. Ardner
Drilling Contractor	: Terra Testing
Drilling Method	: 4.25" HSA
Sampling Method	: 4" Core Barrel
Total Depth (ft.)	: 77.0'

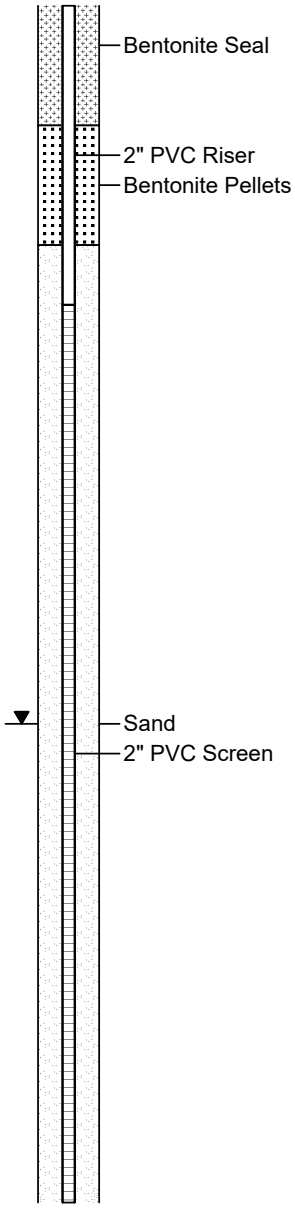
LOG OF BORING M-2000

Soil Samples
- Sample Intervals
- Sample Sent to Lab

Water Levels
- Static
- During Drilling

Well: M-2000

Depth in Feet	Sample Interval/ Sample Recovery	Sampler Type/ Sample Number	DESCRIPTION
40–41			Medium-grained, yellowish brown, moderately weathered, SANDSTONE; thin; fractured.
42	5/5	RC-3 42.0-47.0	Same as above; highly to moderately fractured. RQD = 56.7%
47	3/1.1	RC-4 47.0-50.0	Medium grained, greenish grey, moderately weathered, moderately strong, SANDSTONE; thin; fractured; becoming wet. RQD = 0%
50	2/2	RC-5 50.0-52.0	Medium grained, yellowish brown to grey, slightly weathered, moderately strong, SANDSTONE; thin; moderately fractured. RQD = 75%
52	5/4.8	RC-6 52.0-57.0	Medium grained, yellow brown to grey, moderately weathered, moderately strong, SANDSTONE; siliceous bedding; slightly rough; thin; moderately fractured. RQD = 54.4%
57	5/5	RC-7 57.0-62.0	Medium grained, very thin to medium, yellow brown to grey, moderately weathered, moderately strong; bedding fractured to moderately fractured. RQD = 56.7%



HULL
Environment / Energy / Infrastructure

Cardinal Operating Company
306 County Road 7E
Brilliant, Ohio
BPG003

Date Started	: 3-6-2019
Date Completed	: 3-8-2019
Logged by	: Mielecki
Reviewed by	: J. Ardner
Drilling Contractor	: Terra Testing
Drilling Method	: 4.25" HSA
Sampling Method	: 4" Core Barrel
Total Depth (ft.)	: 77.0'

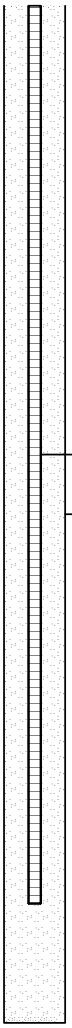
LOG OF BORING M-2000

Soil Samples
- Sample Intervals
- Sample Sent to Lab

Water Levels
- Static
- During Drilling

Well: M-2000

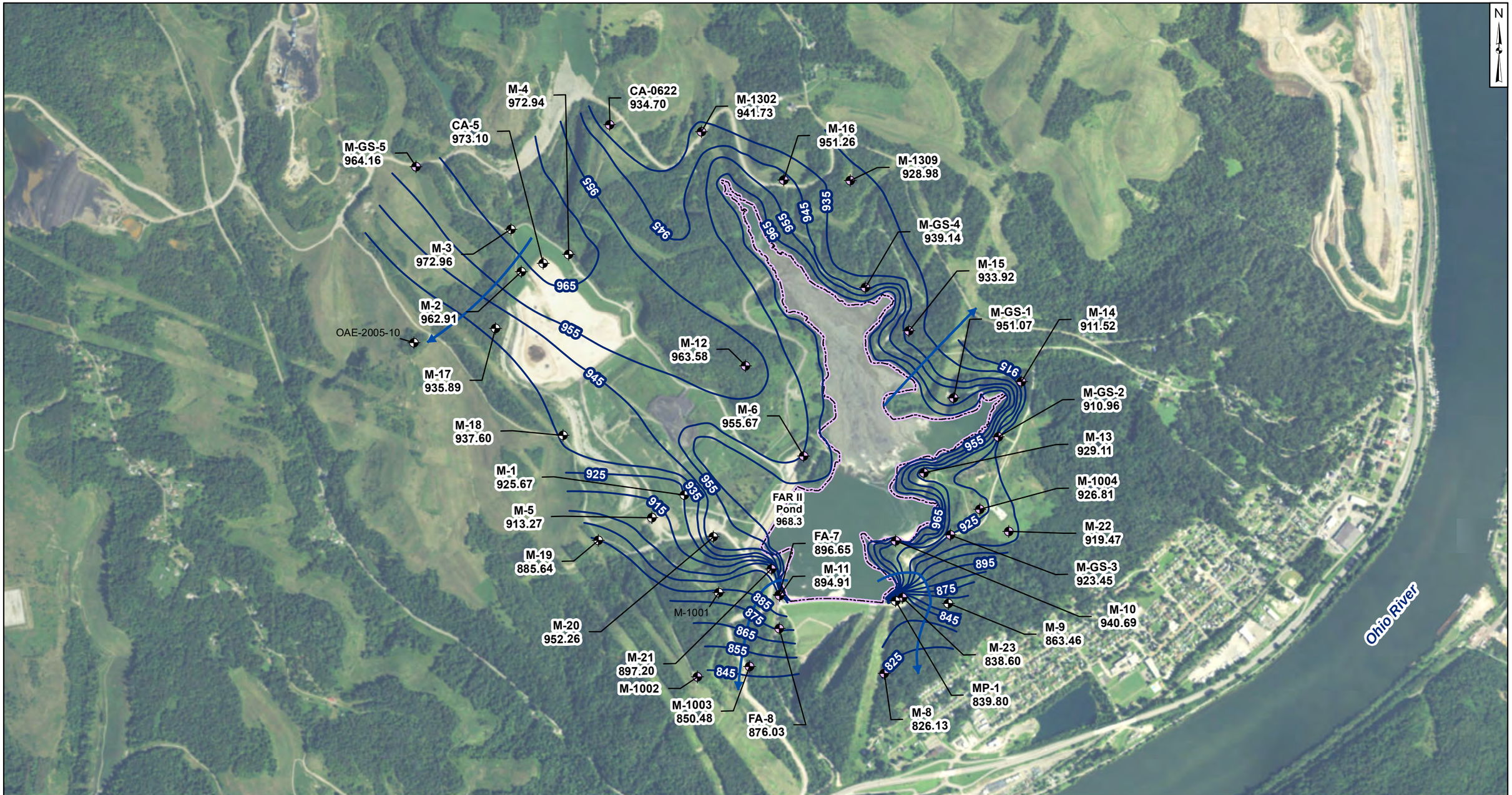
Depth in Feet	Sample Interval/ Sample Recovery	Sampler Type/ Sample Number	Sample	GRAPHIC	Water Level	DESCRIPTION
60						Medium, very thin to medium, yellow brown to grey, moderately weathered, moderately strong; bedding fractured to moderately fractured.
61						Same as above; some black shale streaks below 61'
62	5/4.6	RC-8 62.0-67.0				Medium, grey with black shale, moderately weathered, moderately strong, SANDSTONE; thin bedding; vertical fracture from 64-65'; some iron staining; moderately fractured. RQD = 69.1%
63						
64						
65						
66						
67	5/5	RC-9 67.0-72.0				
68						
69						Medium, grey, unweathered, medium strong SANDSTONE; slightly fractured. RQD = 60%
70						
71						
72	5/5	RC-10 72.0-77.0				RQD = 68.3%
73						
74						
75						Soft grey fine CLAY and unweathered blue grey SHALE; moderately strong; laminated; bedding; moderately fractured.
76						
77						End of Boring @ 77'
78						
79						
80						



Fly Ash Reservoir II

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

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



Legend

- Inactive FAR II Network Monitoring Well
- FAR II Network Monitoring Well
- State/Other Program Monitoring Well
- Approximate Groundwater Flow Direction
- Groundwater Elevation Contour
- Fly Ash Reservoir (FAR) II

Notes

- Monitoring well coordinates and water level data (collected between June 21 and June 22, 2016) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir II - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Morgantown Aquifer
Fly Ash Reservoir (FAR) II
June 2016

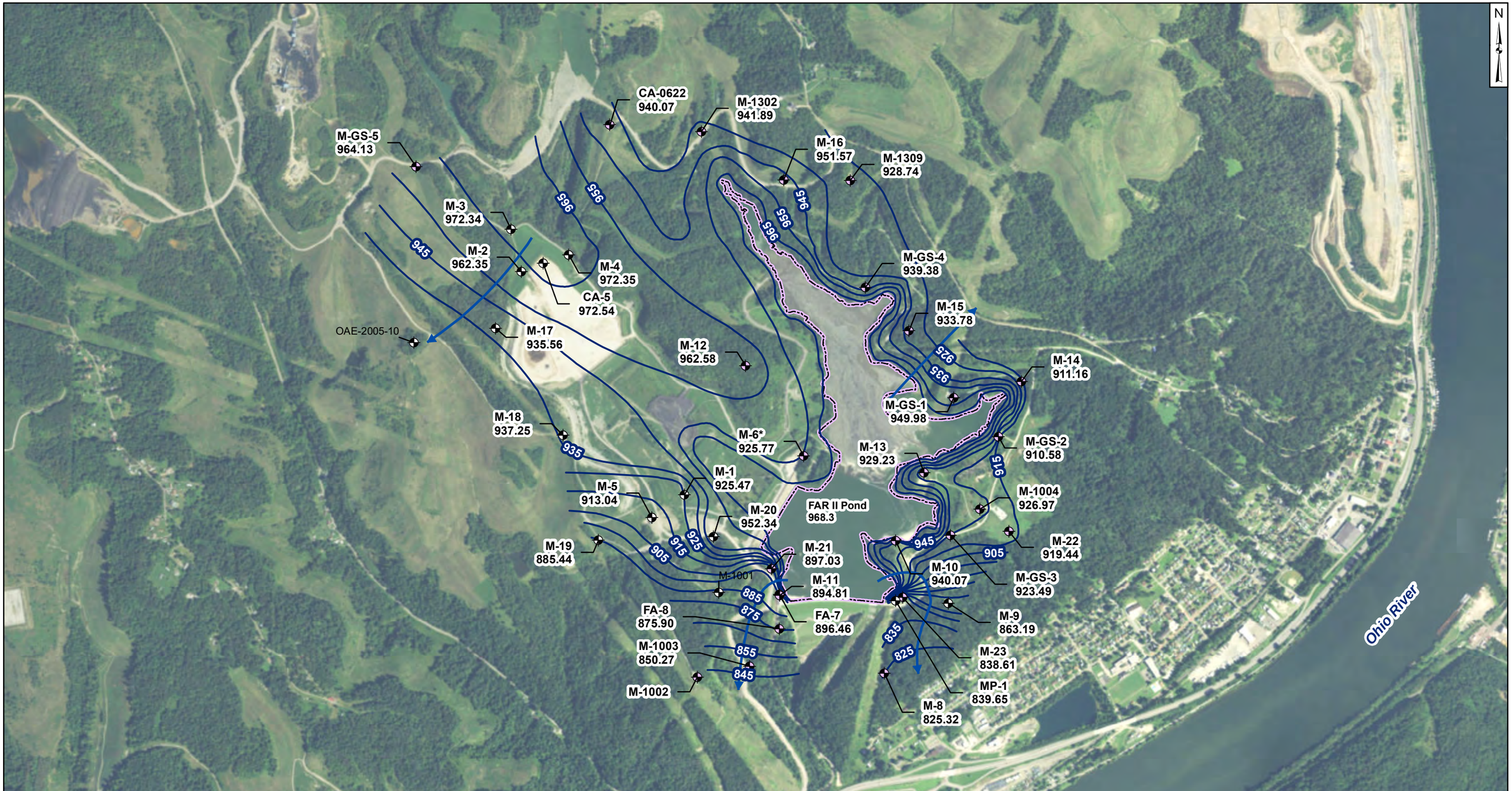
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/10/24

Figure 1

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_II\AEP-Cardinal_FAR II_GW_2016-06_June.mxd. MMuenich. 10/24/2017. CHA8423/01/08.



Legend

- Inactive FAR II Network Monitoring Well
- FAR II Network Monitoring Well
- State/Other Program Monitoring Well
- Approximate Groundwater Flow Direction
- Groundwater Elevation Contour
- Fly Ash Reservoir (FAR) II

Notes

- Monitoring well coordinates and water level data (collected between August 1 and August 2, 2016) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir II - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.

1,000 500 0 1,000
Feet

Potentiometric Surface Map - Morgantown Aquifer
Fly Ash Reservoir (FAR) II
August 2016

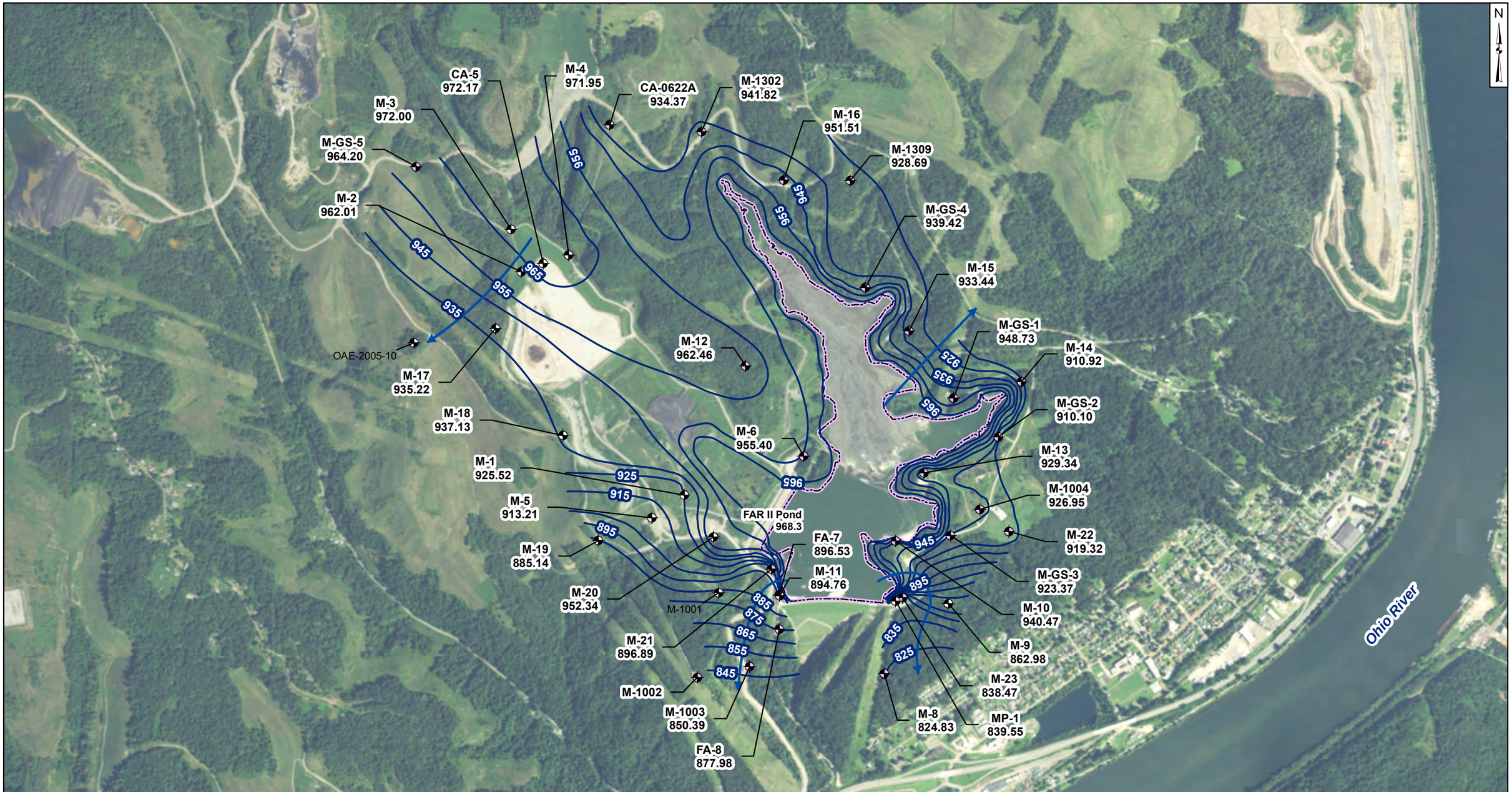
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/12/19

Figure 2

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_II\AEP-Cardinal_FAR II_GW_2016-08Aug.mxd. MMuenich. 12/19/2017. CHA8423/01/08.



Legend

- Inactive FAR II Network Monitoring Well
- FAR II Network Monitoring Well
- State/Other Program Monitoring Well
- Approximate Groundwater Flow Direction
- Groundwater Elevation Contour
- Fly Ash Reservoir (FAR) II

Notes

- Monitoring well coordinates and water level data (collected between October 3 and October 4, 2016) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir II - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Morgantown Aquifer
Fly Ash Reservoir (FAR) II
October 2016

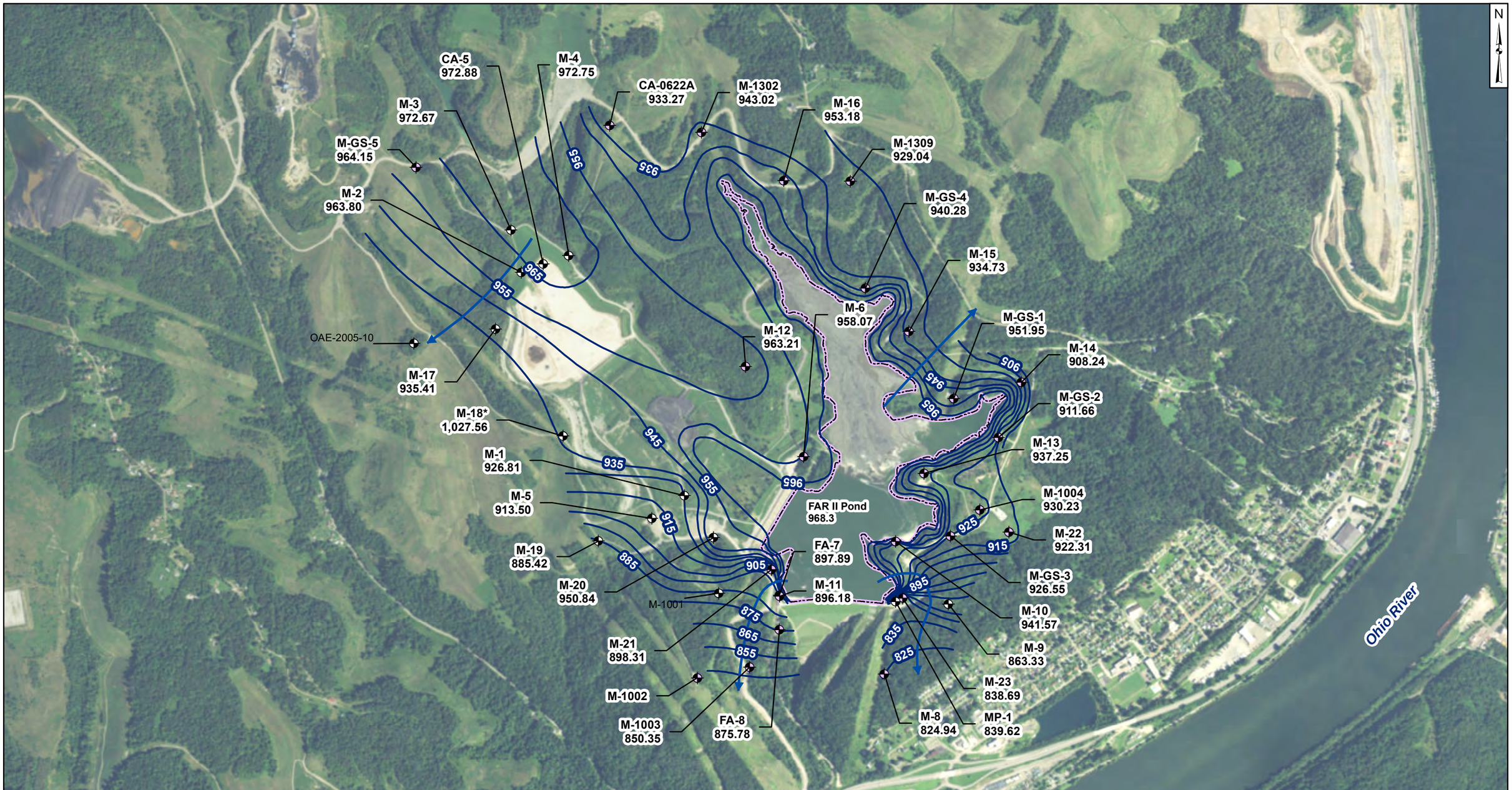
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/12/19

Figure 3

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_II\AEP-Cardinal_FAR II_GW_2016-10Oct.mxd. MMuenich. 12/19/2017. CHA8423/01/08.



Legend

- Inactive FAR II Network Monitoring Well
- FAR II Network Monitoring Well
- State/Other Program Monitoring Well
- Approximate Groundwater Flow Direction
- Groundwater Elevation Contour
- Fly Ash Reservoir (FAR) II

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 - Former Fly Ash Reservoir II - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
* Data not used for groundwater contouring due to inconsistent/anamolous reading.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Morgantown Aquifer
Fly Ash Reservoir (FAR) II
November 2016

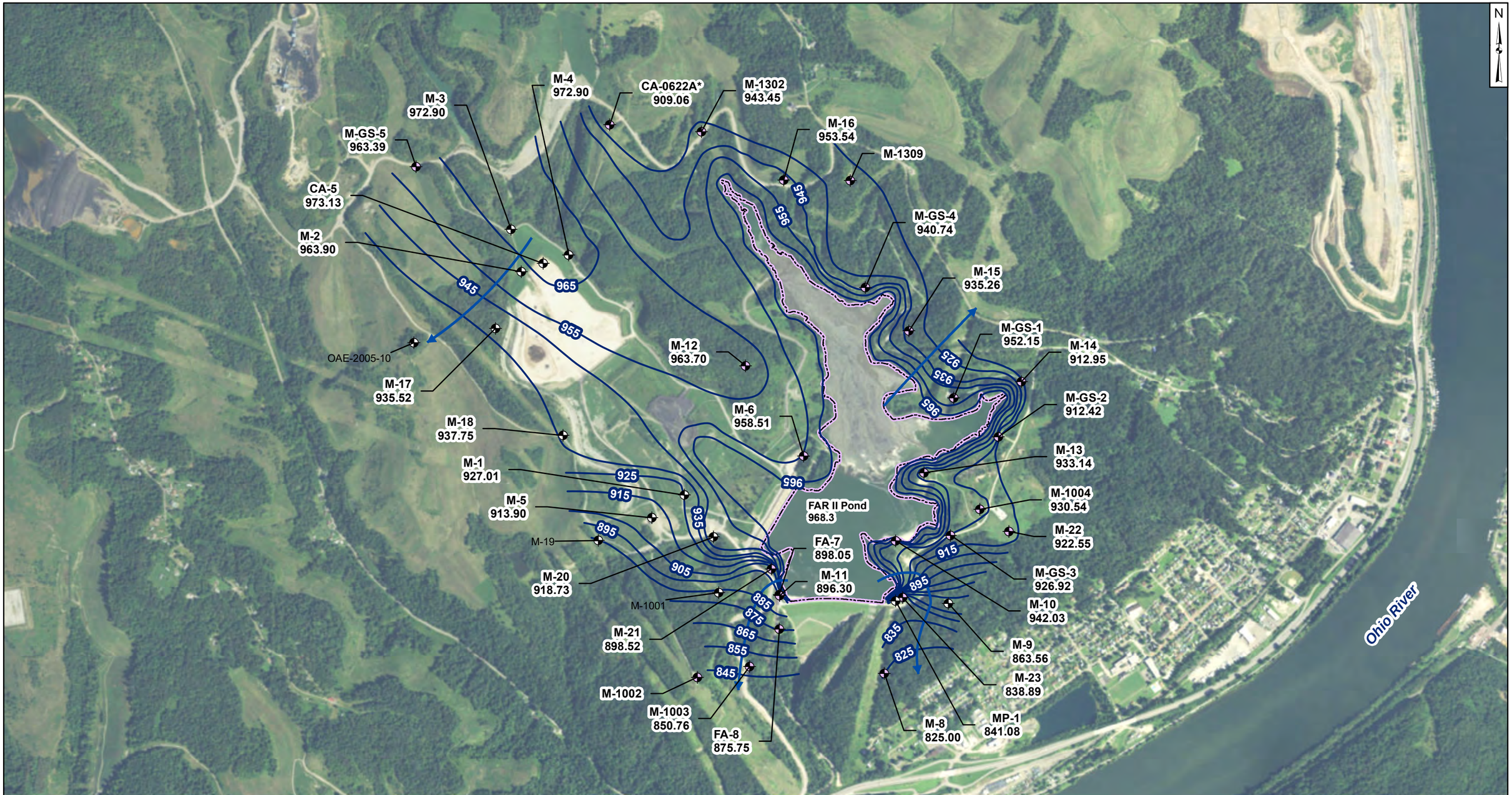
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/12/20

Figure 4

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_II\AEP-Cardinal_FAR II_GW_2016-11Nov.mxd. MMuenich. 12/20/2017. CHA8423/01/08.



Legend

- Inactive FAR II Network Monitoring Well
- FAR II Network Monitoring Well
- State/Other Program Monitoring Well
- Approximate Groundwater Flow Direction
- Groundwater Elevation Contour
- Fly Ash Reservoir (FAR) II

Notes

- Monitoring well coordinates and water level data (collected on December 12, 2016) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir II - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
* Data not used for contouring due to inconsistent/anamolous reading.

1,000 500 0 1,000
Feet

Potentiometric Surface Map - Morgantown Aquifer
Fly Ash Reservoir (FAR) II
December 2016

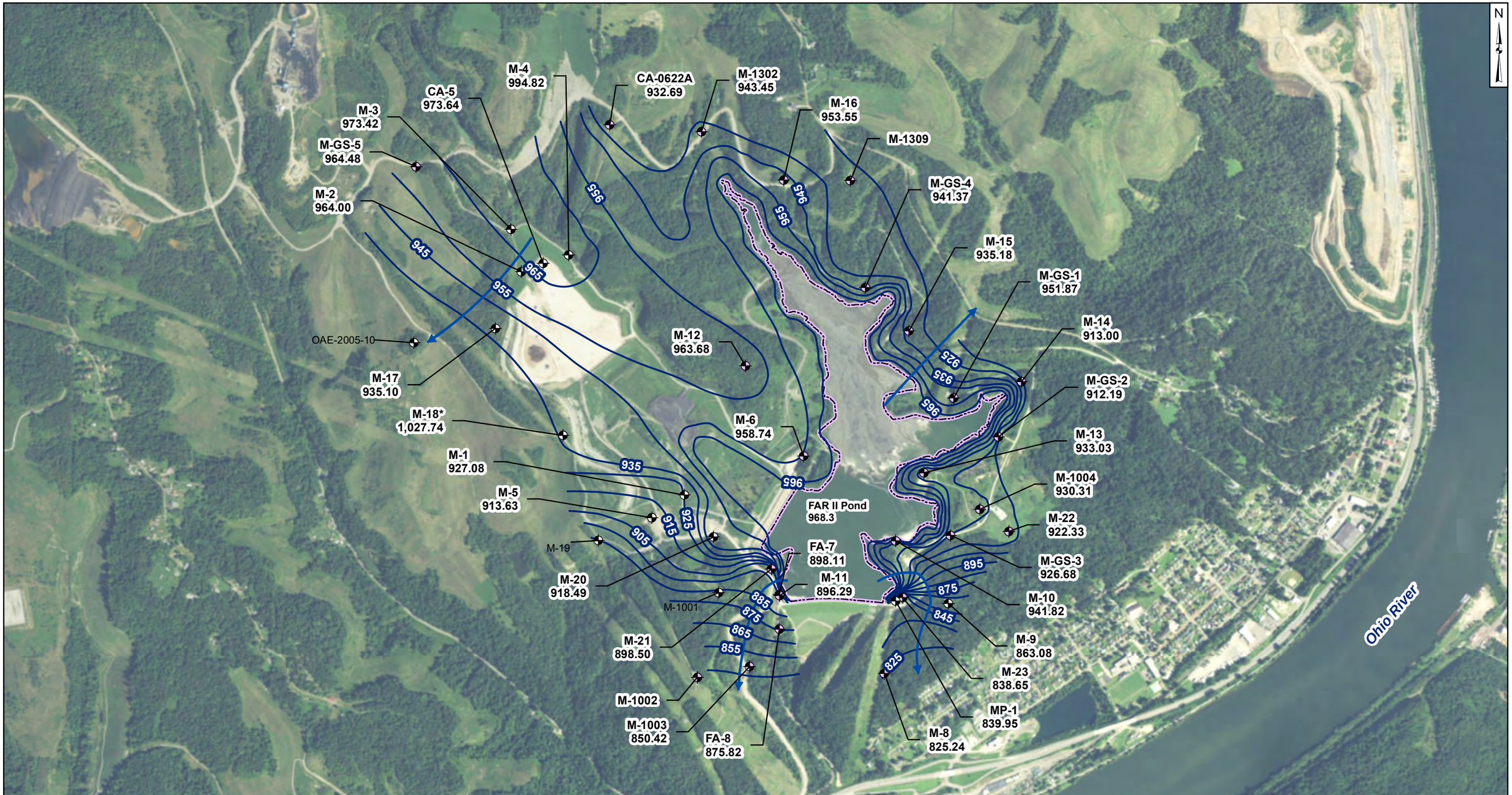
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/12/20

Figure 5

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_II\AEP-Cardinal_FAR II_GW_2016-12Dec.mxd. MMuenich. 12/20/2017. CHA8423/01/08.



Legend

- Inactive FAR II Network Monitoring Well
- FAR II Network Monitoring Well
- State/Other Program Monitoring Well
- Approximate Groundwater Flow Direction
- Groundwater Elevation Contour
- Fly Ash Reservoir (FAR) II

Notes

- Monitoring well coordinates and water level data (collected on January 9, 2017) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir II - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
* Data not used for contouring due to inconsistent/anamolous reading.

1,000 500 0 1,000
Feet

Potentiometric Surface Map - Morgantown Aquifer
Fly Ash Reservoir (FAR) II
January 2017

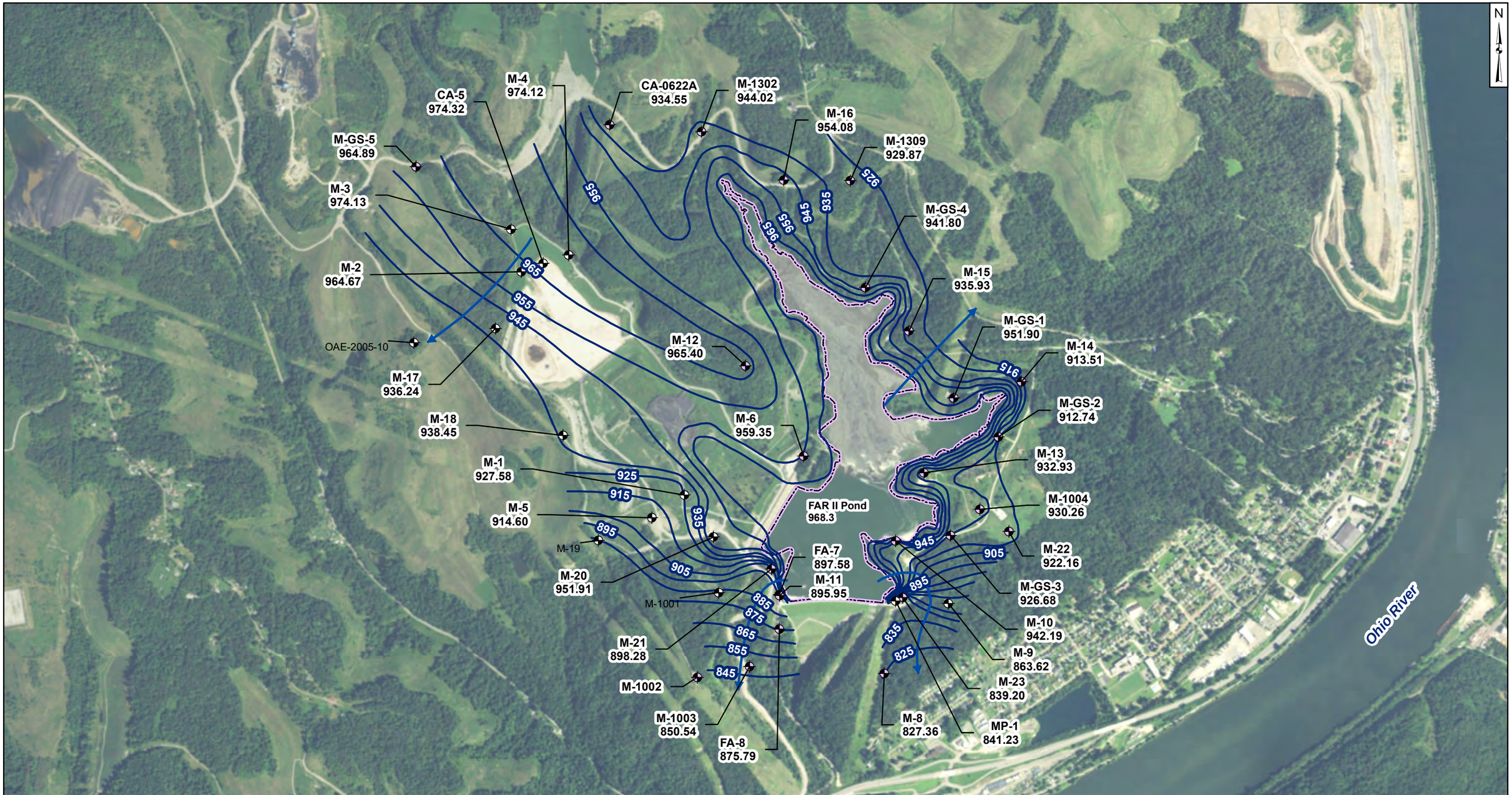
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/12/20

Figure 6

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_II\AEP-Cardinal_FAR II_GW_2017-01Jan.mxd. MMuenich. 12/20/2017. CHA8423/01/08.



Legend

- Inactive FAR II Network Monitoring Well
- FAR II Network Monitoring Well
- State/Other Program Monitoring Well
- Approximate Groundwater Flow Direction
- Groundwater Elevation Contour
- Fly Ash Reservoir (FAR) II

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 - Former Fly Ash Reservoir II - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
* Data not used for contouring due to inconsistent/anamolous reading.

1,000 500 0 1,000
Feet

Potentiometric Surface Map - Morgantown Aquifer
Fly Ash Reservoir (FAR) II
April 2017

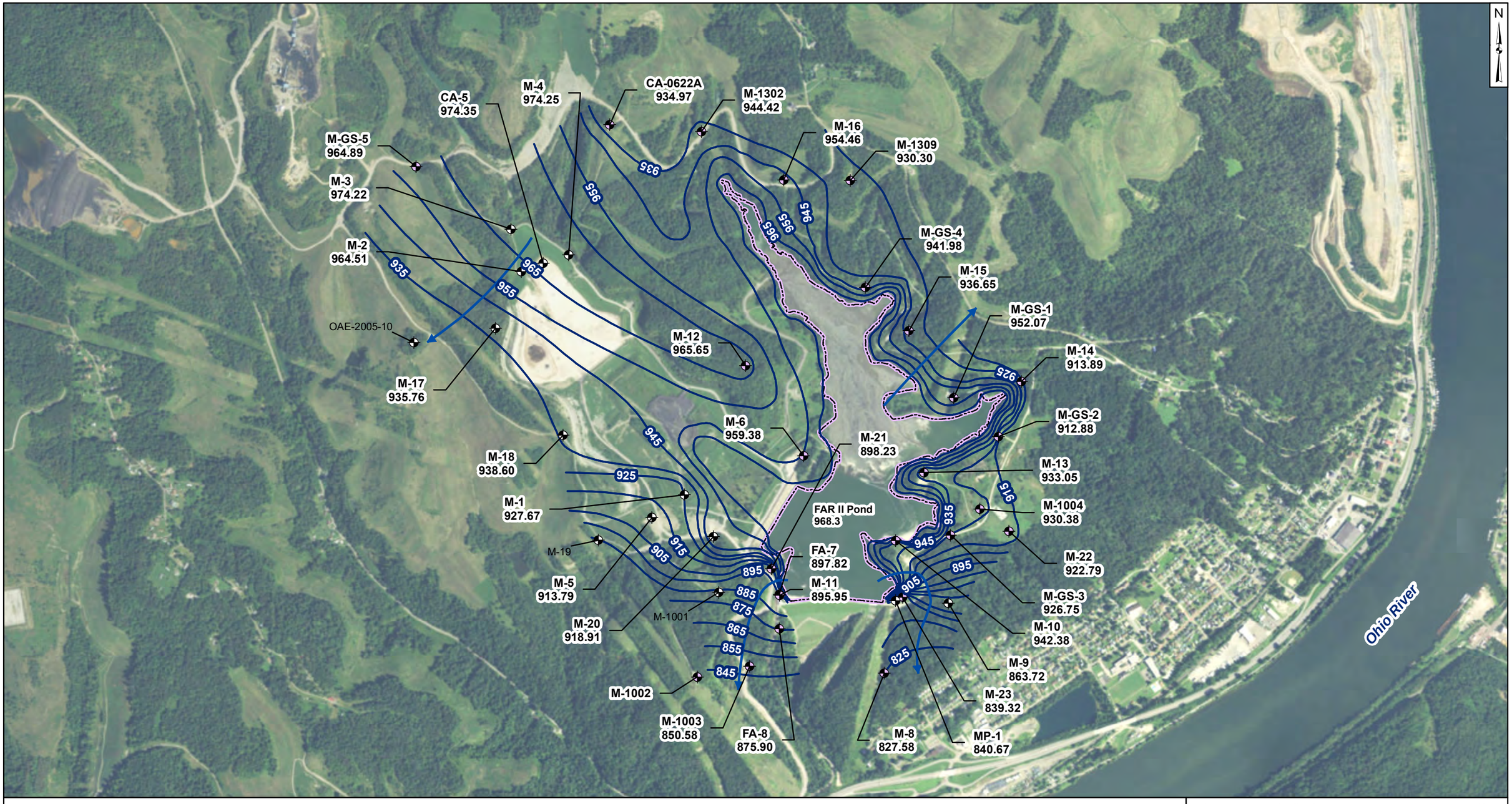
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/12/20

Figure 7

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_II\AEP-Cardinal_FAR II_GW_2017-04Apr.mxd. MMuenich. 12/20/2017. CHA8423/01/08.



Legend

- Inactive FAR II Network Monitoring Well
- FAR II Network Monitoring Well
- State/Other Program Monitoring Well
- Approximate Groundwater Flow Direction
- Groundwater Elevation Contour
- Fly Ash Reservoir (FAR) II

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 - Former Fly Ash Reservoir II - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
* Data not used for contouring due to inconsistent/anamolous reading.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Morgantown Aquifer
Fly Ash Reservoir (FAR) II
May 2017

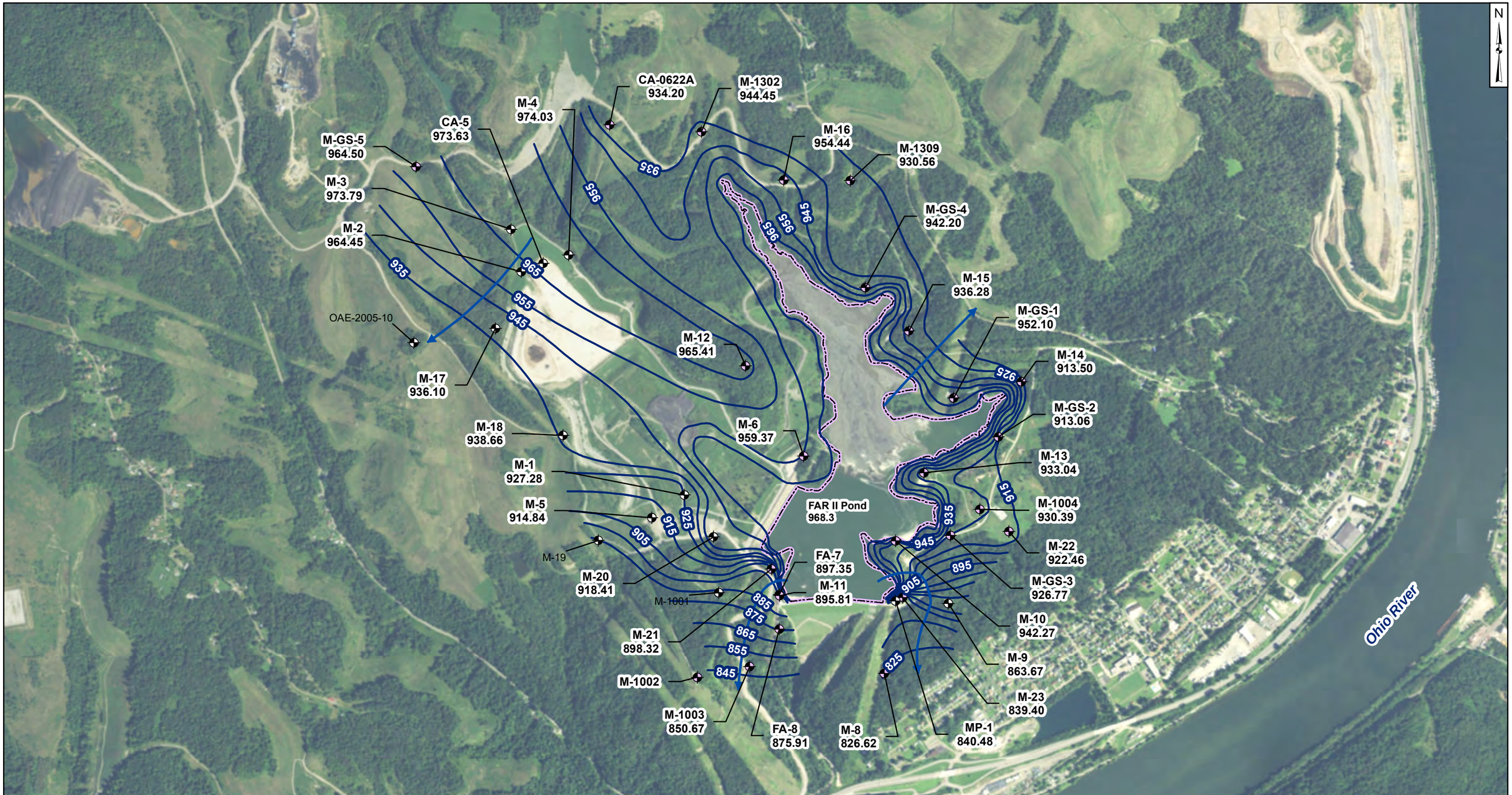
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/12/20

Figure 8

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_II\AEP-Cardinal_FAR II_GW_2017-05May.mxd. MMuenich. 12/20/2017. CHA8423/01/08.



Legend

- Inactive FAR II Network Monitoring Well
- FAR II Network Monitoring Well
- State/Other Program Monitoring Well
- Approximate Groundwater Flow Direction
- Groundwater Elevation Contour
- Fly Ash Reservoir (FAR) II

Notes

- Monitoring well coordinates and water level data (collected between June 21 and June 22, 2017) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir II - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
* Data not used for contouring due to inconsistent/anamolous reading.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Morgantown Aquifer
Fly Ash Reservoir (FAR) II
June 2017

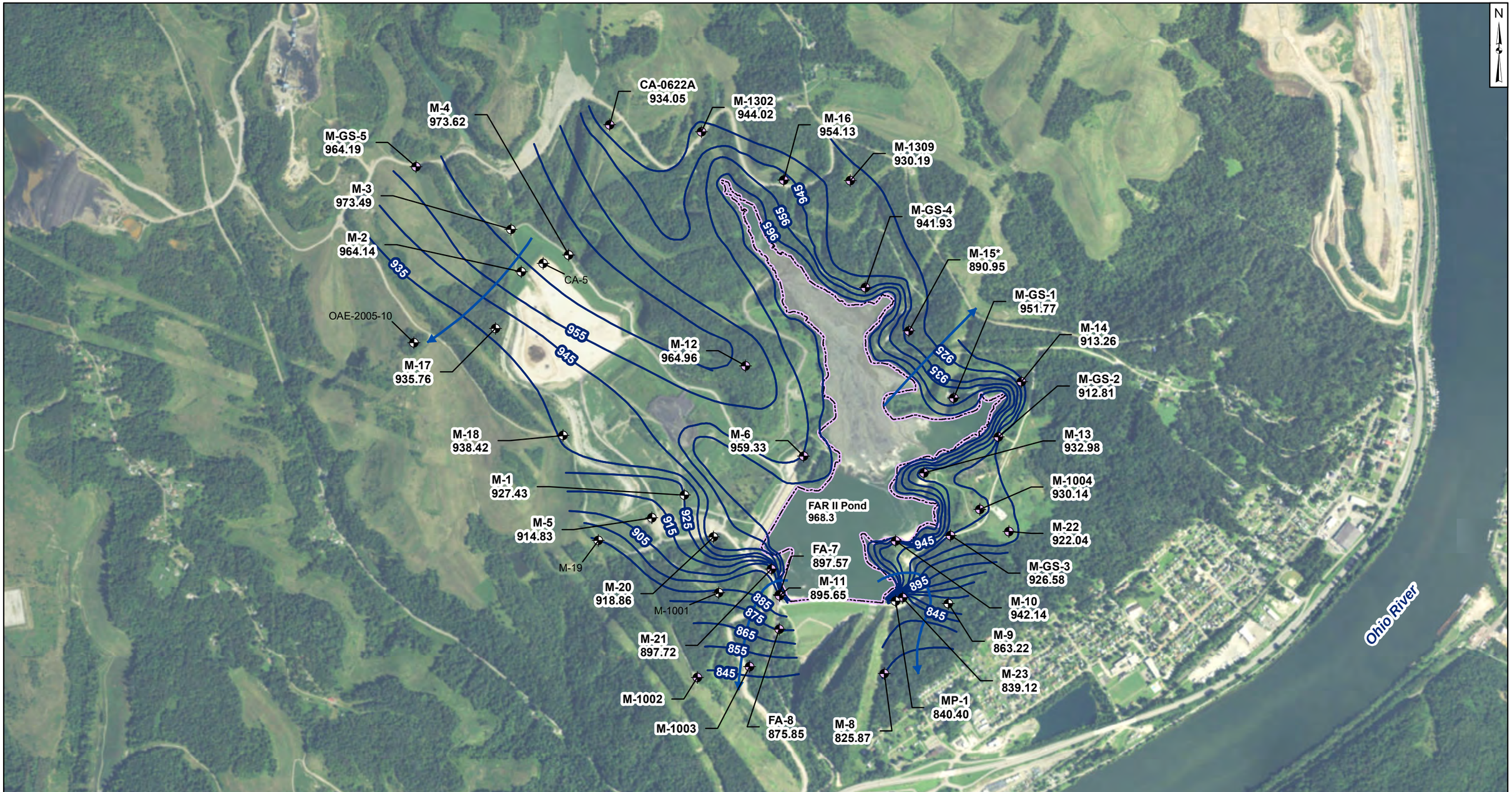
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/12/20

Figure 9

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_II\AEP-Cardinal_FAR II_GW_2017-06Jun.mxd. MMuenich. 12/20/2017. CHA8423/01/08.



Legend

- Inactive FAR II Network Monitoring Well
- FAR II Network Monitoring Well
- State/Other Program Monitoring Well
- Approximate Groundwater Flow Direction
- Groundwater Elevation Contour
- Fly Ash Reservoir (FAR) II

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 - Former Fly Ash Reservoir II - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
* Data not used for contouring due to inconsistent/anamolous reading.

Potentiometric Surface Map - Morgantown Aquifer
Fly Ash Reservoir (FAR) II
July 2017

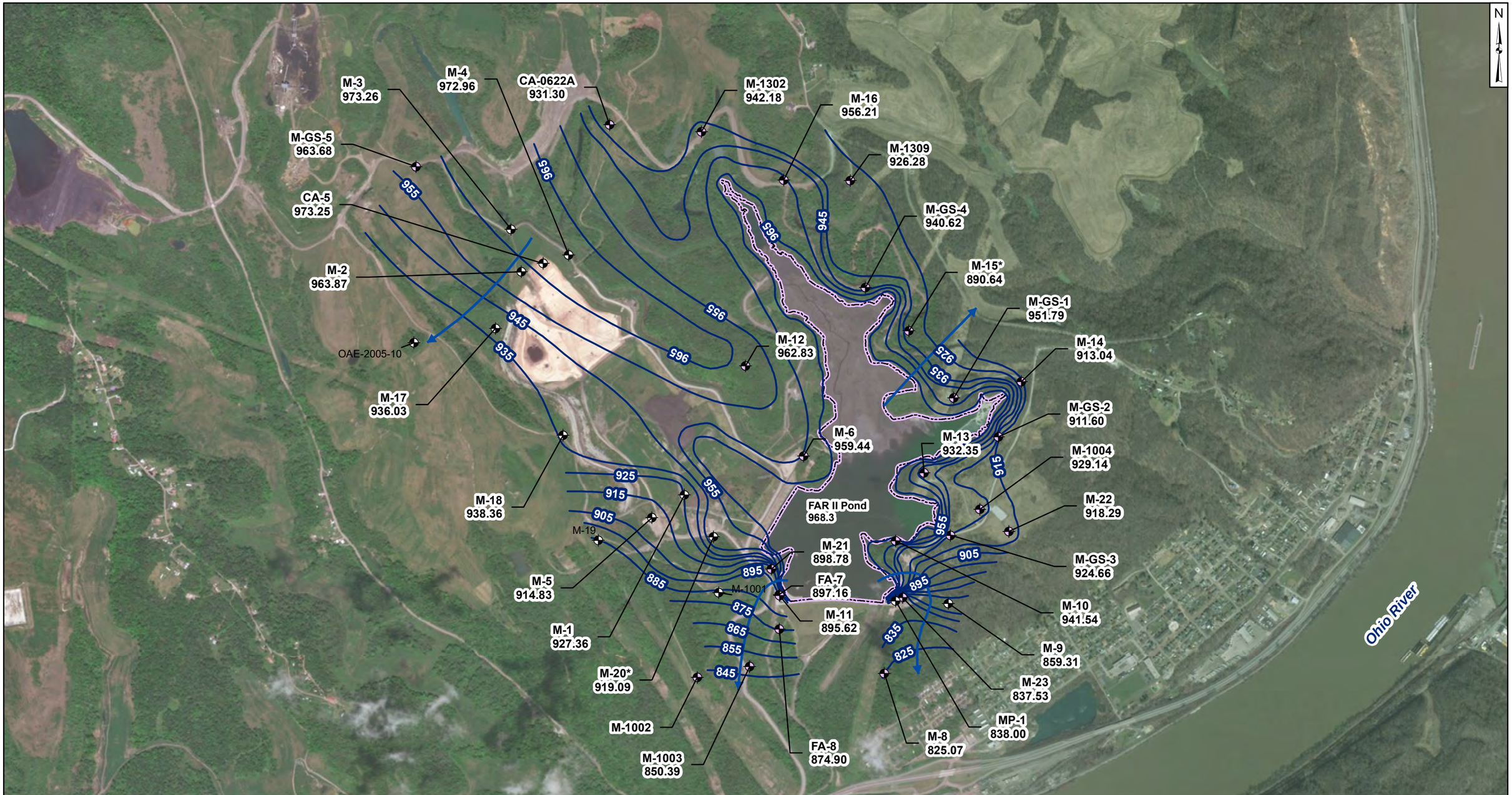
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/12/20

Figure 10

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_II\AEP-Cardinal_FAR II_GW_2017-07Jul.mxd. MMuenich. 12/20/2017. CHA8423/01/08.



Legend

- FAR II Network Monitoring Well
- State/Other Program Monitoring Well
- Approximate Groundwater Flow Direction
- Groundwater Elevation Contour
- Fly Ash Reservoir (FAR) II

Notes

- Monitoring well coordinates and water level data (collected on October 1, 2017) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir II - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
* Well not used for contouring due to inconsistent/anamolous data.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Morgantown Aquifer
Fly Ash Reservoir (FAR) II
October 2017

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2018/01/29

Figure 11

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\FAR_II\AEP-Cardinal_FAR II_GW_2017-10Oct.mxd. MMuenich. 1/29/2018. CHA8423/01/08.

Fly Ash Reservoir II

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 - Fly Ash Reservoir II

Parameter	Unit	CA-0622								
		10/25/2016	11/15/2016	12/14/2016	1/10/2017	4/18/2017	5/25/2017	6/20/2017	7/27/2017	9/27/2017
		Background								Detection
Antimony	µg/L	0.37	1U	0.07	0.14	0.09J	0.03J	0.1J	0.2J	-
Arsenic	µg/L	4.32	6.4	16	19.1	36.9	31.8	24.9	25.4	-
Barium	µg/L	99.8	87.2	140	209	253	325	420	860	-
Beryllium	µg/L	0.142	0.2J	0.127	0.399	0.148	0.572	0.08J	0.08J	-
Boron	mg/L	0.385	0.366	0.293	0.306	0.314	0.447	0.305	0.276	0.331
Cadmium	µg/L	0.03	0.4U	0.02J	0.08	0.03J	0.06	0.02J	0.03J	-
Calcium	mg/L	32.3	22.3	22.8	35.8	37.9	64	48.4	67.7	85.4
Chloride	mg/L	119	135	743	1360	1330	1230	2380	3500	4190
Chromium	µg/L	3.52	5.06	3.96	9.48	5.21	11.6	3.02	3.1	-
Cobalt	µg/L	2.29	2.28	1.9	3.95	2.42	5.76	1.61	1.4	-
Combined Radium	pCi/L	2.059	0.601	1.581	1.947	1.421	2.37	3.78	4.93	-
Fluoride	mg/L	0.95	0.79	0.79	0.85	0.92	0.88	0.7J	0.5J	0.55
Lead	µg/L	3.04	1.86	2.33	5.22	2.71	10.5	1.74	1.59	-
Lithium	mg/L	0.031	0.035	0.036	0.054	0.039	0.059	0.054	0.068	-
Mercury	µg/L	0.006	0.003J	0.005U	0.005U	0.002J	0.005U	0.01	0.002J	-
Molybdenum	µg/L	24.2	45.8	60.1	54.5	48.4	22.2	46	32.5	-
Selenium	µg/L	0.6	1J	0.4	0.9	0.4	2	0.2J	0.2J	-
Total Dissolved Solids	mg/L	1180	28500	2240	3300	3100	2940	4590	5860	7140
Sulfate	mg/L	383	340	320	246	246	244	163	56.3	46.9
Thallium	µg/L	0.04J	1U	0.03J	0.209	0.05J	0.06J	0.2U	0.09J	
pH	SU	7.85	7.81	7.76	7.85	7.69	7.69	7.52	8.86	7.91

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 - Fly Ash Reservoir II

Parameter	Unit	FA-8									M-6										
		10/27/2016	11/15/2016	12/13/2016	1/10/2017	5/2/2017	6/1/2017	6/27/2017	7/27/2017	9/26/2017	10/11/2016	4/20/2017	4/26/2017	7/26/2017	8/1/2017	8/21/2017	8/29/2017	9/6/2017	9/27/2017	10/4/2017	10/11/2017
		Background								Detection	Background										Detection
Antimony	µg/L	0.61	0.53	0.5	0.49	0.54	0.53	0.5	0.45	-	-	-	-	0.25	0.25	0.21	0.12	0.23	0.23	0.11	-
Arsenic	µg/L	7.85	5.11	4.04	3.91	6.07	5.99	6.47	6.41	-	-	-	-	1.85	3.2	3.31	2.83	3.37	5.36	4.36	-
Barium	µg/L	44.8	33.7	30	28.4	25.1	28.1	25.9	25.1	-	-	-	-	247	292	288	429	306	556	689	-
Beryllium	µg/L	0.058	0.02J	0.009J	0.009J	0.04U	0.008J	0.04U	0.04U	-	-	-	-	0.399	0.705	0.721	1.29	0.915	1.63	2.02	-
Boron	mg/L	5.46	5.05	4.49	4.84	4.64	4.44	5.05	4.34	4.86	-	-	-	0.212	0.201	0.246	0.198	0.287	0.216	0.234	0.248
Cadmium	µg/L	0.04	0.03	0.04	0.04	0.02J	0.02	0.04U	0.06	-	-	-	-	0.08	0.12	0.11	0.2	0.14	0.3	0.27	-
Calcium	mg/L	233	208	192	207	192	192	174	191	211	-	-	-	8.69	10.2	10.4	14.8	13.2	18.9	21.1	23.8
Chloride	mg/L	59.2	58.6	62.7	60.2	57.3	54.4	52.8	52.2	53.1	-	-	38	37.6	37.6	37.2	37.2	37.5	37.2	37.2	38.3
Chromium	µg/L	1.3	0.36	0.161	0.182	0.07J	0.143	0.131	0.324	-	-	-	-	3.16	5.13	5.09	2.99	4.22	4.89	3.28	-
Cobalt	µg/L	5.89	1.91	0.867	0.737	0.56	0.704	0.627	0.72	-	-	-	-	1.41	2.4	2.55	1.96	2.38	2.83	2.45	-
Combined Radium	pCi/L	1.867	1.197	0.943	0.3211	0.5468	0.16	1.123	1.254	-	-	-	-	3.412	4.68	4.33	9.81	4.43	8.11	7.15	-
Fluoride	mg/L	0.55	0.51	0.43	0.47	0.5	0.49	0.49	0.45	0.52	-	-	1.26	1.2	1.32	1.23	1.24	1.27	1.18	1.19	1.24
Lead	µg/L	2.1	0.523	0.279	0.374	0.061	0.156	0.062	0.08	-	-	-	-	7.25	11.4	11.3	16.4	13	26.8	22.7	-
Lithium	mg/L	0.229	0.228	0.206	0.218	0.207	0.198	0.184	0.199	-	-	-	-	0.015	0.012	0.018	0.011	0.018	0.014	0.016	-
Mercury	µg/L	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	-	-	-	-	0.005U	0.002J	0.005U	0.002J	0.005U	0.2U	0.005U	-
Molybdenum	µg/L	312	361	345	297	302	337	326	308	-	-	-	-	0.66	5.65	0.74	3.31	0.79	0.77	1.18	-
Selenium	µg/L	2.2	2.1	2.1	2.4	2.2	1.4	0.7	0.3	-	-	-	-	0.5	1.8	1.4	1.1	1.4	2.9	1.3	-
Total Dissolved Solids	mg/L	1500	1530	1540	1550	1540	1530	1510	1490	1560	-	-	588	594	580	564	594	612	562	134	288
Sulfate	mg/L	899	907	933	907	875	909	906	886	958	-	-	0.04	0.2	0.2	0.2	0.1J	0.1	0.1U	0.1	1.3
Thallium	µg/L	0.22	0.19	0.153	0.168	0.152	0.187	0.174	0.174		-	-		0.086	0.083	0.106	0.092	0.099	0.127	0.114	
pH	SU	6.49		7.22	7.22	6.79	7.15	7.21	6.97	7.82	8.37	8.4	8.24	7.66	7.18	7.73	8.51	8.25	8.31	8.71	8.4

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 - Fly Ash Reservoir II

Parameter	Unit	M-8											M-10									
		12/13/2016	1/16/2017	2/9/2017	3/9/2017	4/12/2017	4/18/2017	5/1/2017	5/31/2017	6/21/2017	8/1/2017	10/3/2017	10/27/2016	4/26/2017	7/26/2017	8/1/2017	8/21/2017	8/29/2017	9/6/2017	9/27/2017	10/4/2017	10/11/2017
		Background										Detection	Background									Detection
Antimony	µg/L	0.23	0.08	0.02J	0.02J	0.05U	-	-	0.02J	0.05U	0.05U	-	-	-	0.11	0.02J	0.1	0.08	0.05J	0.03J	0.02J	-
Arsenic	µg/L	1.31	0.87	1.22	1.31	1.32	-	-	1.03	1.14	1.18	-	-	-	0.58	0.17	0.84	0.45	0.31	0.36	0.22	-
Barium	µg/L	148	142	119	133	129	-	-	136	125	128	-	-	-	106	97.6	163	109	96	77.5	73.5	-
Beryllium	µg/L	0.02J	0.008J	0.01J	0.01J	0.008J	-	-	0.009J	0.008J	0.01J	-	-	-	0.081	0.02J	0.315	0.078	0.074	0.025	0.01J	-
Boron	mg/L	0.027	0.01	0.038	0.024	0.029	-	-	0.033	0.035	0.01	0.017	-	-	0.51	0.566	0.553	0.501	0.609	0.56	0.661	0.577
Cadmium	µg/L	0.08	0.02J	0.008J	0.02U	0.02U	-	-	0.006J	0.36	0.05	-	-	-	0.89	0.04	0.45	0.46	0.17	0.21	0.07	-
Calcium	mg/L	94.3	88.6	105	98.2	93.6	-	-	92.4	97.5	99.2	93.7	-	-	10.7	13.8	13.7	13.6	14.5	13.3	14.1	13.5
Chloride	mg/L	5.92	5.76	5.79	5.75	-	-	5.86	5.89	5.87	5.8	5.68	-	-	12.3	12.7	12.2	13.1	12.9	12.5	12.9	13.5
Chromium	µg/L	0.38	0.211	0.116	0.06	0.077	-	-	0.096	0.076	0.161	-	-	-	0.777	0.175	1.18	0.547	0.322	0.255	0.04J	-
Cobalt	µg/L	0.438	0.378	0.68	0.454	0.385	-	-	0.309	0.272	0.327	-	-	-	0.173	0.038	0.374	0.146	0.117	0.058	0.032	-
Combined Radium	pCi/L	0.906	1.068	3.78	0.512	1.581	-	-	1.263	1.473	1.162	-	-	-	1.704	1.31	7.382	1.72	1.962	8.7	1.134	-
Fluoride	mg/L	0.09	0.11	0.11	0.11	-	-	0.11	0.1	0.09	0.12	0.09	-	-	0.62	0.76	0.69	0.66	0.74	0.68	0.67	0.66
Lead	µg/L	0.634	0.106	0.297	0.092	0.142	-	-	0.096	0.073	0.072	-	-	-	9.23	0.859	19.6	7.27	4.22	1.23	0.492	-
Lithium	mg/L	0.008	0.006	0.01	0.001U	0.008	-	-	0.011	0.007	0.008	-	-	-	0.02	0.025	0.024	0.014	0.023	0.019	0.02	-
Mercury	µg/L	0.005U	0.005U	0.005U	0.005U	0.005U	-	-	0.005U	0.005U	0.004J	-	-	-	0.014	0.004J	0.005J	0.002J	0.005U	0.2U	0.01U	-
Molybdenum	µg/L	1.56	0.82	0.74	0.63	0.5	-	-	0.55	0.63	0.47	-	-	-	2.53	2.37	2.11	3.91	2.23	2.3	2.5	-
Selenium	µg/L	0.1	0.1U	0.1U	0.1U	0.1U	-	-	0.04J	0.1U	0.1U	-	-	-	0.05J	0.1U	0.3	0.1	0.03J	0.05J	0.1U	-
Total Dissolved Solids	mg/L	418	417	374	450	-	-	424	420	430	440	435	-	761	745	706	752	740	800	754	734	732
Sulfate	mg/L	94.5	90.5	95.4	93	-	-	94.4	97.4	98.5	97.7	94.2	-	-	127	135	127	135	139	137	128	133
Thallium	µg/L	0.153	0.02J	0.01J	0.05U	0.05U	-		0.01J	0.05U	0.05U		-	-	0.02J	0.05U	0.03J	0.01J	0.02J	0.05U	0.05U	
pH	SU	7.19	6.79	6.93	-	8.31	8.64	7.22	7.21	6.82	8.44	8.34	8.44	7.92	7.66	8.17	8.06	8.42	8.24	8.22	8.47	8.58

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 - Fly Ash Reservoir II

Parameter	Unit	M-11										M-12								
		6/30/2016	8/10/2016	10/19/2016	10/26/2016	1/18/2017	4/26/2017	5/24/2017	6/21/2017	8/1/2017	10/4/2017	7/1/2016	8/5/2016	10/26/2016	11/16/2016	1/18/2017	4/20/2017	6/21/2017	8/1/2017	9/28/2017
		Background									Detection	Background								Detection
Antimony	µg/L	0.95	1.1	0.97	-	0.96	0.83	0.63	0.84	0.71	-	0.04J	0.05J	0.05J	0.04J	0.02J	0.08J	0.03J	0.04J	-
Arsenic	µg/L	4.35	3.45	4.28	-	4.04	4.13	4.25	5.05	5.1	-	6.44	7.81	6.24	5.67	4.77	9.68	8.86	6.91	-
Barium	µg/L	26	26.6	27.9	-	29.4	29.4	26.6	25.7	26	-	36	58.8	35	61.2	45.5	51.6	33.9	41.8	-
Beryllium	µg/L	0.005J	0.02U	0.006J	-	0.02U	0.006J	0.02U	0.04U	0.02U	-	0.086	0.06	0.03J	0.038	0.02J	0.054	0.047	0.048	-
Boron	mg/L	4.88	4.91	4.43	-	4.64	4.93	4.87	4.92	5.08	4.69	0.391	0.273	0.295	0.283	0.264	0.266	0.377	0.324	0.276
Cadmium	µg/L	0.01J	0.03	0.01J	-	0.04	0.03	0.02U	0.04U	0.02U	-	0.15	0.09	0.04J	0.04	0.04	0.07	0.04J	0.05	-
Calcium	mg/L	230	207	215	-	201	211	209	203	212	191	341	273	196	112	91	303	307	207	102
Chloride	mg/L	57.2	55.4	58.5	-	57.7	56.9	55	54.6	52.3	52.6	284	288	476	402	658	205	257	391	448
Chromium	µg/L	0.3	0.1	0.1	-	0.168	0.088	0.03J	0.175	0.084	-	0.3	0.3	0.304	0.283	0.386	0.231	0.202	0.555	-
Cobalt	µg/L	0.974	0.749	0.641	-	0.982	0.917	0.546	0.735	0.744	-	26.9	17.5	4.54	4.04	1.3	12.8	13.2	7.39	-
Combined Radium	pCi/L	1.167	0.14	0.46	1.31	0.649	0.333	0.384	2.2142	1.006	-	0.579	1.018	1.408	1.183	2.042	1.302	1.996	6.708	-
Fluoride	mg/L	0.58	0.54	0.58	-	0.58	0.53	0.5	0.47	0.61	0.49	1.38	1.36	1.72	1.64	2.29	1.08	1.2	1.64	2.22
Lead	µg/L	0.171	0.27	0.62	-	6.89	0.757	0.149	0.155	0.127	-	1.44	0.515	0.446	0.494	0.597	1.07	0.366	0.503	-
Lithium	mg/L	0.251	0.208	0.203	-	0.214	0.217	0.223	0.22	0.222	-	0.14	0.107	0.095	0.08	0.06	0.123	0.122	0.098	-
Mercury	µg/L	0.005U	0.005U	0.005U	-	0.005U	0.2U	0.005U	0.005U	0.005U	-	0.005U	0.005U	0.005U	0.01	0.005U	0.005U	0.005U	0.005U	-
Molybdenum	µg/L	316	375	378	-	373	431	362	339	330	-	1.22	1.11	1.23	1.95	2.48	0.98	0.87	1.22	-
Selenium	µg/L	0.3	0.6	2.1	-	3.5	2.7	2	0.8	0.3	-	0.3	0.09J	0.2J	0.09J	0.07J	0.1J	0.2U	0.2U	-
Total Dissolved Solids	mg/L	1480	1510	1570	-	1620	1570	1560	1550	1530	1570	2560	2710	2440	1910	2280	2750	2690	2390	1850
Sulfate	mg/L	881	850	900	-	922	892	835	1000	936	886	1400	1380	898	488	419	1360	1370	1040	416
Thallium	µg/L	0.03J	0.351	0.141	-	0.282	0.375	0.211	0.116	0.074		0.11	0.06J	0.06J	0.02J	0.01J	0.04J	0.02J	0.03J	
pH	SU	7.9	7.62	7.59	-	7.3	7.65	7.67	7.66	7.89	8.44	6.93	6.91	7.09	7.24	7.22	7.6	7.63	7.53	7.9

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 - Fly Ash Reservoir II

Parameter	Unit	M-13										M-14									
		6/30/2016	8/11/2016	10/19/2016	1/18/2017	4/13/2017	4/26/2017	6/1/2017	6/22/2017	7/31/2017	9/28/2017	7/5/2016	8/11/2016	10/18/2016	1/11/2017	4/13/2017	4/27/2017	6/1/2017	6/21/2017	7/31/2017	10/10/2017
		Background									Detection	Background									Detection
Antimony	µg/L	0.05J	0.02J	0.05J	0.03J	0.06	-	0.05	0.04J	0.04J	-	0.02J	0.01J	0.02J	0.02J	0.05U	-	0.05U	0.01J	0.05U	-
Arsenic	µg/L	1.07	1.36	1.39	1.11	1.23	-	1.3	1.19	1.03	-	0.36	0.29	0.32	0.24	0.17	-	0.16	0.14	0.15	-
Barium	µg/L	79.5	138	99.7	130	122	-	141	128	90.8	-	25	19.3	22.9	20.9	14.9	-	15.9	14.9	14.8	-
Beryllium	µg/L	0.121	0.027	0.139	0.255	0.184	-	0.132	0.114	0.116	-	0.062	0.026	0.044	0.035	0.006J	-	0.01J	0.008J	0.007J	-
Boron	mg/L	0.157	0.254	0.176	0.164	0.198	-	0.243	0.233	0.257	0.287	0.208	0.226	0.188	0.188	0.199	-	0.214	0.218	0.189	0.261
Cadmium	µg/L	0.17	0.02U	0.02	0.01J	0.01J	-	0.03	0.008J	0.009J	-	0.09	0.02U	0.006J	0.005J	0.02U	-	0.02U	0.02U	0.008J	-
Calcium	mg/L	6.77	13.1	8.65	9.01	8.86	-	10.5	11.5	7.71	7.8	1.17	0.736	1.05	0.739	0.526	-	0.534	0.595	0.531	0.485
Chloride	mg/L	2.76	2.03	2.74	2.62		2.65	2.42	2.23	2.53	2.43	1.36	1.29	1.33	1.38		1.39	1.31	1.38	1.49	1.4
Chromium	µg/L	0.9	0.3	0.9	0.285	0.846	-	0.657	0.544	0.606	-	0.4	0.2	0.8	0.332	0.092	-	0.117	0.084	0.127	-
Cobalt	µg/L	0.301	0.096	0.358	0.383	0.389	-	0.29	0.241	0.266	-	0.118	0.047	0.107	0.078	0.01	-	0.022	0.02J	0.01J	-
Combined Radium	pCi/L	2.687	0.976	1.243	4.1	2.36	-	1.854	2.583	2.284	-	1.002	1.088	1.229	1.543	0.3533	-	0.3893	1.469	1.353	-
Fluoride	mg/L	1.26	1.66	1.01	0.99		1.14	1.28	1.43	1.19	1.19	0.79	0.74	0.75	0.7		0.76	0.7	0.74	0.84	0.74
Lead	µg/L	0.859	0.221	1.06	1.33	1.47	-	1.11	0.933	0.853	-	0.763	0.285	0.68	0.512	0.037	-	0.082	0.053	0.031	-
Lithium	mg/L	0.021	0.013	0.008	0.01	0.007	-	0.009	0.015	0.012	-	0.009	0.008	0.003	0.005	0.007	-	0.006	0.0003J	0.008	-
Mercury	µg/L	0.005U	0.005U	0.002J	0.005U	0.005U	-	0.005U	0.005U	0.005U	-	0.005U	0.005U	0.005U	0.005U	0.005U	-	0.005U	0.005U	0.005U	-
Molybdenum	µg/L	0.59	0.79	0.67	0.7	0.37	-	1.1	0.6	0.58	-	0.3	0.74	0.44	0.55	1.11	-	0.26	0.33	0.39	-
Selenium	µg/L	0.1	0.07J	0.2	0.06J	0.3	-	0.2	0.2	0.2	-	0.2	0.07J	0.1	0.07J	0.1U	-	0.1U	0.1U	0.1U	-
Total Dissolved Solids	mg/L	478	485	459	482	-	482	498	487	492	485	383	380	381	364	-	379	373	1010	395	381
Sulfate	mg/L	11.7	22.1	8.6	5.6		8.9	14	18	10.2	12.4	3	0.9	0.3	0.6	-	0.2	0.5	0.5	0.3	0.5
Thallium	µg/L	0.01J	0.05U	0.114	0.06	0.02J	-	0.02J	0.01J	0.02J	-	0.02J	0.05U	0.172	0.068	0.05U		0.05U	0.01J	0.05U	-
pH	SU	8.55	8.26	8.83	8.61	8.7	8.45	8.23	8.07	8.36	8.63	8.94	9.11	9.39	7.99	9.09	8.97	9.26	9.09	8.62	9.24

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 - Fly Ash Reservoir II

Parameter	Unit	M-15										M-16									
		7/6/2016	8/11/2016	10/18/2016	1/17/2017	4/13/2017	4/27/2017	6/1/2017	6/26/2017	7/31/2017	9/27/2017	7/6/2016	8/10/2016	10/14/2016	1/11/2017	4/13/2017	4/27/2017	5/25/2017	6/26/2017	8/1/2017	10/2/2017
		Background									Detection	Background									Detection
Antimony	µg/L	0.02J	0.01J	0.02J	0.03J	0.01J	-	0.02J	0.02J	0.01J	-	0.05U	0.05U	0.05U	0.05U	0.05U	-	0.05U	0.05U	0.05U	-
Arsenic	µg/L	2.54	2.48	2.49	2.09	2.36	-	2.58	2.61	2.34	-	0.34	0.31	0.33	0.28	0.29	-	0.23	0.51	0.28	-
Barium	µg/L	46.3	49.3	51	47.3	46.7	-	55.1	49	44.6	-	44	44.2	42.5	42.5	40.9	-	42.7	40.3	41.8	-
Beryllium	µg/L	0.02U	0.02U	0.01J	0.02U	0.02U	-	0.045	0.01J	0.02U	-	0.02U	0.02U	0.02U	0.02U	0.02U	-	0.02U	0.02U	0.02U	-
Boron	mg/L	0.244	0.266	0.225	0.231	0.227	-	0.243	0.115	0.225	0.272	0.174	0.177	0.171	0.171	0.164	-	0.196	0.235	0.185	0.191
Cadmium	µg/L	0.02U	0.09	0.005J	0.008J	0.02U	-	0.008J	0.08	0.009J	-	0.02U	0.02U	0.02U	0.02U	0.02U	-	0.02U	0.02U	0.02U	-
Calcium	mg/L	1.94	1.9	2.1	1.79	1.6	-	1.67	0.369	1.73	1.85	2.26	2.22	2.09	2.19	2.06	-	2.23	2.24	2.37	2.11
Chloride	mg/L	29.6	27.5	28.1	31	-	29	28.7	28.1	28.1	28.5	9.2	8.98	9.37	8.92	-	9.21	9.04	9.06	8.93	9.26
Chromium	µg/L	0.5	0.1	0.2	0.178	0.01J	-	0.332	0.159	0.18	-	0.5	0.1	0.3	0.093	0.01J	-	0.05J	0.063	0.167	-
Cobalt	µg/L	0.027	0.02	0.059	0.033	0.009J	-	0.145	0.064	0.024	-	0.047	0.014	0.031	0.02	0.007J	-	0.01J	0.01J	0.01J	-
Combined Radium	pCi/L	0.551	1.204	2.224	1.806	0.598	-	0.791	1.242	1.645	-	0.209	0.381	0.6464	0.86	0.312	-	1.184	11.683	0.806	-
Fluoride	mg/L	1.32	1.25	1.29	1.18	-	1.21	1.15	1.14	1.34	1.29	0.41	0.37	0.39	0.38	-	0.37	0.35	0.31	0.4	0.33
Lead	µg/L	0.062	0.055	0.18	0.076	0.02U	-	0.414	0.19	0.078	-	0.065	0.02J	0.045	0.02J	0.006J	-	0.02J	0.02J	0.005J	-
Lithium	mg/L	0.009	0.009	0.004	0.008	0.007	-	0.002	0.004	0.009	-	0.01	0.012	0.012	0.015	0.012	-	0.015	0.008	0.013	-
Mercury	µg/L	0.005U	0.005U	0.005U	0.005U	0.005U	-	0.005U	0.005U	0.005U	-	0.005U	0.005U	0.005U	0.005U	0.005U	-	0.005U	0.005U	0.005U	-
Molybdenum	µg/L	0.7	0.74	0.74	1.06	0.92	-	0.72	1.18	0.76	-	0.19	0.39	0.15	0.59	0.28	-	0.27	11.4	0.24	-
Selenium	µg/L	0.1J	0.03J	0.04J	0.04J	0.1U	-	0.07J	0.05J	0.1U	-	0.1J	0.1U	0.03J	0.1U	0.1U	-	0.1U	0.1U	0.1U	-
Total Dissolved Solids	mg/L	588	578	612	565	-	567	578	574	588	572	776	764	758	764	-	776	775	778	795	737
Sulfate	mg/L	7.9	4.7	9.4	0.2J		3.2	2.1	2.4	2.6	3.1	252	251	253	242		250	240	252	273	247
Thallium	µg/L	0.081	0.05U	0.03J	0.02J	0.05U	-	0.02J	0.02J	0.05U	-	0.05U	0.05U	0.01J	0.01J	0.05U		0.05U	0.05U	0.05U	
pH	SU	8.79	9.01	8.98	7.64	9.03	8.84	8.74	8.69	9.39	8.34	8.67	9.08	9.01	8.29	8.98	9.27	8.93	8.6	8.66	8.4

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 - Fly Ash Reservoir II

Parameter	Unit	M-21										
		7/5/2016	8/9/2016	10/19/2016	1/18/2017	4/12/2017	4/20/2017	4/26/2017	5/30/2017	6/22/2017	8/1/2017	10/2/2017
		Background										Detection
Antimony	µg/L	0.27	0.09	0.17	0.07	0.3	-	-	0.07J	0.06J	0.04J	-
Arsenic	µg/L	5.49	2.66	4.24	2.92	5.7	-	-	1.89	2.59	4.62	-
Barium	µg/L	12.8	12.2	12.5	12.3	17.4	-	-	10.1	11.3	13.7	-
Beryllium	µg/L	0.915	0.379	0.739	0.247	0.512	-	-	0.244	0.191	0.091	-
Boron	mg/L	3.08	3.33	2.68	2.88	2.78	-	-	3.15	3.15	3.21	3.08
Cadmium	µg/L	0.03	0.01J	0.009J	0.006J	0.02J	-	-	0.04U	0.04U	0.01J	-
Calcium	mg/L	298	282	262	229	214	-	-	254	241	203	247
Chloride	mg/L	100	79.6	68.6	64.5	-	65.2	-	59.2	64.1	65.8	62.5
Chromium	µg/L	0.3	0.1	0.2	0.262	0.124	-	-	0.119	0.407	0.492	-
Cobalt	µg/L	2.95	2.07	2.41	2.02	1.89	-	-	2.66	2.99	1.89	-
Combined Radium	pCi/L	1.007	0.4449	0.393	0.838	0.811	-	-	1.19	1.306	1.849	-
Fluoride	mg/L	0.1J	0.1J	0.1J	0.1J	-	0.1J	-	0.07J	0.08J	0.1J	0.08
Lead	µg/L	1.52	0.446	0.983	0.544	1.67	-	-	0.392	0.349	0.328	-
Lithium	mg/L	0.082	0.09	0.074	0.082	0.074	-	-	0.08	0.082	0.081	-
Mercury	µg/L	0.005U	0.005U	0.005U	0.005U	0.005U	-	-	0.005U	0.005U	0.005U	-
Molybdenum	µg/L	20.9	14.9	17.2	18.9	16.6	-	-	16.9	18.8	16.9	-
Selenium	µg/L	0.4	0.2	0.3	0.1	0.5	-	-	0.1J	0.07J	0.2U	-
Total Dissolved Solids	mg/L	1940	1840	1810	1850	-	1850	891	1770	1830	1840	1830
Sulfate	mg/L	1070	995	990	986	-	990	-	1020	1030	1080	998
Thallium	µg/L	0.02J	0.02J	0.055	0.02J	0.05U	-	-	0.05J	0.1U	0.1U	
pH	SU	6.94	7.07	7.53	6.42	7.03	8.02	-	6.98	7.43	8.11	7.14

Parameter	M-22									
	6/30/2016	8/9/2016	10/18/2016	1/17/2017	4/13/2017	4/18/2017	4/27/2017	6/1/2017	6/26/2017	8/1/2017	9/27/2017
	Background										Detection
Antimony	0.01J	0.05U	0.01J	0.02J	0.05U	-	-	0.05U	0.05U	0.05U	-
Arsenic	0.49	0.47	0.53	0.62	0.55	-	-	0.56	0.52	0.51	-
Barium	24.6	23.4	25.3	25.1	24.1	-	-	26.1	25.4	24.4	-
Beryllium	0.041	0.032	0.038	0.041	0.033	-	-	0.04	0.037	0.037	-
Boron	3.56	3.81	3.39	3.79	3.5	-	-	3.96	4.14	4.08	4.14
Cadmium	0.006J	0.01J	0.02U	0.004J	0.02U	-	-	0.02U	0.02U	0.02U	-
Calcium	194	182	189	176	161	-	-	175	185	182	195
Chloride	46.1	46.3	46.7	47.8	-	-	49.4	49.4	49.6	50.2	51.8
Chromium	0.1	0.1	0.2	0.258	0.04J	-	-	0.04J	0.052	0.118	-
Cobalt	0.922	1.17	1.13	1.16	1.17	-	-	1.15	1	1.06	-
Combined Radium	1.947	1.197	3.244	2.084	1.255	-	-	1.494	5.156	0.769	-
Fluoride	0.46	0.4	0.44	0.41	-	-	0.42	0.4	0.37	0.43	0.35
Lead	0.007J	0.02J	0.039	0.029	0.027	-	-	0.01J	0.02J	0.02U	-
Lithium	0.068	0.054	0.046	0.057	0.052	-	-	0.062	0.064	0.068	-
Mercury	0.005U	0.005U	0.005U	0.005U	0.005U	-	-	0.005U	0.005U	0.005U	-
Molybdenum	90.8	92.5	97.8	92.7	89	-	-	94.3	93.6	86.8	-
Selenium	0.1	0.1U	0.04J	0.05J	0.04J	-	-	0.05J	0.04J	0.1U	-
Total Dissolved Solids	883	913	916	929	-	-	938	946	961	963	985
Sulfate	378	386	383	390	-	-	399	403	409	415	435
Thallium	0.04J	0.01J	0.064	0.082	0.05U	-		0.05U	0.01J	0.05U	
pH	6.79	6.88	6.99	6.63	6.93	7.92	6.92	6.84	7.21	8.08	7.14

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 - Fly Ash Reservoir II

Parameter	Unit	M-23											M-1003								
		6/30/2016	8/9/2016	10/19/2016	1/16/2017	4/12/2017	4/18/2017	5/1/2017	6/1/2017	6/26/2017	8/1/2017	10/3/2017	6/29/2016	10/25/2016	1/12/2017	5/2/2017	5/31/2017	6/22/2017	8/1/2017	8/4/2016	9/28/2017
		Background										Detection	Background								Detection
Antimony	µg/L	0.03J	0.03J	0.02J	0.03J	0.03J	-	-	0.2U	0.2U	0.2U	-	0.02J	0.04J	0.03J	0.01J	0.01J	0.01J	0.02J	0.05J	-
Arsenic	µg/L	1.31	1.22	1.08	1.18	0.97	-	-	1.11	1.21	1.15	-	0.35	1.05	0.73	0.32	0.36	0.21	0.68	1.92	-
Barium	µg/L	9.59	9.26	8.85	9.33	9.04	-	-	9.75	8.67	8.76	-	76.4	90.5	81.7	73.6	82	71.7	78.2	102	-
Beryllium	µg/L	0.02J	0.02J	0.02J	0.023	0.02J	-	-	0.02J	0.02J	0.02J	-	0.01J	0.039	0.027	0.009J	0.02J	0.007J	0.035	0.055	-
Boron	mg/L	0.62	0.667	0.578	0.589	0.615	-	-	0.637	0.717	0.63	0.601	0.085	0.139	0.106	0.178	0.138	0.189	0.124	0.138	0.124
Cadmium	µg/L	0.04U	0.04U	0.02J	0.009J	0.04U	-	-	0.06U	0.06U	0.06U	-	0.02U	0.006J	0.02U	0.02U	0.02U	0.02U	0.02U	0.01J	-
Calcium	mg/L	121	106	112	92.1	89	-	-	106	100	110	104	67.7	65.1	59.2	60.8	63	68.8	62.8	56.8	61.6
Chloride	mg/L	13	13.2	12.6	13.3	-	-	13.7	12.3	13.8	12.5	12.8	4.51	4.61	4.58	4.66	4.76	4.72	4.92	4.56	4.9
Chromium	µg/L	0.3	0.2	0.1	0.353	0.08J	-	-	0.291	0.208	0.575	-	0.4	0.488	0.494	0.113	0.16	0.107	0.562	0.7	-
Cobalt	µg/L	0.455	0.438	0.376	0.377	0.29	-	-	0.57	0.598	0.486	-	0.195	0.304	0.3	0.249	0.267	0.289	0.346	0.828	-
Combined Radium	pCi/L	3.12	2.108	2.033	6.71	2.879	-	-	2.77	3.92	3.08	-	2.104	4.18	5.06	2.57	2.8	3.13	3.97	4.06	-
Fluoride	mg/L	0.59	0.57	0.55	0.57	-	-	0.54	0.5	0.52	0.6J	0.48	0.22	0.21	0.19	0.19	0.18	0.17	0.23	0.21	0.19
Lead	µg/L	0.112	0.156	0.068	0.188	0.061	-	-	0.188	0.207	0.069	-	0.13	0.415	0.323	0.125	0.19	0.135	0.361	0.679	-
Lithium	mg/L	0.055	0.049	0.048	0.054	0.048	-	-	0.05	0.05	0.059	-	0.026	0.012	0.013	0.012	0.008	0.015	0.013	0.011	-
Mercury	µg/L	0.005U	0.005U	0.005U	0.005U	0.01U	-	-	0.005U	0.005U	0.005U	-	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	-
Molybdenum	µg/L	4.99	0.34	3.8	0.59	0.7	-	-	1.03	1.98	0.46	-	2.63	0.3	0.31	2.9	0.17	0.18	0.43	2.06	-
Selenium	µg/L	0.2	0.2U	0.2U	0.06J	0.2U	-	-	0.3U	0.3U	0.3U	-	0.1J	0.1J	0.04J	0.03J	0.04J	0.1U	0.05J	0.06J	-
Total Dissolved Solids	mg/L	3300	3280	3300	3240	-	-	3140	3220	3210	2980	3210	461	429	448	470	475	487	470	443	488
Sulfate	mg/L	1730	1690	1660	1560	-	-	1610	1650	1690	1830	1620	88.7	91.9	89.8	105	106	113	91.9	79.9	105
Thallium	µg/L	0.03J	0.04J	0.06J	0.078	0.02J	-		0.2U	0.2U	0.2U	-	0.05U	0.03J	0.01J	0.05U	0.02J	0.05U	0.02J	0.02J	-
pH	SU	7	6.99	6.95	6.63	7.69	8.19	7.26	7.51	7.07	8.11	7.96	7.67	7.68	7.37	7.42	7.21	7.77	6.9	7.55	7.47

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 - Fly Ash Reservoir II

Parameter	Unit	M-1004											M-1302										
		6/30/2016	8/9/2016	10/18/2016	1/17/2017	4/12/2017	4/18/2017	4/27/2017	6/1/2017	6/22/2017	7/31/2017	9/27/2017	7/1/2016	8/10/2016	10/13/2016	11/15/2016	1/11/2017	4/13/2017	4/27/2017	5/25/2017	6/21/2017	8/1/2017	10/2/2017
		Background										Detection	Background										Detection
Antimony	µg/L	0.03J	0.05	0.07	0.01J	0.06	-	-	0.03J	0.02J	0.03J	-	0.05U	0.05U	0.05U	0.05U	0.01J	0.05U	-	0.05U	0.05U	0.05U	-
Arsenic	µg/L	2.48	4.01	7.55	2.41	5.26	-	-	3.53	2.94	3.19	-	0.09	0.07	0.08	0.06	0.12	0.05J	-	0.05J	0.05J	0.05J	-
Barium	µg/L	73.1	94.3	102	84.1	90.4	-	-	76.9	67.3	82.3	-	83.6	84.8	94.5	81.9	88.5	95.5	-	69.4	83.9	85.8	-
Beryllium	µg/L	0.09	0.145	0.247	0.093	0.133	-	-	0.11	0.085	0.127	-	0.02U	0.02U	0.02U	0.006J	0.02U	0.02U	-	0.02U	0.02U	0.02U	-
Boron	mg/L	1.63	2.05	1.72	1.78	1.54	-	-	1.9	2.02	1.97	2.25	0.237	0.243	0.26	0.245	0.248	0.297	-	0.255	0.264	0.303	0.302
Cadmium	µg/L	0.006J	0.009J	0.02J	0.02U	0.008J	-	-	0.02J	0.02U	0.007J	-	0.005J	0.007J	0.02U	0.02U	0.007J	0.02U	-	0.02U	0.02U	0.02U	-
Calcium	mg/L	99.9	96.1	95.6	85.6	80.8	-	-	82.5	89.6	85.4	100	4.29	3.87	3.81	3.93	3.93	3.6	-	3.66	3.91	3.88	3.49
Chloride	mg/L	26.1	27.8	29.6	28.5	-	-	29.3	30.3	32.5	30.1	32.1	26.3	25	25.8	25.8	24.5	-	25.7	25.5	26.2	25.8	26.5
Chromium	µg/L	1.9	3.6	7.4	1.83	4.02	-	-	2.6	2.08	3.3	-	0.4	0.2	0.2	0.181	0.138	0.064	-	0.04J	0.056	0.163	-
Cobalt	µg/L	0.588	1.13	2.57	0.369	1.48	-	-	0.902	0.756	0.988	-	0.019	0.015	0.02	0.012	0.038	0.01	-	0.007J	0.008J	0.009J	-
Combined Radium	pCi/L	1.971	1.784	2.213	2.917	1.263	-	-	5.503	2.42	1.954	-	0.2456	0.404	0.878	0.795	1.08	0.186	-	0.76	1.1	1.806	-
Fluoride	mg/L	1.46	1.54	1.53	1.65	-	-	1.86	1.48	1.37	1.69	1.38	1.31	1.14	1.43	1.11	1.26		1.16	1.03	1.23	1.38	1.37
Lead	µg/L	0.527	1.11	2.69	0.544	1.34	-	-	1.03	0.743	0.943	-	0.035	0.039	0.025	0.01J	0.022	0.01J	-	0.02J	0.008J	0.004J	-
Lithium	mg/L	0.035	0.023	0.02	0.022	0.025	-	-	0.023	0.026	0.024	-	0.015	0.013	0.014	0.014	0.018	0.013	-	0.013	0.013	0.016	-
Mercury	µg/L	0.005U	0.005U	0.005U	0.005U	0.005U	-	-	0.005U	0.005U	0.005U	-	0.005U	0.01U	0.005U	0.005U	0.005U	0.005U	-	0.005U	0.005U	0.005U	-
Molybdenum	µg/L	9.44	11.4	11.8	9.87	8.92	-	-	9.92	10.8	9.73	-	0.36	0.27	0.11	0.12	0.58	0.07J	-	0.3	0.1	0.19	-
Selenium	µg/L	0.2	0.1	0.4	0.09J	0.2	-	-	0.1	0.1	0.2	-	0.08J	0.1U	0.1U	0.04J	0.1U	0.1U	-	0.1U	0.1U	0.1U	-
Total Dissolved Solids	mg/L	1010	914	841	877	-	-	855	900	874	874	848	746	765	730	788	754	-	775	789	791	762	712
Sulfate	mg/L	363	272	265	249	-	-	207	269	276	249	267	115	118	93.7	114	95	-	123	126	108	111	82.7
Thallium	µg/L	0.01J	0.03J	0.053	0.02J	0.03J	-		0.02J	0.01J	0.02J		0.01J	0.05U	0.02J	0.02J	0.04J	0.05U		0.05U	0.05U	0.05U	
pH	SU	7.41	7.52	7.38	7.31	7.28	7.16	7.36	6.87	7.7	7.23	7.35	8.66	8.66	8.13	8.53	8.59	8.89	8.57	8.79	8.73	8.42	8.44

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 - Fly Ash Reservoir II

Parameter	Unit	M-1309									MGS-1								
		7/6/2016	8/10/2016	10/26/2016	1/17/2017	5/1/2017	6/1/2017	6/26/2017	7/31/2017	9/28/2017	11/16/2016	12/13/2016	1/11/2017	2/9/2017	5/1/2017	6/1/2017	6/21/2017	7/31/2017	10/5/2017
		Background								Detection	Background								Detection
Antimony	µg/L	0.05	0.05J	0.04J	0.02J	0.03J	0.02J	0.01J	0.01J	-	0.07	0.03J	0.02J	0.01J	0.01J	0.05U	0.05U	0.01J	-
Arsenic	µg/L	3.53	2.68	2.56	2.51	2.43	2.33	2.85	2.45	-	1.03	0.36	0.26	0.24	0.15	0.13	0.11	0.1	-
Barium	µg/L	35.6	39.3	38.4	37.9	35.8	38.8	33.6	33.6	-	113	114	108	101	102	107	96.8	98.2	-
Beryllium	µg/L	0.1	0.073	0.056	0.023	0.022	0.024	0.02J	0.01J	-	0.045	0.01J	0.01J	0.009J	0.01J	0.01J	0.009J	0.01J	-
Boron	mg/L	0.282	0.264	0.276	0.252	0.256	0.284	0.345	0.268	0.278	0.312	0.26	0.28	0.342	0.304	0.313	0.286	0.25	0.268
Cadmium	µg/L	0.02	0.03	0.02J	0.007J	0.01J	0.006J	0.02U	0.02U	-	0.02U	0.004J	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U	-
Calcium	mg/L	17.4	16.8	14.1	12.3	11.3	11.1	9.2	8.85	9.55	4.39	4.31	4.91	5.71	6.48	6.27	6.64	6.75	7.22
Chloride	mg/L	46	40	39.6	38.6	39.9	38.6	38	39	39.2	19.8	35.9	34.5	34.6	36	35.7	36.5	36.5	36.7
Chromium	µg/L	1.5	1	0.828	0.319	0.398	0.224	0.187	0.154	-	0.504	0.14	0.175	0.04J	0.218	0.078	0.079	0.127	-
Cobalt	µg/L	2.34	1.16	0.904	0.506	0.51	0.406	0.336	0.271	-	0.226	0.066	0.025	0.214	0.02J	0.01J	0.01J	0.02J	-
Combined Radium	pCi/L	0.527	0.825	2.84	0.562	0.642	0.695	4.64	3.539	-	2.668	1.745	1.495	0.932	0.526	0.77	1.156	0.959	-
Fluoride	mg/L	1.34	1.11	1.13	1.2	1.21	1.04	1.03	1.26	1.1	0.62	0.45	0.52	0.54	0.56	0.51	0.5	0.64	0.5
Lead	µg/L	1.17	0.924	0.718	0.231	0.261	0.232	0.181	0.122	-	0.665	0.085	0.043	0.025	0.02J	0.01J	0.009J	0.005J	-
Lithium	mg/L	0.04	0.029	0.026	0.029	0.026	0.021	0.025	0.027	-	0.025	0.021	0.019	0.024	0.019	0.014	0.018	0.016	-
Mercury	µg/L	0.005U	0.002J	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	-	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	-
Molybdenum	µg/L	8.94	7.48	5.54	4	3.04	3.46	22.1	2.8	-	0.67	1.71	1.82	0.96	0.73	0.31	0.44	0.56	-
Selenium	µg/L	0.3	0.2	0.2	0.1J	0.08J	0.05J	0.06J	0.1U	-	0.1	0.1U	0.1U	0.1U	0.03J	0.1U	0.1U	0.1U	-
Total Dissolved Solids	mg/L	1070	866	815	804	789	778	790	760	769	496	642	628	642	624	640	640	644	632
Sulfate	mg/L	323	222	193	172	151	149	161	154	149	41.3	84.3	86.5	80.6	83.8	85.6	87.3	87.6	82.4
Thallium	µg/L	0.02J	0.01J	0.02J	0.05U	0.05U	0.02J	0.05U	0.05U	-	0.02J	0.04J	0.05U	0.01J	0.05U	0.05U	0.05U	0.05U	-
pH	SU	7.77	7.79	8.21	7.9	7.99	7.67	8	9.14	8.2	6.86	7.57	7.58	7.18	7.75	8.27	7.95	7.27	8.58

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 - Fly Ash Reservoir II

Parameter	Unit	MGS-2									MGS-3								
		7/5/2016	8/11/2016	12/13/2016	1/17/2017	5/1/2017	6/1/2017	6/21/2017	7/31/2017	10/5/2017	6/30/2016	8/9/2016	11/16/2016	1/11/2017	5/1/2017	6/1/2017	6/21/2017	7/27/2017	10/5/2017
		Background								Detection	Background								Detection
Antimony	µg/L	1.88	1.05	0.64	0.42	0.24	0.22	0.22	0.19	-	2.27	0.65	0.64	0.6	0.3	0.26	0.28	0.22	-
Arsenic	µg/L	16.4	16.3	18.2	16.4	12.1	14.4	13.5	12.3	-	79.1	83.5	101	76.5	11.9	12.7	19.9	20.3	-
Barium	µg/L	42.8	36.3	36.4	32.3	29.2	34.6	32.3	31.1	-	26.2	20.2	19.4	17	13.6	13.9	14.5	12	-
Beryllium	µg/L	0.02J	0.006J	0.009J	0.02U	0.02U	0.02U	0.02U	0.02U	-	0.01J	0.01J	0.03J	0.02J	0.009J	0.01J	0.01J	0.01J	-
Boron	mg/L	0.207	0.222	0.202	0.226	0.208	0.245	0.249	0.205	0.203	0.381	0.614	0.756	0.759	0.423	0.507	0.637	0.734	0.87
Cadmium	µg/L	0.01J	0.006J	0.007J	0.02U	0.02U	0.02U	0.02U	0.02U	-	0.02J	0.05	0.02J	0.02J	0.02J	0.01J	0.02J	0.01J	-
Calcium	mg/L	15.6	14.4	6.77	6.15	6.28	7.65	5.11	6.02	3.97	192	109	102	100	222	216	194	156	94.4
Chloride	mg/L	18.5	20.9	25.8	24.6	25.8	25.8	26.8	26	26.5	15.9	20.7	26.3	25.5	16.3	14.4	20.6	21.8	28.7
Chromium	µg/L	0.6	0.2	0.218	0.15	0.221	0.073	0.058	0.155	-	0.3	0.3	0.498	0.311	0.296	0.103	0.129	0.356	-
Cobalt	µg/L	0.596	0.517	0.603	0.731	0.627	0.449	0.473	0.521	-	5.47	7.16	6.8	4.54	2.15	1.55	2.08	2.2	-
Combined Radium	pCi/L	0.537	0.0543	0.568	1.141	0.2828	0.333	0.853	1.169	-	1.308	1.72	1.253	1.942	1.18	1.888	1.937	1.518	-
Fluoride	mg/L	0.43	0.41	0.36	0.42	0.43	0.39	0.4	0.48	0.4	0.34	0.34	0.34	0.29	0.23	0.2	0.21	0.2	0.24
Lead	µg/L	0.428	0.126	0.154	0.064	0.055	0.031	0.023	0.01J	-	0.461	0.289	0.457	0.479	0.15	0.088	0.263	0.173	-
Lithium	mg/L	0.013	0.016	0.009	0.015	0.016	0.016	0.01	0.017	-	0.06	0.05	0.067	0.062	0.041	0.04	0.05	0.055	-
Mercury	µg/L	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	-	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	-
Molybdenum	µg/L	7.11	5.11	1.65	2.6	1.39	0.93	0.95	1.19	-	9.26	4.64	3.14	3.29	1.9	6.93	2.95	1.77	-
Selenium	µg/L	0.2	0.1	0.07J	0.1U	0.1U	0.05J	0.04J	0.05J	-	0.4	0.06J	0.07J	0.2U	0.2U	0.2U	0.2U	0.2U	-
Total Dissolved Solids	mg/L	644	626	592	572	586	613	597	602	600	2130	2250	2480	2430	2110	2070	2280	2320	2320
Sulfate	mg/L	152	131	91.2	82.9	93.1	95	85.3	101	79.6	1270	1310	1470	1470	1240	1260	1460	1370	1360
Thallium	µg/L	0.01J	0.05U	0.01J	0.03J	0.05U	0.05U	0.05U	0.05U	-	0.241	0.353	0.37	0.39	0.212	0.234	0.292	0.368	-
pH	SU	7.46	7.77	7.59	7.59	7.77	7.21	7.95	7.29	8.45	6.85	6.72	6.14	6.57	6.86	6.98	7.38	8.77	7.84

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 - Fly Ash Reservoir II

Parameter	Unit	MGS-4									MGS-5								
		11/16/2016	12/13/2016	1/11/2017	2/9/2017	5/1/2017	6/1/2017	6/21/2017	7/31/2017	10/2/2017	11/17/2016	12/14/2016	1/10/2017	2/9/2017	4/17/2017	5/30/2017	6/21/2017	7/27/2017	10/3/2017
		Background								Detection	Background								Detection
Antimony	µg/L	0.37	0.08	0.13	0.05	0.06	0.05	0.05J	0.04J	-	2.9	0.36	0.19	0.12	0.1	0.07	0.06	0.05J	-
Arsenic	µg/L	3.57	5.09	9.43	11.1	15	15.6	15.8	14.9	-	5.47	22.7	20.8	20.7	25	24.1	23.1	22.6	-
Barium	µg/L	42	33.5	29.5	23	20.1	19.9	18	16.4	-	71.6	66.9	64	59.1	75.1	77.5	75.4	78.7	-
Beryllium	µg/L	0.066	0.02J	0.01J	0.005J	0.004J	0.02U	0.02U	0.02U	-	0.02J	0.073	0.029	0.01J	0.009J	0.006J	0.02U	0.02U	-
Boron	mg/L	0.178	0.151	0.161	0.267	0.209	0.175	0.191	0.142	0.183	0.168	0.251	0.297	0.36	0.287	0.3	0.302	0.3	0.287
Cadmium	µg/L	0.03	0.02J	0.02J	0.007J	0.02U	0.02U	0.02U	0.02U	-	0.01J	0.02	0.007J	0.009J	0.02U	0.02U	0.02U	0.01J	-
Calcium	mg/L	96.4	131	97.3	74	30.1	27.2	20.2	16.5	11.1	25.5	7.05	5.92	5.36	4.4	4.2	4.09	3.73	3.62
Chloride	mg/L	14.3	16.3	15.3	14.5	13.2	12.8	12.1	11.9	11.5	78.1	163	155	159	159	162	166	161	174
Chromium	µg/L	0.983	0.344	0.841	0.257	0.081	0.118	0.076	0.12	-	0.231	0.517	0.594	0.348	0.173	0.117	0.106	0.217	-
Cobalt	µg/L	3.93	3.21	2.61	1.4	0.484	0.507	0.28	0.243	-	1.46	0.656	0.165	0.065	0.052	0.027	0.024	0.032	-
Combined Radium	pCi/L	0.3336	1.105	1.752	0.635	0.571	0.184	0.3165	0.771	-	0.833	1.572	0.9	2.573	0.3421	1.232	1.868	2.005	-
Fluoride	mg/L	0.31	0.24	0.32	0.34	0.46	0.43	0.45	0.62	0.53	1.61	4.41	4.66	4.73	4.74	4.97	5.27	5.09	5.09
Lead	µg/L	1.62	0.304	0.409	0.133	0.062	0.047	0.027	0.01J	-	0.206	2.22	1.16	0.323	0.19	0.099	0.059	0.127	-
Lithium	mg/L	0.037	0.03	0.031	0.035	0.019	0.018	0.018	0.015	-	0.021	0.019	0.023	0.023	0.012	0.018	0.017	0.017	-
Mercury	µg/L	0.002J	0.005U	0.002J	0.005U	0.005U	0.005U	0.005U	0.005U	-	0.005U	0.005U	0.005U	0.005U	0.002J	0.005U	0.005U	0.005U	-
Molybdenum	µg/L	7.97	5.2	5.87	4.57	2.87	3.47	2.58	2.66	-	42	19	16	12.6	10.6	8.95	8.05	9.78	-
Selenium	µg/L	0.3	0.1	0.08J	0.05J	0.06J	0.04J	0.1U	0.1U	-	0.2	0.2	0.06J	0.08J	0.1U	0.03J	0.1U	0.03J	-
Total Dissolved Solids	mg/L	1540	1630	1410	1200	850	848	717	672	586	798	542	1140	1110	-	1080	1100	1060	1090
Sulfate	mg/L	848	914	741	556	283	298	189	152	98.3	211	94.3	74.3	45.8	29.9	24.8	20.4	14.6	2.7
Thallium	µg/L	0.04J	0.02J	0.125	0.02J	0.05U	0.05U	0.05U	0.05U	-	0.02J	0.02J	0.065	0.04J	0.05U	0.05U	0.05U	0.05U	-
pH	SU	6.64	7.21	7.36	7.1	7.84	7.87	8.03	8.97	8.34	6.98	8.29	8.53	7.96	8.72	8.79	8.47	8.11	8.27

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 - Fly Ash Reservoir II

Parameter	Unit	CA-0622A		FA-8			M-6		M-8		M-10			M-11		
		5/15/2018	8/27/2018	1/24/2018	5/17/2018	8/29/2018	5/16/2018	8/28/2018	5/17/2018	8/27/2018	1/24/2018	5/17/2018	8/23/2018	1/24/2018	5/16/2018	8/27/2018
		Assessment		Detection	Assessment		Assessment		Assessment		Detection	Assessment		Detection	Assessment	
Antimony	µg/L	0.100 J	0.5 U	-	0.460	0.530	0.110	0.5 U	0.0400 J	0.5 U	-	0.0200 J	0.5 U	-	0.570	0.5 U
Arsenic	µg/L	37.2	24.4	-	5.49	6.60	4.58	0.5 U	2.65	2.40	-	0.200	0.5 U	-	4.62	4.70
Barium	µg/L	1060	1240	-	25.1	23.1	413	189	120	126	-	69.7	88.4	-	26.0	26.1
Beryllium	µg/L	0.100	0.140	-	0.02 U	0.1 U	1.35	0.1 U	0.0300	0.1 U	-	0.0100 J	0.120	-	0.02 U	0.1 U
Boron	mg/L	0.368	0.331	5.16	4.97	5.47	0.247	0.229	0.0800	0.0282	0.599	0.663	0.591	5.10	5.17	5.24
Cadmium	µg/L	0.0300 J	0.1 U	-	0.0300	0.140	0.280	0.1 U	0.0400	0.1 U	-	0.0300	0.370	-	0.0300	0.160
Calcium	mg/L	80.8	67.8	-	214	196	17.1	5.51	102	89.6	-	12.6	12.6	-	224	205
Chloride	mg/L	3930	4300	-	54.7	6.80	37.1	37.5	6.15	52.3	-	13.4	13.8	-	53.3	50.4
Chromium	µg/L	1.98	3.70	-	0.206	1.30	3.35	1 U	1.14	1 U	-	0.208	1 U	-	0.149	1 U
Cobalt	µg/L	1.61	1.40	-	0.570	0.760	3.39	0.5 U	1.34	1.30	-	0.0360	0.5 U	-	0.699	0.760
Combined Radium	pCi/L	4.76	8.73	-	0.530	0.524	93.3	2.69	1.19	1.44	-	0.758	0.885	-	0.712	0.775
Fluoride	mg/L	0.600 J	0.05 U	-	0.590	0.0940	1.24	1.20	0.100 J	0.510	-	0.790	0.710	-	0.590	0.500
Lead	µg/L	2.63	2.30	-	0.167	0.5 U	22.7	0.520	1.35	1.20	-	0.664	5.10	-	0.315	0.5 U
Lithium	mg/L	0.0820	0.0738	-	0.204	0.218	0.00700	10 U	0.001 U	10 U	-	0.0150	0.0198	-	0.213	0.211
Mercury	µg/L	0.005 U	0.0123	-	0.005 U	0.5 U	0.00900	0.0166	0.00200 J	0.00179	-	0.005 U	0.00300	-	0.005 U	0.000530
Molybdenum	µg/L	18.9	8.00	-	285	336	0.510	0.5 U	0.550	0.900	-	2.25	2.30	-	324	337
pH	SU	7.63	7.98	7.34	7.29	7.29	8.15	8.35	7.29	7.30	8.01	8.13	7.42	7.75	7.47	7.11
Selenium	µg/L	0.400 J	0.5 U	-	2.20	0.810	2.40	0.5 U	0.100	0.5 U	-	0.0400 J	0.5 U	-	2.80	0.5 U
Total Dissolved Solids	mg/L	5960	6980	-	1530	1520	598	548	428	437	-	749	726	-	1600	1550
Sulfate	mg/L	57.8	62.5	945	937	99.3	1.30	0.370	99.1	959	-	128	146	-	942	849
Thallium	µg/L	0.0600 J	0.5 U	-	0.148	0.5 U	0.146	0.5 U	0.0400 J	0.5 U	-	0.0200 J	0.5 U	-	0.343	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 - Fly Ash Reservoir II

Parameter	Unit	M-12		M-13		M-14		M-15		M-16		M-21			M-22		
		5/16/2018	8/27/2018	5/16/2018	8/23/2018	5/16/2018	8/23/2018	5/16/2018	8/22/2018	5/16/2018	8/22/2018	1/24/2018	5/22/2018	8/28/2018	1/24/2018	5/17/2018	8/23/2018
		Assessment		Assessment		Assessment		Assessment		Assessment		Detection	Assessment		Detection	Assessment	
Antimony	µg/L	0.0500 J	0.5 U	0.0200 J	0.5 U	0.05 U	0.5 U	0.0200 J	0.5 U	0.05 U	0.5 U	-	0.0800 J	0.5 U	-	0.0100 J	0.5 U
Arsenic	µg/L	7.18	4.30	0.860	0.690	0.120	0.5 U	2.50	2.00	0.300	0.5 U	-	1.90	2.80	-	0.460	0.5 U
Barium	µg/L	58.6	27.2	100	122	14.1	14.3	50.2	46.3	39.4	37.8	-	9.87	13.0	-	26.3	27.8
Beryllium	µg/L	0.0740	0.1 U	0.0620	0.1 U	0.02 U	0.1 U	0.0100 J	0.1 U	0.02 U	0.1 U	-	0.419	0.1 U	-	0.0380	0.1 U
Boron	mg/L	0.388	0.364	0.285	0.242	0.350	0.225	0.341	0.262	0.215	0.180	3.24	3.41	3.37	4.26	4.35	4.38
Cadmium	µg/L	0.0700	0.1 U	0.0100 J	0.1 U	0.00800 J	0.1 U	0.00900 J	0.1 U	0.02 U	0.1 U	-	0.0200 J	0.1 U	-	0.0100 J	0.1 U
Calcium	mg/L	320	285	9.17	11.2	0.587	0.534	1.85	1.61	2.49	2.15	-	266	180	-	187	177
Chloride	mg/L	237	284	2.79	3.70	1.56	1.90	27.0	28.2	9.72	10.7	-	59.4	61.1	-	52.6	50.7
Chromium	µg/L	0.496	1 U	0.359	1 U	0.175	1 U	0.237	1 U	0.148	1 U	-	0.212	1 U	-	0.211	1 U
Cobalt	µg/L	13.6	9.00	0.131	0.5 U	0.00900 J	0.5 U	0.0630	0.5 U	0.0100 J	0.5 U	-	2.66	1.60	-	0.985	0.5 U
Combined Radium	pCi/L	1.12	0.450	2.21	0.997	0.414	0.491	0.887	0.806	0.755	1.51	-	1.17	0.738	-	2.12	2.17
Fluoride	mg/L	1.12	0.990	1.24	1.30	0.800	0.810	1.34	1.40	0.410	0.350	0.100 J	0.100 J	0.05 U	-	0.450	0.460
Lead	µg/L	0.770	0.5 U	0.465	0.5 U	0.0350	0.5 U	0.245	0.5 U	0.0290	0.5 U	-	0.791	0.5 U	-	0.0300	0.5 U
Lithium	mg/L	0.136	0.116	0.00500	0.0103	0.001 U	10 U	0.00500	10 U	0.00800	0.0108	-	0.0960	0.0699	-	0.0650	0.0655
Mercury	µg/L	0.005 U	0.00201	0.005 U	0.000880	0.005 U	0.5 U	0.005 U	0.00130	0.005 U	0.5 U	-	0.005 U	0.000940	-	0.005 U	0.000920
Molybdenum	µg/L	0.590	0.5 U	0.390	0.5 U	0.260	0.5 U	0.650	0.520	0.210	0.5 U	-	15.5	15.5	-	83.2	82.9
pH	SU	6.73	6.83	8.64	8.42	9.01	9.34	8.88	8.92	8.82	8.91	7.14	7.09	7.29	7.02	6.92	7.40
Selenium	µg/L	0.100 J	0.5 U	0.0700 J	0.5 U	0.1 U	0.5 U	0.0400 J	0.5 U	0.0300 J	0.5 U	-	0.300	0.5 U	-	0.1 U	0.5 U
Total Dissolved Solids	mg/L	2800	2800	465	450	376	365	573	548	770	784	-	1780	1840	-	961	914
Sulfate	mg/L	1470	1510	10.1	13.8	0.400	0.800	3.60	4.40	255	287	-	1020	1060	421	415	437
Thallium	µg/L	0.0400 J	0.5 U	0.05 U	0.5 U	0.05 U	0.5 U	0.0100 J	0.5 U	0.0200 J	0.5 U	-	0.0400 J	0.5 U	-	0.05 U	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 - Fly Ash Reservoir II

Parameter	Unit	M-23			M-1003		M-1004			M-1302		M-1309		MGS-1		
		1/24/2018	5/17/2018	8/24/2018	5/16/2018	8/28/2018	1/24/2018	5/17/2018	8/27/2018	5/16/2018	8/22/2018	5/16/2018	8/29/2018	1/23/2018	5/16/2018	8/28/2018
		Detection	Assessment		Assessment		Detection	Assessment		Assessment		Assessment		Detection	Assessment	
Antimony	µg/L	-	0.0200 J	0.5 U	0.0100 J	0.5 U	-	0.0100 J	0.5 U	0.05 U	0.5 U	0.0100 J	0.5 U	-	0.05 U	0.5 U
Arsenic	µg/L	-	0.510	0.750	0.440	0.5 U	-	1.81	1.80	0.0400 J	0.5 U	2.54	2.40	-	0.0500	0.5 U
Barium	µg/L	-	8.99	8.40	77.0	76.7	-	48.6	48.1	72.9	92.1	36.9	34.4	-	89.7	90.7
Beryllium	µg/L	-	0.0100 J	0.1 U	0.0200	0.1 U	-	0.0600	0.1 U	0.02 U	0.1 U	0.0200 J	0.1 U	-	0.00900 J	0.1 U
Boron	mg/L	0.684	0.748	0.731	0.150	0.159	1.89	2.37	2.56	0.284	0.283	0.313	0.296	-	0.326	0.314
Cadmium	µg/L	-	0.02 U	0.1 U	0.0300	0.1 U	-	0.0100 J	0.1 U	0.00700 J	0.1 U	0.0100 J	0.1 U	-	0.02 U	0.1 U
Calcium	mg/L	-	118	104	61.8	47.6	-	99.6	89.6	4.17	3.58	6.90	5.49	-	10.3	10.0
Chloride	mg/L	-	13.4	15.5	5.73	6.60	-	33.6	35.0	26.5	27.7	41.5	41.9	35.8	36.8	37.3
Chromium	µg/L	-	0.0860	1 U	0.268	1 U	-	0.775	1 U	0.135	1 U	0.277	1 U	-	0.104	1 U
Cobalt	µg/L	-	0.432	0.5 U	0.168	0.5 U	-	0.197	0.5 U	0.00700 J	0.5 U	0.285	0.5 U	-	0.0100 J	0.5 U
Combined Radium	pCi/L	-	2.49	3.51	4.13	2.77	-	1.62	0.929	0.684	0.253	0.576	0.547	-	0.267	1.11
Fluoride	mg/L	-	0.590	0.300	0.220	0.190	-	1.40	1.30	1.16	1.60	1.26	1.20	-	0.630	0.590
Lead	µg/L	-	0.0320	0.5 U	0.200	0.5 U	-	0.202	0.5 U	0.0210	0.5 U	0.200	0.5 U	-	0.0100 J	0.5 U
Lithium	mg/L	-	0.0470	0.0549	0.00900	10 U	-	0.0150	0.0165	0.0110	0.0140	0.0150	0.0182	-	0.0130	0.0184
Mercury	µg/L	-	0.005 U	0.000600	0.005 U	0.00178	-	0.005 U	0.000730	0.005 U	0.51 U	0.005 U	0.00356	-	0.005 U	0.5 U
Molybdenum	µg/L	-	0.450	0.5 U	0.120	0.5 U	-	9.89	10.4	0.0700 J	0.5 U	1.76	1.70	-	0.320	0.5 U
pH	SU	7.21	7.09	7.35	7.82	7.53	7.42	7.16	7.72	8.57	8.70	8.24	7.64	7.49	7.42	7.30
Selenium	µg/L	-	0.0300 J	0.5 U	0.1 U	0.5 U	-	0.0600 J	0.5 U	0.1 U	0.5 U	0.0600 J	0.5 U	-	0.1 U	0.5 U
Total Dissolved Solids	mg/L	-	3190	3450	459	433	-	871	876	774	671	755	713	-	614	604
Sulfate	mg/L	-	1580	1690	92.7	96.7	-	290	315	141	97.8	123	121	-	78.9	83.9
Thallium	µg/L	-	0.0200 J	0.5 U	0.05 U	0.5 U	-	0.0100 J	0.5 U	0.05 U	0.5 U	0.0100 J	0.5 U	-	0.05 U	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
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Table 1: Groundwater Data Summary
Cardinal Plant - Fly Ash Reservoir II

Parameter	Unit	MGS-2		MGS-3			MGS-4		MGS-5	
		5/16/2018	8/28/2018	1/24/2018	5/17/2018	8/28/2018	5/16/2018	8/23/2018	5/15/2018	8/21/2018
		Assessment		Detection	Assessment		Assessment		Assessment	
Antimony	µg/L	0.100	0.5 U	-	0.220	0.5 U	0.0400 J	0.5 U	0.0400 J	0.5 U
Arsenic	µg/L	9.29	8.00	-	8.68	10.8	9.52	7.10	18.7	16.0
Barium	µg/L	28.5	27.1	-	11.8	10.4	12.1	11.7	91.9	104
Beryllium	µg/L	0.02 U	0.1 U	-	0.02 U	0.1 U	0.02 U	0.1 U	0.02 U	0.1 U
Boron	mg/L	0.313	0.238	0.338	0.444	0.924	0.319	0.192	0.433	0.331
Cadmium	µg/L	0.02 U	0.1 U	-	0.0100 J	0.1 U	0.02 U	0.1 U	0.02 U	0.1 U
Calcium	mg/L	8.83	9.21	-	327	150	9.39	6.45	3.15	2.92
Chloride	mg/L	25.7	26.2	-	11.3	24.2	11.5	12.2	167	171
Chromium	µg/L	0.156	1 U	-	0.152	1 U	0.157	1 U	0.272	1 U
Cobalt	µg/L	0.426	0.5 U	-	0.359	1.60	0.142	0.5 U	0.0260	0.5 U
Combined Radium	pCi/L	0.709	0.456	-	1.94	1.15	0.228	0.941	1.62	1.43
Fluoride	mg/L	0.470	0.420	-	0.210	0.110	0.610	0.610	5.50	5.10
Lead	µg/L	0.0250	0.5 U	-	0.0780	0.5 U	0.0310	0.5 U	0.0430	0.650
Lithium	mg/L	0.0110	0.0152	-	0.0280	0.0514	0.00600	10 U	0.0100	0.0151
Mercury	µg/L	0.005 U	0.5 U	-	0.005 U	0.5 U	0.005 U	0.000800	0.005 U	0.000760
Molybdenum	µg/L	1.26	1.40	-	1.66	1.30	2.72	2.10	3.26	2.90
pH	SU	7.58	7.53	6.81	6.74	6.47	8.16	8.50	8.36	8.52
Selenium	µg/L	0.1 U	0.5 U	-	0.0400 J	0.5 U	0.1 U	0.5 U	0.1 U	0.5 U
Total Dissolved Solids	mg/L	630	583	-	1870	2220	600	519	1100	1090
Sulfate	mg/L	117	115	-	1100	1380	121	73.1	3.60	3.80
Thallium	µg/L	0.05 U	0.5 U	-	0.0890	0.5 U	0.0100 J	0.5 U	0.0100 J	0.5 U

Notes:
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Table 1 - Groundwater Data Summary
Cardinal Plant - Fly Ash Reservoir II

Parameter	Unit	CA-0622A		FA-8		M-6		M-8		M-10		M-11	
		3/26/2019	10/1/2019	4/4/2019	10/9/2019	3/28/2019	10/3/2019	4/1/2019	10/3/2019	4/2/2019	10/3/2019	4/5/2019	10/9/2019
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	0.700	0.620
Arsenic	µg/L	29.2	25.8	7.70	9.20	4.10	4.70	0.940	1.10	0.500 U	0.500 U	3.00	5.40
Barium	µg/L	934	952	24.5	22.2	435	442	127	120	78.0	80.6	23.9	20.8
Beryllium	µg/L	0.100 U	0.100 U	0.100 U	0.100 U	1.50	1.80	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Boron	µg/L	284	337	4,980	4,740	231	239	26.6	25.8	580	536	4,670	5,000
Cadmium	µg/L	0.100 U	0.100 U	0.240	0.150	0.230	0.260	0.100 U	0.100 U	0.100 U	0.190	0.400	0.180
Calcium	µg/L	75,400	74,200	198,000	218,000	16,000	15,600	108,000	102,000	14,100	12,400	195,000	219,000
Chloride	mg/L	4,900	3,470	43.4	46.6	32.9	39.8	6.00	6.10	12.6	12.6	44.2	45.7
Chromium	µg/L	1.50	1.20	1.00 U	1.10	9.20	11.8	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Cobalt	µg/L	0.620	0.630	0.870	0.920	4.90	5.60	0.660	0.500 U	0.500 U	0.500 U	1.20	1.20
Combined Radium	pCi/L	11.6	11.9	0.188	1.17	6.51	5.15	0.476	0.776	1.68	0.815	0.453	1.28
Fluoride	mg/L	0.470	0.0500 U	0.600	0.570	1.20	1.10	0.0880	0.0500 U	0.690	0.670	0.580	0.550
Lead	µg/L	0.500 U	0.500 U	0.500 U	0.500 U	22.0	25.9	0.590	0.730	0.850	1.20	0.980	0.640
Lithium	µg/L	89.8	86.7	198	194	18.3	18.6	10.0 U	10.0 U	19.6	20.0	193	188
Mercury	µg/L	0.00108	0.00185	0.000500 U	0.000570	0.0104	0.00694	0.00116	0.00214	0.000570	0.000500 U	0.000500 U	0.000610
Molybdenum	µg/L	3.40	1.90	321	303	1.00 U	1.20	0.500 U	0.500 U	2.40	2.30	316	338
Selenium	µg/L	0.500 U	1.00	2.00	0.500 U	1.00 U	1.70	0.500 U	0.500 U	0.500 U	0.500 U	4.50	0.640
Sulfate	mg/L	72.0	40.4	885	762	2.00	7.70	95.8	99.9	133	134	960	781
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	0.500 U	0.500 U
Total Dissolved Solids	mg/L	6,680	7,250	1,430	1,360	478	695	421	409	711	710	1,400	1,360
pH	SU	7.49	7.85	7.12	7.02	7.71	7.95	7.37	7.33	8.40	8.44	8.01	7.15

Notes:
mg/L: milligrams per liter
µg/L: micrograms per liter
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J: Estimated value. Parameter was detected in concentrations below the reporting limit
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Table 1 - Groundwater Data Summary
Cardinal Plant - Fly Ash Reservoir II

Parameter	Unit	M-12		M-13		M-14			M-15			M-16		
		4/3/2019	10/9/2019	4/3/2019	10/8/2019	3/27/2019	7/2/2019	10/7/2019	3/25/2019	5/1/2019	9/30/2019	3/27/2019	7/2/2019	10/1/2019
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	5.60	2.10	1.40	1.00	0.500 U	-	0.500 U	2.00	-	2.00	0.500 U	-	0.500 U
Barium	µg/L	89.1	28.3	218	159	14.6	-	14.3	43.2	-	45.4	37.1	-	37.4
Beryllium	µg/L	0.100	0.100 U	0.930	0.100 U	0.100 U	-	0.100 U	0.100 U	-	0.100 U	0.100 U	-	0.100 U
Boron	µg/L	324	290	261	285	224	-	231	228	-	258	192	-	184
Cadmium	µg/L	0.130	0.100 U	0.100 U	0.100 U	0.100 U	-	0.100 U	0.100 U	-	0.100 U	0.100 U	-	0.100 U
Calcium	µg/L	371,000	188,000	14,600	15,400	513	-	603	1,550	-	1,490	2,240	-	2,260
Chloride	mg/L	184	270	2.10	2.10	-	1.80	1.50	-	25.7	26.0	-	10.0	10.2
Chromium	µg/L	1.00 U	1.00 U	3.40	1.00 U	1.00 U	-	1.00 U	1.00 U	-	1.00 U	1.00 U	-	1.00 U
Cobalt	µg/L	31.7	6.20	1.20	0.500 U	0.500 U	-	0.500 U	0.500 U	-	0.500 U	0.500 U	-	0.500 U
Combined Radium	pCi/L	1.14	1.19	3.87	1.56	0.680	-	1.22	0.681	-	0.00	0.553	-	0.805
Fluoride	mg/L	0.990	1.30	1.70	1.80	-	0.730	0.780	-	1.40	1.30	-	0.350	0.350
Lead	µg/L	1.20	0.500 U	3.30	0.530	0.500 U	-	0.500 U	0.500 U	-	0.500 U	0.500 U	-	0.500 U
Lithium	µg/L	106	108	15.8	10.8	10.0 U	-	10.0 U	10.0 U	-	10.0 U	10.4	-	11.0
Mercury	µg/L	0.00583	0.00169	0.00267	0.000510	0.000500 U	-	0.000500 U	0.000500 U	-	0.000500 U	0.000500 U	-	0.000500 U
Molybdenum	µg/L	0.500 U	0.500 U	0.730	0.680	0.500 U	-	0.500 U	0.500 U	-	0.500 U	0.500 U	-	0.500 U
Selenium	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	-	0.610
Sulfate	mg/L	1,590	1,020	28.8	30.5	-	0.800	1.10	-	3.00	1.50	-	332	276
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	2,910	2,290	510	492	347	-	347	540	-	552	780	-	757
pH	SU	667	7.22	8.15	7.48	9.19	-	8.83	9.13	-	9.03	8.34	-	8.81

Notes:
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Table 1 - Groundwater Data Summary
Cardinal Plant - Fly Ash Reservoir II

Parameter	Unit	M-21		M-22		M-23		M-1003		M-1004		M-1302		
		4/3/2019	10/8/2019	4/3/2019	10/9/2019	4/1/2019	10/3/2019	4/8/2019	10/9/2019	4/2/2019	10/7/2019	3/25/2019	5/1/2019	10/1/2019
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	0.500 U	-	0.500 U
Arsenic	µg/L	5.40	3.60	0.500 U	0.500 U	3.40	0.930	0.530	0.500 U	1.50	1.50	0.500 U	-	0.500 U
Barium	µg/L	14.1	13.8	25.1	21.8	27.3	8.50	84.2	79.4	47.2	44.8	107	-	106
Beryllium	µg/L	1.40	0.780	0.100 U	0.100 U	0.250	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	-	0.100 U
Boron	µg/L	3,210	3,100	3,990	3,760	695	696	128	130	2,310	2,680	244	-	295
Cadmium	µg/L	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	-	0.100 U
Calcium	µg/L	237,000	176,000	188,000	178,000	125,000	105,000	69,100	68,300	97,900	115,000	3,490	-	3,340
Chloride	mg/L	51.9	63.8	44.0	43.9	12.0	13.4	5.80	6.20	31.8	35.6	-	26.6	28.4
Chromium	µg/L	1.00 U	1.00 U	1.00 U	1.00 U	3.50	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	-	1.00 U
Cobalt	µg/L	1.80	0.910	0.500 U	1.50	2.60	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	-	0.500 U
Combined Radium	pCi/L	0.573	0.980	0.776	1.18	2.30	2.21	2.10	3.24	0.890	1.25	0.771	-	0.421
Fluoride	mg/L	0.100	0.130	0.520	0.380	0.330	0.390	0.230	0.200	1.20	1.20	-	1.20	1.70
Lead	µg/L	3.70	1.00	0.500 U	0.500 U	3.30	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	-	0.500 U
Lithium	µg/L	80.0	66.5	52.6	52.5	57.9	48.6	10.0 U	10.0 U	21.0	18.0	13.1	-	11.7
Mercury	µg/L	0.00366	0.00156	0.000680	0.000500 U	0.0127	0.000500 U	0.000500 U	0.000640	0.000500 U	0.000510	0.000510 U	-	0.000510 U
Molybdenum	µg/L	21.3	16.6	56.5	79.1	0.500 U	0.500 U	0.500 U	0.500 U	9.40	11.6	0.500 U	-	0.500 U
Selenium	µg/L	0.500 U	0.500 U	0.500 U	0.500 U	0.560	0.530	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	-	0.590
Sulfate	mg/L	1,170	968	382	400	1,570	1,750	98.3	112	272	341	-	111	60.9
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	0.500 U	-	0.500 U
Total Dissolved Solids	mg/L	1,810	1,760	896	905	3,320	3,210	466	437	859	869	699	-	721
pH	SU	7.21	7.21	7.11	7.09	7.21	7.14	7.56	7.39	7.48	7.27	8.79	-	8.51

Notes:
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Table 1 - Groundwater Data Summary
Cardinal Plant - Fly Ash Reservoir II

Parameter	Unit	M-1309			M-2000		MGS-1		MGS-2		MGS-3		MGS-4		MGS-5	
		4/4/2019	10/10/2019	11/12/2019	4/5/2019	10/9/2019	3/27/2019	10/7/2019	4/2/2019	10/9/2019	4/3/2019	10/4/2019	4/1/2019	10/8/2019	3/26/2019	10/2/2019
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	0.500 U	0.500 U	0.500 U	0.500 U
Arsenic	µg/L	2.20	2.00	-	0.530	0.880	0.500 U	0.500 U	11.7	12.9	36.7	10.3	5.40	5.10	14.1	12.5
Barium	µg/L	33.6	34.6	-	86.7	25.1	92.0	89.6	38.6	45.7	12.2	9.40	12.3	13.0	103	105
Beryllium	µg/L	0.100 U	0.100 U	-	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Boron	µg/L	285	283	-	254	4,970	288	321	214	169	536	879	193	204	335	271
Cadmium	µg/L	0.100 U	0.100 U	-	0.100 U	0.100	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Calcium	µg/L	5,690	4,390	-	218,000	216,000	13,200	13,300	20,900	46,300	284,000	147,000	8,170	8,040	2,950	2,730
Chloride	mg/L	37.8	38.9	-	46.6	50.0	32.7	38.3	20.6	21.1	16.8	27.6	12.1	12.1	170	206
Chromium	µg/L	1.00 U	1.00 U	-	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Cobalt	µg/L	0.500 U	0.500 U	-	0.500 U	1.10	0.500 U	0.500 U	0.770	1.20	0.660	0.840	0.500 U	0.500 U	0.500 U	0.500 U
Combined Radium	pCi/L	0.936	1.71	-	1.72	1.24	0.316	0.901	0.307	0.177	1.37	0.850	0.0710	0.221	0.181	0.527
Fluoride	mg/L	1.10	1.20	-	0.370	0.380	0.650	0.640	0.370	0.370	0.170	0.140	0.510	0.510	5.40	6.60
Lead	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	0.500 U	0.500 U	0.500 U	0.500 U
Lithium	µg/L	23.4	17.2	-	201	190	17.7	16.6	13.5	13.2	38.0	47.6	10.0 U	10.0 U	16.7	14.0
Mercury	µg/L	0.00170	-	0.000850	0.000500 U	0.000500 U	0.000500 U	0.000500 U	0.000500 U	0.000500 U	0.000500 U	0.000500 U	0.000500 U	0.000500 U	0.000500 U	0.000500 U
Molybdenum	µg/L	1.50	1.10	-	0.500 U	208	0.500 U	0.500 U	4.30	10.3	2.30	2.10	4.20	5.50	2.30	1.90
Selenium	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	0.500 U	0.500 U	0.500 U	0.500 U
Sulfate	mg/L	94.6	88.1	-	820	830	78.9	91.2	164	162	1,330	1,290	98.1	86.7	3.50	1.60
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	0.500 U	0.500 U	0.500 U	0.500 U
Total Dissolved Solids	mg/L	693	687	-	721	1,440	616	597	618	651	2,030	2,000	572	522	1,030	1,070
pH	SU	7.94	7.57	-	6.83	6.80	7.75	7.47	7.62	7.51	679	6.59	8.46	8.13	8.70	8.50

Notes:
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Spring 2020 App III & IV Parameters_Rev 1
Cardinal Plant - Fly Ash Reservoir II

Parameter	Unit	CA-0622A	FA-8	M-6	M-8	M-10	M-11	M-12	M-13	M-14	M-15	M-16	M-21	M-21 Resamp	M-22	M-23	M-1003	M-1004	M-1302	M-1309	MGS-1	MGS-2	MGS-3	MGS-4	MGS-5
		4/09/2020	4/20/2020	4/14/2020	4/15/2020	4/15/2020	4/17/2020	4/15/2020	4/16/2020	4/21/2020	4/08/2020	4/09/2020	4/21/2020	6/22/2020	4/15/2020	4/17/2020	4/21/2020	4/16/2020	4/08/2020	4/20/2020	4/16/2020	4/15/2020	4/10/2020	4/09/2020	4/13/2020
Antimony	µg/L	*2.5 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	0.63	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	2.8	*0.5 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*
Arsenic	µg/L	25.8	8.6	3.7	0.65	*0.50 U*	3.3	3.6	0.57	*0.50 U*	1.8	*0.50 U*	440	1.7	*0.50 U*	0.8	*0.50 U*	1.5	*0.50 U*	1.8	*0.50 U*	6	35.9	4.1	8.5
Barium	µg/L	1080	24.3	381	116	78.8	22.2	71.1	127	13.7	45.2	36.7	1650	12.6	24.1	7.6	72.5	40	114	29.7	81.1	28.1	9.6	12.9	113
Beryllium	µg/L	*0.50 U*	*0.10 U*	1.6	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*	168	0.26	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*	*0.50 U*
Boron	ug/L	279	4770	209	25.7	537	4760	316	240	219	250	175	3780	3400	3790	666	140	2380	270	277	273	219	774	181	310
Cadmium	µg/L	*0.50 U*	*0.10 U*	0.2	*0.10 U*	*0.10 U*	*0.10 U*	0.15	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*	12.3	*0.1 U*	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*	*0.10 U*
Calcium	ug/L	76700	208000	14500	101000	11900	206000	368000	11500	*500 U*	1660	2340	352000	230000	170000	103000	74500	108000	3180	3960	11800	7320	163000	4890	2510
Chloride	mg/L	4450	48.5	36.7	6.9	13.7	53.4	163	2.6	1.8	28.7	11	61	50.6	51.5	15.7	7.2	37.6	30	39.5	35.4	26.6	35.8	21.2	162
Chromium	µg/L	*5.0 U*	1.3	10	*1.0 U*	*1.0 U*	*1.0 U*	*1.0 U*	*1.0 U*	*1.0 U*	*1.0 U*	*1.0 U*	95.7	*1.0 U*	*1.0 U*	*1.0 U*	*1.0 U*	*1.0 U*	*1.0 U*	*1.0 U*	*1.0 U*	*1.0 U*	*1.0 U*	*1.0 U*	*1.0 U*
Cobalt	µg/L	*2.5 U*	0.92	4.6	*0.50 U*	*0.50 U*	0.97	32.4	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	143	2.4	1	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	0.82	*0.50 U*	*2.5 U*
Combined Radium	pCi/L	10.5	0.755	7.41	1.4	0.792	0.5	0.41	1.44	0.205	1.35	0.592	8.46	1.58	1.25	2	2.47	1.06	0.963	0.0571	0.245	0.515	0.886	0.321	1.99
Fluoride	mg/L	*0.050 U*	0.59	1.2	0.16	0.81	0.68	1.3	1.9	0.85	1.3	0.37	0.14	0.13	0.49	0.63	0.23	1.3	1.8	1.1	0.67	0.45	0.19	0.54	5.7
Lead	µg/L	*0.50 U*	*0.50 U*	21.2	*0.50 U*	1.1	*0.50 U*	1.1	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	689	1.3	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*
Lithium	ug/L	99.5	194	22.3	*10.0 U*	20.4	191	149	11.8	*10.0 U*	*10.0 U*	12.2	122	87.8	65.1	54	11.3	25.7	14.8	19.4	17.4	16.5	54.9	*10.0 U*	16
Mercury	µg/L	0.00073	0.00062	0.00819	0.0018	0.00066	0.00103	0.00187	0.00139	0.00077	*0.0005 U*	*0.0005 U*	0.679	0.00381	*0.0005 U*	*0.0005 U*	0.00091	*0.0005 U*	*0.00051 U*	0.00178	*0.0005 U*	*0.0005 U*	*0.0005 U*	*0.0005 U*	*0.0005 U*
Molybdenum	µg/L	*2.5 U*	298	1.1	*0.50 U*	2.2	289	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	707	29.7	77.2	*0.50 U*	*0.50 U*	9.9	*0.50 U*	1	*0.50 U*	2.3	2.4	4.2	*2.5 U*
pH	SU	7.52	7.09	7.4	7.24	8.35	7.23	7.18	8.01	8.99	8.87	8.65	6.84	7.2	6.94	7.12	7.3	7.17	8.57	8.19	7.47	7.48	6.65	8.17	8.51
Selenium	µg/L	*2.5 U*	1.4	1	*0.50 U*	*0.50 U*	3.2	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	79.8	29.7	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*
Total Dissolved Solids	mg/L	6890	1300	606	422	710	1290	2600	511	340	548	791	900	1650	942	3250	440	850	719	679	599	613	2020	586	1130
Sulfate	mg/L	47	740	5.2	103	133	778	1630	29.7	0.85	1.2	300	1030	914	403	1740	125	312	54.2	83.7	75.7	105	1400	134	42.8
Thallium	µg/L	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*2.5 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*0.50 U*	*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 – FLY ASH RESERVOIR II
BRILLIANT, OHIO

Submitted to

Cardinal Operating Compnay
306 County Road 7E
Brilliant, Ohio 43913

Submitted by

Geosyntec consultants
engineers | scientists | innovators

941 Chatham Lane, Suite 103
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January 13, 2020

CHA8468

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Attachment A: Monitoring Well M-2000 Construction Diagram

LIST OF ACRONYMS AND ABBREVIATIONS

ACM	Assessment of Corrective Measures
CCR	Coal Combustion Residuals
CFR	Code of Federal Regulations
ESP	Electrostatic Precipitator
FAD	Fly Ash Dam
FAR	Fly Ash Reservoir
FGD	Flue Gas Desulfurization
GWPS	Groundwater Protection Standards
MCL	Maximum Contaminant Level
NPDES	National Pollutant Discharge Elimination System
RSL	Risk-Based Screening Level
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 Fly Ash Reservoir (FAR) II, 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 SUMMARY

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 capacity and annual coal use of 5.2 million tons (Geosyntec, 2017a). 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.

FAR II is an existing wet fly ash disposal reservoir that is located approximately one mile north of the plant site and immediately east of the FAR I Residual Solid Waste (RSW) Landfill. The reservoir is contained within Blockhouse Hollow (also referred to as Blockhouse Run in references and drawings) by Fly Ash Dam (FAD) 2 and the decommissioned FAD I. FAR II receives sluiced fly ash from the generating units' ESPs and collected stormwater and leachate from the FAR I RSW Landfill. FAR II/FAD 2 has a permitted discharge through the National Pollutant Discharge Elimination System (NPDES) Outfall 019 (Geosyntec, 2017a).

2.2 Regional Physiographic Setting

The Site is underlain by horizontal sequences of lower Permian and upper Pennsylvanian sedimentary rock. The Conemaugh Group, 500 feet (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, 2017a). Above the current grade of the 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 lies within the Morgantown Sandstone, which is overlain by a shale aquitard. Groundwater in the uppermost aquifer generally flows south-southeast towards the Ohio River with hydraulic conductivity ranging from 1×10^{-1} to 1×10^{-4} centimeters per second

(cm/s). The hydraulic conductivity of the confining shale layer ranges from 1×10^{-7} to 1×10^{-9} cm/s (AEP, 2006).

3. GROUNDWATER MONITORING SYSTEM

The FAR II'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, 2017a).

The FAR II groundwater monitoring network consists of twenty-three monitoring wells, as shown in **Figure 2.** Five upgradient monitoring wells (CA-0622A, M-12, M-1302, M-6, and MGS-5) are used to measure background conditions and eighteen downgradient monitoring wells (FA-8, M-10, M-1003, M-1004, M-11, M-13, M-1309, M-14, M-15, M-16, M-21, M-22, M-23, M-8, MGS-1, MGS-2, MGS-3, and MGS-4) 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, 2017b). 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 (RSL) 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 GWPS was completed in January 2019 and is described in the *Statistical Analysis Summery – Fly Ash Reservoir* (Geosyntec, 2019b). The statistical analysis report identified statistically significant levels (SSLs) of lithium and molybdenum above their respective GWPS at monitoring wells FA-8 and M-11. An alternate source was not identified for the SSLs and the CCR unit transitioned to corrective measures, as discussed in **Section 4.3**.

4.2 2019 Sampling and Data Evaluation Activities

4.2.1 Assessment Monitoring Program

Assessment monitoring sampling events were conducted in March and October 2019 in accordance with 40 CFR 257.95(b) and 40 CFR 257.95(d)(1). Samples were analyzed for all Appendix III and Appendix IV parameters, with results provided 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 the compliance and background monitoring wells. Potentiometric surface maps based on groundwater elevations measured during the March and October 2019 assessment monitoring events are presented on **Figure 3** and **Figure 4**, respectively. The potentiometric maps show that groundwater near FAR II flows southeast towards the Ohio River. The groundwater residence times within the wells at the FAR II ranged from 0.6 days at M-GS-2 to 21.6 days at M-12. A summary of hydraulic gradients and groundwater residence times at the FAR II 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;
- Chain of custody forms were 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.

Samples collected in March 2019 from monitoring wells M-15 and M-1302 were not analyzed by USEPA method 9056 for chloride, fluoride, and sulfate within an acceptable hold time as a result of laboratory error. Monitoring wells M-15 and M-1302 were re-sampled in May 2019 and analyzed for the USEPA 9056 anions only. All other data received during 2019 were considered complete and usable.

4.3 Corrective Measures Program

Following detection of lithium and molybdenum SSLs at FA-8 and M-11, a Notification of Exceedance of Groundwater Protection Standards was published to the public internet site on February 7, 2019 in accordance with 40 CFR 257.105(h) (Buckeye Power, 2019). As required for characterization of the nature and extent of the release, monitoring well M-2000 was installed in accordance with 40 CFR 257.95(g)(1) on March 8, 2019 and sampled during the March and October 2019 assessment monitoring events. Monitoring well installation and sampling efforts are described in the *Groundwater Characterization Report, Cardinal Site – Fly Ash Reservoir II*

(Geosyntec, 2019c). The boring and construction log for monitoring well M-2000 is provided as **Attachment A**.

An Assessment of Corrective Measures (ACM) Report was completed in July 2019 in accordance with 40 CFR 257.96 and published to the public internet site (Geosyntec, 2019d). The ACM report lists four potential corrective measures that may be appropriate for addressing the elevated lithium and molybdenum concentrations in Site groundwater. A public meeting was held on September 4, 2019 in Steubenville, Ohio where the selection and implementation of potential corrective measures outlined in the ACM Report were reviewed and discussed.

4.4 Problems Encountered and Resolutions

No problems were encountered during 2019 which were related to assessment monitoring activities at the FAR II. Monitoring well M-2000 was installed in 2019 to facilitate characterization of the nature and extent of the release within the corrective measures program. No monitoring wells were gauged dry or abandoned within the well network during 2019.

Samples for chloride, fluoride, and sulfate at M-14 and M-16 were not collected during the March 2019 event due to sampling error. Samples were instead collected from M-14 and M-16 in July 2019 and submitted for analysis of anions. The mercury sample collected at M-1309 on October 10, 2019 was unable to be analyzed due to laboratory error. An additional sample was collected from M-1309 in November 2019 and submitted for mercury analysis. The March 2019 samples for chloride, fluoride, and sulfate at M-15 and M-1302 were analyzed out of hold time. These data will not be included in any statistical evaluation and additional samples were collected in May 2019. All other analytical data received were deemed to be of acceptable quality.

5. STATUS OF MONITORING PROGRAM

The Site was in the assessment monitoring program from May 2018 through January 2019 and transitioned to the corrective measures program in February 2019. Assessment monitoring events were conducted in March and October 2019. FAR II will remain in the corrective measures program in 2020.

6. PLANNED KEY ACTIVITIES FOR 2020

The following activities are planned for 2020 at the FAR II:

- The 2019 Annual Groundwater Monitoring Report will be entered into the facility's operating record and posted to the public internet site;
- The assessment monitoring statistics revision for data collected in 2019 will be completed and the potential for SSLs of Appendix IV parameters and Statistically Significant Increases (SSIs) of Appendix III parameters over background will be evaluated;

- Two semi-annual groundwater assessment monitoring program events will be conducted;
- A semi-annual report describing the progress in selecting and designing the remedy will be prepared and posted to the public internet site;
- A remedy, outlined in the ACM, will be selected in accordance with 40 CFR 257.97. A final report describing the selected remedy, and initiation of remedial activities will be prepared and posted to the public internet site; and
- The 2020 Annual Groundwater Monitoring Report will be prepared for submittal in January 2021.

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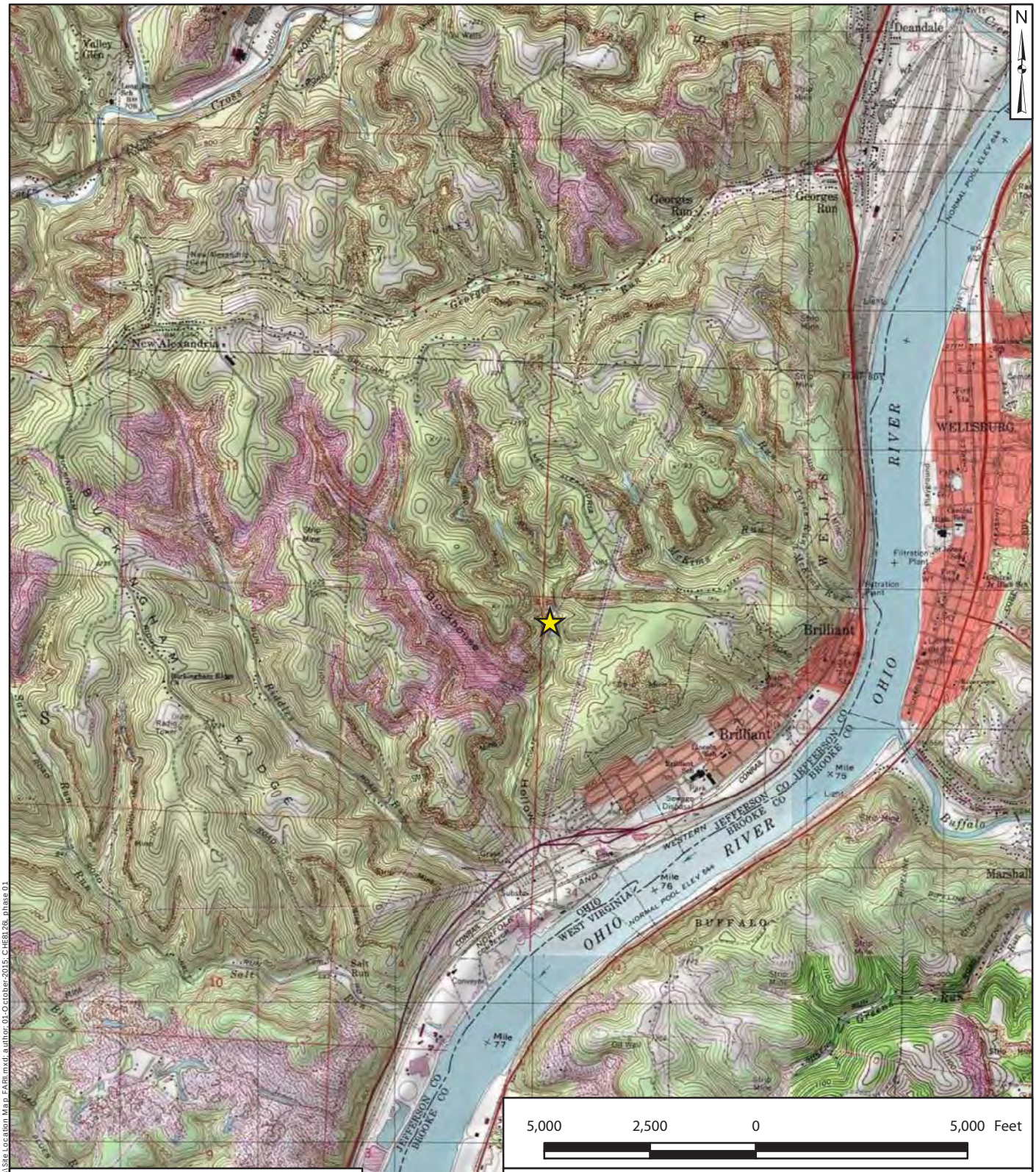
FIGURES



Legend

Site Location

Notes

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

Site Location Map
FAR II

Cardinal Power Plant
Brilliant, Ohio

Geosyntec consultants

Ann Arbor, Michigan | 01-October-2015

Figure 1

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Monitoring Well Network

- Compliance Sampling Location
- Background Sampling Location
- Corrective Measures Delineation Well
- Jules Verne Seep

Fly Ash Reservoir (FAR) II

Notes
- Monitoring well coordinates provided by Buckeye Power.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Fly Ash Reservoir II (Geosyntec, 2017) provided by Buckeye Power.

1,000 500 0 1,000 Feet

Site Layout
Fly Ash Reservoir II

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2020/01/14

Figure 2

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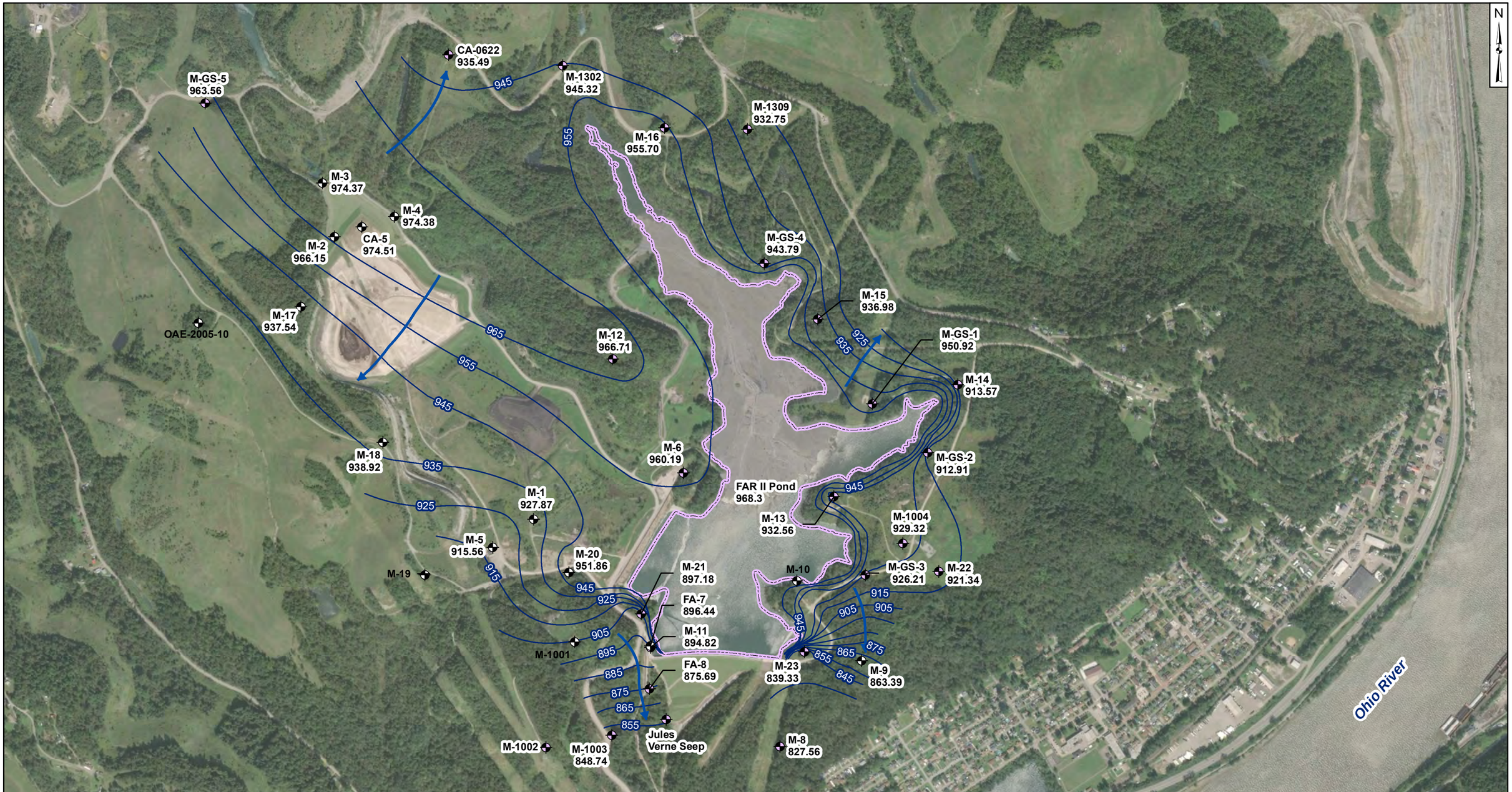

Legend

- FAR II Network Monitoring Well
- State/Other Program Monitoring Well
- Fly Ash Reservoir (FAR) II
- Groundwater Elevation Contour
- Approximate Groundwater Flow Direction

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 - Fly Ash Reservoir II (Geosyntec, 2017) provided by AEP.
- Groundwater discharge observed from Jules Verne Seep location.
- OAE-2005-10, M-10, M-19, and M-1001 were not gauged in March 2019.
- Groundwater elevation units are feet above mean sea level.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Morgantown Aquifer
Fly Ash Reservoir II
March 2019

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2020/01/03

Figure X

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Legend

- FAR II Network Monitoring Well
- State/Other Program Monitoring Well
- Groundwater Elevation Contour
- Approximate Groundwater Flow Direction
- Fly Ash Reservoir (FAR) II

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 - Fly Ash Reservoir II (Geosyntec, 2017) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
- Groundwater discharge observed from Jules Verne Seep location.
- OAE-2005-10, M-12, M-17, M-19, M-1001, M-1002, and MP-1 were not gauged in October 2019.
- An obstruction was noted in M-1309 at elevation 967.61 ft amsl
* Well not used for contouring due to inconsistent/anamolous reading.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Morgantown Aquifer
Fly Ash Reservoir II
October 2019

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2019/12/31

Figure X

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TABLES

Table 1 - Groundwater Data Summary
Cardinal Plant - Fly Ash Reservoir II

Parameter	Unit	CA-0622A		FA-8		M-6		M-8		M-10		M-11	
		3/26/2019	10/1/2019	4/4/2019	10/9/2019	3/28/2019	10/3/2019	4/1/2019	10/3/2019	4/2/2019	10/3/2019	4/5/2019	10/9/2019
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	0.700	0.620
Arsenic	µg/L	29.2	25.8	7.70	9.20	4.10	4.70	0.940	1.10	0.500 U	0.500 U	3.00	5.40
Barium	µg/L	934	952	24.5	22.2	435	442	127	120	78.0	80.6	23.9	20.8
Beryllium	µg/L	0.100 U	0.100 U	0.100 U	0.100 U	1.50	1.80	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Boron	µg/L	284	337	4,980	4,740	231	239	26.6	25.8	580	536	4,670	5,000
Cadmium	µg/L	0.100 U	0.100 U	0.240	0.150	0.230	0.260	0.100 U	0.100 U	0.100 U	0.190	0.400	0.180
Calcium	µg/L	75,400	74,200	198,000	218,000	16,000	15,600	108,000	102,000	14,100	12,400	195,000	219,000
Chloride	mg/L	4,900	3,470	43.4	46.6	32.9	39.8	6.00	6.10	12.6	12.6	44.2	45.7
Chromium	µg/L	1.50	1.20	1.00 U	1.10	9.20	11.8	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Cobalt	µg/L	0.620	0.630	0.870	0.920	4.90	5.60	0.660	0.500 U	0.500 U	0.500 U	1.20	1.20
Combined Radium	pCi/L	11.6	11.9	0.188	1.17	6.51	5.15	0.476	0.776	1.68	0.815	0.453	1.28
Fluoride	mg/L	0.470	0.0500 U	0.600	0.570	1.20	1.10	0.0880	0.0500 U	0.690	0.670	0.580	0.550
Lead	µg/L	0.500 U	0.500 U	0.500 U	0.500 U	22.0	25.9	0.590	0.730	0.850	1.20	0.980	0.640
Lithium	µg/L	89.8	86.7	198	194	18.3	18.6	10.0 U	10.0 U	19.6	20.0	193	188
Mercury	µg/L	0.00108	0.00185	0.000500 U	0.000570	0.0104	0.00694	0.00116	0.00214	0.000570	0.000500 U	0.000500 U	0.000610
Molybdenum	µg/L	3.40	1.90	321	303	1.00 U	1.20	0.500 U	0.500 U	2.40	2.30	316	338
Selenium	µg/L	0.500 U	1.00	2.00	0.500 U	1.00 U	1.70	0.500 U	0.500 U	0.500 U	0.500 U	4.50	0.640
Sulfate	mg/L	72.0	40.4	885	762	2.00	7.70	95.8	99.9	133	134	960	781
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	0.500 U	0.500 U
Total Dissolved Solids	mg/L	6,680	7,250	1,430	1,360	478	695	421	409	711	710	1,400	1,360
pH	SU	7.49	7.85	7.12	7.02	7.71	7.95	7.37	7.33	8.40	8.44	8.01	7.15

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
All samples were collected as part of the assessment monitoring program in accordance with 40 CFR 257.90(e)(3).

Table 1 - Groundwater Data Summary
Cardinal Plant - Fly Ash Reservoir II

Parameter	Unit	M-12		M-13		M-14			M-15			M-16		
		4/3/2019	10/9/2019	4/3/2019	10/8/2019	3/27/2019	7/2/2019	10/7/2019	3/25/2019	5/1/2019	9/30/2019	3/27/2019	7/2/2019	10/1/2019
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	5.60	2.10	1.40	1.00	0.500 U	-	0.500 U	2.00	-	2.00	0.500 U	-	0.500 U
Barium	µg/L	89.1	28.3	218	159	14.6	-	14.3	43.2	-	45.4	37.1	-	37.4
Beryllium	µg/L	0.100	0.100 U	0.930	0.100 U	0.100 U	-	0.100 U	0.100 U	-	0.100 U	0.100 U	-	0.100 U
Boron	µg/L	324	290	261	285	224	-	231	228	-	258	192	-	184
Cadmium	µg/L	0.130	0.100 U	0.100 U	0.100 U	0.100 U	-	0.100 U	0.100 U	-	0.100 U	0.100 U	-	0.100 U
Calcium	µg/L	371,000	188,000	14,600	15,400	513	-	603	1,550	-	1,490	2,240	-	2,260
Chloride	mg/L	184	270	2.10	2.10	-	1.80	1.50	-	25.7	26.0	-	10.0	10.2
Chromium	µg/L	1.00 U	1.00 U	3.40	1.00 U	1.00 U	-	1.00 U	1.00 U	-	1.00 U	1.00 U	-	1.00 U
Cobalt	µg/L	31.7	6.20	1.20	0.500 U	0.500 U	-	0.500 U	0.500 U	-	0.500 U	0.500 U	-	0.500 U
Combined Radium	pCi/L	1.14	1.19	3.87	1.56	0.680	-	1.22	0.681	-	0.00	0.553	-	0.805
Fluoride	mg/L	0.990	1.30	1.70	1.80	-	0.730	0.780	-	1.40	1.30	-	0.350	0.350
Lead	µg/L	1.20	0.500 U	3.30	0.530	0.500 U	-	0.500 U	0.500 U	-	0.500 U	0.500 U	-	0.500 U
Lithium	µg/L	106	108	15.8	10.8	10.0 U	-	10.0 U	10.0 U	-	10.0 U	10.4	-	11.0
Mercury	µg/L	0.00583	0.00169	0.00267	0.000510	0.000500 U	-	0.000500 U	0.000500 U	-	0.000500 U	0.000500 U	-	0.000500 U
Molybdenum	µg/L	0.500 U	0.500 U	0.730	0.680	0.500 U	-	0.500 U	0.500 U	-	0.500 U	0.500 U	-	0.500 U
Selenium	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	-	0.610
Sulfate	mg/L	1,590	1,020	28.8	30.5	-	0.800	1.10	-	3.00	1.50	-	332	276
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	2,910	2,290	510	492	347	-	347	540	-	552	780	-	757
pH	SU	667	7.22	8.15	7.48	9.19	-	8.83	9.13	-	9.03	8.34	-	8.81

Notes:
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All samples were collected as part of the assessment monitoring program in accordance with 40 CFR 257.90(e)(3).

Table 1 - Groundwater Data Summary
Cardinal Plant - Fly Ash Reservoir II

Parameter	Unit	M-21		M-22		M-23		M-1003		M-1004		M-1302		
		4/3/2019	10/8/2019	4/3/2019	10/9/2019	4/1/2019	10/3/2019	4/8/2019	10/9/2019	4/2/2019	10/7/2019	3/25/2019	5/1/2019	10/1/2019
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	0.500 U	-	0.500 U
Arsenic	µg/L	5.40	3.60	0.500 U	0.500 U	3.40	0.930	0.530	0.500 U	1.50	1.50	0.500 U	-	0.500 U
Barium	µg/L	14.1	13.8	25.1	21.8	27.3	8.50	84.2	79.4	47.2	44.8	107	-	106
Beryllium	µg/L	1.40	0.780	0.100 U	0.100 U	0.250	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	-	0.100 U
Boron	µg/L	3,210	3,100	3,990	3,760	695	696	128	130	2,310	2,680	244	-	295
Cadmium	µg/L	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	-	0.100 U
Calcium	µg/L	237,000	176,000	188,000	178,000	125,000	105,000	69,100	68,300	97,900	115,000	3,490	-	3,340
Chloride	mg/L	51.9	63.8	44.0	43.9	12.0	13.4	5.80	6.20	31.8	35.6	-	26.6	28.4
Chromium	µg/L	1.00 U	1.00 U	1.00 U	1.00 U	3.50	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	-	1.00 U
Cobalt	µg/L	1.80	0.910	0.500 U	1.50	2.60	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	-	0.500 U
Combined Radium	pCi/L	0.573	0.980	0.776	1.18	2.30	2.21	2.10	3.24	0.890	1.25	0.771	-	0.421
Fluoride	mg/L	0.100	0.130	0.520	0.380	0.330	0.390	0.230	0.200	1.20	1.20	-	1.20	1.70
Lead	µg/L	3.70	1.00	0.500 U	0.500 U	3.30	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	-	0.500 U
Lithium	µg/L	80.0	66.5	52.6	52.5	57.9	48.6	10.0 U	10.0 U	21.0	18.0	13.1	-	11.7
Mercury	µg/L	0.00366	0.00156	0.000680	0.000500 U	0.0127	0.000500 U	0.000500 U	0.000640	0.000500 U	0.000510	0.000510 U	-	0.000510 U
Molybdenum	µg/L	21.3	16.6	56.5	79.1	0.500 U	0.500 U	0.500 U	0.500 U	9.40	11.6	0.500 U	-	0.500 U
Selenium	µg/L	0.500 U	0.500 U	0.500 U	0.500 U	0.560	0.530	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U	-	0.590
Sulfate	mg/L	1,170	968	382	400	1,570	1,750	98.3	112	272	341	-	111	60.9
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	0.500 U	-	0.500 U
Total Dissolved Solids	mg/L	1,810	1,760	896	905	3,320	3,210	466	437	859	869	699	-	721
pH	SU	7.21	7.21	7.11	7.09	7.21	7.14	7.56	7.39	7.48	7.27	8.79	-	8.51

Notes:
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Table 1 - Groundwater Data Summary
Cardinal Plant - Fly Ash Reservoir II

Parameter	Unit	M-1309			M-2000		MGS-1		MGS-2		MGS-3		MGS-4		MGS-5	
		4/4/2019	10/10/2019	11/12/2019	4/5/2019	10/9/2019	3/27/2019	10/7/2019	4/2/2019	10/9/2019	4/3/2019	10/4/2019	4/1/2019	10/8/2019	3/26/2019	10/2/2019
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	0.500 U	0.500 U	0.500 U	0.500 U
Arsenic	µg/L	2.20	2.00	-	0.530	0.880	0.500 U	0.500 U	11.7	12.9	36.7	10.3	5.40	5.10	14.1	12.5
Barium	µg/L	33.6	34.6	-	86.7	25.1	92.0	89.6	38.6	45.7	12.2	9.40	12.3	13.0	103	105
Beryllium	µg/L	0.100 U	0.100 U	-	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Boron	µg/L	285	283	-	254	4,970	288	321	214	169	536	879	193	204	335	271
Cadmium	µg/L	0.100 U	0.100 U	-	0.100 U	0.100	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U	0.100 U
Calcium	µg/L	5,690	4,390	-	218,000	216,000	13,200	13,300	20,900	46,300	284,000	147,000	8,170	8,040	2,950	2,730
Chloride	mg/L	37.8	38.9	-	46.6	50.0	32.7	38.3	20.6	21.1	16.8	27.6	12.1	12.1	170	206
Chromium	µg/L	1.00 U	1.00 U	-	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U
Cobalt	µg/L	0.500 U	0.500 U	-	0.500 U	1.10	0.500 U	0.500 U	0.770	1.20	0.660	0.840	0.500 U	0.500 U	0.500 U	0.500 U
Combined Radium	pCi/L	0.936	1.71	-	1.72	1.24	0.316	0.901	0.307	0.177	1.37	0.850	0.0710	0.221	0.181	0.527
Fluoride	mg/L	1.10	1.20	-	0.370	0.380	0.650	0.640	0.370	0.370	0.170	0.140	0.510	0.510	5.40	6.60
Lead	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	0.500 U	0.500 U	0.500 U	0.500 U
Lithium	µg/L	23.4	17.2	-	201	190	17.7	16.6	13.5	13.2	38.0	47.6	10.0 U	10.0 U	16.7	14.0
Mercury	µg/L	0.00170	-	0.000850	0.000500 U	0.000500 U	0.000500 U	0.000500 U	0.000500 U	0.000500 U	0.000500 U	0.000500 U	0.000500 U	0.000500 U	0.000500 U	0.000500 U
Molybdenum	µg/L	1.50	1.10	-	0.500 U	208	0.500 U	0.500 U	4.30	10.3	2.30	2.10	4.20	5.50	2.30	1.90
Selenium	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	0.500 U	0.500 U	0.500 U	0.500 U
Sulfate	mg/L	94.6	88.1	-	820	830	78.9	91.2	164	162	1,330	1,290	98.1	86.7	3.50	1.60
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	0.500 U	0.500 U	0.500 U	0.500 U
Total Dissolved Solids	mg/L	693	687	-	721	1,440	616	597	618	651	2,030	2,000	572	522	1,030	1,070
pH	SU	7.94	7.57	-	6.83	6.80	7.75	7.47	7.62	7.51	679	6.59	8.46	8.13	8.70	8.50

Notes:
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Table 2: Residence Time Calculation Summary
Cardinal Plant - Fly Ash Reservoir II

			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)
Fly Ash Reservoir II	CA-0622/A [1]	2.0	9.4	6.5	13.0	4.7
	FA-8 [2]	2.0	20.5	3.0	17.7	3.4
	M-10 [2]	0.75	NC	NC	35.0	0.7
	M-1003 [2]	2.0	20.0	2.7	13.8	3.8
	M-1004 [2]	2.0	9.1	6.7	5.0	12.1
	M-11 [2]	1.0	15.7	1.9	17.5	1.7
	M-12 [1]	2.0	2.8	21.6	NC	NC
	M-13 [2]	2.0	11.6	5.2	5.7	10.6
	M-1302 [1]	2.0	7.9	7.7	25.4	2.4
	M-1309 [2]	2.0	5.2	11.8	NC	NC
	M-14 [2]	2.0	65.8	0.9	62.9	1.0
	M-15 [2]	2.0	17.2	3.5	16.9	3.6
	M-16 [2]	2.0	12.2	5.0	21.9	2.8
	M-21 [2]	2.0	7.5	8.2	8.9	6.9
	M-22 [2]	2.0	3.7	16.3	3.8	15.9
	M-23 [2]	2.0	4.3	14.0	3.9	15.5
	M-6 [1]	1.0	13.3	4.6	11.9	5.1
	M-8 [2]	2.0	7.0	8.7	13.1	4.7
	M-GS-1 [2]	2.0	13.9	4.4	19.1	3.2
	M-GS-2 [2]	2.0	100.9	0.6	89.1	0.7
	M-GS-3 [2]	2.0	20.7	2.9	20.7	2.9
	M-GS-4 [2]	2.0	39.6	1.5	20.0	3.0
	M-GS-5 [1]	2.0	4.6	13.4	9.5	6.4

Notes:
[1] - Background Well
[2] - Downgradient Well
NC - Groundwater residence time could not be calculated

ATTACHMENT A

Monitoring Well M-2000 Construction Diagram

HULL
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Cardinal Operating Company
306 County Road 7E
Brilliant, Ohio
BPG003

Date Started	: 3-6-2019
Date Completed	: 3-8-2019
Logged by	: Mielecki
Reviewed by	: J. Ardner
Drilling Contractor	: Terra Testing
Drilling Method	: 4.25" HSA
Sampling Method	: 4" Core Barrel
Total Depth (ft.)	: 77.0'

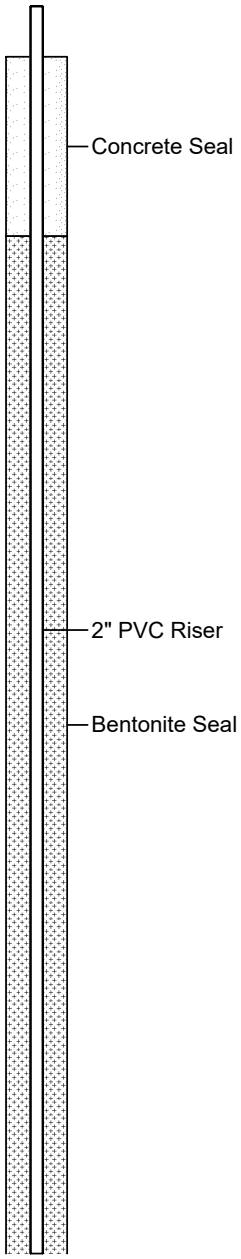
LOG OF BORING M-2000

Soil Samples
- Sample Intervals
- Sample Sent to Lab

Water Levels
- Static
- During Drilling

Depth in Feet	Sample Interval/ Sample Recovery	Sampler Type/ Sample Number	Sample	GRAPHIC	Water Level	DESCRIPTION
0						Straight drill using 4.25-inch Hollow Stem Augers to bedrock refusal.
1						Bottom Ash (0-32')
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

Well: M-2000



HULL
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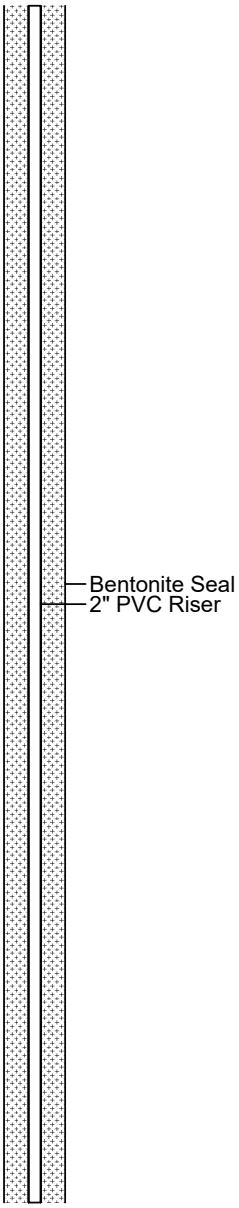
LOG OF BORING M-2000

Soil Samples
- Sample Intervals
- Sample Sent to Lab

Water Levels
- Static
- During Drilling

Well: M-2000

Depth in Feet	Sample Interval/ Sample Recovery	Sampler Type/ Sample Number	Sample	GRAPHIC	Water Level	DESCRIPTION
20–32						Bottom Ash (Continued).
32						Weathered SANDSTONE; augers set at 35.0 feet.
35	2/0.8	RC-1 35.0-37.0				Medium, reddish orange, moderately weathered, strong, SANDSTONE; fractured. Rock Quality Designation (RQD) = 0%
37	5/3.9	RC-2 37.0-42.0				Medium-grained, yellowish brown, moderately weathered, SANDSTONE; thin; fractured. RQD = 36.2%



HULL
Environment / Energy / Infrastructure

Cardinal Operating Company
306 County Road 7E
Brilliant, Ohio
BPG003

Date Started	: 3-6-2019
Date Completed	: 3-8-2019
Logged by	: Mielecki
Reviewed by	: J. Ardner
Drilling Contractor	: Terra Testing
Drilling Method	: 4.25" HSA
Sampling Method	: 4" Core Barrel
Total Depth (ft.)	: 77.0'

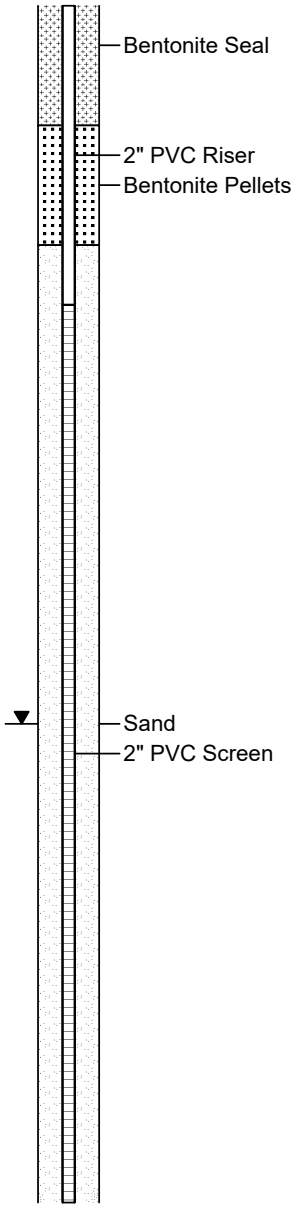
LOG OF BORING M-2000

Soil Samples
- Sample Intervals
- Sample Sent to Lab

Water Levels
- Static
- During Drilling

Well: M-2000

Depth in Feet	Sample Interval/ Sample Recovery	Sampler Type/ Sample Number	DESCRIPTION
40–41			Medium-grained, yellowish brown, moderately weathered, SANDSTONE; thin; fractured.
42	5/5	RC-3 42.0-47.0	Same as above; highly to moderately fractured. RQD = 56.7%
47	3/1.1	RC-4 47.0-50.0	Medium grained, greenish grey, moderately weathered, moderately strong, SANDSTONE; thin; fractured; becoming wet. RQD = 0%
50	2/2	RC-5 50.0-52.0	Medium grained, yellowish brown to grey, slightly weathered, moderately strong, SANDSTONE; thin; moderately fractured. RQD = 75%
52	5/4.8	RC-6 52.0-57.0	Medium grained, yellow brown to grey, moderately weathered, moderately strong, SANDSTONE; siliceous bedding; slightly rough; thin; moderately fractured. RQD = 54.4%
57	5/5	RC-7 57.0-62.0	Medium grained, very thin to medium, yellow brown to grey, moderately weathered, moderately strong; bedding fractured to moderately fractured. RQD = 56.7%



HULL
Environment / Energy / Infrastructure

Cardinal Operating Company
306 County Road 7E
Brilliant, Ohio
BPG003

Date Started	: 3-6-2019
Date Completed	: 3-8-2019
Logged by	: Mielecki
Reviewed by	: J. Ardner
Drilling Contractor	: Terra Testing
Drilling Method	: 4.25" HSA
Sampling Method	: 4" Core Barrel
Total Depth (ft.)	: 77.0'

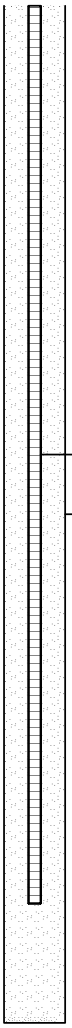
LOG OF BORING M-2000

Soil Samples
- Sample Intervals
- Sample Sent to Lab

Water Levels
- Static
- During Drilling

Well: M-2000

Depth in Feet	Sample Interval/ Sample Recovery	Sampler Type/ Sample Number	Sample	GRAPHIC	Water Level	DESCRIPTION
60						Medium, very thin to medium, yellow brown to grey, moderately weathered, moderately strong; bedding fractured to moderately fractured.
61						Same as above; some black shale streaks below 61'
62	5/4.6	RC-8 62.0-67.0				Medium, grey with black shale, moderately weathered, moderately strong, SANDSTONE; thin bedding; vertical fracture from 64-65'; some iron staining; moderately fractured. RQD = 69.1%
63						
64						
65						
66						
67	5/5	RC-9 67.0-72.0				
68						
69						Medium, grey, unweathered, medium strong SANDSTONE; slightly fractured. RQD = 60%
70						
71						
72	5/5	RC-10 72.0-77.0				RQD = 68.3%
73						
74						
75						Soft grey fine CLAY and unweathered blue grey SHALE; moderately strong; laminated; bedding; moderately fractured.
76						
77						End of Boring @ 77'
78						
79						
80						



Fly Ash Reservoir II

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

A description of site hydrogeology including stratigraphic cross-sections

- Dam Raising Design Summary – Cardinal Fly Ash Retention Pond II – Waste Water PTI Application, April 2012, Submitted to OEPA Division of Water Surface, AEP Service Corp.
- Dam Raising Design Report – Cardinal Fly Ash Reservoir No. 2, January 2013, Submitted to ODNR Division of Soil and Water Resources, AEP Service Corp. and S&ME, Inc., and Revised Permit Application Comment Response, January 16, 2013.

2.4 Hydrogeologic Setting

2.4.1 Climate and Water Budget

The major drainage feature of FAR II is Blockhouse Run, which drains into the Ohio River. Approximately one mile upstream, Blockhouse Run splits into the East Branch and West Branch. The West Branch drains the western watershed and was dammed to form the former FAR 1, while the East Branch drains the eastern watershed. The FAR II inundates the East Branch, and runoff from the western watershed drains into the FAR II. The total area of the western watershed is 677 acres, while the eastern watershed is 675 acres.

The 2015 average monthly temperature and precipitation values for the Brilliant, Ohio area are presented in the table below (NOAA, 2016). The climatological data was collected from the nearest weather station (USC00338025) located in Steubenville, OH.

NOAA Climatological Summary (2015)		
Month	**Average Temperature (°F)**	**Average Precipitation (inches)**
January	23.0	2.16
February	16.0	1.34
March	30.9	4.02
April	51.1	3.60
May	64.6	2.95
June	70.0	10.69
July	71.4	4.66
August	70.5	2.81
September	69.3	6.70
October	53.2	2.56
November	47.8	1.17
December	46.6	3.24

2.4.2 Regional and Local Geologic Setting

The geology at FAR II and the vicinity consists of nearly horizontal sequences of lower Permian and upper Pennsylvanian sedimentary rock. The Permian-age Dunkard Group occurs only on the tops of some ridges above an elevation of approximately 1250 feet (ft), northwest and west of the FAR 1 RSW Landfill and FAR II sites.

The Monongahela Group is up to 230 feet thick in Jefferson County, consisting of shale, sandstone, limestone, coal, claystone and siltstone. These rocks form much of the slopes above the current levels of the FAR II and FAR 1 RSW Landfill sites. Below the Monongahela Group is the Conemaugh Group, which is generally over 500 feet thick in Jefferson County. The Conemaugh Group consists of shale, sandstone, limestone, coal, claystone and siltstone, including the Morgantown Sandstone, which is a developed aquifer in the area. Beneath the Morgantown Sandstone is a sequence of the Conemaugh Group including the Elk Lick Limestone, the Skelly Limestone and shale, the Ames Limestone, several thick shale sequences, the Cow Run Sandstone and the Buffalo Sandstone.

2.4.3 Surface Water and Surface Water-Groundwater Interactions

Both surface stormwater and leachate from the FAR 1 RSW Landfill is transferred to FAR II as FAR II serves as the facilities sedimentation pond and leachate collection pond. The intermittent stream of the western branch of Blockhouse Hollow at the northwest end of the FAR 1 RSW Landfill was historically re-routed during surface mining operations and flows into FAR II. Streams within the watersheds of the western and eastern branches of Blockhouse Run are recharged by precipitation. The entirety of the western and eastern watersheds, including approximately 1,033 acres of woodland, drains into the FAR II Reservoir. Blockhouse run discharges to the Ohio River approximately 1.0 mile further downstream to the east. According to USACE maps, the next nearest tributary which discharges to the Ohio River is Riddles Run, which is located approximately 0.75 miles to the southwest (USACE, 2003).

Recharge of the Morgantown Sandstone aquifer occurs through vertical infiltration of precipitation at upgradient outcrops. The Morgantown Sandstone is also directly recharged by the FAR II Reservoir as it is incised through the Morgantown Sandstone unit.

2.4.4 Water Users

According to water well records obtained from the Ohio Department of Natural Resources (ODNR), the nearest water supply well is located approximately 2,000 feet east of FAR II. Additionally, ODNR records indicate a series of water supply wells in the Tidd-Dale Subdivision of Brilliant, Ohio, approximately 3,000 to 4,000 feet southeast of FAR II. These water supply wells are developed in the deeper Buffalo Sandstone, which underlies the uppermost aquifer. The ground surface elevation for these wells, generally around 750 feet, is lower than the elevation of the bottom

of the Morgantown Sandstone, generally ranging from approximately 780 feet to 800 feet in the vicinity of FAR II. One of these water supply wells has a reported pumping rate of 3.0 gallons per minute (gpm).

Approximately one mile west of FAR II, a series of water supply wells develop several limestone horizons, the Arnoldsburg and Benwood Limestone units. These well logs report pumping rates ranging from approximately 1.0 gpm to 8.0 gpm with significant drawdown (Geosyntec, 2006).

According to the 2014 Drinking Water Consumer Confidence Report prepared by 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 one mile east of FAR II. ODNR records indicate these wells are screened within the alluvial deposits of the Ohio River and exhibit pumping rates of up to 700 gpm.

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 east of FAR II. The hydrogeology around FAR II is characterized by an uppermost aquifer comprised of sandstone, shale and limestone units, specifically the Morgantown Sandstone, which lies below a shale aquitard that caps the Morgantown Sandstone. FAR II is positioned within a former river valley and is incised into the Morgantown Sandstone. Geologic cross-sections illustrating the horizontal and vertical position of FAR II relative to the uppermost aquifer are provided in Appendix B.

3.1.2 Overall Flow Conditions

Based on monitoring well data in the vicinity of the FAR II, the uppermost aquifer is the Morgantown Sandstone unit. A shale aquitard above the Morgantown Sandstone has very low hydraulic conductivity values, in the range of 1 x 10-7 to 1 x 10-9 cm/sec. Hydraulic conductivity values of the Morgantown Sandstone are in the range of 1 x 10-1 to 1 x 10-6 cm/sec and tends to be driven by interconnected fracture flow. The Morgantown Sandstone has a gradient to the east, southeast, and southwest, generally flowing away from FAR II (AEP, 2014). Contours depicting the groundwater elevations in the Morgantown Sandstone are shown in Figure 3-1.

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 the 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

The hydrostratigraphy in the vicinity of FAR II is characterized by an uppermost aquifer system comprised of Morgantown Sandstone unit, which lies below the shale aquitard that caps the Morgantown Sandstone. FAR II is partially incised through the Morgantown Sandstone.

Based on ODNR water well logs, the nearest wells with a recorded pumping rate (not including wells screened in the alluvial sediments near the Ohio River) occur approximately one mile west of FAR II. These wells are screened within limestone and shale units, and at a similar elevation to the upper aquifer system at FAR II. These wells have recorded pumping rates ranging from 1.0 to 8.0 gpm. Another series of wells occurs approximately 3 miles southwest of FAR II, and are screened within sandstone and siltstone units at a similar elevation to the Morgantown Sandstone near FAR II.

Based on the information gathered from ODNR, previous analytical data, and geological conditions at FAR II, the uppermost continuous and usable aquifer is considered to be the Morgantown Sandstone.

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

3.3.1 Overview

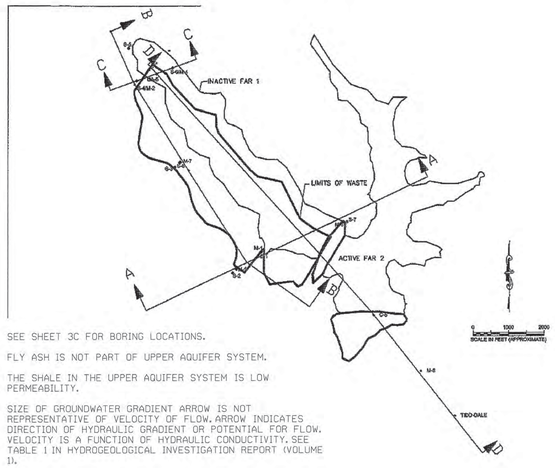
The groundwater monitoring network is shown on Figure 3-2 and consists of five (5) monitoring wells (CA-0622, M-6, M-12, M-1302 and M-GS-5) located upgradient and 18 monitoring wells (FA-8, M-8, M-10, M-11, M-13, M-14, M-15, M-16, M-21, M-22, M-23, M-1003, M-1004, M-1309, M-GS-1, M-GS-2, M-GS-3 and M-GS-4) and Seep-1, also referred to as the Jules Verne Seep, located downgradient of FAR II. The groundwater monitoring wells and Seep-1 provide detection monitoring for the uppermost aquifer (Morgantown Sandstone). 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 and span the full thickness of the uppermost aquifer system. 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 and Appendix D, respectively.

3.3.2 Compliance Assessment

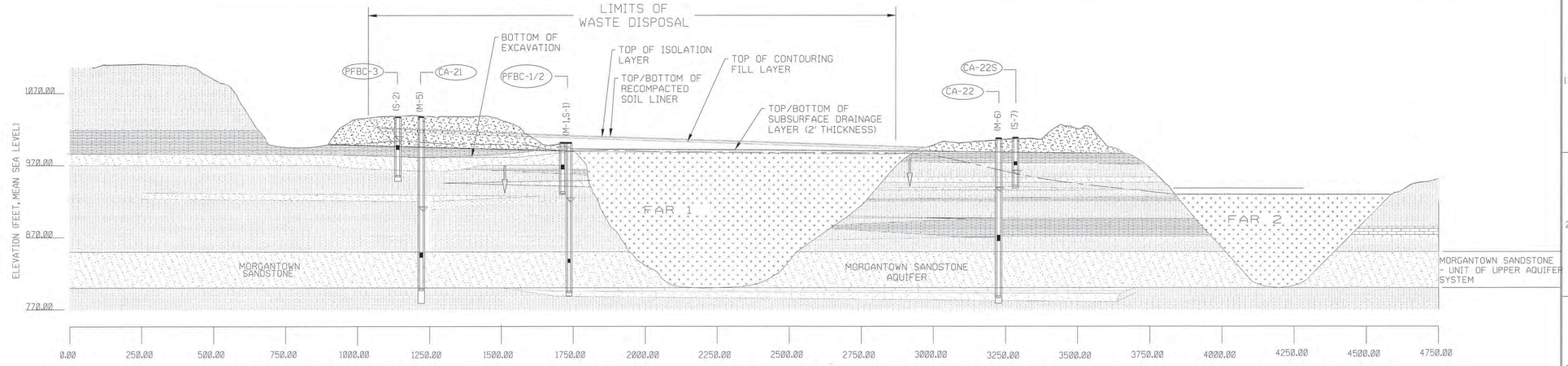
Review of the existing groundwater monitoring well network in relation to the geologic and hydrogeologic conditions in the area of FAR II indicates that the monitoring well network consists of a sufficient number of wells installed at the appropriate depths to collect groundwater samples from the uppermost aquifer that accurately represent the groundwater quality upgradient and downgradient of FAR II. 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 (Morgantown Sandstone) nearest the waste boundary.

DWG. NO. - 13-30100-5A

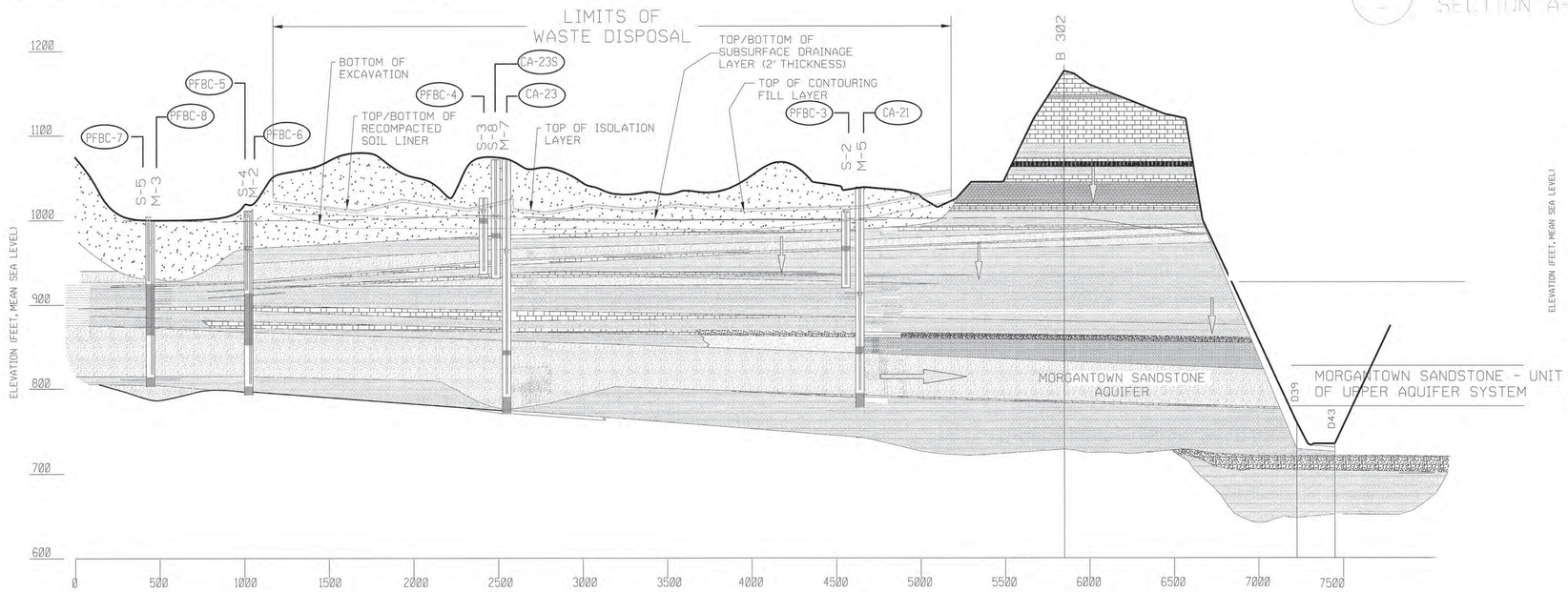
SECTION LOCATION PLAN



1. SEE SHEET 3C FOR BORING LOCATIONS.
2. FLY ASH IS NOT PART OF UPPER AQUIFER SYSTEM.
3. THE SHALE IN THE UPPER AQUIFER SYSTEM IS LOW PERMEABILITY.
4. SIZE OF GROUNDWATER GRADIENT ARROW IS NOT REPRESENTATIVE OF VELOCITY OF FLOW. ARROW INDICATES DIRECTION OF HYDRAULIC GRADIENT OR POTENTIAL FOR FLOW. VELOCITY IS A FUNCTION OF HYDRAULIC CONDUCTIVITY. SEE TABLE 1 IN HYDROGEOLOGICAL INVESTIGATION REPORT (VOLUME 1).

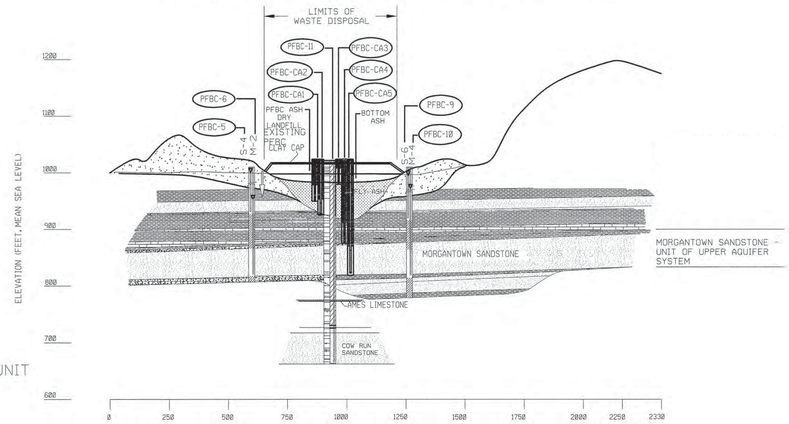


A SECTION
SECTION A-A'

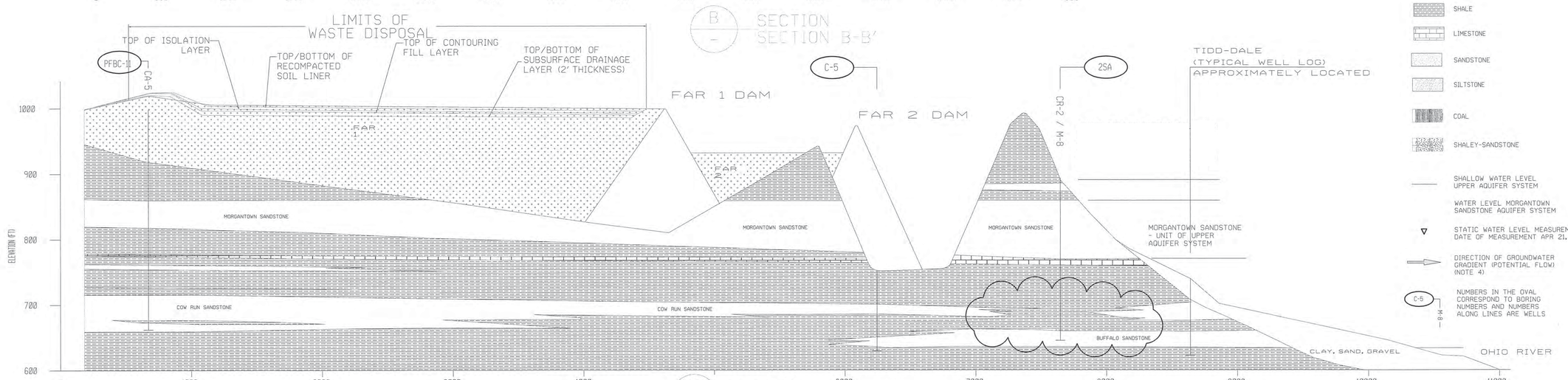


B SECTION
SECTION B-B'

NOTE: SEE DRAWING 13-30560 FOR EXTENSION OF THIS SECTION FROM RIDDLES RUN TO CROTS CREEK.



C SECTION
SECTION C-C'



D SECTION
SECTION D-D'

LEGEND

- FLY ASH
- MINESPOIL
- SHALE
- LIMESTONE
- SANDSTONE
- SILTSTONE
- COAL
- SHALEY-SANDSTONE
- SHALLOW WATER LEVEL UPPER AQUIFER SYSTEM
- WATER LEVEL MORGANTOWN SANDSTONE AQUIFER SYSTEM
- STATIC WATER LEVEL MEASUREMENTS DATE OF MEASUREMENT APR 21, 2004
- DIRECTION OF GROUNDWATER GRADIENT (POTENTIAL FLOW) (NOTE 4)
- C-5 — M-8: NUMBERS IN THE OVAL CORRESPOND TO BORING NUMBERS AND NUMBERS ALONG LINES ARE WELLS

DATE	NO.	DESCRIPTION	APPD.
3/6/12	D	REVISED BY AEP FOR SECTION D-D TO SHOW SHALE STRATA SEPARATING COW RUN FROM BUFFALO SANDSTONE.	H/Z
NOV 17 2006	C	REVISED - NOD 2 RESPONSE	DGB
MAY 26 2006	B	REVISED NOD 1 RESPONSE	DGB
OCT 24 2005	A	ISSUED FOR PERMIT	DGB

REVISIONS

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CARDINAL OPERATING COMPANY

BRILLIANT OHIO

TITLE: CARDINAL FAR 1 RESIDUAL WASTE LANDFILL GEOLOGIC/HYDROGEOLOGIC CROSS SECTIONS

DWG. NO. 13-30100-5A-D

GEOSYNTEC CONSULTANTS
55 WEST WACKER DRIVE, SUITE 1200
CHICAGO, IL 60601 USA
(312) 850-0700

SIGNATURE
DATE

SCALE: CIVIL ENGINEERING DIVISION
DR.
CK.
ENGR.
PROJ. ENGR.
DATE:
AS BUILT DRAWING

PROJECT NO. CHE8126
FILE NO.
DRAWING 5A OF 39

AEP AMERICAN ELECTRIC POWER
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

SYSTEM DATE:

Fly Ash Reservoir II

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

Any corrective measures assessment conducted as required at 40 CFR 257.96

ASSESSMENT OF CORRECTIVE MEASURES

CARDINAL SITE – FLY ASH RESERVIOR II - REV.1

BRILLIANT, OHIO

Prepared for

Cardinal Operating Company
306 County Road 7E
Columbus, Ohio 43213

Prepared by

Geosyntec consultants

engineers | scientists | innovators

941 Chatham Lane, Suite 103
Columbus, OH 43221
Project Number CHA6468

November 2020

CARDINAL FAR II ASSESSMENT
OF CORRECTIVE MEASURES RECORD REVISION

Date	Changes Made
7/09/2019	Initial Report Completed, Uploaded to Facility Operating Record
11/30/20	Supplemental information added as "Attachment 1" to support Site Characterization for Site Specific Alternative Closure Demonstration

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Figure 5: Potentiometric Surface Map – Morgantown Aquifer

LIST OF ACRONYMS AND ABBREVIATIONS

ACM	Assessment of Corrective Measures
AEP	American Electric Power Service Corporation
AMSL	Above Mean Sea Level
BAC	Bottom Ash Complex
CCR	Coal Combustion Residual
CFR	Code of Federal Regulations
ESP	Electrostatic Precipitator
FAD	Fly Ash Dam
FAR	Fly Ash Reservoir
FGD	Flue Gas Desulfurization
GWPS	Groundwater Protection Standards
MNA	Monitored Natural Attenuation
MSE	Mechanically Stabilized Earth
MW	Megawatts
NPDES	National Pollutant Discharge Elimination System
PMF	Probable Maximum Flood
PTI	Permit to Install
RCC	Roller Compacted Concrete
RSW	Residual Solid Waste
SCR	Selective Catalytic Reduction
SSL	Statistically Significant Levels
TDS	Total Dissolved Solids
USEPA	United States Environmental Protection Agency

1. INTRODUCTION

On behalf of our client, Cardinal Operating Company, Geosyntec has produced this Assessment of Corrective Measures (ACM) report for the Fly Ash Reservoir II (FAR II) at the Cardinal Generating Plant (the Site or Facility). The Site is located one mile south of Brilliant, Ohio in Jefferson County, along the Ohio River. Under the United States Environmental Protection Agency (USEPA) Coal Combustion Residual (CCR) Rule (40 Code of Federal Regulations (CFR) 257 Subpart D), groundwater monitoring is required to assess impacts of CCR activities to groundwater compared to background conditions. In 2018, statistically significant levels (SSL) of lithium and molybdenum above their respective groundwater protection standards (GWPS) were observed at the Site, requiring an ACM under 40 CFR 257.96. This document was developed to identify potential corrective measures that may be appropriate for addressing elevated lithium and molybdenum concentrations in site groundwater and was prepared in accordance with 40 CFR 257.96.

1.1 Background

The Facility is located approximately one mile south of Brilliant, Ohio in Jefferson County along the Ohio River (**Figure 1**). The generating station consists of three units with a nominal capacity of 1,830 megawatts (MW). Units 1 and 2 began operation in 1967 and Unit 3 began operation in 1977. All three units are coal powered, with an average annual coal use of 5.2 million tons for the entire plant. 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. Fly ash generated at the plant was formerly sluiced to the Fly Ash Reservoir I (FAR I), which was impounded by Fly Ash Dam 1 (FAD 1) from 1977 through 1988 when it was filled to capacity. The closure process for FAR I began in 1990 per Permit to Install (PTI) Application No. 17-709 (Buckeye Power, 2019).

The three CCR storage units currently utilized by the Facility, the Bottom Ash Complex (BAC), the FAR I Residual Solid Waste Landfill (FAR I RSW Landfill), and the FAR II reservoir are shown in **Figure 1**. Fly ash is currently sluiced to FAR II, which is impounded by FAD 1 and FAD 2. The construction of FAD 2 and subsequent dam raisings are discussed further in **Section 2.4**. FAR II receives sluiced fly ash from the generating unit's ESPs and collected stormwater and leachate from the FAR I RSW Landfill. FAR II/FAD 2 has a permitted discharge (Outfall 019) through the national pollutant discharge elimination system (NPDES) (Geosyntec, 2017). Monitoring wells within the CCR rule monitoring network and select other locations of interest are shown in **Figure 2**.

1.2 ACM Objective

The purpose of this ACM Report is to identify and evaluate potential technologies that may be appropriate for reducing lithium and molybdenum present in site groundwater to acceptable regulatory cleanup levels in accordance with 40 CFR 257.96. The target cleanup levels are the GWPS defined under 40 CFR 257.95(h). The site-specific GWPS for lithium and molybdenum are 140 µg/L and 100 µg/L, respectively. This ACM relies on the Groundwater Characterization Report for the FAR II Unit prepared by Geosyntec in 2019 to focus the evaluation of remedial technologies that will achieve the most efficient and cost-effective method of obtaining concentrations of lithium and molybdenum below the GWPS.

1.3 Report Organization

The remainder of this ACM Report is organized as follows:

Section 2: *Summary of Site Conditions* – This section provides a brief description of the site setting, history, and summarizes the investigations performed to support the ACM for the Site, as well as a description of anticipated future conditions at the Site.

Section 3: *Evaluation of Corrective Measure Alternatives* – This section provides evaluation criteria, primary corrective measure technologies, as well as a comprehensive evaluation of the most appropriate groupings of technologies identified to remediate the lithium and molybdenum groundwater impacts at the Site.

Section 4: *Next Steps* – This section presents a summary of follow-on actions pertaining to remedy selection and schedule for implementation and completion.

Section 5: *References* – This section provides a listing of the references cited in this ACM Report

2. SUMMARY OF CURRENT CONDITIONS

2.1 Site Setting and History

2.1.1 Site Geology

The Site is underlain by horizontal sequences of lower Permian and upper Pennsylvanian sedimentary rock. In the vicinity of the Site, the Dunkard Group is the upper most stratigraphic unit of the Washington Formation, and is characterized by non-marine cyclic sequences of sandstone, siltstone, shale, limestone, and coal. Associated rock outcrops appear along the northwest and west ridges of the FAR I/FAD 1 RSW Landfill.

Underlying the Dunkard Group is the Monongahela Group, which is approximately 230 feet thick in the vicinity of the Site. The Monongahela Group consists of sandstone and shale, siltstone, limestone, sandstone, and coal (American Electric Power Service Corporation [AEP], 2006).

Beneath the Monongahela Group, is the Conemaugh Group, which consists of shale, sandstone, limestone, claystone, and coal and is approximately 500 feet thick in Jefferson County (AEP, 2006). This group includes the Morgantown Sandstone underlain by the Elk Lick Limestone, the Skelly Limestone and Shale, the Ames Limestone, the Cow Run Sandstone, and the Buffalo Sandstone. The Morgantown Sandstone is a fractured and jointed conglomeratic sandstone that is approximately 75 to 100 feet thick in the vicinity of the western abutment of FAD 2 (Sanborn Head & Associates, Inc. [Sanborn Head], 2018). In the vicinity of FAD 2, the base of the Morgantown Sandstone slopes south from M-21 to the Jules Verne Seep, and east from M-1003 to the Jules Verne Seep (Sanborn Head, 2018). The Elk Lick Limestone, the Skelly Limestone and Shale and the Ames Limestone vary in a combined thickness of approximately 80 feet. At the bottom of the Conemaugh Group, the Cow Run Sandstone is approximately 20 to 30 feet thick (AEP, 2006).

Prior to the development of the FAR II, overburden in the FAR II valley consisted of 10 to 30 feet of residual soils, mine spoil, landside debris and alluvial deposits (AEP, 1984; AEP, 2006). Along the valley walls, the overburden consisted of clayey colluvium (Amaya et al., 2009). Prior to the construction of FAD 2, a landslide upstream of the western abutment of FAD 2 occurred, exposing the face of the Morgantown Sandstone at approximately 880 feet above mean sea level (AMSL).

FAR II incises the Monongahela Group and partially incises the Conemaugh Group, including the Morgantown Sandstone. Cross sections for the geology at FAD 2 are shown in **Figure 3** and **Figure 4**.

2.1.2 Site Hydrogeology

Groundwater at FAR II is present in three aquifers of interest to the ACM: the surficial aquifer, the Morgantown Sandstone, and the Cow Run Sandstone.

The surficial aquifer is contained in the Monongahela group, primarily the Connellsville Sandstone, the Summer Field Limestone, the Bellaire Sandstone, former room and pillar mines, and mine spoils. The groundwater flow in the shallow aquifer tends to follow local topography and generally has high hydraulic conductivity, ranging from 1×10^{-1} to 1×10^{-4} centimeters per second (cm/sec; AEP, 2006). The surficial aquifer and the Morgantown Sandstone are separated by a shale aquitard with a hydraulic conductivity ranging from 1×10^{-7} to 1×10^{-9} cm/s (AEP, 2006).

Regionally, the Morgantown Aquifer flows south-southeast towards the Ohio River in the vicinity of the Site. Groundwater flow in the vicinity of FAR II flows around the eastern and western abutments of the FAD 2 structure (**Figure 5**). Along the western abutment, the Morgantown Sandstone outcrops and groundwater is discharged through the Jules Verne Seep (**Figure 4**)

The Cow Run Sandstone is separated from the Morgantown Sandstone by approximately 50 to 100 feet of low permeability shale and limestone beds. The Cow Run Sandstone Aquifer generally flows south-southeast towards the Ohio River in the vicinity of the Site. Regionally, the Cow Run Aquifer is a saline aquifer, with total dissolved solids (TDS) concentrations at CR-1 and CR-2 frequently reported above 2,000 milligrams per liter (mg/L).

2.1.3 Construction of FAD 2

Construction of FAR II began in 1985 under PTI 06-1250 (Buckeye, 2019). The FAR II foundation consists of a claystone and shale, and the abutment consists of the Monongahela Group and a portion of the Conemaugh Group including the Morgantown Sandstone. Prior to the construction of FAR II, permeability testing was conducted on the abutment and foundation rock structures which indicated that the Morgantown Sandstone would be relatively impervious except where the rock face was exposed to the surface of the FAR II unit. The clayey colluvium overburden was left in place along the abutment to provide a naturally impervious barrier (Amaya et.al, 2009). However, prior the construction of FAD 2, a small landslide occurred in the clayey colluvium overburden covering the Morgantown Sandstone just upgradient of the western abutment of FAD 2 at approximately 880 feet AMSL. A cut to rock was made and a grout curtain was installed (AEP, 2016). The abutment was installed such that the clay core contacted the competent rock at 90-degree angles on the upstream side of the abutment to prevent

seepage beneath the dam and reduce cracking of the core (AEP 2016). The dam had a final crest height of 925 feet AMSL (AEP, 1997).

The FAD 2 structure has been raised twice since the initial construction. In 1997, the dam elevation was raised to 970 feet AMSL (AEP, 1997). The raising included an earthen embankment with a Roller Compacted Concrete (RCC) zone. The RCC zone was supported on the downstream side of FAD 2 with mine spoils. In 2013, the dam was raised again to a crest height of 983 feet AMSL with a back-to-back mechanically stabilized earth (MSE) wall. The MSE wall consists of a vinyl sheet pile wall that extends from the existing clay core to the Probable Maximum Flood (PMF) level (AEP, 2016). The current maximum operating stage of the FAR II unit is 974 feet AMSL (AEP, 2016).

2.1.4 Summary of ACM Investigations

Additional investigation work was completed in spring 2019 in accordance with 40 CFR 257.95(g)(1). Monitoring well M-2000 was installed in March 2019 to delineate the lithium and molybdenum release and to serve as the additional monitoring well at the facility boundary (FAR II Unit). Additional sampling of the wells in the monitoring network, M-2000, and seeps along the FAD II abutment were sampled in March, April, and May 2019. Concentrations of lithium and molybdenum above the GWPSs were observed at monitoring wells FA-8, M-11, M-2000, and the Jules Verne Seep. These results suggest impacts to the Morgantown Aquifer extend from M-11 to the Jules Verne Seep. These investigation activities and their results were documented in a *Groundwater Characterization Report* (Geosyntec, 2019a).

2.2 Characterization of Release

The FAR II unit discharges into the Morgantown Aquifer and impacts from the FAR II unit are limited to monitoring wells FA-8, M-11, M-2000, and the Jules Verne Seep. The Morgantown Aquifer consists of a fractured and jointed conglomeratic sandstone with fractures and joints through which water from the FAR II unit flows around the FAD 2 structure on the western side and ultimately to the Jules Verne Seep. As shown in **Figure 3**, the hydraulic head in the Morgantown Aquifer along the north-south transect of the dam is from north to south (M-11 to M-2000). Along the east-west transect, the hydraulic gradient is from west to east and ultimately discharges through the Jules Verne Seep (M-1003 to Jules Verne Seep; **Figure 4**). Therefore, impacts from FAR II enters the Morgantown Aquifer in the vicinity of M-11 and discharges through the outcrop of the Morgantown Sandstone at Jules Verne Seep. Groundwater discharging from the Jules Verne Seep is collected at the base of FAD 2 and discharged to the Ohio River through NPDES Permitted Outfall 19.

2.3 Anticipated Future Conditions

As required under 40 CFR 257.101(a)(1), by October 31, 2020 the facility will cease placing CCR and non-CCR waste streams into the FAR II unit and close the unit in accordance with 40 CFR 257.102. This change in waste disposal practices will be achieved through operational changes to dry ash handling.

Following closure, the facility will comply with the post-closure care and maintenance requirements for a period of 30 years or more, as required by 40 CFR 257.104. These post-closure requirements include maintaining the final cover system, maintaining the leachate collection system, maintaining the groundwater monitoring system, and monitoring groundwater in accordance with 40 CFR 257.90 through 257.98.

3. EVALUATION OF CORRECTIVE MEASURES ALTERNATIVES

3.1 Evaluation Criteria

The evaluation criteria used to determine the appropriateness of the proposed remedies are outlined in 40 CFR 257.96 and include (1) performance, (2) reliability, (3) ease of implementation, (4) potential impacts, (5) time to begin/complete remedy, and (6) institutional requirements. Each of the evaluation criteria are defined and briefly described in the following paragraphs.

3.1.1 Performance

Corrective measure remedies must be protective of human health and the environment. Human health can be protected by preventing exposures through engineering and institutional controls or by reducing concentrations of all chemicals in all media to levels that meet the required corrective measure standards[1].

---

[1] The risk to human health and the environment from exposure to CCR-related constituents in groundwater at the Site was assessed (Geosyntec, 2019b). The risk assessment included an exposure assessment, and a screening-level risk evaluation. The purpose of the exposure assessment was to identify potentially complete exposure pathways by which human or ecological receptors may contact lithium or molybdenum in groundwater, while the purpose of the screening-level risk evaluation was to quantitatively evaluate receptor-exposure scenarios for pathways identified as complete or assumed-to-be compete.

The assessment evaluated current conditions at the Site and assumed that any changes in site conditions, such as FAR II no longer receiving fly ash, likely result in an overestimate of potential exposures and risks. Based on the results of the exposure assessment and screening-level risk evaluation, lithium and molybdenum in FAR II groundwater are unlikely to pose an unacceptable risk to human or ecological receptors in the vicinity of the site under current or near-term future conditions. Anticipated future site conditions are expected to further reduce these risks in the future; however, in the interim, additional actions are not necessary to protect human health and the environment.

Preference is generally given to techniques that include source control or reduce the potential for future environmental releases, continuing migration or exposures to human health and the environment by reducing the toxicity, mobility, or volume of source material released.

3.1.2 Reliability

This evaluation criterion is used to consider future conditions, which is important for locations where remedial goals and objectives will take several decades or more to be achieved. Corrective measures that incorporate some degree of source removal or control are more effective and reliable in the long-term than technologies that rely on perpetual operation. Alternatives are compared in terms of the risk remaining at the site after the cleanup objectives have been met; the long-term impacts of any adverse consequence of any alternative; operation and maintenance requirements; and the continuity of institutional controls through administrative changes and ownership transactions.

3.1.3 Ease of Implementation

This criterion addresses both technical and administrative feasibility of executing a remedial alternative and the availability of various services and materials required during its implementation. The ease of implementation considers:

- Availability of materials and skilled workers to construct, operate, and maintain the system;
- Ease of undertaking or implementing additional remedial actions, off-site storage, or disposal services;
- Consistency of approach with measures that are already operating at the Site;
- Time for full-scale implementation; and
- Time required for beneficial results to be achieved.

Administrative ease of implementation, which involves evaluation of the time and practicability of obtaining needed permits, rights-of-way, or any other administrative approvals, is addressed in the Institutional Requirements evaluation criteria.

3.1.4 Potential Impacts

This evaluation criterion considers the potential impacts of the corrective measure implementation. Per 40 CFR 257.96, these impacts include “safety impacts, cross-media impacts and control of exposure to residual contamination.” Impacts may be negative such as increased risk of accidents due to trucking, or carbon emissions due to pumping requirements. Some impacts may be unknown due to data gaps, such as potential

alteration of the geochemistry resulting in mobilization of other constituents or a reduction of groundwater base flow to adjacent waterbodies.

3.1.5 Time Requirements

This evaluation criterion considers the time to begin and complete the remedy to minimize risk in the interim. This evaluation includes the timing of construction, start-up and completion. In this way the assessment may consider the immediate to short-term reduction in exposure risk to receptors. Remedial actions that offer more rapid reduction of COCs in media of concern are favored over remedies that may not reach full effect for years or decades.

3.1.6 Institutional Requirements

This evaluation criterion addresses how the specific corrective measure activities will be conducted in compliance with all applicable local, state and federal regulations (e.g., waste handling, closure requirements, land disposal restrictions, discharge permits).

3.2 Development of Remedial Technologies

An initial screening was conducted across a range of existing remedial technologies including containment, in-situ treatment, mass removal, ex-situ and integrated approaches. This screening resulted in the identification of five primary corrective measure technologies that could feasibly be implemented within the limitations of the physical setting and geochemistry of the FAR II Unit. The five technologies are (1) Monitored Natural Attenuation (MNA), (2) Vertical Barrier, (3) Cap & Operational Modification, (4) Groundwater Extraction, and (5) Ex-Situ Treatment.

3.2.1 MNA

MNA is an in-situ remedial technology that relies on natural processes occurring in aquifers to attenuate dissolved contaminants and thereby reduce their concentrations in groundwater. MNA is effective at sites where the source is controlled, the contaminant plume is stable, and contaminant concentrations are low. Natural attenuation of lithium mainly relies on the dilution process. Dilution is a physical attenuation mechanism that reduces concentrations by distributing constituent concentrations over large volumes of groundwater. Molybdenum is geochemically more reactive and may be attenuated further through precipitation or sorption processes. Precipitation and sorption are chemical mechanisms that reduce concentrations by immobilizing constituents in groundwater.

As concluded in the risk evaluation (Section 1.2), lithium and molybdenum are unlikely to pose unacceptable risks to nearby human or ecological receptors. Additionally, the concentrations of these inorganic constituents in groundwater is low, with concentrations

remaining less than one order of magnitude above the GWPS. Due to the low risk to human and ecological receptors and low constituent concentrations, MNA is a viable remedial option.

Advantages:

One of the main advantages of MNA technology is the ability to utilize naturally occurring processes to attenuate concentrations in groundwater. In addition, MNA requires little infrastructure and causes minimal disruption to remediation areas.

Disadvantages:

The MNA remedial option requires that groundwater impacts be stable, otherwise source treatment and control may be required. Another disadvantage for application of MNA for molybdenum is that attenuation of metals does not result in their destruction and the attenuation processes could be reversed under changed subsurface conditions.

3.2.2 Vertical Barrier

Vertical barriers are remedial technologies that utilize low-permeability vertical barriers, such as slurry walls or grout curtains, installed around or downgradient of the waste mass to limit the future migration of groundwater impacts. Soil-bentonite slurry walls are commonly used and are installed by either conventional trenching, continuous trenching, or bio-polymer slurry trenching. Grout curtains are typically installed using injection of cement-based grout into underlying bedrock. Slurry walls and/or grout curtains are installed generally with surface caps for more complete containment. Gradient control systems can be used in conjunction with the vertical barrier technology to prevent groundwater mounding behind the barrier. Because this approach does not rely on the geochemical properties of lithium and molybdenum, it is likely to be equally successful for both constituents of interest.

Advantages:

Employment of vertical barriers is a proven technology that is a reliable source control measure for the entire suite of CCR constituents of interest, especially when used in combination with other technologies, such as capping and gradient control systems. Specifically, slurry walls are an effective technology that prevents groundwater migration in the subsurface and grout curtains mitigate groundwater flow through fractured bedrock. Barriers can also be implemented at both active and closed CCR sites.

Disadvantages:

The vertical barrier technology is limited by installation depth and the requirement to find a suitable low permeability layer. In addition, geologic considerations at the site may make it difficult to construct the barrier. For example, variability in fractured bedrock creates difficulty in ensuring the full continuity of the grout curtain. Moreover, dewatering or groundwater extraction may be necessary to relieve backpressure from groundwater flow prior to grouting. Additionally, groundwater extraction may be required after grouting to relieve backpressure as groundwater flow is restricted behind the barrier.

3.2.3 Cap & Operational Modification

The capping technology includes a low permeability cover installed over the waste surface to prevent vertical infiltration of stormwater into the CCR unit and reduce impacted groundwater generation. The implementation of a cap system would require operational modification to dry ash handling and subsequent unit closure.

Advantages:

Caps are an effective means for source control by preventing vertical infiltration and generation of impacted groundwater.

Disadvantages:

Although caps are effective at minimizing stormwater infiltration, the effectiveness increases when used with other technologies.

3.2.4 Groundwater Extraction

Groundwater extraction technology consists of a network of vertical or horizontal extraction wells to capture and remove contaminated groundwater. Wells can be located both downgradient and within the waste to effectively limit horizontal migration of the groundwater plume and reduce total contaminant mass. Because lithium and molybdenum are not attenuated, they can be readily extracted with groundwater. The extracted groundwater will require ex-situ treatment and permitted discharge.

Advantages:

Groundwater extraction is a proven technology effective at source capture and removal. Groundwater extraction can be used successfully in bedrock aquifers.

Disadvantages:

Groundwater extraction systems will likely require a large quantity of extraction wells to provide adequate hydraulic containment. Complex site geology and anisotropic conditions could challenge the effectiveness of the extraction system. This technology also requires ex-situ water treatment system with additional operation and maintenance considerations.

3.2.5 Ex-Situ Treatment

Ex-situ treatment consists of various technologies that treat extracted groundwater prior to permitted discharge. Such technologies include; precipitation/co-precipitation, adsorption, and membrane filtration.

Precipitation/co-precipitation uses chemicals to transform dissolved contaminants into an insoluble solid. The precipitation/co-precipitated solid is then removed from the liquid phase by clarification or filtration. Adsorption is accomplished by passing contaminated groundwater through a column where the contaminants are adsorbed into the column media. The column must be regenerated or replaced when the media becomes full. Lastly, membrane filtration separated contaminants from water by passing it through a semi-permeable barrier or membrane.

Advantages:

Ex-situ treatment can be combined with other technologies to facilitate their application.

Disadvantages:

This approach has limited applicability for lithium lithium precipitation is limited and dependent on pH and other variables. Likewise, lithium adsorption is rarely favorable. Both lithium and molybdenum require additional removal steps and produce large volumes of residuals. Additionally, the potential for high concentrations of competing contaminants and the fouling of the adsorption media due to the presence of other suspended or dissolved matter could inhibit its efficiency

3.3 Description and Assessment of Corrective Measure Options

The five identified technologies discussed in **Section 3.2** were then assembled into four corrective measure options:

(1) *MNA* – includes MNA only

(2) *Closure and Monitor* – FAR II unit closure and capping with long-term monitoring

(3) *Bedrock Grouting* –bedrock grouting of west FAD 2 abutment, with groundwater extraction to control hydraulic gradients and ex-situ treatment if needed

(4) *Hydraulic Gradient Control* – Groundwater extraction upgradient of west FAD 2 abutment with ex-situ treatment

Each of the four corrective measure options is described and evaluated based on the evaluation criteria presented in Section 3.1. The findings of this section are summarized in **Table 1**.

3.3.1 Option #1 – Monitored Natural Attenuation

MNA relies on natural attenuation processes to achieve site-specific GWPS within a reasonable time frame. It requires demonstration of attenuation mechanisms and aquifer attenuation capacity over the long term. While there are few potential impacts and a high ease of implementation, the time to complete the remedy cannot be determined at this time as it relies on performance and this technology performs best when paired with source control.

3.3.2 Option #2 – Closure of FAR II unit with Long-Term Monitoring

Anticipated operational changes to dry ash handling allows for unit closure and capping. As part of closure, the unit will be dewatered and the proposed cap will prevent infiltration of precipitation in to the groundwater system. Closure will be completed in accordance with 40 CFR 257.100 through 257.104. This plan will incorporate long-term monitoring and will address any potential long-term impacts, including any groundwater issues associated with future Site conditions.

3.3.3 Option #3 – Bedrock Grouting or Cutoff Wall

This option will include bedrock grouting of the FAD 2 western abutment to cut off flow of impacted groundwater from the vicinity of M-11 to Jules Verne seep. Groundwater extraction will be required to minimize hydraulic head such that the grouting can be implemented. Data gaps associated with complex fractured bedrock geology limit evaluation of the performance of this option. Long-term groundwater extraction may be required to control groundwater flow following implementation of bedrock grouting if it changes groundwater direction or hydrostatic pressure behind the dam. If long-term extraction is required, the time to complete remedy could be infeasible. Extracted groundwater may require treatment prior to discharge.

3.3.4 Option #4 – Hydraulic Gradient Control

Extraction wells are used to capture impacted groundwater and hydraulically contain impacts. Captured groundwater may subsequently require ex-situ treatment and discharge to a permitted outfall. Reliability and performance may be limited due to the complex, fractured bedrock geology. Additionally, the time to complete this remedy could be infeasible.

4. NEXT STEPS

According to the 40 CFR 257.96, the owner or operator must discuss the results of this ACM in a public meeting with interested and affected parties at least 30 days prior to the selection of the remedy. Remedy selection will occur as soon as feasible based on the need to fill data gaps prior to remedy selection. The remedy selection will include a schedule for implementation and completion. The unit will cease receiving waste no later than October 31, 2020, which will initiate the closure and post-closure care process.

5. REFERENCES

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TABLES

TABLE 1 - DEVELOPMENT AND EVALUATION OF POSSIBLE CORRECTIVE MEASURE OPTIONS SUMMARY

Assessment of Potential Corrective Measures for Groundwater CCR Unit - Fly Ash Reservoir II

Cardinal Plant, Brilliant, Ohio

Possible Corrective Measures Technologies / Evaluation Criteria Considered		**Corrective Measures Options**			
		CMO #1: MNA	CMO #2: Closure and Monitoring	CMO #3: Bedrock Grouting	CMO #4: Hydraulic Gradient Control
Primary Corrective Measure Technologies	Monitored Natural Attenuation	●	●		
	Vertical Barrier			●	
	Cap & Oper. Modification		●		
	Groundwater Extraction			●	●
	Ex-Situ Treatment			o	●
Summary	Description of CMO	MNA of CCR related metals and other inorganic species relies on physical and chemical processes to achieve site-specific groundwater protection standards (GWPS) within a reasonable time frame. This approach requires demonstration of attenuation mechanisms and aquifer capacity over the performance period. The primary constituents of interest at FAR II are molybdenum and lithium. The primary attenuation process for these metals is dilution.	The 'closure and monitor' corrective measure requires operational changes to dry ash handing allowing for unit closure, dewatering and capping. Capping acts as source control to prevent influx of precipitation and production of leachate. As with CMO #1, MNA relies on natural attenuation processes to achieve site-specific GWPS within a reasonable time frame and to monitor impacts within the aquifer.	The bedrock grouting corrective measure involves grouting fractured bedrock along the western abutment of Fly Ash Dam II in order to limit the migration of impacted groundwater. Groundwater extraction will be required to reduce hydraulic head prior to grouting. Additional measures, including groundwater extraction and treatment may be necessary to address groundwater migration through fractured bedrock.	Installation of extraction wells would be required in the vicinity of the western abutment upgradient of the existing groundwater seeps. Groundwater extraction wells are used to capture and hydraulically contain impacted groundwater. Extracted groundwater would subsequently require on site ex-situ treatment and discharge to a permitted outfall.
Assessment Criteria (40 CFR §257.96)	Performance	MNA can be an effective option to achieve GWPS within a reasonable time frame. Currently, dilution is the primary attenuation process that reduces exposure pathways. Additional data is needed to further evaluate the attenuation capacity of the site and determine the future performance of the MNA corrective measure because the FAR II is incised into the Morgantown sandstone and upgradient groundwater will continue to migrate through the fly ash within the unit. Additionally, precipitation may infiltrate the fly ash and mobilize lithium and molybdenum. However, performance of MNA is enhanced when it is used in combination with source control technologies.	Closing in conjunction with MNA has proven to effectively achieve GWPS. Currently, dilution is the primary attenuation process that eliminates exposure risks. After dewatering and closure, it is expected that the hydrostatic head within the impoundment should approximately equal historic groundwater elevations in the Morgantown sandstone at the west abutment. Additional data will be collected after the closure of the unit to address any post-closure concerns.	Bedrock grouting has been used effectively to prevent groundwater seepage and limit groundwater flow in fractured bedrock aquifers. However, the complex bedrock geology increases the difficulty of barrier construction and the heterogeneity of the bedrock could limit performance. Additional data from pump tests, flow modeling, capture zone analysis, and subsurface geologic investigations will need to be collected to adequately evaluate performance.	Groundwater extraction can be effectively used to limit infiltration, control hydraulic gradient, and reduce hydraulic head behind the dam. Additional data from pump tests, flow modeling, and capture zone analysis will need to be collected to adequately evaluate performance.
	Reliability	An evaluation will be needed to gather additional data necessary to evaluate the reliability of the MNA option. It is important to plan a tiered approach, where each subsequent change in hydraulic conditions is assessed for impacts on the transport of Li and Mo. If favorable aquifer conditions and adequate attenuation capacity exist it is possible that MNA will be reliable when coupled with source control.	Capping is effective at preventing infiltration of precipitation into the groundwater system and thus achieving source control. Given that no current exposure risks were identified, MNA is a sufficient method to monitor downgradient concentrations.	Depending on the extent of bedrock fractures, bedrock grouting ranges from moderately uncertain to moderately reliable as a source control measure to prevent migration of impacted groundwater. Pairing with groundwater extraction will improve the reliability of the approach. .	Hydraulic gradient control is a reliable measure for source control. However, given the fractured geology, complete capture of groundwater using the system is not guaranteed.

6/28/2019
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TABLE 1 - DEVELOPMENT AND EVALUATION OF POSSIBLE CORRECTIVE MEASURE OPTIONS SUMMARY

Assessment of Potential Corrective Measures for Groundwater CCR Unit - Fly Ash Reservoir II

Cardinal Plant, Brilliant, Ohio

Possible Corrective Measures Technologies / Evaluation Criteria Considered		**Corrective Measures Options**			
		CMO #1: MNA	CMO #2: Closure and Monitoring	CMO #3: Bedrock Grouting	CMO #4: Hydraulic Gradient Control
Primary Corrective Measure Technologies	Monitored Natural Attenuation	●	●		
	Vertical Barrier			●	
	Cap & Oper.Modification		●		
	Groundwater Extraction			●	●
	Ex-Situ Treatment			o	●
Assessment Criteria (40 CFR 257.96)	Ease of Implementation	The ease of implementation would be relatively straightforward with respect to the installation of infrastructure. The current groundwater monitoring well network should continue to provide adequate monitoring capability for mass flux calculations needed as part of MNA.	The ease of implementation is moderate with respect to infrastructure as capping of the unit is a significant effort. A sufficient groundwater monitoring well network currently exists. Additional groundwater sampling which will be required as part of the post-closure plan will also assist in monitoring progress in attenuation.	The ease of implementation is moderate with respect to construction. Additional data is required to aid in design of both the groundwater extraction system and the bedrock grouting approach. If utilized, the groundwater extraction and water treatment systems will have additional operation and maintenance requirements.	The ease of implementation is moderate, as the groundwater extraction and water treatment systems will have additional operation and maintenance requirements.
	Potential Impacts	The potential impacts of MNA are minimal. MNA relies on processes that are naturally occurring in the aquifer; therefore, surface and subsurface impacts that are adverse to treatment are unlikely. Although exceedances have been demonstrated in Site wells and seeps, there are currently no receptors at risk of exposure.	Short term impacts are expected during construction and include land disturbance, trucking and equipment activity, and carbon emissions. Any long-term impacts will be evaluated under the post-closure monitoring program.	Intermediate impacts include changes to groundwater flow/rerouting and increase in hydrostatic pressure behind the dam. While unlikely, dam weakening is a potential impact. Additional data will need to be collected to determine the potential impacts from changed groundwater conditions.	Short term impacts are expected during installation. Long-term impacts include disposal of spent media from the ex-situ treatment process.
	Time to Begin/Complete Remedy	With the groundwater monitoring network already established, the time to implement the MNA option is very short. However, it will take some additional time to collect the data necessary to establish groundwater flow characteristics and attenuation capacity. The time to complete the remedy cannot be determined at this time, as it relies on MNA performance.	Time to implement capping and monitoring will be moderate. It will take time to complete dewatering operations, cap design, cap construction. Upon completion, monitoring can begin immediately since the groundwater monitoring network is already established. The time to complete the remedy cannot be determined at this time, as it relies on MNA performance.	The time to implement the corrective measure is moderate. It will take time to complete the design, groundwater extraction system installation, ex-situ water treatment system installation (if needed), and bedrock grouting operations. The groundwater extraction and treatment systems must be maintained long term; therefore, the time to complete is indefinite	The time to implement the corrective measure is moderate. It will take time to complete the design, groundwater extraction system installation, and ex-situ treatment installation. The groundwater extraction and treatment systems must be maintained long term; therefore, the time to complete is indefinite.
	Institutional Requirements	Groundwater is currently captured and discharged under the existing NPDES permit. There are no anticipated changes to present operations and water will continue to be discharged under the existing NPDES permit. Given that receptors are currently not at risk of exposure, no additional changes are required to minimize risk.	Groundwater and seepage are currently captured and discharged under the NPDES permit after mixing with other discharge streams.	If ex-situ treatment is required, discharge permitting may be needed.	A permit would be required for discharge of extracted groundwater.

Notes:

CMO - corrective measures option

MCL - federal drinking water maximum contaminant level

● = technology is part of CMO

o = technology may be required for success of CMO

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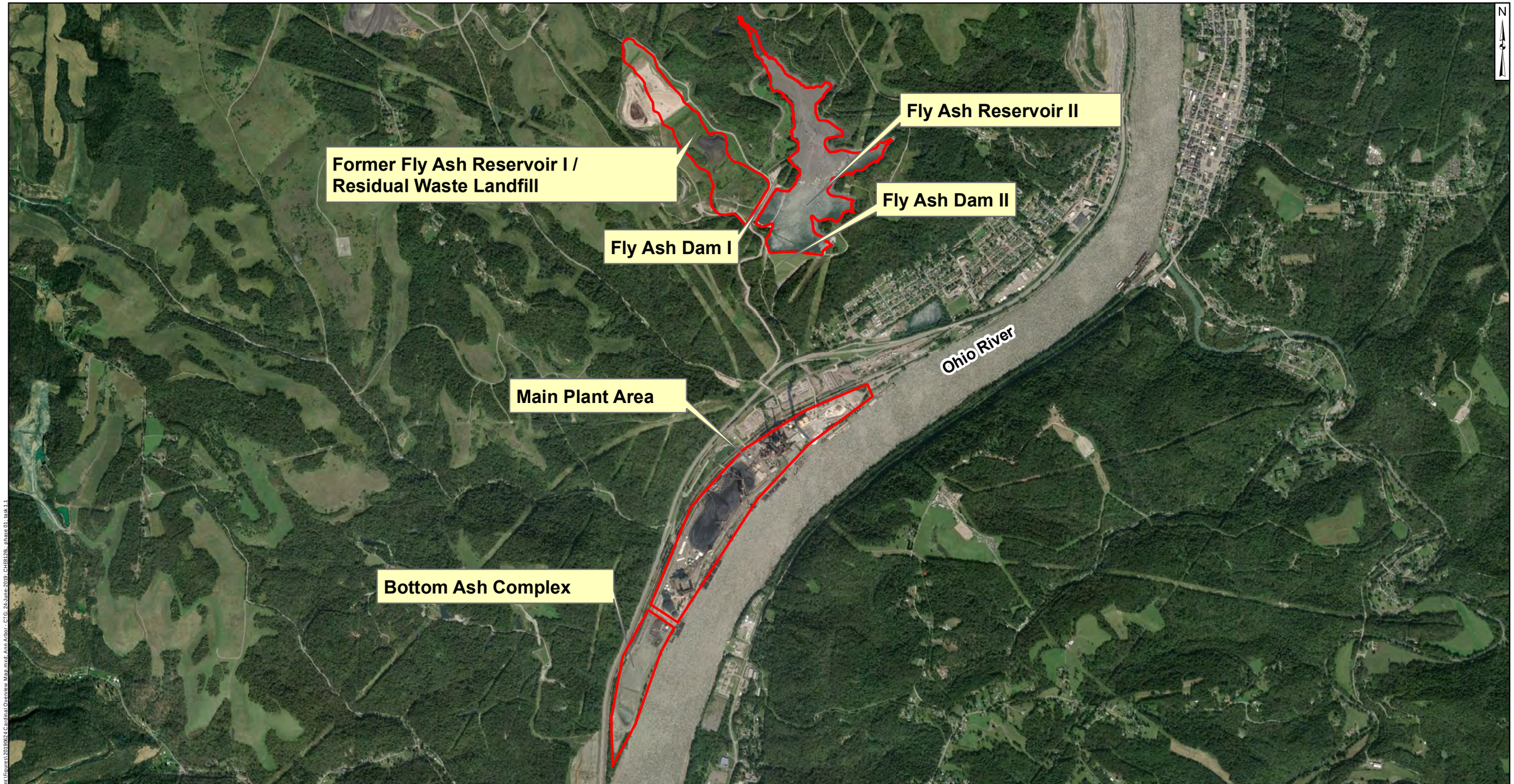
FIGURES



Legend

Site Boundary

Notes
- Aerial imagery courtesy of ESRI.
- All boundaries are approximate.
- CCR = Coal Combusion Residual

2,000 1,000 0 2,000 Feet

Plant and CCR Unit Location Map
Fly Ash Reservoir II

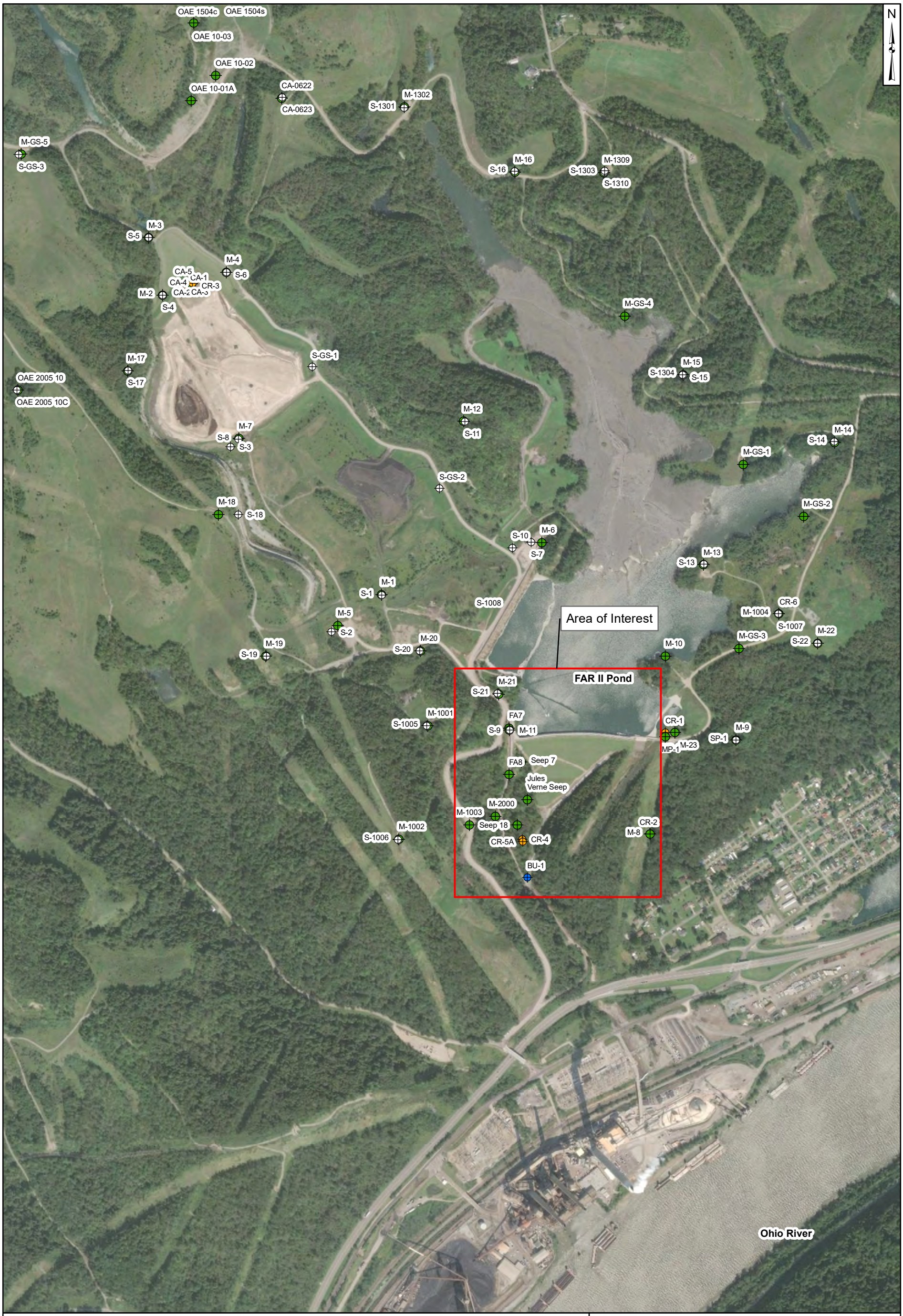
Buckeye Power Cardinal GeneratingPlant
Brilliant, Ohio

Geosyntec consultants

Ann Arbor, Michigan | 06/24/2019

Figure 1

\\annarbor\011Projects\AEP\Cardinal\CCR Compliance Document\Figures\20190624 Cardinal Overview Map.mxd; Ann Arbor - CTG; 24-June-2019; CH8312B; phase 01; task 1.1



Monitoring Wells

- Buffalo
- Cow Run
- Morgantown
- Shallow

Notes

- Monitoring well coordinates and water level data (collected on August 21, 2018) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Fly Ash Reservoir II (Geosyntec, 2017) provided by AEP.

0 250 500 1,000 Feet

Monitoring Well **Network**
Fly Ash Reservoir II

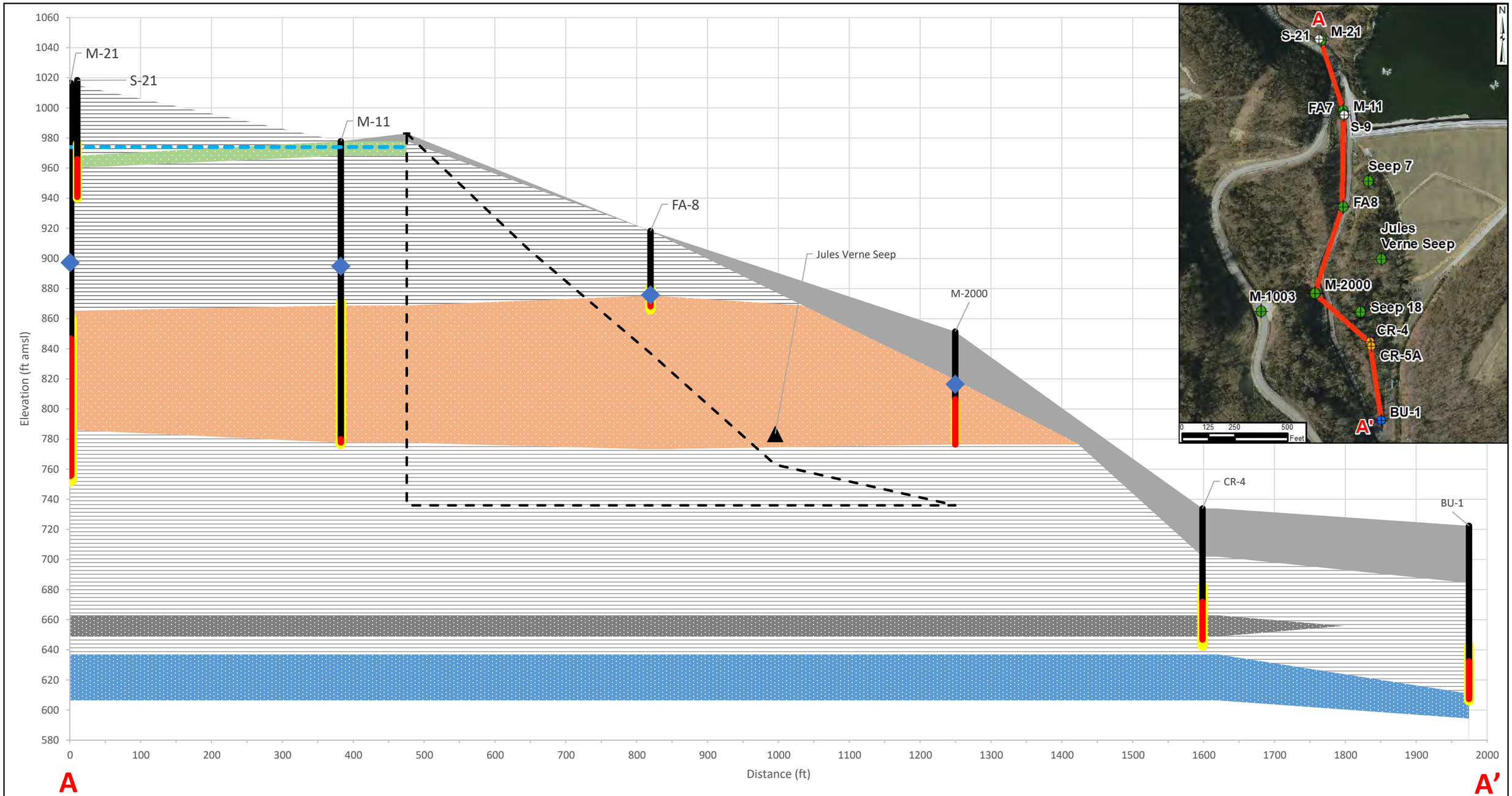
Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2019/06/21

Figure 2

C:\Users\eolree\Documents\ArcGIS\Buckeye-Cardinal_FAR_II_CMS_SiteOverview_2019-06.mxd. EOlree. 6/21/2019. CHA8423/01/08.



Legend

- Overburden
- Shales, Limestones, Minor Sandstones
- Connellsville Sandstone
- Morgantown Sandstone
- Cow Run Sandstone
- Buffalo Sandstone
- Well Casing
- Well Screen
- Well Sand Pack
- FAD II Outline
- FAR II Max Stage
- March 2019 Water Level in Morgantown Sandstone Well

Notes:
1. FAD – Fly Ash Dam
2. FAR – Fly Ash Reservoir
3. Elevations are approximate and were developed and interpolated from boring logs, existing cross sections, available LiDAR data, and well construction information.
4. The FAD II Outline and Jules Verne Seep locations represent an estimated projection against the cross-section plane from available LiDAR data.
5. LiDAR data for topography projections and inset aerial imagery from the Ohio Statewide Imagery Program (OSIP)
6. Inset map in Ohio State Plane North projection.

Cross Section A-A'
Fly Ash Reservoir II

Buckeye Power Cardinal Generating Plant
Brilliant, OH

Geosyntec consultants

CHA8468 | June 2019

Figure 3

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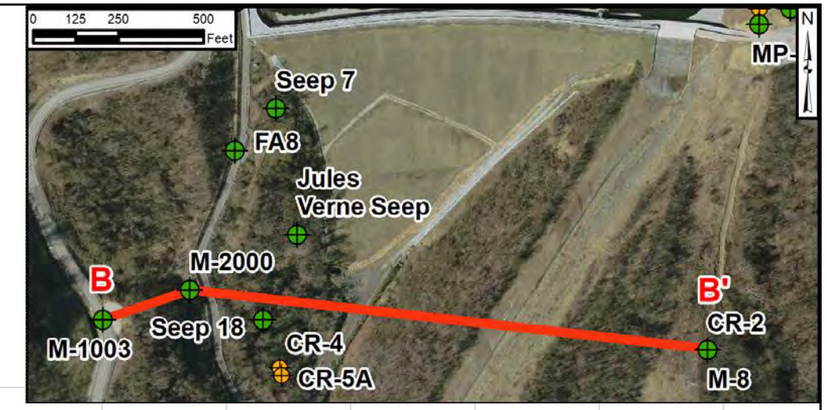

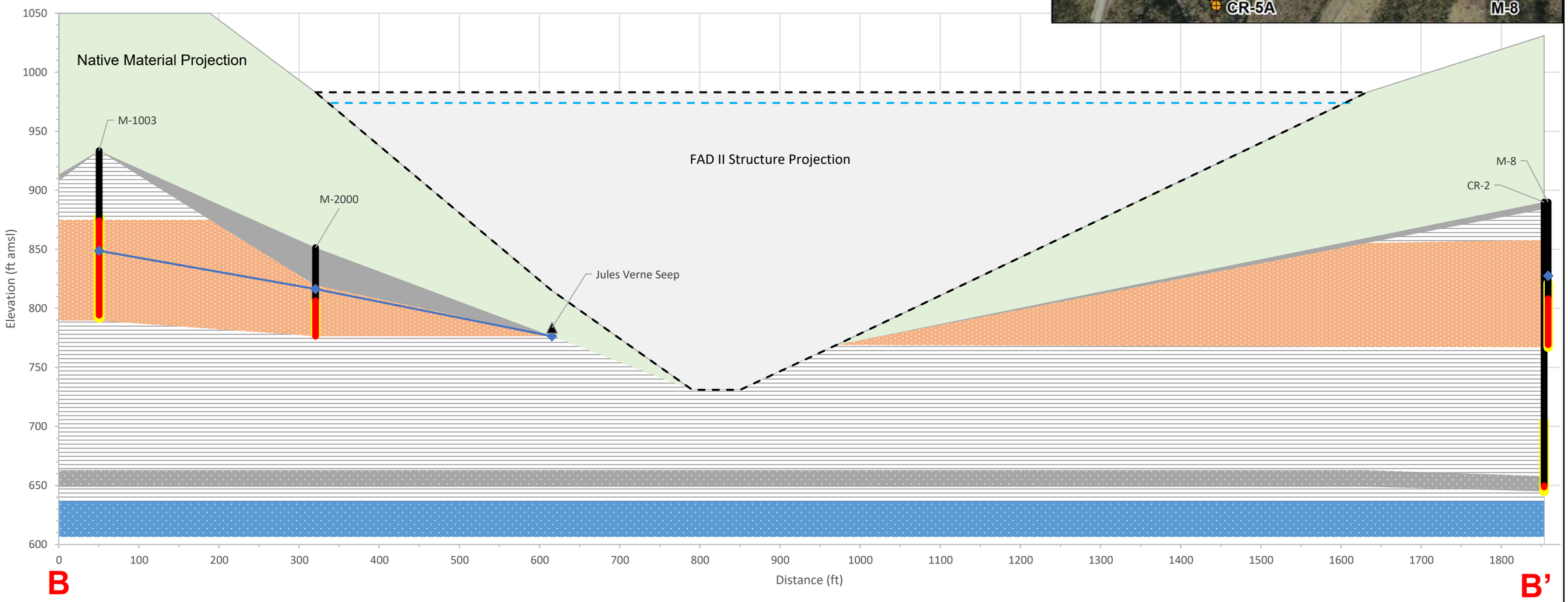

Legend

- Overburden
- Shales, Limestones, Minor Sandstones
- Connellsville Sandstone
- Morgantown Sandstone
- Cow Run Sandstone
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Cross Section B-B'
Fly Ash Reservoir II

Buckeye Power Cardinal Generating Plant
Brilliant, OH

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Figure 4

\\annarbor-01\data\Projects\Buckeye Power\Corrective Measures Assessment\Cross Sections

Legend

- FAR II Network Monitoring Well
- State/Other Program Monitoring Well
- Groundwater Elevation Contour
- Approximate Groundwater Flow Direction

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 - Fly Ash Reservoir II (Geosyntec, 2017) provided by AEP.
- Groundwater discharge observed from Jules Verne Seep location.
- OAE-2005-10, M-10, M-19, and M-1001 were not gauged in March 2019.
- Groundwater elevation units are feet above mean sea level.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Morgantown Aquifer
Fly Ash Reservoir II
March 2019

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2019/06/24

Figure 5

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Attachment 1

Supplemental Information to the FAR II Assessment of Corrective Measures for US EPA CCR Extension Request

CARDINAL SITE – FLY ASH RESERVIOR II

BRILLIANT, OHIO

Prepared for

Cardinal Operating Company
306 County Road 7E
Columbus, Ohio 43213

Prepared by

Geosyntec consultants

engineers | scientists | innovators

941 Chatham Lane, Suite 103
Columbus, OH 43221
Project Number CHA8468

November 2020

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Table 2: Groundwater Analytical Data – Spring 2019
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Figure 7: Sodium vs Lithium in Cow Run Aquifer

TABLES

Table 1: Groundwater Elevation Data - March 2019
Cardinal Plant - Fly Ash Reservoir II

Geosyntec Consultants, Inc.

Monitoring Well	Top of Casing Elevation (ft AMSL)	Water Level (ft AMSL)	Groundwater Elevation (ft AMSL)
BU-1	736.72	29.77	706.95
CR-4	724.92	17.92	707.00
CR-5A	735.83	29.00	706.83
FA-8	921.03	45.34	875.69
M-1003	935.88	87.14	848.74
M-11	980.21	85.39	894.82
M-2000	854.30	37.90	816.40
M-21	1,018.61	121.43	897.18
S-21	1,018.40	49.93	968.47
S-9	980.56	39.04	941.52

Notes:
ft AMS: feet above mean sea level.
1. Groundwater elevations were collected on March 21, 2019.

Table 2: Groundwater Analytical Data - Spring 2019
Cardinal Plant - Fly Ash Reservoir II

Parameter		Lithium		Molybdenum		Sodium	
		Dissolved	Total	Dissolved	Total	Dissolved	Total
Site-Specific GWPS		NA	140	NA	100	NA	NA
CR-4	3/26/2019	10.9	-	<1.0	-	161,000	-
CR-5A	3/26/2019	13.1	-	<1.0	-	113,000	-
FA-8	4/4/2019	-	**198**	-	**321**	-	143,000
	5/22/2019	-	**193**	-	**313**	-	-
M-8	4/1/2019	-	<10	-	<0.5	-	18,300
M-11	3/12/2019	-	**196**	-	**323**	-	-
	4/5/2019	-	**193**	-	**316**	-	138,000
M-21	4/3/2019	-	80	-	21.3	-	296,000
M-1003	4/8/2019	-	<10	-	<0.5	-	76,700
M-2000	3/12/2019	-	**200**	-	**184**	-	-
	5/22/2019	-	**184**	-	**201**	-	-
S-19	3/28/2019	-	-	-		-	124,000
Jules Verne Seep	4/4/2019	-	**264**	-	**413**	-	199,000
Seep 18	3/26/2019	-	88.7	-	69	-	-
	5/22/2019	-	104	-	75.5	-	-
Face of Dam	3/11/2019	-	**236**	-	**160**	-	-

Notes:
-: Not sampled
µg/L: micrograms per liter
GWPS: Groundwater Protection Standard
NA: GWPSs not applicable for parameter.
1. Groundwater concentrations are shown in units of micrograms per liter.
2. The Site-specific GWPSs were established in accordance with United Stated Environmental Protection Agency 40 CFR 257.95.
3. **Bolded values exceed the GWPS.**

Table 3: Jules Verne Flow Rates
Cardinal Plant - Fly Ash Reservoir II

Date	Flow Rate (GPM)
10/20/2017	75
11/17/2017	75
12/15/2017	75
6/29/2018	75
7/27/2018	75
8/24/2018	75
9/10/2018	75
9/25/2018	75
10/25/2018	60
11/21/2018	75
12/19/2018	75
1/18/2019	75
2/15/2019	75
3/15/2019	75
4/12/2019	30
5/10/2019	75
6/7/2019	75
Average	**71**

Notes:
GPM: gallons per minute
1. Flow rates are collected as part of the monthly dam inspection.

Table 4: Mass of Lithium and Molybdenum Released
Cardinal Plant - Fly Ash Reservoir II

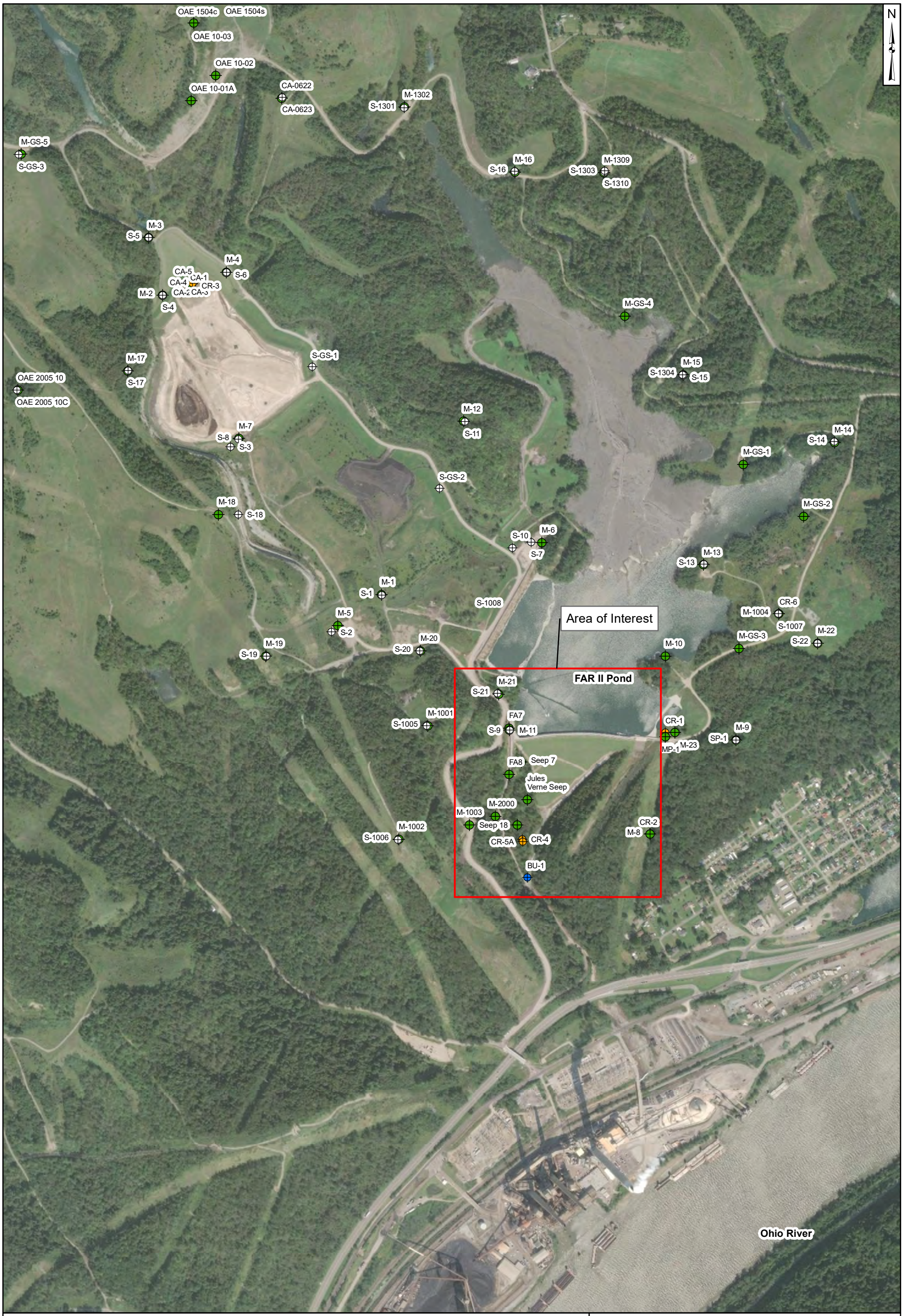
Parameter	Average Concentration (µg/L)	Mass Released (lbs)
Lithium	265	2,124
Molybdenum	463	3,702

Notes:
µg/L: micrograms per liter
lbs: pounds

1. Mass of parameter released calculated as the historical average concentration multiplied by the historical average seepage rate over a 24.5 year period (January 1995 through July 2019).

2. Table 3 contains historical analytical data for Jules Verne Seep. A combination of total and dissolved metals data was used to calculate the average concentration at Jules Verne Seep. For sample dates where total and dissolved metals were analyzed, the maximum value was used to calculate the average.

FIGURES



Monitoring Wells

- Buffalo
- Cow Run
- Morgantown
- Shallow

Notes

- Monitoring well coordinates and water level data (collected on August 21, 2018) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Fly Ash Reservoir II (Geosyntec, 2017) provided by AEP.

0 250 500 1,000 Feet

Monitoring Well **Network**
Fly Ash Reservoir II

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2019/06/21

Figure **1**

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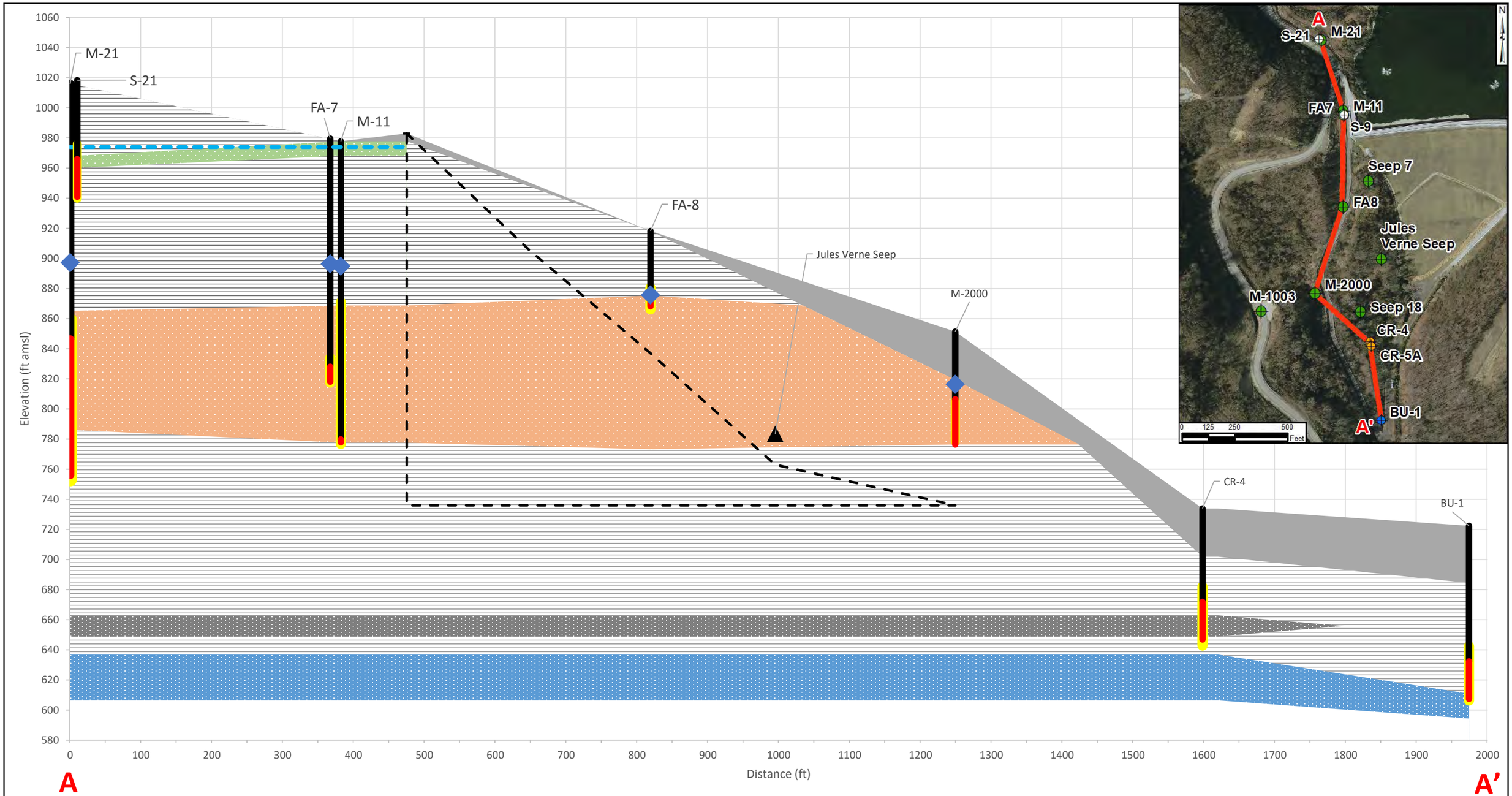

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Cross Section A-A'
Fly Ash Reservoir II

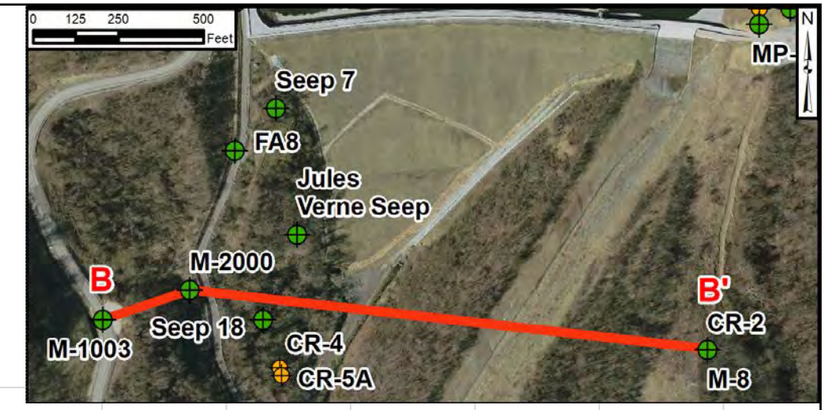
Buckeye Power Cardinal Generating Plant
Brilliant, OH

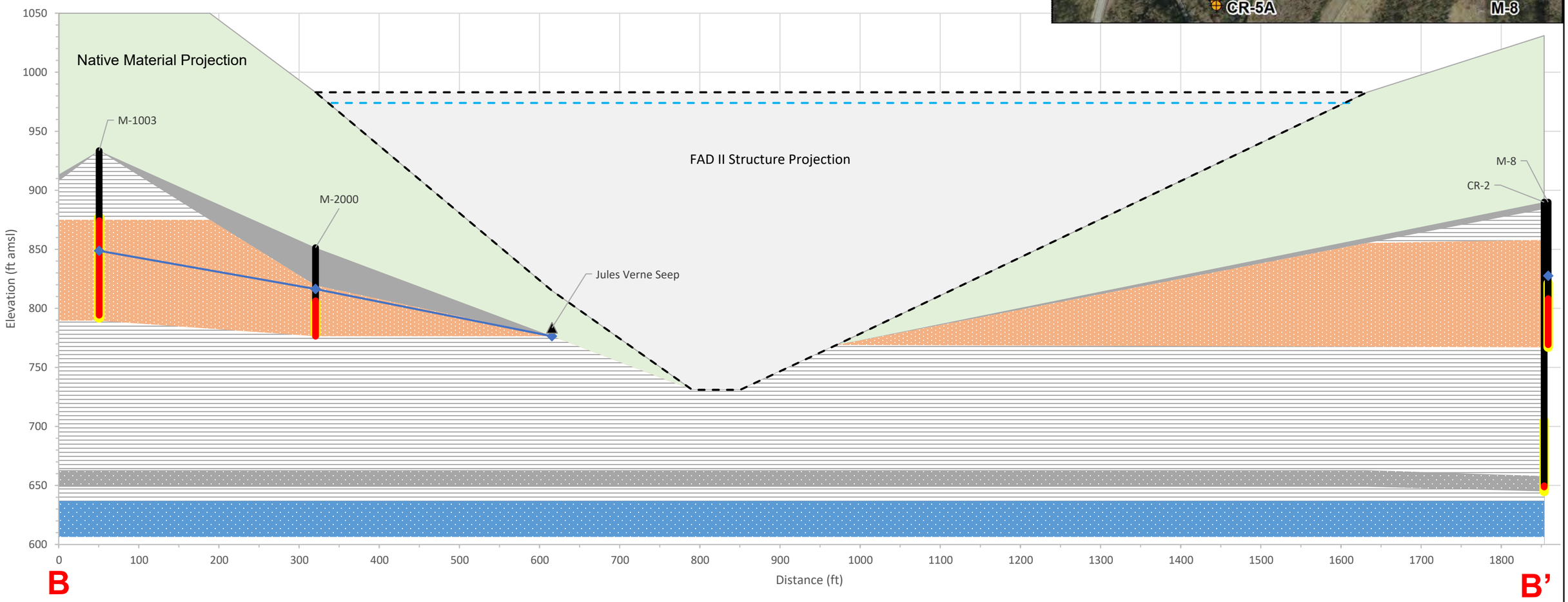
Geosyntec consultants

CHA8468 | June 2019

Figure 2

\\annarbor-01\data\Projects\Buckeye Power\Corrective Measures Assessment\Cross Sections





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Cross Section B-B'
Fly Ash Reservoir II

Buckeye Power Cardinal Generating Plant
Brilliant, OH

Geosyntec consultants

CHA8468 | June 2019

Figure 3

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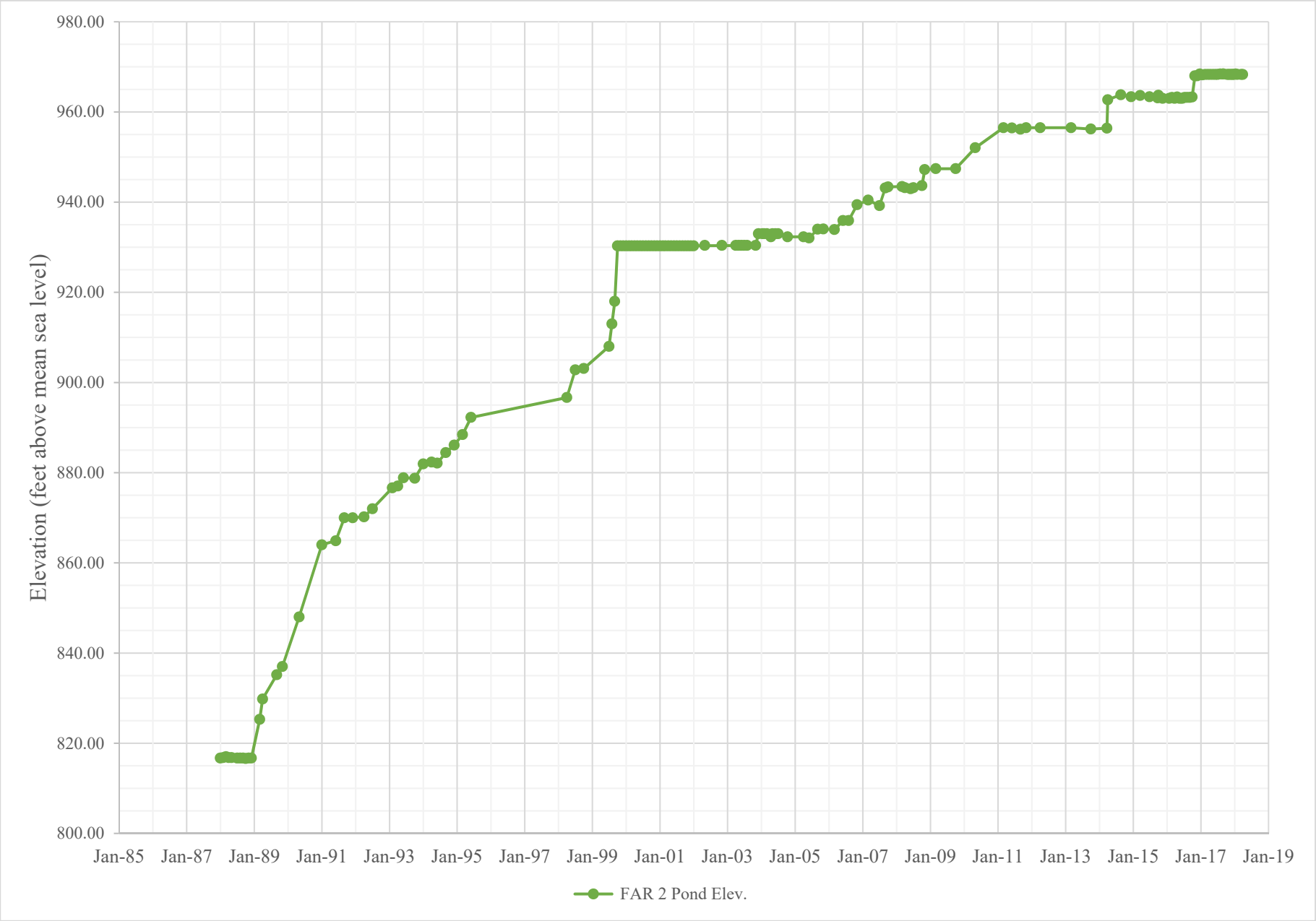
Figure 4
Historical FAR II Groundwater Elevation



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- Approximate Groundwater Flow Direction

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Potentiometric Surface Map - Morgantown Aquifer
Fly Ash Reservoir II
March 2019

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2019/06/24

Figure 5

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Figure 6
Sodium vs Lithium in Morgantown Aquifer and Seeps

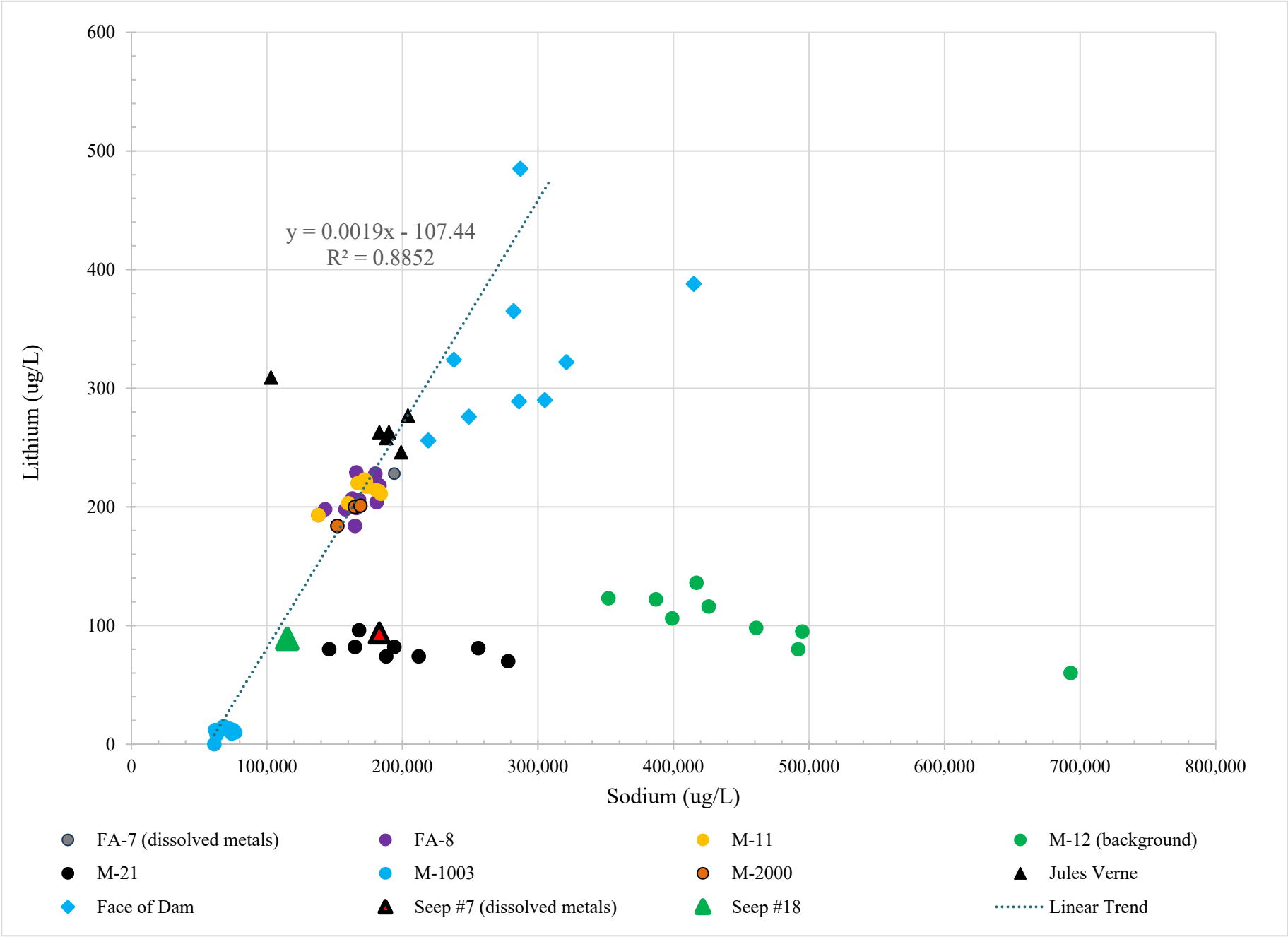
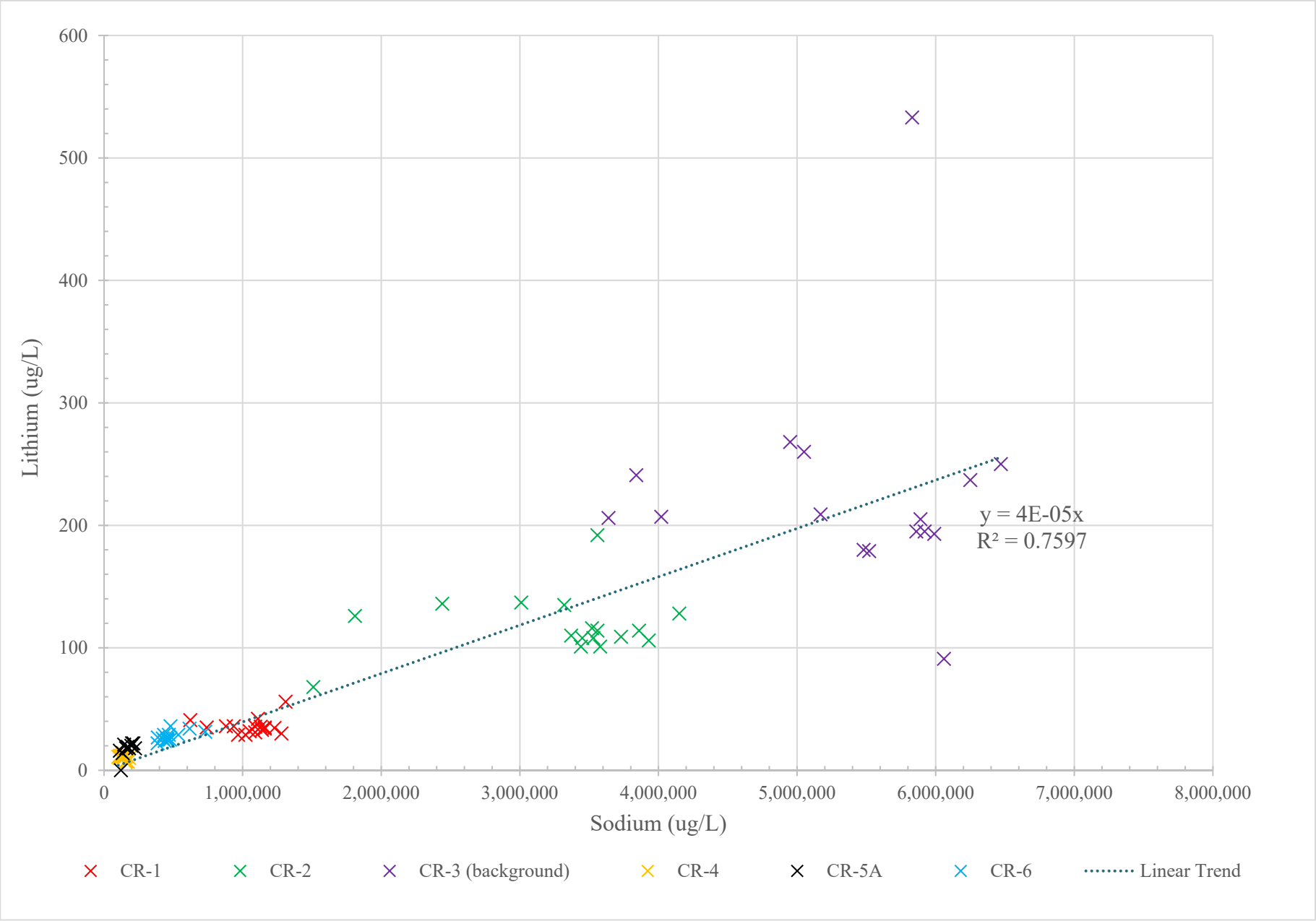


Figure 7

Sodium vs Lithium in Cow Run Aquifer



Fly Ash Reservoir II

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)

March 6, 2020

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

Semi-Annual Progress Report on Groundwater Corrective Measures at FAR II

This Progress Report is prepared to provide an update on the status of selecting and designing the remedy/ corrective measure in accordance with CCR Rule § 257.97(a).

A public meeting was held on September 4th, 2019 to discuss the Assessment of Corrective Measures (ACM) Report for groundwater protection exceedances at Monitoring Wells M-11 and FA-8. The ACM outlined four corrective measure options which Cardinal has been reviewing since the report was prepared.

As described in § 257.97(b), Cardinal must select a remedy that:

- Protects human health and environment;
- Attains the groundwater protection standards;
- Controls the source of the release to reduce or eliminate, to the maximum extent feasible, further releases of constituents in Appendix IV to the environment;
- Removes from the environment as much of the contaminant material that was released from the CCR Unit as is feasible; and
- Comply with standards for waste management.

Additionally, Cardinal shall consider the following evaluation factors when selecting a remedy, as prescribed in § 257.97(c):

- The long term and short-term effectiveness and protectiveness of the remedy, along with the degree of certainty that the remedy will prove successful;
- The effectiveness of the remedy in controlling the source to reduce further releases;
- The ease or difficulty of implementing a potential remedy; and
- The degree to which community concerns are addressed.

At this time Cardinal is still evaluating groundwater flow conditions at the Facility to determine which remedy would be most effective at meeting the requirements stated above. Cardinal believes a decision on the corrective measure should be made prior to the end of the year.

Once the corrective measure is selected, a report detailing the implementation, schedule and effectiveness of meeting § 257.97(b), will be published on Cardinal's CCR Compliance Website.

September 4, 2020

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

Semi-Annual Progress Report on Groundwater Corrective Measures at FAR II

This Progress Report is prepared to provide an update on the status of selecting and designing the remedy/ corrective measure in accordance with CCR Rule § 257.97(a).

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- Removes from the environment as much of the contaminant material that was released from the CCR Unit as is feasible; and
- Comply with standards for waste management.

At this time, Cardinal is in the final phases of selecting a remedy and is currently preparing the Remedy Selection Report in accordance with § 257.97(a). As stated in the first semi-annual progress report, Cardinal is still on schedule to make a decision on the Remedy and upload the Remedy Selection Report to the Facility's publicly available internet website, prior to the end of the year.

REMEDY SELECTION REPORT
CARDINAL SITE – FLY ASH RESERVIOR II
BRILLIANT, OHIO

Prepared for

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

Prepared by

Geosyntec consultants
engineers | scientists | innovators
941 Chatham Lane, Suite 103
Columbus, OH 43221
Project Number CHA6468

October 2020

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym	Definition
µg/L	Micrograms per Liter
cm/s	Centimeters per Second
ACM	Assessment of Corrective Measures
AEP	American Electric Power
AMSL	Above Mean Sea Level
BAC	Bottom Ash Complex
CCR	Coal Combustion Residual
CFR	Code of Federal Regulations
ESP	Electrostatic Precipitator
FAD 1	Fly Ash Dam 1
FAD 2	Fly Ash Dam 2
FAR I	Fly Ash Reservoir I
FAR II	Fly Ash Reservoir II
FGD	Flue Gas Desulfurization
GWPS	Groundwater Protection Standards
LLDPE	Low-Density Polyethylene
MCL	Maximum Contaminant Level
MNA	Monitored Natural Attenuation
MW	Megawatts
NPDES	National Pollutant Discharge Elimination System
OAC	Ohio Administrative Code
OEPA	Ohio Environmental Protection Agency
PTI	Permit to Install
QA/QC	Quality Assurance and Quality Control
RCRA	Resource Conservation and Recovery Act
RSR	Remedial Selection Report
RSW	Residual Solid Waste Landfill
SAP	Statistical Analysis Plan
SCR	Selective Catalytic Reduction (SCR) System
SSL	Statistically Significant Levels
UCL	Upper Confidence Limit
USEPA	United States Environmental Protection Agency

SECTION 1

INTRODUCTION

On behalf of our client, Cardinal Operating Company (Cardinal), Geosyntec Consultants, Inc. (Geosyntec) has produced this Remedy Selection Report (RSR) for the Fly Ash Reservoir II (FAR II), a regulated impoundment at the Cardinal Generating Plant (the Site or Facility). The Site is located one mile south of Brilliant, Ohio in Jefferson County, along the Ohio River (Figure 1). Under the United States Environmental Protection Agency (USEPA) Coal Combustion Residual (CCR) Rule (40 Code of Federal Regulations (CFR) 257 Subpart D), groundwater monitoring is required to assess impacts of CCR activities to groundwater compared to background conditions.

In 2019, an Assessment of Corrective Measures Report (ACM) and a Closure Plan for FAR II were prepared for the Site to address statistically significant levels (SSLs) of lithium and molybdenum above their respective groundwater protection standards (GWPS) that were observed at the Site in 2018 (Geosyntec, 2019a). This RSR has been prepared as required by and in accordance with 40 CFR 257.97 and was developed to select remedial measures for addressing elevated lithium and molybdenum concentrations in site groundwater.

1.1 Purpose and Scope

The purpose of this RSR is to present the selected remedial strategies and technologies for the reduction of lithium and molybdenum present in Site groundwater to acceptable regulatory cleanup levels in accordance with 40 CFR 257.97. The target cleanup levels are the GWPS defined under 40 CFR 257.95(h). The current site-specific GWPS for lithium and molybdenum are 149 micrograms per liter (µg/L) and 100 µg/L, respectively. While the ACM identified a GWPS of 140 µg/L for lithium, this value was updated to 149 µg/L following completion of the first semiannual assessment monitoring event of 2020 (Geosyntec, 2020a).

This RSR report relies on the 2019 Assessment of Corrective Measures, the 2019 Groundwater Characterization Report prepared by Geosyntec Consultants and the 2019 Final Closure Plan prepared by TRC Engineers, Inc. (TRC) to focus the selection of remedial technologies that will achieve the most efficient and reliable method of reducing concentrations of lithium and molybdenum to below the GWPS.

1.2 Remedial System Requirements

Per 40 CFR 257.97, the selected remedial system is required to, at minimum:

- Be protective of human health and the environment;
- Attain the groundwater protection standards pursuant to 40 CFR 257.95(h);
- Control the source of the releases so as to reduce or eliminate, to the maximum extent feasible, further releases of constituents in Appendix IV to 40 CFR 257;
- Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems; and
- Comply with standards for management of wastes as specified in 40 CFR 257.98(d).

The effectiveness of the selected remedy in meeting these requirements is discussed in **Section 4**.

SECTION 2

SITE BACKGROUND

2.1 Site Operational History

The Site is located approximately one mile south of Brilliant, Ohio in Jefferson County along the Ohio River (**Figure 1**). The generating station consists of three units with a nominal capacity of 1,830 megawatts (MW). Units 1 and 2 began operation in 1967 and Unit 3 began operation in 1977. All three units are coal powered, with an average annual coal use of 5.2 million tons for the entire plant. 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 regulated CCR storage unit addressed in the RSR and currently used by the Facility is the FAR II reservoir. The locations of the FAR II unit is shown in **Figure 1**. Fly ash is currently sluiced to FAR II, which is impounded by Fly Ash Dam 2 (FAD 2). FAR II/FAD 2 has a permitted discharge (Outfall 019) through the national pollutant discharge elimination system (NPDES).

Construction of FAR II began in 1985 under PTI 06-1250 (Cardinal, 2019b). The FAR II foundation consists of a bedrock base (claystone and shale), and geology adjacent to the eastern and western abutments consists of bedrock units, the Monongahela Group and a portion of the Conemaugh Group including the Morgantown Sandstone.

Prior to the construction of FAD 2, a colluvium landslide upstream of the western abutment of FAR II occurred, exposing the face of the Morgantown Sandstone. The abutment was installed such that the clay core contacted the competent bedrock at 90-degree angles on the upstream side of the abutment to prevent seepage beneath the dam and reduce cracking of the core (American Electric Power [AEP], 2016). The dam was constructed with an open cut to rock and a grout curtain was installed (AEP, 2016). The dam had a final crest height of 925 feet above mean sea level (AMSL; AEP, 1997).

The FAD 2 structure has been raised twice since the initial construction. The dam was raised to an elevation of 970 AMSL in 1997 and the final crest height of 983 ft AMSL in 2013 (AEP, 1997; AEP, 2016).

Groundwater monitoring for FAR II is conducted in accordance with 40 CFR 257. Monitoring wells within the CCR rule monitoring network and select other locations of interest are shown in **Figure 2**.

2.2 Geologic Site Conditions

The Site is underlain by horizontal sequences of lower Permian and upper Pennsylvanian age sedimentary bedrock. The geologic units of interest in the vicinity of FAR II/FAD 2 are the Pennsylvanian aged Monongahela Group and the Conemaugh Group. The Monongahela group is approximately 203 ft thick in the vicinity of the Site and consists of sandstone and shale, siltstone, limestone, sandstone, and coal (AEP, 2006).

The Conemaugh group is approximately 500 feet thick in the vicinity of the Site and 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, the Cow Run Sandstone, and the Buffalo Sandstone. The Morgantown Sandstone is a fractured and jointed conglomeratic sandstone that is approximately 75 to 100 feet thick in the vicinity of the western abutment of FAD 2 (Sanborn Head & Associates, Inc. [Sanborn Head], 2018). In the vicinity of FAD 2, the base of the Morgantown Sandstone slopes south from M-21 to the Jules Verne Seep, and east from M-1003 to the Jules Verne Seep (Sanborn Head, 2018). The Elk Lick Limestone, the Skelly Limestone and Shale and the Ames Limestone vary in a combined thickness of approximately 80 feet. At the bottom of the Conemaugh Group, the Cow Run Sandstone is approximately 20 to 30 feet thick (AEP, 2006).

Prior to the development of the FAR II, overburden in the FAR II valley consisted of 10 to 30 feet of residual soils, mine spoil, landside debris and alluvial deposits (AEP, 1984; AEP, 2006). Along the valley walls, the overburden consisted of clayey colluvium (Amaya et al., 2009). Prior to the construction of FAD 2, a landslide upstream of the western abutment of FAD 2 occurred, exposing the face of the Morgantown Sandstone at approximately 880 feet AMSL. FAR II incises the Monongahela Group and partially incises the Conemaugh Group, including the Morgantown Sandstone. Cross sections for the geology at FAD 2 are shown in **Figure 3** and **Figure 4**.

2.3 Hydrogeologic Site Conditions

Groundwater in the vicinity of FAR II is present in three aquifers: the surficial aquifer, the Morgantown Sandstone, and the Cow Run Sandstone. The surficial aquifer is comprised of the Conemaugh group, primarily the Connellsville Sandstone, the Summerfield Limestone, the Bellaire Sandstone, former room and pillar mines, and mine spoils. The groundwater flow in the surficial aquifer tends to follow local topography. Underlying the surficial aquifer is a shale aquitard.

The Morgantown Sandstone aquifer is found below the shale aquitard and consists of a fractured and jointed conglomeratic sandstone with fractures. Regionally, groundwater in the Morgantown Aquifer flows south-southeast towards the Ohio River southeast of the Site. In the vicinity of FAD 2, groundwater in the Morgantown Aquifer travels through FAR II and around FAD 2 with discharges on the eastern and western abutments. Along the western abutment, the Morgantown Sandstone outcrops, and groundwater is discharged through the Jules Verne Seep (**Figure 4**).

Underlying the Morgantown Sandstone is approximately 50 to 100 feet of low permeability shale and limestone beds followed by the Cow Run Sandstone Aquifer. The Cow Run Sandstone Aquifer generally flows south-southeast towards the Ohio River in the vicinity of the Site. Additional details of the hydrogeologic conditions at the Site are discussed in the 2019 ACM report.

2.4 Groundwater Quality

A groundwater sampling program is in place at the Site to monitor background groundwater conditions and groundwater conditions downgradient of the FAR II unit in accordance with 40 CFR 257. In 2018, SSLs of lithium and molybdenum above their respective GWPS were observed at the Site (Geosyntec, 2019a).

Efforts completed in 2019 to delineate groundwater impacts found that although the FAR II unit discharges into the Morgantown Aquifer, the impacts from the FAR II are limited to monitoring wells FA-8, M-11, M-2000, and the Jules Verne Seep (Geosyntec, 2019c). Additionally, concentrations of lithium and molybdenum in the Cow Run Aquifer were generally much lower than concentrations in the impacted Morgantown Aquifer monitoring wells indicating that there is little to no vertical migration from the Morgantown Aquifer to the Cow Run Aquifer.

Groundwater flow and geochemical analysis of water from the Jule Verne Seep indicates that the seep water originates from the FAR II unit (Sanborn Head, 2018; Geosyntec, 2019c). The entry point for the water from FAR II is likely the location of the colluvium landside that occurred in the native overburden at 880 ft AMSL feet during the installation of FAD 2.

The hydraulic gradient in the Morgantown Aquifer along the north-south transect of the dam is from north to south (M-11 to M-2000) as shown in **Figure 3.** Along the east-west transect, the hydraulic gradient is from west to east and ultimately discharges through the Jules Verne Seep (M-1003 to Jules Verne Seep; **Figure 4**). Therefore, impacts from FAR II likely enter the Morgantown Aquifer in the vicinity of M-11 and discharge through the

outcrop of the Morgantown Sandstone at the Jules Verne Seep. Groundwater discharging from the Jules Verne Seep is collected at the base of FAD 2 and discharged to the Ohio River through NPDES Permitted Outfall No. 19.

SECTION 3

SELECTED REMEDY

3.1 Overview

The selected remedy for the Site to mitigate and remediate SSLs of lithium and molybdenum in the affected portion of the Morgantown Aquifer includes the closure of the FAR II unit via dewatering and capping and long-term monitoring in accordance with the closure plan.

The FAR II unit will be closed by closure in place in accordance with 40 CFR 257.102(d) commencing in 2021. Closure in place will be achieved by:

- Removal of free water from the CCR material (unwatering),
- dewatering the CCR material,
- regrading the CCR material, leaving the existing CCR material within the unit in place, and
- installing a geomembrane cover system in accordance with 40 CFR 257.102(d) with drainage channels to divert water away from the capped CCR unit.

The existing dam and spillway are proposed to remain.

A written final closure plan was developed by TRC (TRC, 2019) in accordance with 40 CFR 257.102(b) and approved by Ohio Environmental Protection Agency (OEPA) on February 2, 2020. The closure process is expected to take approximately five years, after which groundwater impacts will be addressed through long-term groundwater monitoring. The individual steps that will be taken to achieve the remedial system requirements presented in **Section 1.2** are discussed in detail in the following subsections.

3.2 Remedy Selection Process

Four remedial alternatives were assessed in the 2019 ACM report, including monitored natural attenuation (MNA); closure of the FAR II unit with long-term monitoring; installation of bedrock grouting or a cutoff wall; and, hydraulic gradient control

(Geosyntec, 2019c). The corrective measure alternatives were evaluated based on the criteria provided in 40 CFR 257.96(c).

Prior to the selection of the remedy, the results of the ACM were presented at a public meeting with interested and affected parties on September 4, 2019, which was at least 30 days prior to the selection of the remedy as required by 40 CFR 257.96.

The conclusions of the ACM and public comments resulted in the selection of closure of the FAR II unit with long-term monitoring as the selected remedial approach as detailed in **Section 3.3**.

3.3 Selected Remedial System

3.3.1 Removal of Free Water

The FAR II unit currently receives sluiced fly ash waste from the generating unit's ESP and stormwater runoff from the FAR I RSW Landfill. Operational changes from wet to dry ash handling will result in the termination of disposal of sluiced fly ash in the FAR II. Additionally, as part of the FAR II unit closure plan, stormwater will be diverted from FAR I and FAR II to sedimentation ponds via earthen berms and ultimately discharged through NPDES Permitted Outfall No. 19.

The changes in operation of the FAR II unit will allow the start of the free water removal process from the FAR II unit (unwatering). Free water will be removed by lowering the stop logs of the existing service spillway and with pumps when needed.

3.3.2 CCR Dewatering

The CCR material in the FAR II unit will be dewatered to provide a stable surface for the final cap. Dewatering is anticipated to reduce pore water elevations within FAR II to below the elevation of the colluvium landslide (880 ft AMSL) which is the main entry point for water to enter the Morgantown from FAR II and discharge at Jules Verne seep. The final dewatering process will be followed as described in the Closure Plan (TRC, 2019).

3.3.3 CCR Stabilization

Once the FAR II unit has been dewatered, the CCR material will be stabilized to prevent sloughing or movement of the final cover system. CCR stabilization will be completed as described in the Closure Plan (TRC, 2019).

3.3.4 CCR Regrading

The CCR in the FAR II unit will be regraded to achieve the planned final grade of the cover system. As presented in the 2019 Permit-to-Install Modification Application, the site will be regraded to provide a final slope for the cover system of 1% to 2% from east to west in the main length of FAR II with general side grading of 3% to 5% with a maximum slope of 3:1 (TRC, 2019). The surface of FAR II will also include grading for stormwater collection and redirection of runoff towards the NPDES Permitted Outfall No. 19.

3.3.5 Cover Installation

The cover system will be constructed to control, minimize, or eliminate, to the maximum extent feasible, infiltration of precipitation into the FAR II unit as prescribed by 40 CFR 257.102(d)(i). The system will cover approximately 160 acres of CCR. The system will be installed directly over the dewatered and regraded CCR material and will consist of:

- a 40-mil linear low-density polyethylene (LLDPE) geomembrane placed directly on the CCR material;
- a geocomposite drainage layer within the swale or a cushion geotextile;
- an infiltration layer that contains 18 inches of earthen material, and
- six inches of earthen material capable of supporting native vegetation (TRC, 2019).

The Closure Plan states: "The geomembrane or general fill material will be selected such that the permeability of the cover system is less than or equal to the permeability of the natural subsoils and is not greater than $1x10^{-5}$ centimeters per second (cm/s)" (TRC, 2019).

3.3.6 Final Site Restoration

The final cover system will be vegetated to prevent erosion. Maintenance of the cover system will include mowing. The final cover will be inspected and maintained, including the drainage channels, the cover, the final cover surface, and the surface drainage system.

3.3.7 Long Term Monitoring

The Facility will comply with the post-closure care and maintenance requirements for a period of 30 years, as required by 40 CFR 257.104. These post-closure requirements include maintaining the final cover system, maintaining the leachate collection system, maintaining the groundwater monitoring system, and monitoring groundwater in

accordance with 40 CFR 257.90 through 257.98. A post-closure plan has been developed in accordance with 40 CFR 257.104(d) (TRC, 2019).

Groundwater will continue to be monitored at the site after closure. Groundwater upgradient, down gradient and cross gradient to FAR II will continue to be monitored during closure and post-closure in accordance with 40 CFR 257.90 through 257.98 and with the site-specific CCR Groundwater Monitoring Design Network and Statistical Analysis Plan (TRC, 2019; Geosyntec, 2020b).

SECTION 4

EFFECTIVENESS OF SELECTED REMEDY

In accordance with 40 CFR 257.97(b), this section provides an evaluation of the effectiveness of the selected remedy at protecting human health and the environment, the attaining groundwater protection standards, controlling the source, removing released material, and managing wastes during the implementation of the remedy. Additionally, this section addresses the consideration of the evaluation factors listed in 40 CFR 257.97(c).

4.1 Protection of Human Health and the Environment

Under 40 CFR 257.97(b)(1), the selected remedy must be protective of human health and the environment. The risk to human health and the environment from exposure to CCR-related constituents in groundwater at the Site was assessed (Geosyntec, 2019b). The risk assessment included an exposure assessment and a screening-level risk evaluation. The purpose of the exposure assessment was to identify potentially complete exposure pathways by which human or ecological receptors may contact lithium or molybdenum in groundwater, while the purpose of the screening level risk evaluation was to quantitatively evaluate receptor-exposure scenarios for pathways identified as complete or assumed-to-be complete.

Based on the results of the exposure assessment and screening-level risk evaluation, lithium and molybdenum in FAR II groundwater are unlikely to pose an unacceptable risk to human or ecological receptors in the vicinity of the site under current or near-term future conditions. Until the remedy can be implemented, additional actions are not necessary to protect human health and the environment. Anticipated future remedy implementation and resulting site conditions are expected to further reduce these risks.

4.2 Ability to Attain the Groundwater Protection Standards

Under 40 CFR 257.97(b)(2), the selected remedy must be able to attain the GWPSs developed for the Site pursuant to 40 CFR 257.95(h). GWPSs must be established for each detected Appendix IV constituent. The GWPS shall be the greater of the background concentration and the maximum contaminant level (MCL) established by the USEPA for that constituent. The selected remedy will achieve GWPS by reducing impacts from FAR II to groundwater in the vicinity of the unit. Evaluation of whether the remedy has achieved the GWPSs will follow the statistical approach outlined in Section 4.2.1.

4.2.1 Corrective Action Effectiveness Evaluation

Following implementation of remedial activities, a corrective action groundwater monitoring program will be established in accordance with 40 CFR 257.98(a)(1). The effectiveness of the corrective action will be evaluated by comparing groundwater monitoring results to the site GWPSs developed in 2020. A Statistical Analysis Plan (SAP) has been prepared for the Site in accordance with the CCR Rule (Geosyntec, 2020b) and USEPA's *Statistical Analysis of Groundwater monitoring Data at Resource Conservation and Recovery Act (RCRA) Facilities, Unified Guidance* (USEPA, 2009). The SAP incorporates a logic process regarding the appropriate statistical analysis of groundwater data collected in compliance with the CCR Rules. Additionally, the SAP describes the statistical procedures to be used to establish background conditions and implement corrective action monitoring.

The conclusion that the remedy has successfully decreased concentrations below the GWPS is made when average concentrations of monitoring well-constituent pairs where an SSL has previously been identified are less than the GWPS (i.e., when the *upper* confidence limit [UCL] is *less* than the GWPS). Further, a remedy is considered complete when, among other things, confidence intervals constructed for Appendix IV constituents for monitoring wells identified with SSLs have not exceeded the GWPS for three consecutive years [40 CFR 257.98(c)(2)]. The statistical analysis plan includes a detailed path for calculating the UCL for the monitoring well-constituent pairs based on the nature of the data (i.e. seasonality, distribution of data, significant non-detects, etc.).

If a corrective action monitoring program is in place, it must meet the requirements of an assessment monitoring program [40 CFR 257.98(a)(1)(i)].

4.3 <u>Source Control</u>

In accordance with 40 CFR 257.97(b)(3), the remedy must control the source such that further releases are reduced to the "maximum extent feasible". The selected remedy should result in minimal further releases, as capping and dewatering the unit to below the elevation of the colluvium landslide is expected to eliminate the main pathway of water entry from FAR II to the environment.

4.4 <u>Removal of Released Material</u>

Under 40 CFR 257.97(b)(4), the selected remedy must remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible. As

discussed in **Section 2.4**, seep water from the Jules Verne Seep is currently collected and discharged to a NPDES permitted outfall.

Assessment of the hydrogeology along the western abutment of FAD 2 indicates that collection of groundwater at the Jules Verne Seep is an effective way of capturing lithium and molybdenum impacted water released from FAR II. This practice will continue until the flow of seep water ceases after installation of the cap and dewatering of the CCR material or concentrations of lithium and molybdenum in seep water decrease below GWPS. Groundwater upgradient, within, and downgradient of the impacted portion of the aquifer will continue to be monitored to assess the post-closure groundwater concentrations as discussed in **Section 3.3.7**.

4.5 Compliance with Standards for Management of Wastes

The CCR material will be managed in compliance with applicable RCRA requirements as required under 40 CFR 257.98(d).

4.6 Evaluation Factors

In selecting the remedy, the evaluation factors listed in 40 CFR 257.97(c) were considered. A brief summary of each evaluation is provided below.

4.6.1 Long-Term and Short-Term Effectiveness and Protectiveness

In accordance with 40 CFR 257.97(c)(1), the long-term and short-term effectiveness and protectiveness of the potential remedy was evaluated, along with the degree of certainty that the remedy will prove successful based on consideration of multiple factors.

4.6.1.1 Short-Term Effectiveness and Protectiveness

As discussed in **Section 2.4**, water impacted with SSLs of lithium and molybdenum are released from the FAR II unit into the Morgantown Aquifer and ultimately discharge to the Jules Verne Seep. Impacts from the FAR II are limited to monitoring wells FA-8, M-11, M-2000, and the Jules Verne Seep (Geosyntec, 2019c). Impacted water discharged at the Jules Verne Seep is currently collected at the base of FAD 2 and discharged to the Ohio River through NPDES Permitted Outfall No. 19.

Assessment of the hydrogeology along the western abutment of FAD 2 indicates that collection of groundwater at the Jules Verne Seep is an effective way of capturing lithium and molybdenum impacted water released from FAR II. The risk assessment found that lithium and molybdenum in FAR II groundwater are unlikely to pose an unacceptable

risk to human or ecological receptors in the vicinity of the site under current or near-term future conditions (Geosyntec, 2019b).

4.6.1.2 Long-Term Effectiveness

Dewatering and capping of FAR II will provide long-term source control of lithium and molybdenum at the Site. Ponded water in the FAR II unit will be removed to a sufficient elevation to provide structural stability and capped as part of the closure plan. Dewatering will be sufficient to reduce the hydraulic head in the CCR material in FAR II to below the elevation of the landslide in the native colluvium that is the assumed entry point for the water from FAR II into the Morgantown Aquifer as discussed in **Section 2.4**. Capping will reduce to the maximum extent possible infiltration of precipitation into the groundwater system, which will reduce the future potential for groundwater flow from FAR II to the Morgantown Aquifer.

Once the remedy is in place, a groundwater monitoring program will be implemented similar to the existing and on-going monitoring program under the Federal CCR Rule. As discussed in **Section 4.1.3**, an SAP has been developed for the Site which includes a logic process regarding the appropriate statistical analysis of groundwater for corrective action monitoring. The monitoring program will meet the requirements of 40 CFR 257.98(a)(1)(i) and progress towards remedy completion will be documented in an annual report that will include [40 CFR 257.95(d)(3)]:

- Analytical results for Appendix III and detected Appendix IV constituents,
- Background concentrations for all Appendix III and Appendix IV constituents, and
- GWPSs established for detected Appendix IV constituents.

4.6.2 Effectiveness of the Remedy

In accordance with 40 CFR 257.97(c)(3), the effectiveness of the remedy in reducing further releases should include consideration of the extent to which containment practices will reduce further releases and the extent to which treatment technologies may be used. The selected remedy uses industry-standard containment technologies which are anticipated to reduce the potential for further releases. The use of treatment technologies is not included in the design of the proposed remedy.

4.6.3 Ease of Implementation

While closure of the unit is a significant effort, the remedy can be implemented with respect to infrastructure. A written Closure Plan for FAR II has been developed in accordance with 40 CFR 257.102(b) and was approved by OEPA on February 2, 2020. The Closure Plan includes a plan for Quality Assurance and Quality Control (QA/QC) during construction which will facilitate long-term operational reliability of the implemented remedy. Closure and capping of FAR II is anticipated to take five years.

4.6.4 Community Concerns

Prior to the selection of the remedy, the results of the ACM were presented at a public meeting with interested and affected parties on September 4, 2019. Attendees of the meeting expressed no direct concerns with any of the proposed remedies.

4.7 Remedy Completion

The remedy will be considered complete when compliance with the GWPS have been achieved at all points within the plume of contamination that lie beyond the groundwater monitoring well system and confidence intervals constructed for Appendix IV constituents for wells identified with SSLs have not exceeded the GWPS for three consecutive years.

Upon completion of the remedy, the facility must prepare a notification that the remedy has been completed. The notification must be certified by a qualified professional engineer or approved by the State Director or USEPA and placed in the operating record [40 CFR 257.98(e)].

SECTION 5

REMEDY IMPLEMENTATION

The proposed remedy implementation schedule was developed in accordance with 40 CFR 257.97(d) and the anticipated schedule for the closure for the FAR II unit.

5.1 Schedule of Remedial Activities

The engineering and design for the closure of FAR II was approved by OEPA in 2020 (OEPA, 2020). The plant will stop receiving process water and divert storm water flows in 2021 and begin FAR II closure. CCR closure activities are expected to take five years to complete. Experience has shown that completion of remedial activities in five years at a pond of this size is within a reasonable period of time. Post-closure care, including groundwater monitoring, is expected to continue for 30 years after closure, in accordance with 40 CFR 257.104 (c).

5.2 Schedule Implementation Factors

The proposed remedy implementation schedule considers the factors established in CFR 257.97(d), as discussed in the **Section 5.2.1** through **Section 5.2.5**.

5.2.1 Extent and Nature of Contamination

The extent of lithium and molybdenum groundwater impacts has been defined to the area near the Jules Verne Seep. Impacted water discharged at the Jules Verne Seep is currently collected at the base of FAD 2 and discharged to the Ohio River through NPDES Permitted Outfall No. 19. Collection of seep water will continue until the flow of seep water ceases or concentrations of lithium and molybdenum in seep water decrease below GWPS.

The extent and nature of contamination does not strongly influence the remedy implementation schedule. The extent of contamination in groundwater is limited to on-site impacts and is unlikely to pose an unacceptable risk to human health or ecological receptors under current or near-term future conditions (Geosyntec, 2019b).

5.2.2 Reasonable Probability of Remedial Technologies in Achieving Compliance

The selected remedy is highly likely to achieve compliance with the GWPS established for the site. As the water level within FAR II is reduced below the elevation of the colluvium landslide, the main entry point for impacts to enter the groundwater will be eliminated. Following reduction in inputs of impacts to groundwater, concentrations are

expected to decline below the GWPS and groundwater flow through the Jules Verne Seep is expected to significantly decline or cease over time.

Consequently, the reasonable probability of the selected remedy achieving compliance does not strongly influence the remedy selection implementation schedule.

5.2.3 Availability of Treatment or Disposal

Impacted groundwater is currently collected at the base of FAD 2 and discharged to the Ohio River through NPDES Permitted Outfall No. 19. Collection of seep water will continue until the flow of seep water ceases or concentrations of lithium and molybdenum in seep water decrease below GWPS.

Consequently, the availability of treatment for impacted does not strongly influence the remedy selection implementation schedule.

5.2.4 Potential Risks to Human Health and the Environment

The risk assessment conducted by Geosyntec (Geosyntec, 2019b) concluded that lithium and molybdenum in FAR II groundwater are unlikely to pose an unacceptable risk to human or ecological receptors in the vicinity of the site under current or near-term future conditions. Until the remedy can be implemented, additional actions are not necessary to protect human health and the environment.

Consequently, potential risks to human health and the environment do not strongly influence the remedy implementation schedule.

5.2.5 Resource Value of the Aquifer

Impacts of lithium and molybdenum at the Site have been delineated, with no off-site migration of impacts observed. Because there are no off-site impacts and there are no current or future uses of groundwater from the impacted aquifer on-site, the resource value of the aquifer is not affected in a way that would strongly influence the remedy implementation schedule. Additionally, the risk assessment found that lithium and molybdenum in FAR II groundwater are unlikely to pose an unacceptable risk to human or ecological receptors in the vicinity of the site under current or near-term future conditions (Geosyntec, 2019b). There are abundant alternate water supplies near the Site, with highly productive wells installed in the sand and gravel aquifer adjacent to the Ohio River, which is located less than one mile from the Site, provides abundant alternative water supplies. These resources provide additional support for the conclusion that the schedule for remedy implementation is not affected by the resource value of the aquifer.

SECTION 6

CERTIFICATION BY A PROFESSIONAL ENGINEER

By means of this certification, I certify that I have reviewed the Remedy Selection Report for the Fly Ash Reservoir II unit at the Cardinal Operating Company's Cardinal Plant and it meets the requirements of Section 40 CFR 257.97.

John Seymour, P.E.

Printed Name of Registered Professional Engineer

STATE OF OHIO
JOHN
SEYMOUR
E-85326
REGISTERED
PROFESSIONAL ENGINEER

John Seymour

Signature

E-85326	OHIO	10/19/2020
Registration No.	Registration State	Date

SECTION 7

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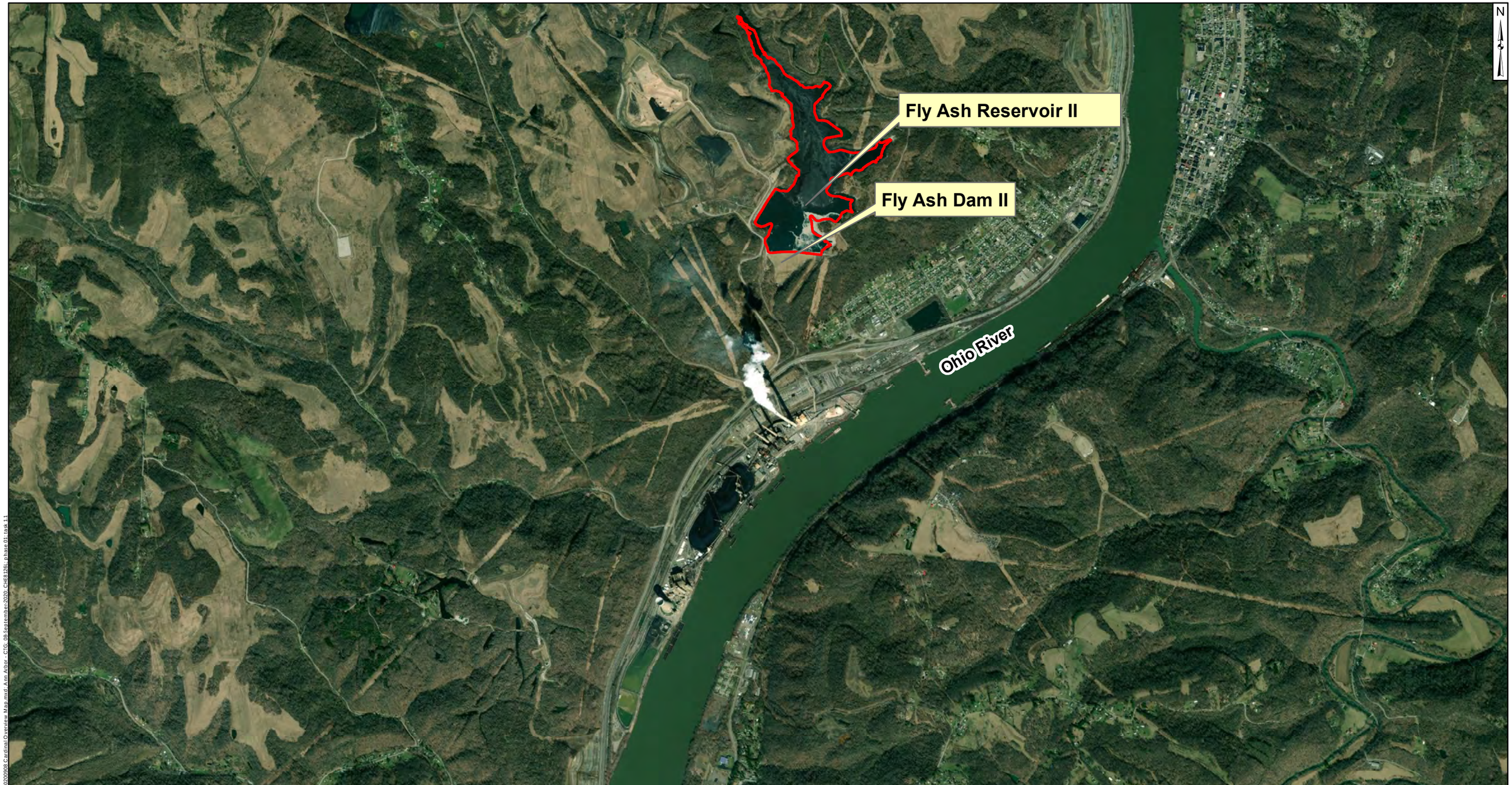
FIGURES



Legend

FAR II Reservoir

Notes
- Aerial imagery courtesy of ESRI.
- All boundaries are approximate.
- FAR = Fly Ash Reservoir

2,000 1,000 0 2,000 Feet

Fly Ash Reservoir II
Location Map

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Ann Arbor, Michigan | 09/08/2020

Figure 1

P:\Projects\AEP\Cardinal\CCR Compliance Document\Figures\20200908 Cardinal Overview Map.mxd, Ann Arbor - CTG, 08-September-2020, CHE8126, phase 01, task 11

Legend

- Monitoring Wells
- Out of Network Locations

Notes
- Monitoring well coordinates provided by Buckeye Power.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Fly Ash Reservoir II (Geosyntec, 2017) provided by Buckeye Power.

1,000 500 0 1,000
Feet

Monitoring Well Network
Fly Ash Reservoir II

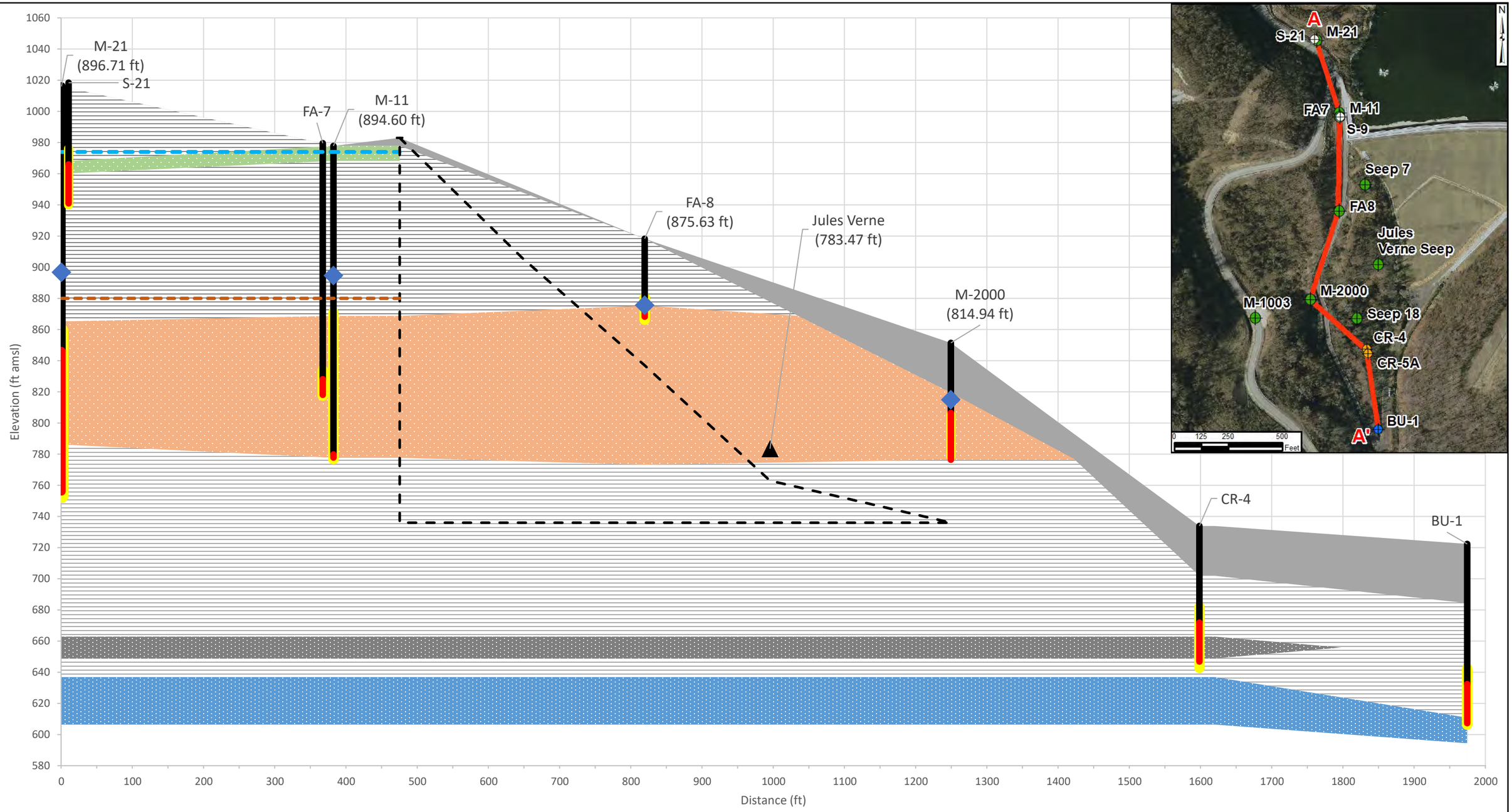
Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2020/09/09

Figure 2

P:\Projects\Buckeye Power\GIS\MXDs\FAR II\AEP-Cardinal_FAR-II_Site_Layout_20200908.mxd. HDuff. 9/9/2020. CHA8423/01/08.



Legend

- Overburden
- Shales, Limestones, Minor Sandstones
- Connellsville Sandstone
- Morgantown Sandstone
- Cow Run Sandstone
- Buffalo Sandstone
- Well Casing
- (875.63 ft) April 2020 Water Level
- Well Screen
- Well Sand Pack
- FAD II Outline
- FAR II Max Stage
- Approximate Landslide Elevation
- April 2020 Water Level in Morgantown Sandstone Well

Notes:
1. FAD – Fly Ash Dam
2. FAR – Fly Ash Reservoir
3. Elevations are approximate and were developed and interpolated from boring logs, existing cross sections, available LiDAR data, and well construction information.
4. The FAD II Outline and Jules Verne Seep locations represent an estimated projection against the cross-section plane from available LiDAR data.
5. LiDAR data for topography projections and inset aerial imagery from the Ohio Statewide Imagery Program (OSIP)
6. Inset map in Ohio State Plane North projection.

Cross Section A-A'
Fly Ash Reservoir II

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

CHA8468 | August 2020

Figure 3

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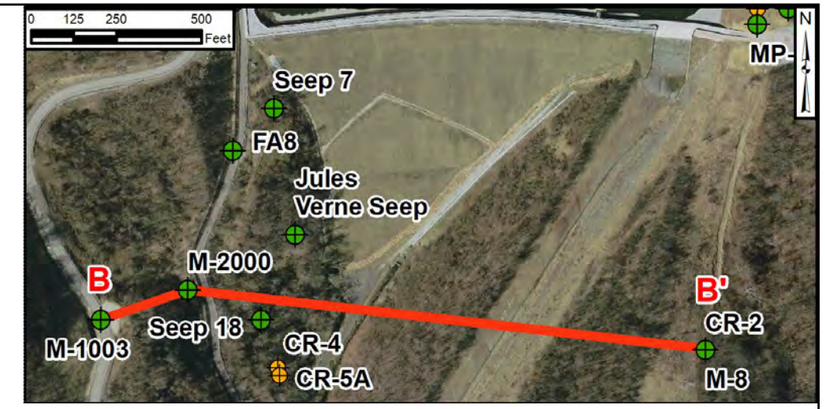

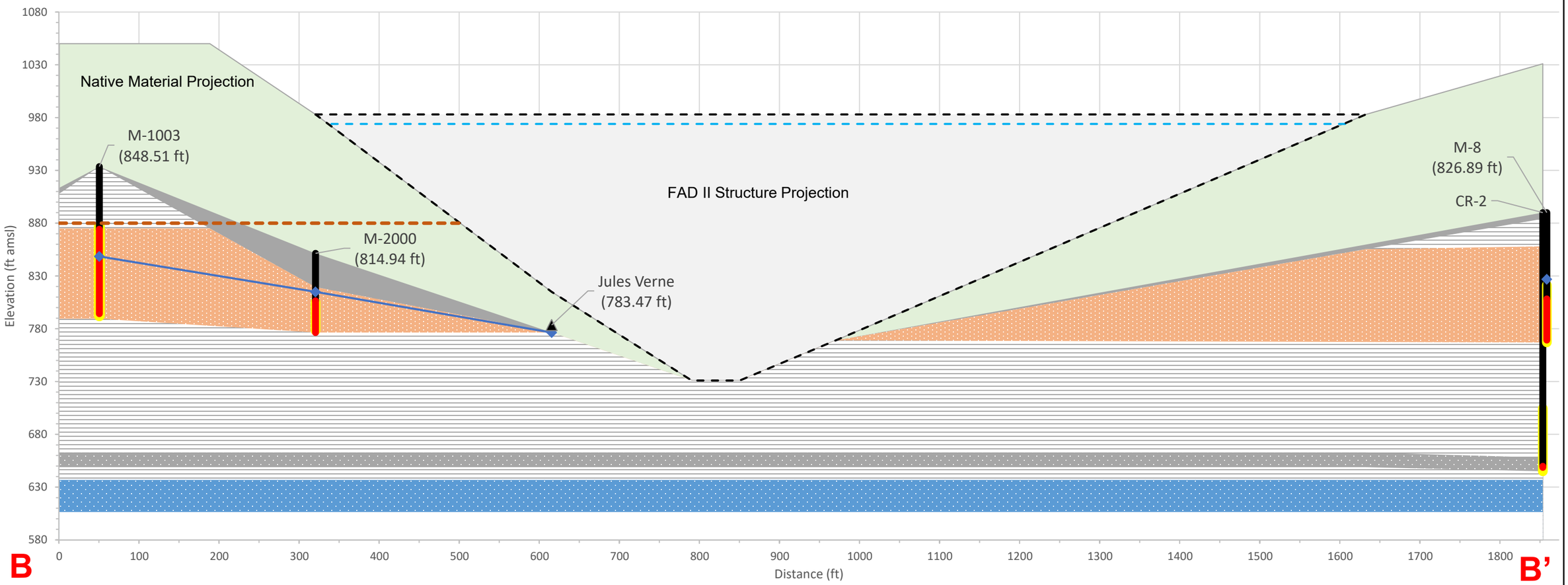

Legend

- Overburden
- Shales, Limestones, Minor Sandstones
- Connellsville Sandstone
- Morgantown Sandstone
- Cow Run Sandstone
- Buffalo Sandstone
- Well Casing
- (848.51 ft) April 2020 Water Level
- Well Screen
- Well Sand Pack
- FAD II Outline
- FAR II Max Stage
- Approximate Landslide Elevation
- April 2020 Water Level in Morgantown Sandstone Well

Notes:
1. FAD – Fly Ash Dam
2. FAR – Fly Ash Reservoir
3. Elevations are approximate and were developed and interpolated from boring logs, existing cross sections, available LiDAR data, and well construction information.
4. The FAD II Outline and Jules Verne Seep locations represent an estimated projection against the cross-section plane from available LiDAR data.
5. LiDAR data for topography projections and inset aerial imagery from the Ohio Statewide Imagery Program (OSIP)
6. Inset map in Ohio State Plane North projection.

Cross Section B-B'
Fly Ash Reservoir II

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

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Figure 4

\\annarbor-01\Data\Projects\Buckeye Power\Reporting\2020-05 Remedy Selection Report\Figures

Legend

- FAR II Network Monitoring Well
- State/Other Program Monitoring Well
- Groundwater Elevation Contour
- Approximate Groundwater Flow Direction

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 - Fly Ash Reservoir II (Geosyntec, 2017) provided by AEP.
- Groundwater discharge observed from Jules Verne Seep location.
- OAE-2005-10, M-10, M-19, and M-1001 were not gauged in March 2019.
- Groundwater elevation units are feet above mean sea level.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Morgantown Aquifer
Fly Ash Reservoir II
March 2019

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2019/06/24

Figure 5

P:\Projects\Buckeye Power\GIS\MXDs\Buckeye-Cardinal_FAR_II_GW_2019-03.mxd. ARevezzo. 6/24/2019. CHA8423/01/08.

Fly Ash Reservoir II

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)

Fly Ash Reservoir II

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-16-121

STRUCTURAL STABILITY ASSESSMENT
CFR 257.73(d)
FLY ASH RESERVOIR II
CARDINAL PLANT

GERS-16-121

PREPARED BY Mohammad A. Ajlouni, Ph.D.,P.E. **DATE** 9/28/2016

REVIEWED BY John T. Massey-Norton **DATE** 9/29/2016

APPROVED BY Gary F. Zych, P.E. **DATE** 10/5/2016

Manager – AEP Geotechnical Engineering

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)

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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. It is owned by Buckeye Power and AEP Generation Resources (GENCO) and is operated by Cardinal Operating Company. The facility operates two surface impoundments for storing CCR; the Bottom Ash Complex and Cardinal Fly Ash Reservoir II (FAR II) Dam. The focus of this report is the FAR II Dam.

The FAR II Dam is a valley filled dam with a unique structure whose current configuration is the result of the original earth fill dam and two separate raisings. The original earth fill dam (Stage 1) consisted of a 180 feet high arched earth embankment incorporating a zoned cross section. At 925 feet NGVD, the dam featured a 70-foot wide by 1,055-feet long crest. The maximum operating pool that could be achieved with the original configuration was El. 913. In 1997, the original dam was raised, referred to as Stage 2. Following this raising, the dam was 237 feet high with a 30-foot wide crest. In 2013, the dam was raised 13 feet using back-to-back MSE walls, bringing the dam into its current, Stage 3 configuration. The principal features of the typical section are the MSE wall themselves and a vinyl sheet pile wall extending from the existing clay core to the top of the PMF flood level for seepage cutoff purposes.

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.]

Since the overburden is saturated and appeared to be heterogeneous, with some material having a softer consistency than that of the sample tested, it was determined to be unsuitable as a foundation material, and was removed in the area beneath the dam and along the valley slopes up to approximately elevation 800 feet NGVD.

Based on the design drawings, a foundation key was constructed along the centerline of the dam. The key was excavated 6-8 feet into the rock beneath the dam and along the valley slopes up to approximately elevation 800 feet NGVD.

At the abutments location, a cut to rock was made at the proposed abutment. The orientation of the trimmed faces has been designed so that the upstream core of the dam intersects the abutments at right angles. This symmetrical configuration resulted in balanced seating of the clay core against the rock which reduces interface seepage and minimizes the potential for cracking of the core.

A grout curtain was provided in the abutments of the dam. The dam was arched in the upstream direction and camber was provided to compensate for settlement. Slope protection consisted of RCC

Facing for stage 2 in the upstream and grass and riprap on the downstream for stage 1 and 2 slopes with riprap in the groin of the dam. Stage 3 does not require slope protection.

Based on recent subsurface investigations, the density and description of the foundation materials are adequate for this CCR unit.

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

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

Slope protection consisted of RCC Facing for stage 2 in the upstream and grass on the downstream for stage 1 and 2 slopes with riprap in the groin of the dam. Stage 3 does not require slope protection. Any erosion 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 design drawings show that the embankment materials were to be compacted to 90% Modified proctor density. Recent borings through the embankment indicate that the material is stiff and representative of compacted earthen materials.

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 spillway system consists of a primary weir box and pipe for normal operations and an open channel spillway to pass flood events. The CCR unit has a high Hazard rating and design flood is the PMF flood. The facility can safely pass this flood (PMF) without overtopping the dam crest.

7.1 SERVICE SPILLWAY

The existing service spillway is a vertical concrete shaft structure with side opening for effluent discharge connecting into a sloping concrete shaft structure with one side opening, four feet wide, connecting into a 54 inch diameter pre-stressed concrete cylinder pipe (PCCP), designed for 200 feet of internal hydraulic pressure and 200 feet of overburden pressure. During most operating conditions, discharge through the service spillway is controlled by the-weir flow over the side openings in the shaft. The bottom of the sloping concrete shaft and the entire 54-inch concrete pipe were constructed within bedrock as part of the 1997 raising. Stop logs are utilized to maintain settling action and control the operating pool level.

Results of the reservoir routings establish a maximum operating level of 974.0 feet, with the 50-year design flood reaching a level of 975.5 feet, 1.5 feet above the maximum operating pool.

7.2 EMERGENCY SPILLWAY

As of 2013 construction, the existing emergency was raised to El. 975.5 through the use of a mass concrete gravity section in conjunction with reinforced concrete training walls, in a manner similar to the existing configuration. The new walls direct the flow into the existing spillway outlet channel.

In accordance with State of Ohio dam safety requirements for Class 1 dams, the new emergency spillway was designed to pass the design probable maximum flood (PMF) without overtopping the dam. The new spillway features a 108 foot long by 15 foot wide concrete control section positioned at El. 975.5, or 1.5 feet above the maximum operating pool. The training walls are located above elevation 975.5 and will consequently not be exposed to a continuous pool reducing corrosion concerns.

Based on the flood routing, the calculated peak discharge from the dam is 5,409 cfs at a maximum pool elevation of 981.9 feet NGVD. The PMF routing was also checked with the service spillway blocked, which resulted in a maximum pool elevation of 982.8 and 0.2 feet of freeboard.

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 principal outlet pipe from FAR II Pond passes though the dam near the southwestern side of the impoundment. The portion of the outlet pipe that passes though the embankment is a 54 inch diameter pre-stressed concrete cylinder pipe (PCCP), designed for 200 feet of internal hydraulic pressure and 200 feet of overburden pressure. The entire 54-inch concrete pipe was constructed within bedrock as part of the 1997 raising. There are no performance issues with the outlet pipe that would indicate plugging or failure of the pipe. Given that this portion of pipe is reinforced concrete, structural integrity is not considered to be an issue. In general reinforced concrete pipe has a long service life under a range of conditions and is an appropriate design for this application.

Based on recent video inspection of the pipe, the concrete pipe is in excellent conditions with no signs of deformation or deterioration.

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 Fly Ash Reservoir II is not expected to be inundated from any adjacent water bodies.

Fly Ash Reservoir II

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

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

Fly Ash Reservoir II Dam
Initial Safety Factor Assessment

Cardinal Power Plant
Brilliant, Ohio
S&ME Project No. 7217-15-006A

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

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

September 18, 2015

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Appendix I – Safety Factor Assessment Figures

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*. S&ME performed the design and construction administration for the dam raising completed in 2014. 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 Historic Overview

The Cardinal Power Plant is located along the Ohio River, approximately 8 miles south of Steubenville in Jefferson County. Then Fly Ash Reservoir II is an on-stream reservoir within the east branch of Blockhouse Run, located approximately, three-quarters of a mile north of the plant. Completed in 1986, the original earth fill dam, referred to as Stage 1, consisted of a 180 feet high arched dam constructed as a conventional zoned earth embankment. At 925 feet NGVD, the dam featured a 70-foot wide by 1,055-feet long crest. The maximum operating pool that could be achieved with the original configuration was El. 913. Construction of the first dam raising, referred to as Stage 2, was completed in 1997 which brought the dam to a maximum height of 225 feet with a 30 foot wide crest at Elevation 970 feet and a maximum operating pool Elevation of 960 feet. The dam raising was achieved through the use of an upstream soil cement block (cement stabilized bottom ash) in conjunction with a downstream earth fill along with extensions of the upstream bottom ash filter, clay core, chimney drain and downstream mine spoil shell. At the completion of the 1997 raising, the upper portion of the entire dam crest consisted of a minimum of 9 feet of RCC to both protect the dam from erosion and serve as a roadway. In 2013, the dam was raised an additional 13 feet with the construction of a double-sided mechanically stabilized earth (MSE) wall system on top of the RCC, raising the maximum operating pool to Elevation 974 feet. To control seepage, a cement-bentonite slurry wall was constructed which penetrated into the existing clay core. A non-structural vinyl sheet pile wall was then inserted full depth through the slurry wall and extended to the top of the raised dam in between the MSE reinforced zones. The raised dam also includes a modified auxiliary spillway composed of mass concrete, and a precast service spillway extension.

Figure 1-1 – Location Map

1.3 Previous Investigations and Design Work

In 2010, the undersigned senior engineer, when in the employment of BBC&M Engineering, Inc., completed a supplemental geotechnical assessment of the FAR-II Dam. The assessment consisted of performing slope stability analysis for various steady-state, seismic, rapid drawdown, and surcharge loading cases load cases which were not previously addressed.

S&ME began design work for the FAR-II dam raising in 2011. In support of the design, S&ME conducted a subsurface investigation consisting of soil borings, test pits, and core samples of the soil cement block. S&ME then worked closely with AEP and state dam safety officials to permit this unique structure,

including evaluating a variety of seepage and stability failure modes as well as the potential for corrosion of the reinforced concrete wall panels. S&ME then served in a construction administration role for the duration of construction. Upon completion of the project in April of 2014, S&ME issued an Engineering Certification Letter to the Ohio Department of Natural Resources, Division of Soil and Water. S&ME also completed a First Filling Plan and updated the Operation, Maintenance, and Inspection Manual and Emergency Action Plan.

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 the previously conducted design work for the recent dam raising, as well as a previous design reports and construction documents made available by AEP.

2. S&ME visited the site along with personnel from AEP to observe the facility. It should be noted that the ODNR Division of Soil and Water, Dam Safety Section conducted the 1-year inspection of the dam in June of 2015 and concluded that construction was performed in accordance with the terms of the permit, plans, specifications, and approved changes.

3. Action values relating to instrumentation measurements were determined based on slope stability analyses using the critical cross-section and examination of historical piezometer readings provided by AEP.

4. Upon completing Tasks 1 through 4, S&ME's determined that there was sufficient information to certify the structural integrity of the surface impoundment in accordance with the requirements of 40 CFR § 257.73(e). A separate letter has been prepared to this effect.

3.0 Information Review and Site Visit

To support the safety factor assessment, S&ME conducted a cursory review of previous documents relating to the FAR-II Dam and conducted a site visit at the facility. While not a comprehensive list, AEP provided S&ME with the following documents during the course of our involvement with this facility:

- Design Report: Proposed Dam for Fly Ash Retention Pond II, December 1984
- Construction Plans, Fly Ash Dam 2
- Final Design Report: Proposed Earth Fill-Roller Compacted Concrete Raising of Dam for Fly Ash Retention Pond II, March, 1997
- Construction Plans, Dam Raising of Fly Ash Retention Dam II, March 1997
- RCC QA/QC Plan for 1997 Raising, July 1998
- 1997 Failure Repair Report
- 1999 Post Construction Performance Report
- 2004 Seepage Report

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 FAR-II Dam. The participants observed the site and discussed recent monitoring results, as well as

tentative plans to raise the pool level by adding additional stop logs. S&ME observed slight rutting along the wheel path on top of the dam, as well as minor settlement of the granular infill adjacent to the panels. Instrumentation readings from 12 tiltmeter sensors placed on the MSW wall panels indicate that both the upstream and downstream MSE wall panels are leaning outward slightly, however the rate of movement has now generally leveled off. This outward tilt appears to be an expression of the rotational movement needed to fully engage the geogrid reinforcement. S&ME understands that AEP is closely monitoring the ongoing instrumentation readings. While the site visit was not a formal inspection, visual observations of the FAR-II Dam did not reveal any dam safety concerns, and the downstream slopes appear to be in a similar condition as observed during construction of the recent dam raising.

4.0 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.

4.1 Limit Equilibrium Analyses

Our 2013 Dam Raising Design Report discusses 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 FAR-II Dam Raising design. S&ME focused on evaluating the cross-section through the high point of the dam with additional slope stability runs performed for the section through the existing emergency spillway. Two dimensional slope stability analyses were performed under End of Construction, Long Term Maximum Pool (Static), Maximum Surcharge Pool, Rapid Drawdown, and seismic loading conditions in conformance with the US Army Corps of Engineers Manual 1110-2-1902 entitled Slope Stability. The phreatic surface was modeled based on current piezometer data collected from at the site and the results of the finite element seepage analysis. However, the phreatic surface was entered manually to minimize the potential for computation uncertainty as compared to directly using the finite element analysis output pressures.

Shear strength parameters representing the existing dam zones were developed by AEP and their consultants for the design of the Stage 1 and Stage 2 dams. These values were used as the starting point for the Stage 3 global stability analyses but were modified in some cases to reflect the results of the current investigation or to investigate particular failure modes. Additionally, the Stage 3 raising included several new material zones: the MSE wall reinforced zone (No. 57 stone), ODOT Item 304 surface course,

the cement-bentonite slurry wall, and the vinyl sheet pile wall. The shear strength parameters for these new materials were estimated based on past experience. It should also be noted that the strength of these materials does not appreciably impact the global stability analyses. Additional discussion of the shear strength values for the most critical zones is provided in the 2013 Final Design Report.

4.2 Liquefaction Potential of Embankment Soils

S&ME reviewed the material and compaction specifications of the embankment fill for the original dam construction and subsequent raisings. The dam was constructed entirely of engineered materials and was designed in accordance with the methods used to design conventional water reservoirs. The embankment fill consists of fine grained overburden soil and mine spoil fill from near the project site. With the exception of the blanket drain, chimney drain, and rip rap zone, all earthen material was compacted to 100% of the standard proctor compaction test. Based on this understanding, the embankment soils are considered non-liquefiable. Furthermore, liquefaction of the foundation soils is not a concern as the overburden beneath the dam was removed prior to fill placement, with the dam supported directly on bedrock

4.3 Summary of Results

Based on our previous investigations and current assessment of the Bottom Ash Pond facility, S&ME certifies that this assessment meets the requirements of 40 CFR § 257.73(e), *Periodic Safety Factor Assessments*. A summary of the computed safety factors for the critical cross-section is provided in Table 5-1. 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 II.

Table 4-1 – Safety Factor Summary

Analysis Case	Minimum Safety Factor	Computed Safety Factor
Long-term, maximum storage pool	1.50	1.75
Maximum surcharge pool	1.40	1.68
Pseudo-static seismic loading	1.00	1.11
Embankment Liquefaction	1.20	Non-liquefiable

5.0 Certification

Based on our previous investigation, design, and construction administration work associated with the Fly Ash Reservoir II Dam, S&ME certifies that this assessment meets the requirements of 40 CFR § 257.73(e), *Periodic Safety Factor Assessments.* A summary of the computed safety factors for the critical cross-section is provided in the table below. Also included in the table are the minimum values defined in 40 CFR § 257.73(e)(1) subparts (i) through (iv).

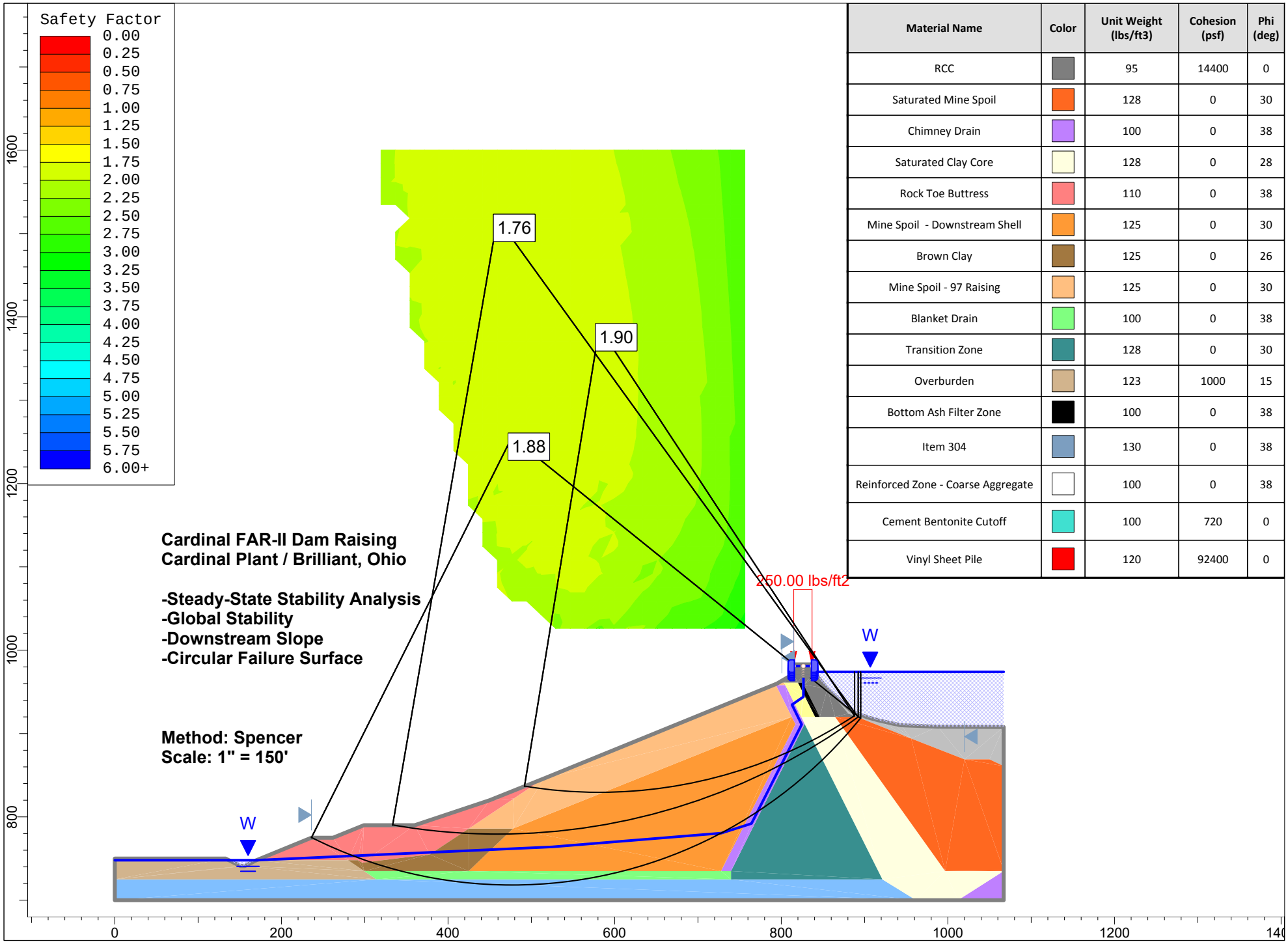
Michael T. Romanello, P.E.
Project Engineer
Registration No. 74384

STATE OF OHIO
MICHAEL GILBERT ROWLAND
#E-65559
REGISTERED
PROFESSIONAL ENGINEER
9-18-15

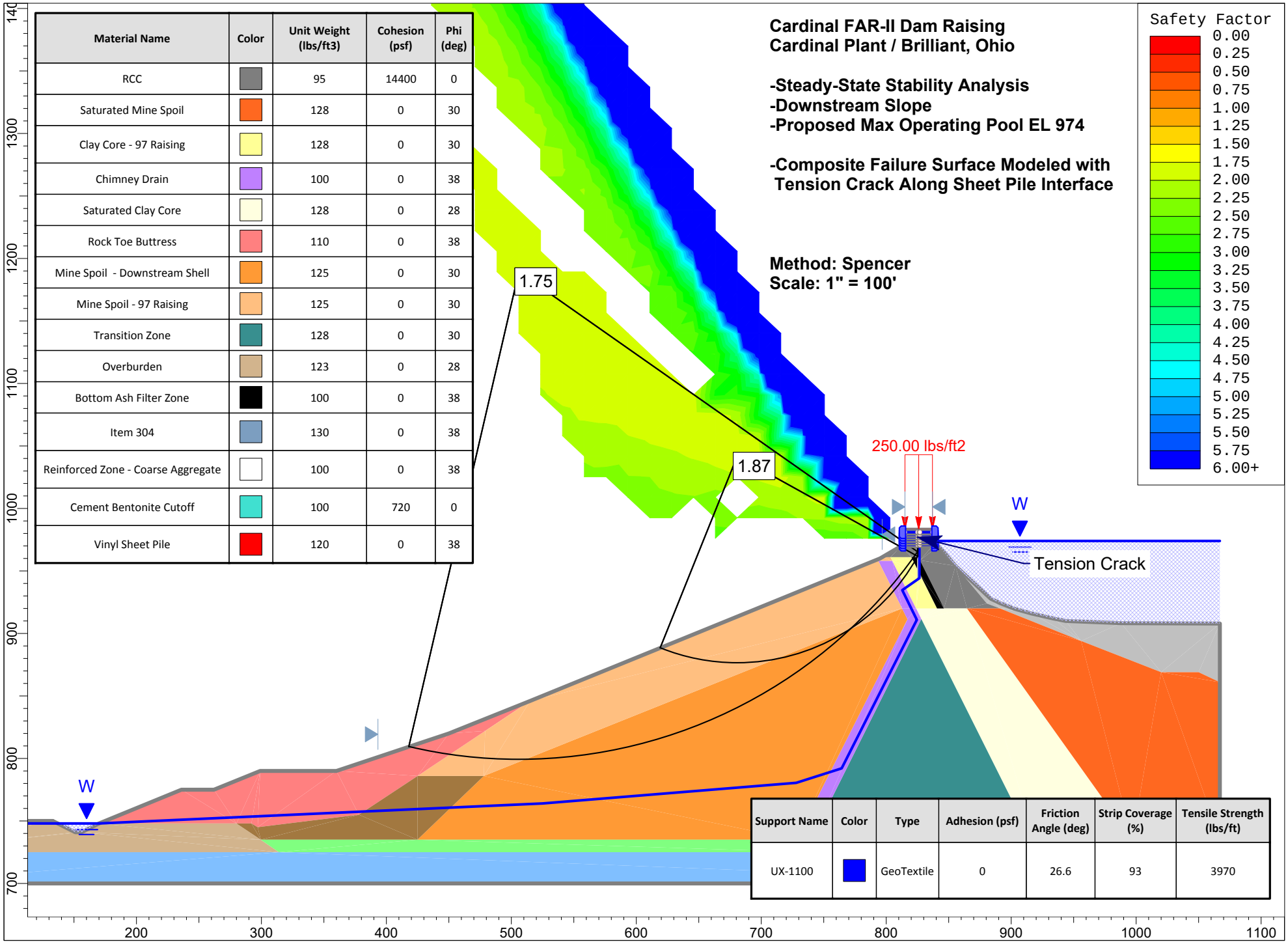
Michael G. Rowland, P.E.
Senior Engineer
Registration No. 65559

Appendices

Appendix I – Safety Factor Assessment Figures

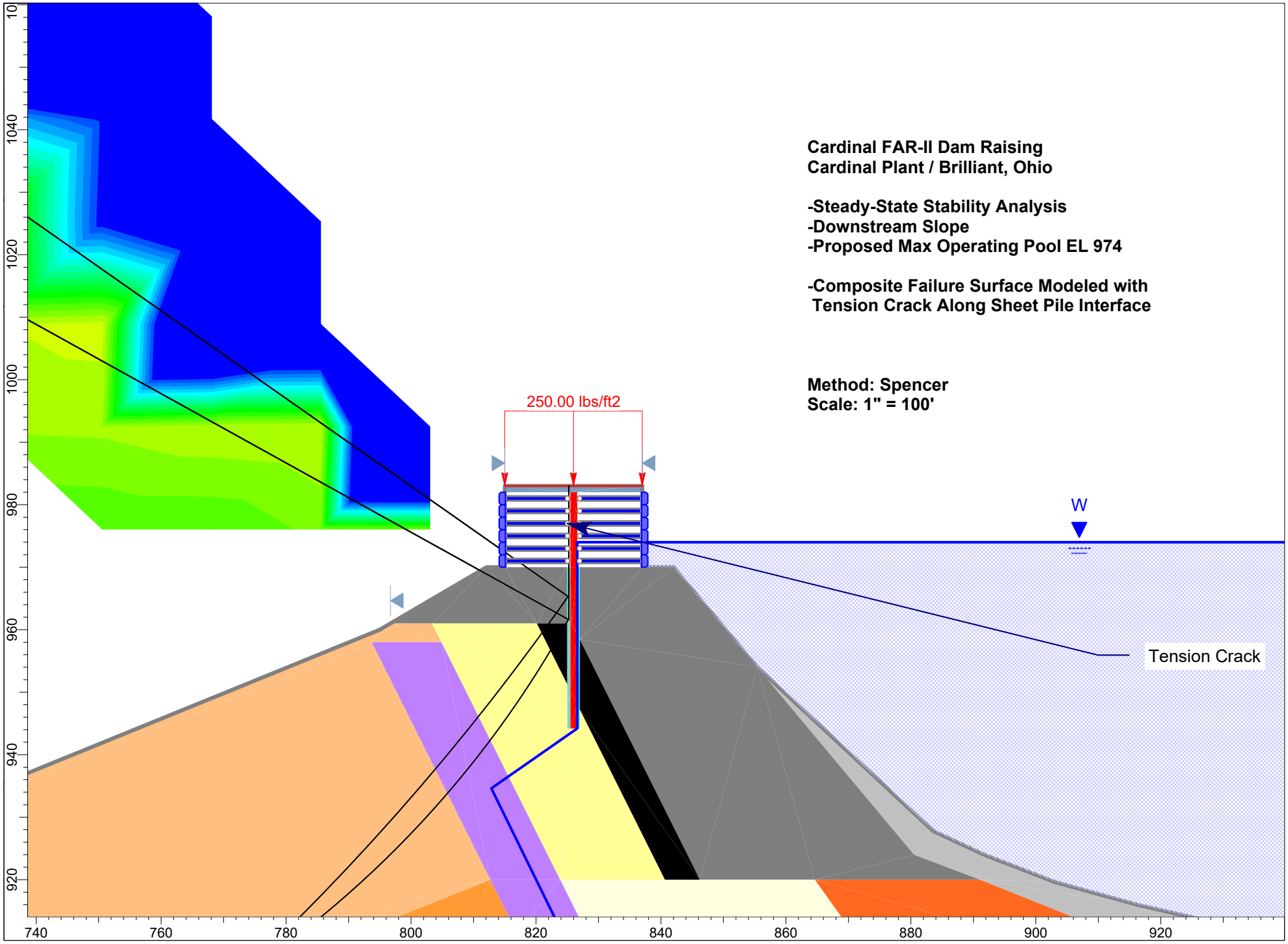


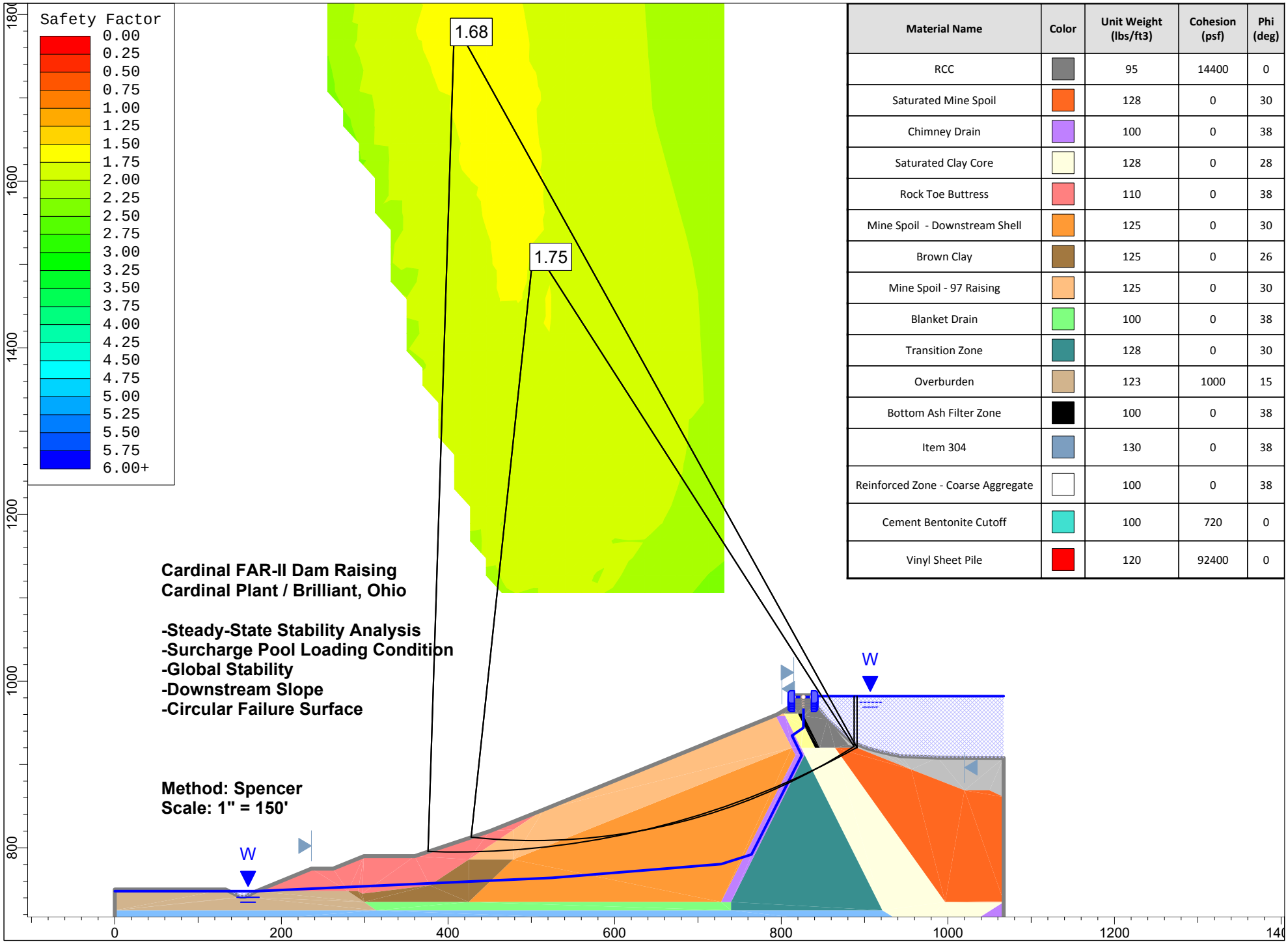
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
RCC		95	14400	0
Saturated Mine Spoil		128	0	30
Chimney Drain		100	0	38
Saturated Clay Core		128	0	28
Rock Toe Buttress		110	0	38
Mine Spoil - Downstream Shell		125	0	30
Brown Clay		125	0	26
Mine Spoil - 97 Raising		125	0	30
Blanket Drain		100	0	38
Transition Zone		128	0	30
Overburden		123	1000	15
Bottom Ash Filter Zone		100	0	38
Item 304		130	0	38
Reinforced Zone - Coarse Aggregate		100	0	38
Cement Bentonite Cutoff		100	720	0
Vinyl Sheet Pile		120	92400	0



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
RCC		95	14400	0
Saturated Mine Spoil		128	0	30
Clay Core - 97 Raising		128	0	30
Chimney Drain		100	0	38
Saturated Clay Core		128	0	28
Rock Toe Buttress		110	0	38
Mine Spoil - Downstream Shell		125	0	30
Mine Spoil - 97 Raising		125	0	30
Transition Zone		128	0	30
Overburden		123	0	28
Bottom Ash Filter Zone		100	0	38
Item 304		130	0	38
Reinforced Zone - Coarse Aggregate		100	0	38
Cement Bentonite Cutoff		100	720	0
Vinyl Sheet Pile		120	0	38

Support Name	Color	Type	Adhesion (psf)	Friction Angle (deg)	Strip Coverage (%)	Tensile Strength (lbs/ft)
UX-1100		GeoTextile	0	26.6	93	3970


Cardinal FAR-II Dam Raising
Cardinal Plant / Brilliant, Ohio
-Steady-State Stability Analysis
-Downstream Slope
-Proposed Max Operating Pool EL 974
-Composite Failure Surface Modeled with
Tension Crack Along Sheet Pile Interface
Method: Spencer
Scale: 1" = 100'
250.00 lbs/ft2
W
Tension Crack
1040
1020
1000
980
960
940
920
740
760
780
800
820
840
860
880
900
920



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
RCC		95	14400	0
Saturated Mine Spoil		128	0	30
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Mine Spoil - 97 Raising		125	0	30
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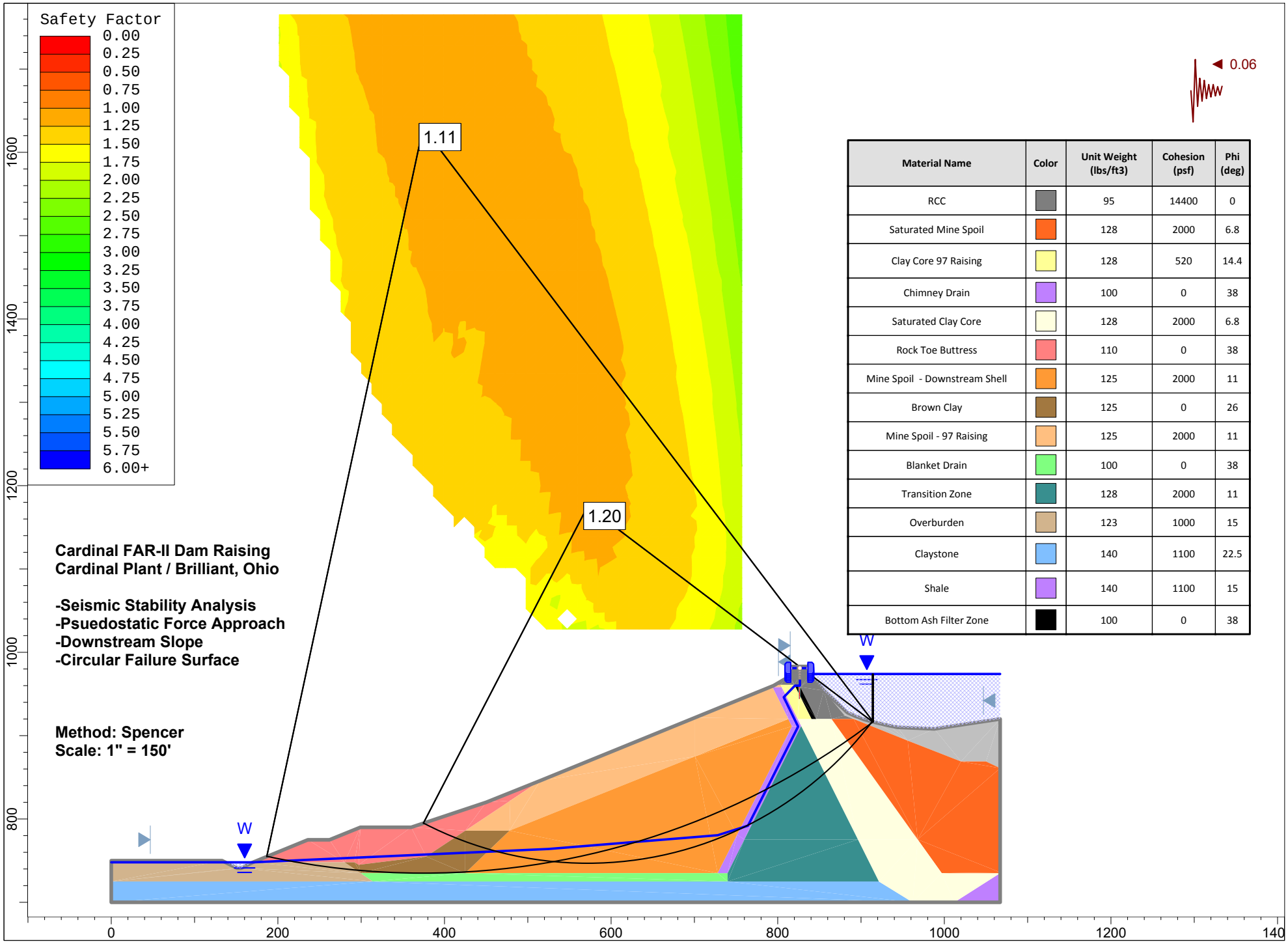
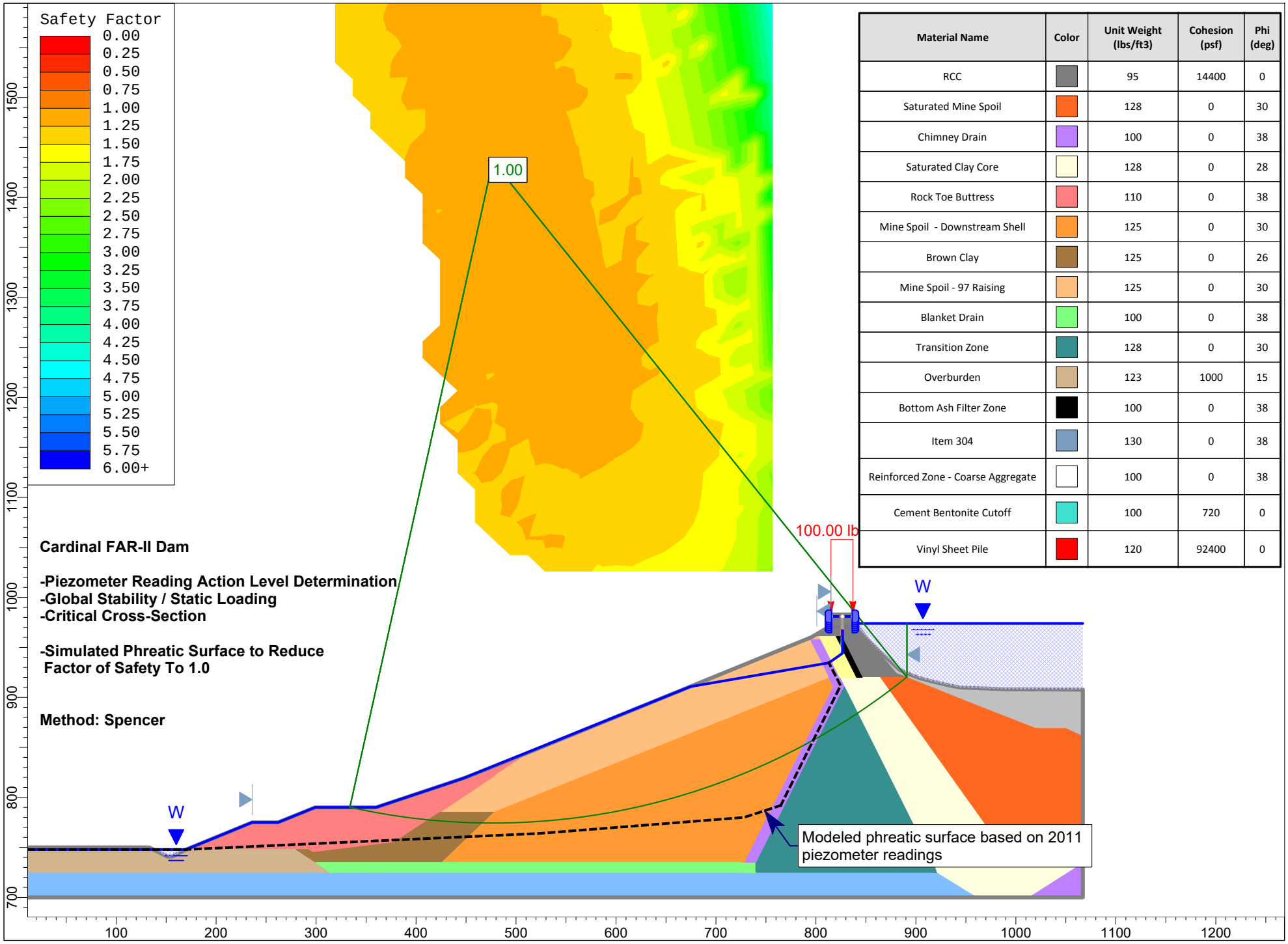
Transition Zone		128	0	30
Overburden		123	1000	15
Bottom Ash Filter Zone		100	0	38
Item 304		130	0	38
Reinforced Zone - Coarse Aggregate		100	0	38
Cement Bentonite Cutoff		100	720	0
Vinyl Sheet Pile		120	92400	0

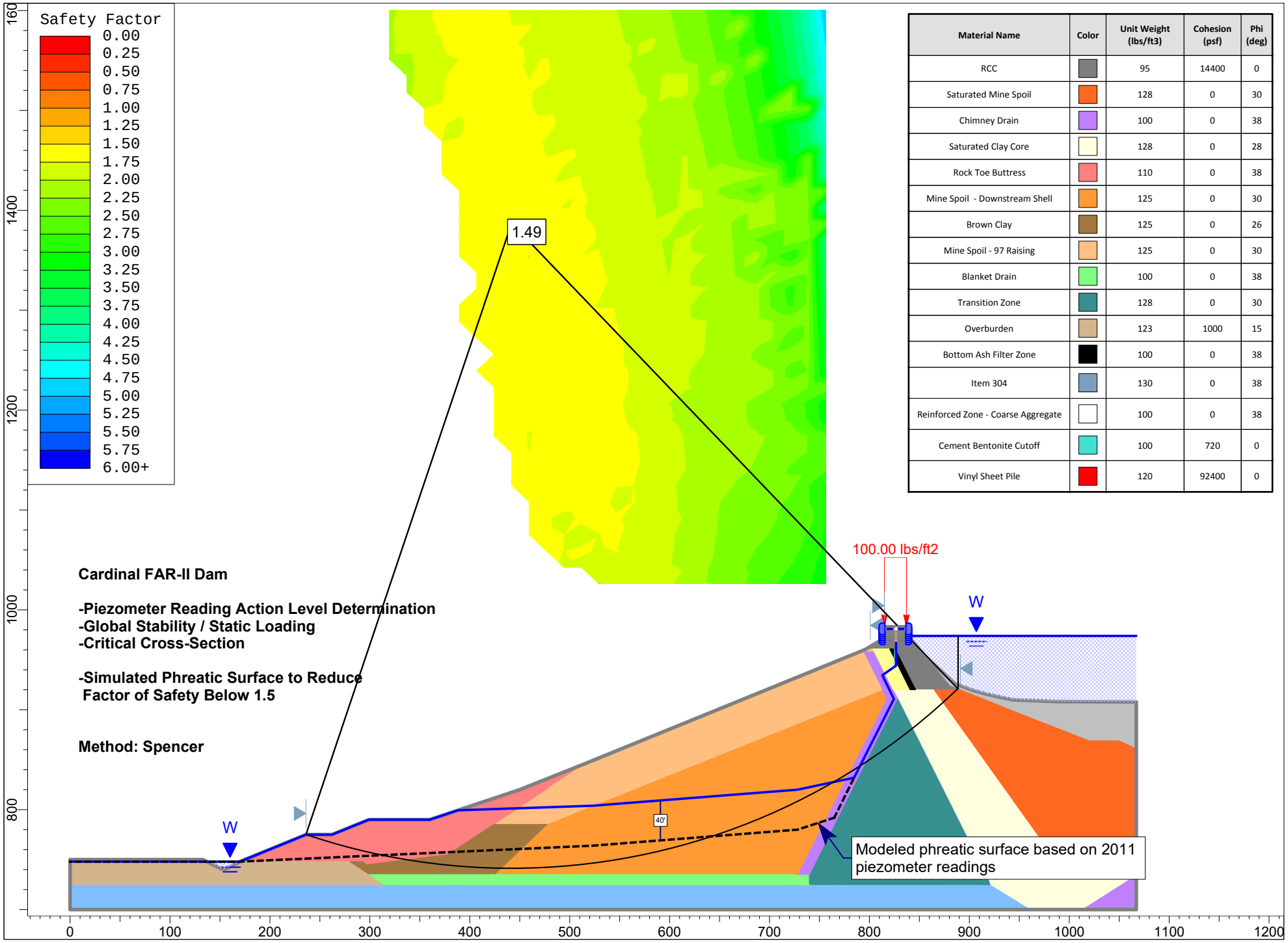


Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
RCC		95	14400	0
Saturated Mine Spoil		128	2000	6.8
Clay Core 97 Raising		128	520	14.4
Chimney Drain		100	0	38
Saturated Clay Core		128	2000	6.8
Rock Toe Buttress		110	0	38
Mine Spoil - Downstream Shell		125	2000	11
Brown Clay		125	0	26
Mine Spoil - 97 Raising		125	2000	11
Blanket Drain		100	0	38
Transition Zone		128	2000	11
Overburden		123	1000	15
Claystone		140	1100	22.5
Shale		140	1100	15
Bottom Ash Filter Zone		100	0	38

Appendix II – Action Value Recommendation Figures

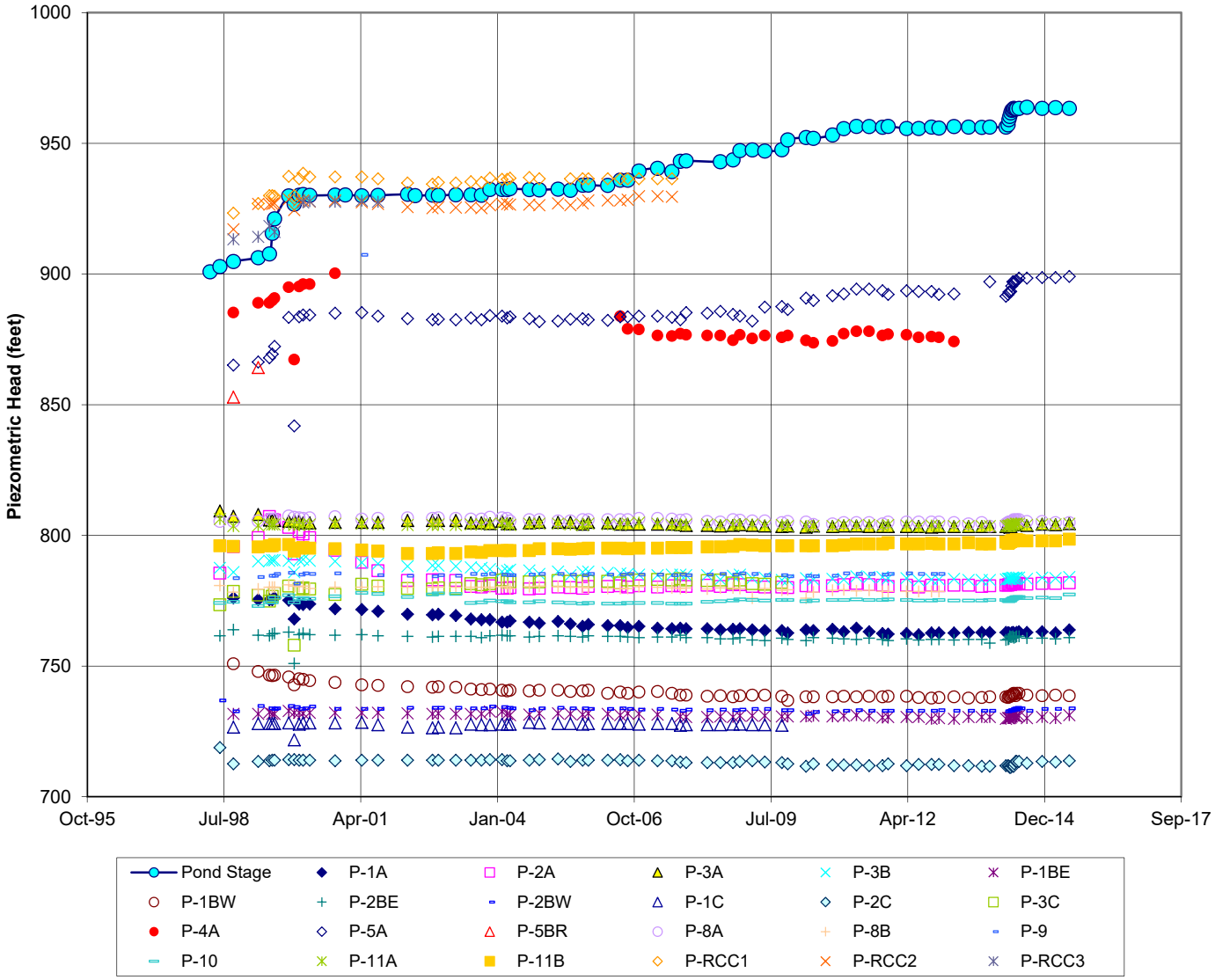


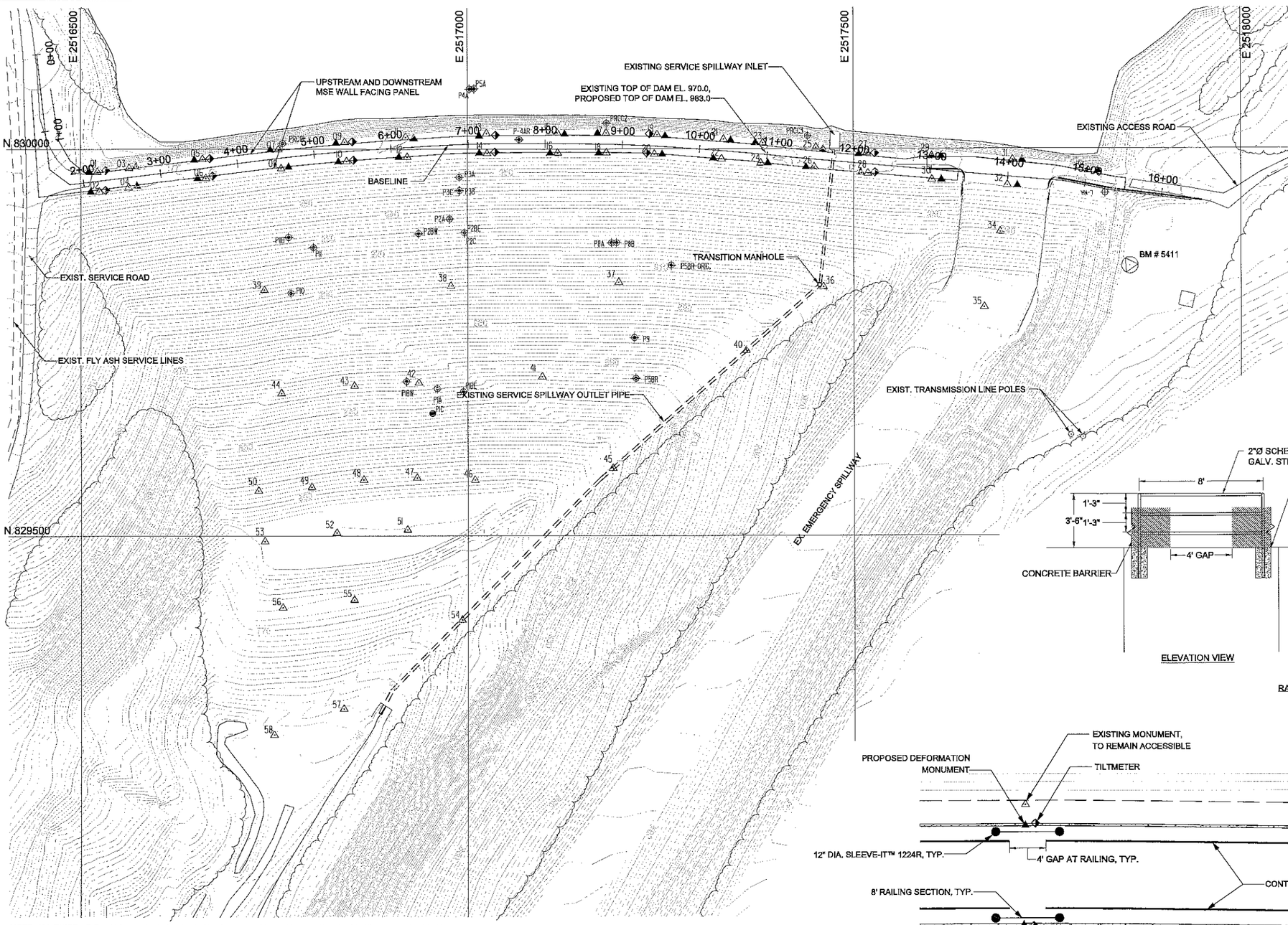
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
RCC		95	14400	0
Saturated Mine Spoil		128	0	30
Chimney Drain		100	0	38
Saturated Clay Core		128	0	28
Rock Toe Buttress		110	0	38
Mine Spoil - Downstream Shell		125	0	30
Brown Clay		125	0	26
Mine Spoil - 97 Raising		125	0	30
Blanket Drain		100	0	38
Transition Zone		128	0	30
Overburden		123	1000	15
Bottom Ash Filter Zone		100	0	38
Item 304		130	0	38
Reinforced Zone - Coarse Aggregate		100	0	38
Cement Bentonite Cutoff		100	720	0
Vinyl Sheet Pile		120	92400	0



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
RCC		95	14400	0
Saturated Mine Spoil		128	0	30
Chimney Drain		100	0	38
Saturated Clay Core		128	0	28
Rock Toe Buttress		110	0	38
Mine Spoil - Downstream Shell		125	0	30
Brown Clay		125	0	26
Mine Spoil - 97 Raising		125	0	30
Blanket Drain		100	0	38
Transition Zone		128	0	30
Overburden		123	1000	15
Bottom Ash Filter Zone		100	0	38
Item 304		130	0	38
Reinforced Zone - Coarse Aggregate		100	0	38
Cement Bentonite Cutoff		100	720	0
Vinyl Sheet Pile		120	92400	0

Figure 5a
Cardinal Far 2





PIEZOMETER #	NORTH	EAST	TIP ELEV.
P6B	829880.385	2517198.101	776.0
P6A	829890.185	2517191.730	802.1
P2BE nested	829893.405	2517001.135	730.0
P2C nested	829893.405	2517001.135	711.0
P3B nested	829965.095	2516994.335	772.3
P3A nested	829965.095	2516994.335	802.3
P3C	829947.865	2516994.545	712.3
P2BW	829892.985	2516941.390	731.1
P2A	829910.895	2518891.870	771.0
P11	829874.275	2518865.610	802.6
P11B	829867.670	2516773.430	789.1
P10	829815.120	2516776.440	759.1
P9	829757.800	2517221.600	771.2
P1BE	829687.855	2516999.390	728.0
P1A	829692.010	2516965.335	752.3
P1C	829692.010	2516965.335	714.4
P5BR-Orig.	829851.135	2517269.030	725.0
P5BR-el. daylite	829705.160	2517222.820	CONNECTOR EL.997.0
P1BW	829701.320	2516925.760	735.9
PRCC3	830018.040	2517446.700	913.3
PRCC2	830034.680	2517185.460	913.4
PRCC1	830006.870	2516765.950	923.3
P4A	830078.650	2517007.960	801.7
P4AR	830014.140	2517072.240	969.6
P5A	830078.170	2517013.940	774.7

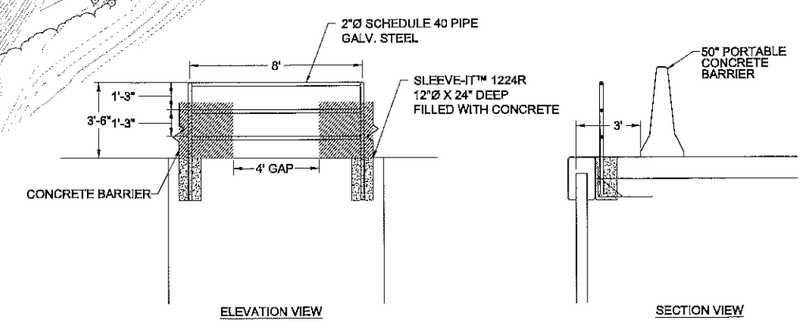
LEGEND

- EXISTING CONTOUR 10FT INTERVAL
- EXISTING CONTOUR 2FT INTERVAL
- EXISTING ACCESS ROADS
- EXISTING FLY ASH SERVICE LINES
- BENCHMARK
- EXISTING TREELINE
- EXISTING DEFORMATION MONUMENT NO. 29901-29958 (LAST TWO DIGITS SHOWN ON THE PLAN)
- NEW DEFORMATION MONUMENT
- NEW TILTMETER
- EXISTING PIEZOMETER
- NEW PIEZOMETER

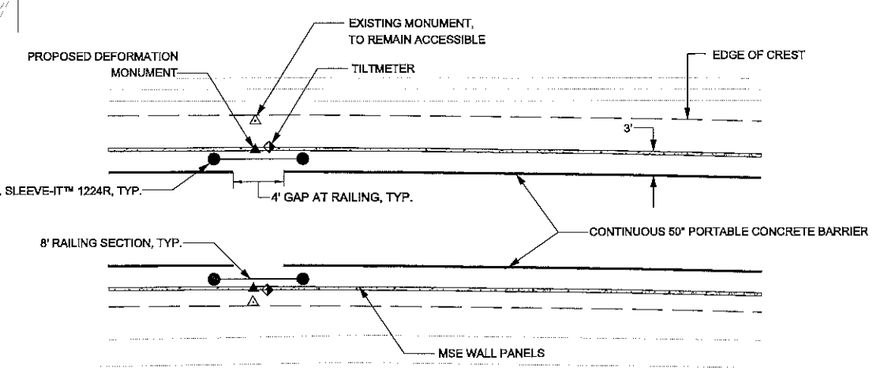
SCALE IN FEET (0, 50, 100)

GENERAL NOTES

1. TOPOGRAPHIC MAPPING DEVELOPED FROM AERIAL SURVEY PERFORMED ON 3/5/2009 AND 1986 AS-BUILT DATA.



RAILING AND BARRIER DETAIL
N.T.S.



RAILING AND BARRIER PLAN
N.T.S.

NOTE: ALL EXISTING DEFORMATION MONUMENTS TO REMAIN ACCESSIBLE EXCEPT #29931 THROUGH #29934.

⚠ ALL OF EXISTING DEFORMATION MONUMENTS DESTROYED DURING CONSTRUCTION

⚠ NEW DEFORMATION MONUMENTS AND TILTMETERS ARE SHOWN NEAR AS-BUILT LOCATION

S&ME, INC.
6190 ENTERPRISE COURT
DUBLIN, OH 43016
PHONE: 614-793-2226
FAX: 614-793-2410
www.smeinc.com

STATE OF OHIO — MICHAEL GILBERT ROWLAND — E-65559 — REGISTERED PROFESSIONAL ENGINEER

MICHAEL GILBERT ROWLAND | E-65559 NUMBER | JAN 18, 2013 DATE

DATE	NO.	DESCRIPTION	APPD.
3/23/14	D	AS-BUILT SUBMITTAL	MGR
1/16/13	C	REVISED PER ODNR COMMENTS REC'D 12/4/2012	MGR
9/12/12	B	REVISED PER ODNR COMMENTS REC'D 7/18/12	MGR
5/23/12	A	ISSUED FOR PERMIT INITIAL SUBMITTAL	MGR

REVISIONS

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CARDINAL OPERATING COMPANY

CARDINAL PLANT

BRILLIANT OHIO

DAM RAISING

FLY ASH RETENTION DAM II

INSTRUMENTATION PLAN

DWG. NO. 13-38858-0

ARCH — ELEC — MECH — STR CS

SCALE: AS SHOWN | CIVIL ENGINEERING DIVISION

PROJECT NUMBER: 011-11497-042	DRAWN BY: EDV	S&ME	AMERICAN ELECTRIC POWER — 1 RIVERSIDE PLAZA COLUMBUS, OH 43215
DRAWING DATE: 9/28/12	ENGINEER: MTR		
LAST UPDATED: 1/18/13	APPROVED BY: MGR		
	SCALE: AS NOTED		

SYSTEM DATE: 20-MAR-2014 SYSTEM TIME: HH:MM:SS

Bottom Ash Pond

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.

Bottom Ash Pond

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:

- 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. 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

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
	0					AGGREGATE - 34 INCHES	
667.0		1	47/34/26	75	100		
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
662.8	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.	
		4	7/40/7	59	67		
658.3		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
	10	7	6/8/5	16	100		H=2.5-3.5
653.8		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'.	
	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		
		16	6/3/2	6	80		
643.8	25						
		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
641.0		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
	30						

NATURAL CONSISTENCY INDEX — NATURAL MOISTURE CONTENT — PLASTIC LIMIT — LIQUID LIMIT — 10 20 30 40

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-

2010 NEW DEFAULT BORING LOG-W/ N60

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

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
	30								
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 22B 22C	■	SH / SH / 1	0	100			H=1.0-1.5
	40						Very-loose gray fine to coarse sand, interbedded with silty clay seams, wet.		
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'. - Encountered cobbles at 4.4 and 18.2'. - Borehole converted to monitoring well upon completions. See separate well completion diagram. - Boring locations and elevation surveyed by AEP. - Datum: Ohio State Plane South. - NAD 27/NAVD 29 (Plant Grid).		
	60								

2010 NEW DEFAULT BORING LOG-W/ N60

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

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 EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
	0					AGGREGATE - 23 INCHES	
668.0		1	19/11/25	45	87		
666.3		2	25/33/30	79	47	FILL: Dense to very-dense dark-gray fine to coarse sand, trace to little fine gravel, trace to little silt, moist.	
	5	3	33/11/8	24	60	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.	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							
	15	10	3/6/5	14	67	FILL: Medium-stiff to very-stiff brown mottled with gray silty clay, some fine to coarse sand, little fine to coarse gravel, moist.	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							
	20	13	3/3/4	9	87	FILL: Very-loose to loose dark-gray fine to coarse sand, trace to little fine gravel, little silt, moist becoming wet.	H=2.0
		14	3/4/3	9	67		
		15	SH/SH/1	0	100	- Contains sand seams at 20.0' to 20.3'.	
		16	SH/1/1	3	100		
644.7	25	17	1/1/1	3	100		H=0.5
643.9						FILL: Very-loose dark-gray silt, trace fine to coarse sand, slightly organic, wet.	
		18	SH/SH/3	0	53	Stiff gray mottled with brown silty clay, some fine sand, trace medium to coarse sand, slightly organic, silt seams, damp.	H=2.0
641.9							
		19	SH/SH/	0	100	Medium-stiff dark-gray organic clayey silt, little fine sand, damp.	H=1.0
	30						

NATURAL CONSISTENCY INDEX — NATURAL MOISTURE CONTENT — PLASTIC LIMIT — LIQUID LIMIT — 10 20 30 40

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-

2010 NEW DEFAULT BORING LOG-W/ N60

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	N_{60}	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT (PLASTIC LIMIT – LIQUID LIMIT; 10 20 30 40)	TEST RESULTS
639.4	30								
		20	■	SH / 2 / 2 / 1	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								
							- 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).		
	50								
	55								
	60								

2010 NEW DEFAULT BORING LOG-W/ N60

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

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 EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	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		
649.4	20	13	1/4/2	8	67		
		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						

NATURAL CONSISTENCY INDEX — NATURAL MOISTURE CONTENT — PLASTIC LIMIT — LIQUID LIMIT — 10 20 30 40

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-

2010 NEW DEFAULT BORING LOG-W/ N60

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	N_{60}	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT (PLASTIC LIMIT – LIQUID LIMIT; 10 20 30 40)	TEST RESULTS
	30						sand seams and roots, wet.		
		19	■	1 / 2 / 4 / 2	5	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 sand seams and roots, wet.		
		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.		
		25	■	6 / 11 / 17	35	80	- Contains zones of fine to coarse sand at 49.0'.		
	50	26	■	22 / 35 / 25	75	53			G
		27	■	21 / 8 / 8	20	33			
614.9	55						- Encountered seepage at 16.0'. - Encountered water at 20.5'. - Borehole converted to monitoring well upon completion - See separate well completion diagram. - Datum: Ohio State Plane South. NAD		
	60								

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

JOB: 7217-15-007B

-CONTINUED-

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	N_{60}	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT (PLASTIC LIMIT — LIQUID LIMIT) 10 20 30 40	TEST RESULTS
	60						27/NAVD 29 (Plant Grid).		
	65								
	70								
	75								
	80								
	85								
	90								

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

PLATE 9

2010 NEW DEFAULT BORING LOG-W/ N60

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	N_{60}	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
	0						AGGREGATE - 12 INCHES	
660.1								
		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		
655.8	5							
655.3		4		35/13/12	31	87	FILL: Very-soft brown and gray silty clay, "and" fine to coarse sand, little fine to coarse gravel.	G
653.6		5		50-3"R		20	FILL: Dense brown fine to coarse sand, little fine to coarse gravel, "and" clayey silt, cobbles, moist.	
		6		2/3/4	9	87	Stiff to very-stiff dark-brown mottled with dark-gray silty clay, little fine to coarse sand, trace fine gravel, slightly organic, damp.	H=2.0-3.0
	10							
				P				H=1.25-2.5
	15							
644.9								
		7		3/5/6	14	87	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.	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							
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
		12		1/2/	4	100		
	30							

NATURAL CONSISTENCY INDEX — NATURAL MOISTURE CONTENT — PLASTIC LIMIT — LIQUID LIMIT — 10 20 30 40

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-

2010 NEW DEFAULT BORING LOG-W/ N60

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	N_{60}	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT (PLASTIC LIMIT – LIQUID LIMIT; 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						- 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).		
	45								
	50								
	55								
	60								

2010 NEW DEFAULT BORING LOG-W/ N60

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

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

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
	0						AGGREGATE - 12 INCHES	
668.2								
		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		G
663.7								
		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
660.7								
		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.	
659.2	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
655.7								
		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			
652.3		10A		4 / 6 / 10	20	100		
		10B					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		G=0.5-1.25
646.2								
		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							
				P				
				P				
	30							

NATURAL CONSISTENCY INDEX — NATURAL MOISTURE CONTENT — PLASTIC LIMIT — LIQUID LIMIT — 10 20 30 40

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

JOB: 7217-15-007B

-CONTINUED-

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

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	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
623.7	45							
		19	■	SH/SH/1	0	100	Stiff gray mottled with brown and dark-gray silty clay, trace fine to coarse sand, slightly organic, damp.	H=0.75
621.2								
		20	■	SH/SH/SH	0	100	Medium-stiff to stiff gray and dark-gray organic clayey silt, trace fine to coarse sand, damp.	H=0.75-1.25
618.7	50							
		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.	G
		22	■	8/21/34	69	87		
613.8	55							
		23	■	14/20/14	43	80	Medium-dense to dense gray and brown fine to coarse sand, "and" fine to coarse gravel, little silt, wet.	
		24	■	7/12/	35	60		G
	60							

NATURAL CONSISTENCY INDEX — NATURAL MOISTURE CONTENT — PLASTIC LIMIT — LIQUID LIMIT — 10 20 30 40

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

JOB: 7217-15-007B

-CONTINUED-

2010 NEW DEFAULT BORING LOG-W/ N60

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

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
	60						Medium-dense to dense gray and brown fine to coarse sand, "and" fine to coarse gravel, little silt, wet.		
606.7		25	■	8 / 4 / 16 / 5	11	60			
	65						- Encountered water at 17.0'. - 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).		
	70								
	75								
	80								
	85								
	90								

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 (%)

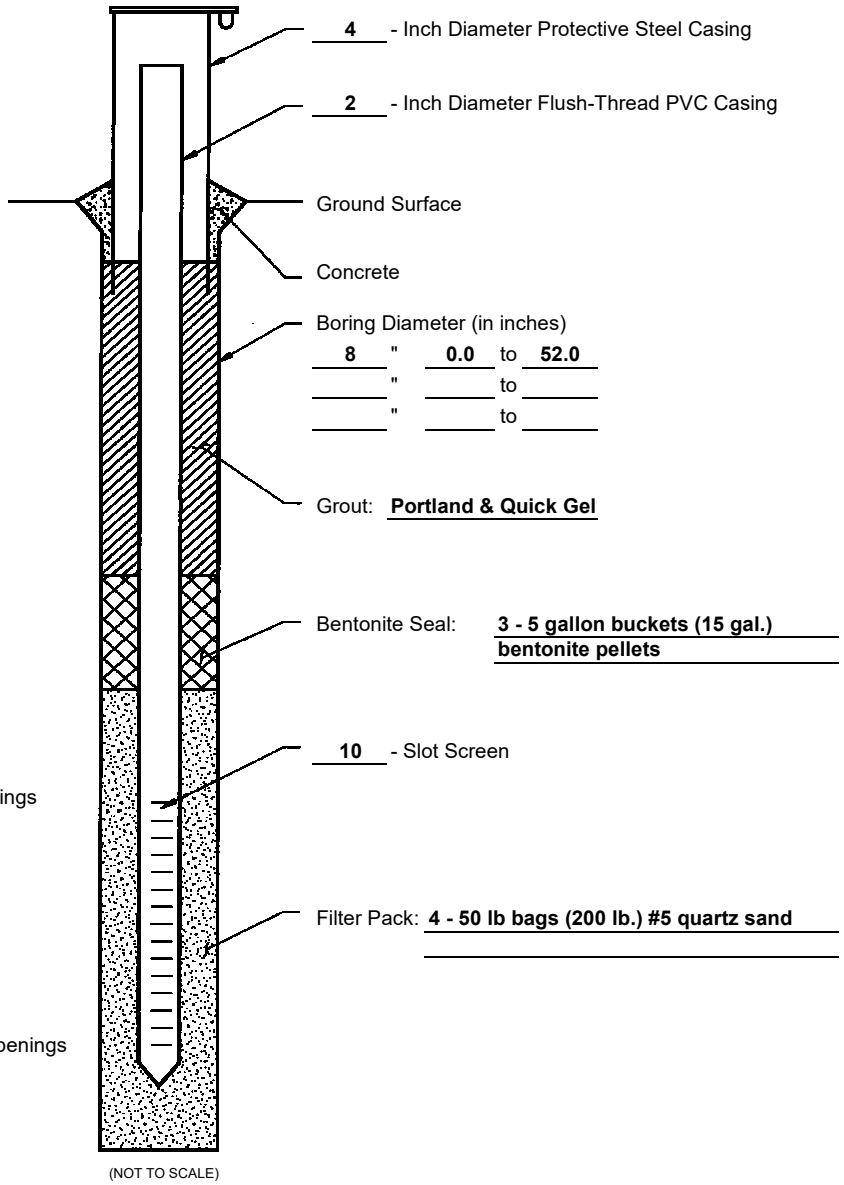
Drill Rod Energy Ratio : 0.75
Last Calibration Date : 8/2/2013
Drill Rig Number : S&ME
ATV 550-2

JOB: 7217-15-007B

PLATE 14

2010 NEW DEFAULT BORING LOG-W/ N60

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



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

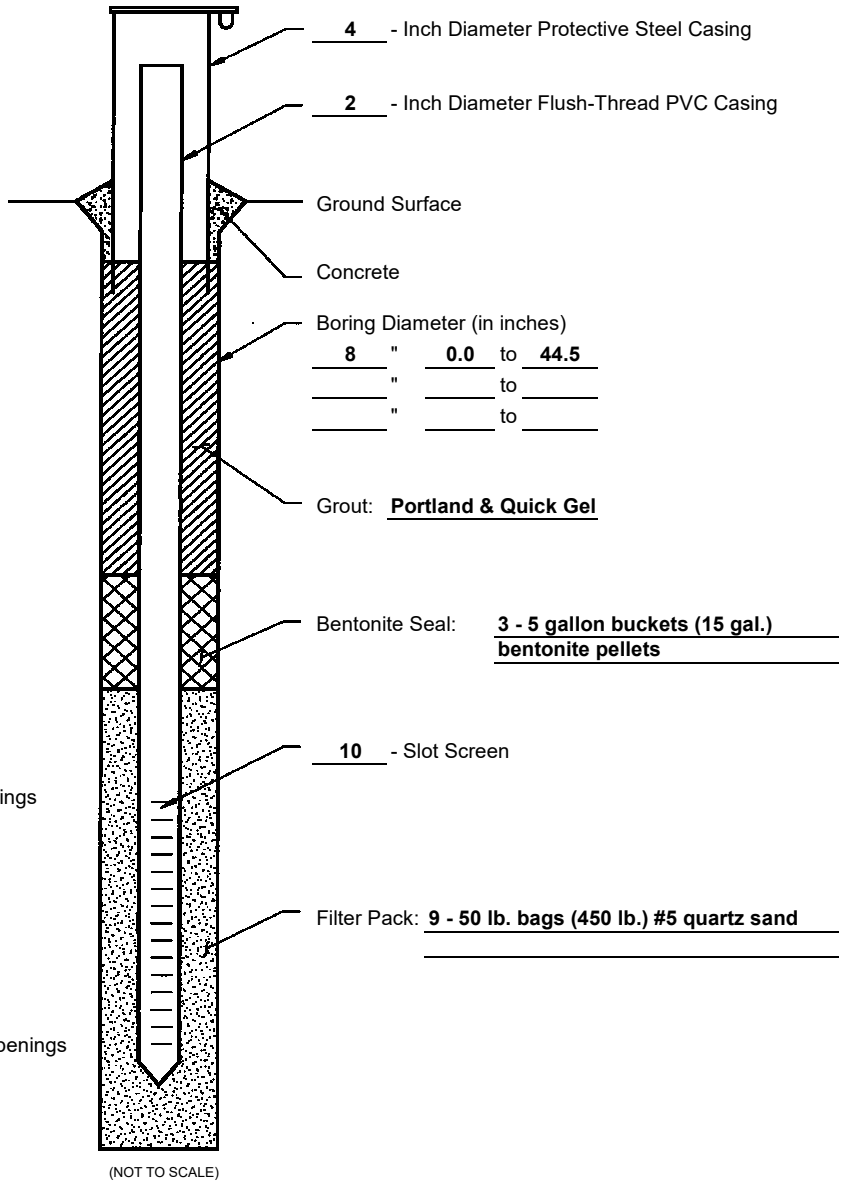
Project Location:
Cardinal Plant / Brilliant, Ohio

Project Number:
7217-15-007A

Boring Number:
MW-BAP-1

Date Well Installed:
12/10/2015

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



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

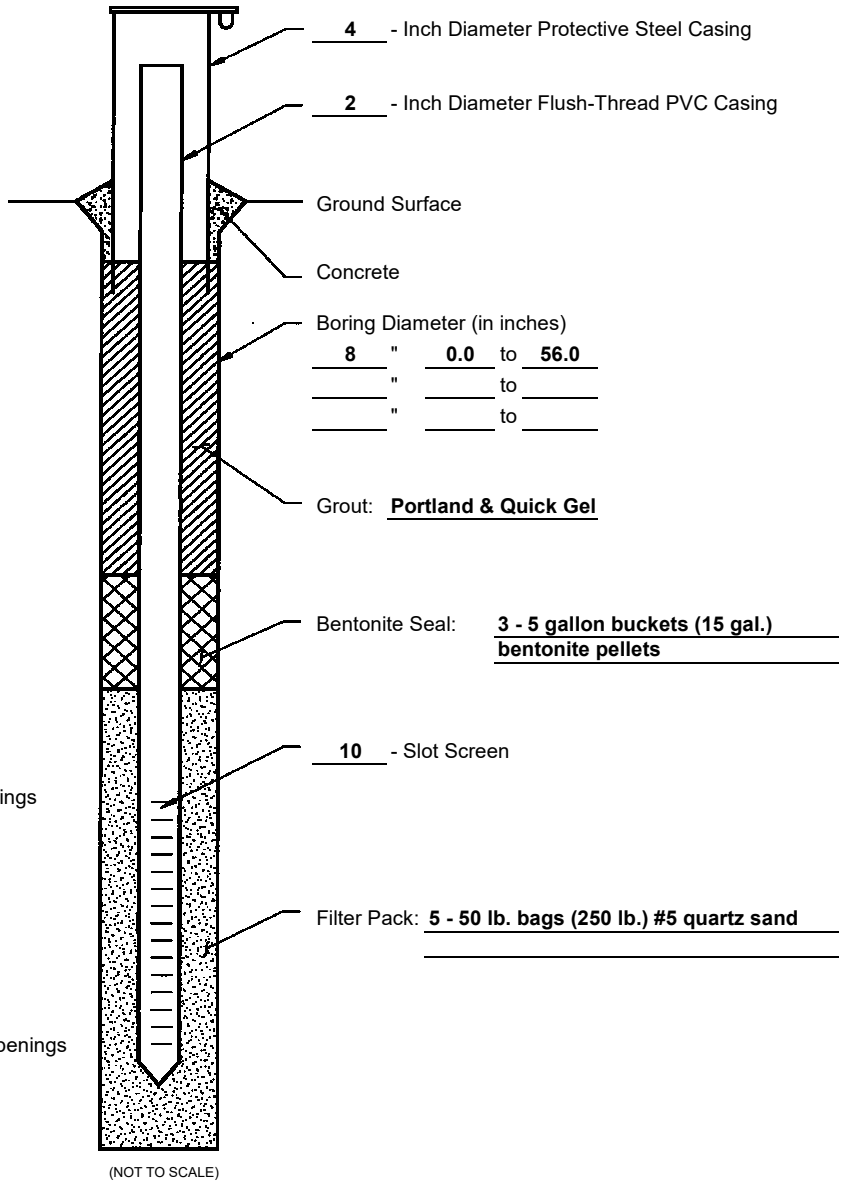
Project Location:
Cardinal Plant / Brilliant, Ohio

Project Number:
7217-15-007A

Boring Number:
MW-BAP-2

Date Well Installed:
12/2/2015

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



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

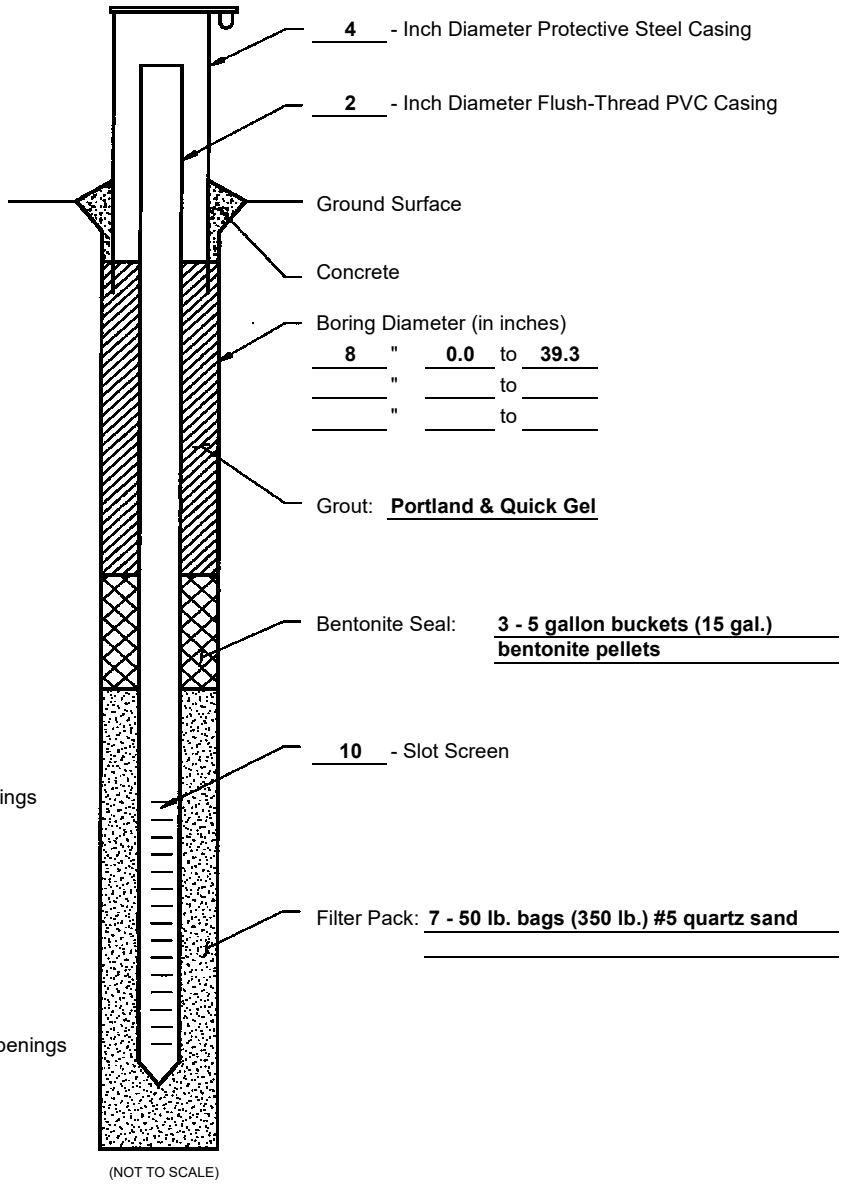
Project Location:
Cardinal Plant / Brilliant, Ohio

Project Number:
7217-15-007A

Boring Number:
MW-BAP-3

Date Well Installed:
11/13/2015

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



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

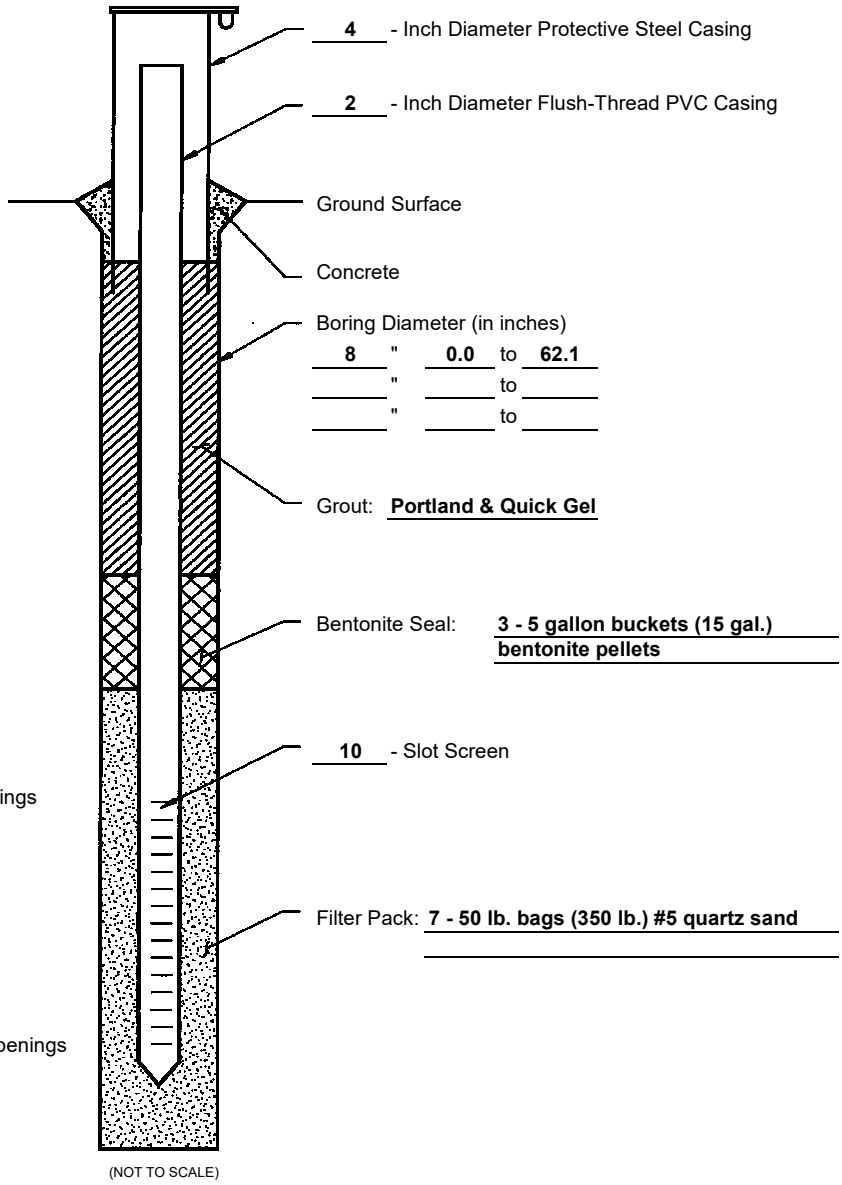
Project Location:
Cardinal Plant / Brilliant, Ohio

Project Number:
7217-15-007A

Boring Number:
MW-BAP-4

Date Well Installed:
11/23/2015

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



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

Bottom Ash Pond

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

Columbus, Ohio | 2017/08/16

Figure 1

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\BAP\AEP-Cardinal_BAP_GW_2016-06_June.mxd. MMuenich. 8/16/2017. CHA8423/01/08.

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

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Figure 3

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\BAP\AEP-Cardinal_BAP_GW_2016-10_October.mxd. MMuenich. 8/16/2017. CHA8423/01/08.

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.

250 125 0 250 Feet

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

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\BAP\AEP-Cardinal_BAP_GW_2016-11_November.mxd. MMuenich. 8/16/2017. CHA8423/01/08.

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 6

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\BAP\AEP-Cardinal_BAP_GW_2017-01_January.mxd. MMuenich. 8/16/2017. CHA8423/01/08.

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

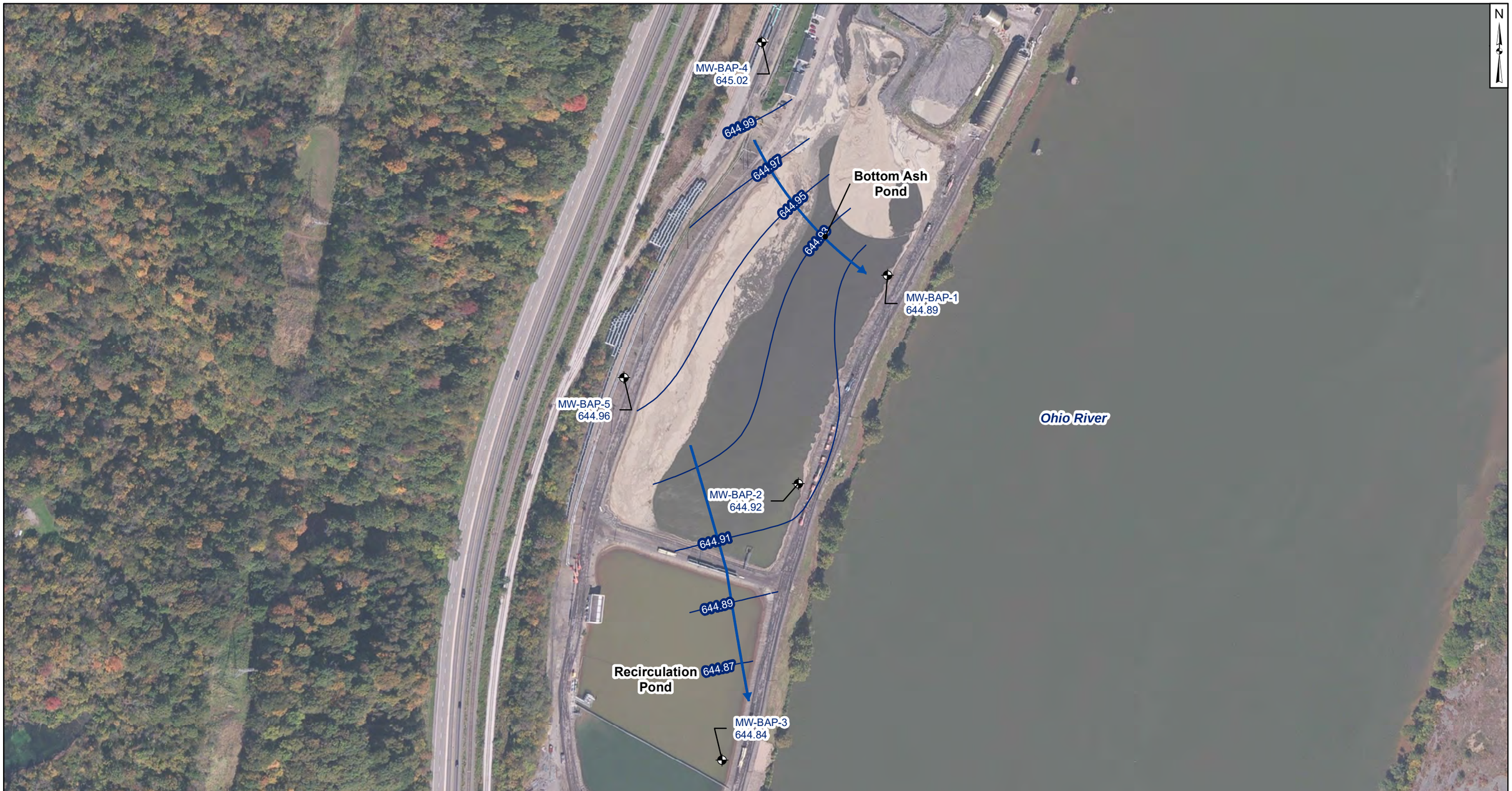
AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/08/16

Figure 7

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\BAP\AEP-Cardinal_BAP_GW_2017-02_February.mxd. MMuenich. 8/16/2017. CHA8423/01/08.



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

Columbus, Ohio | 2017/08/23

Figure 8

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\BAP\AEP-Cardinal_BAP_GW_2017-04_April.mxd. MMuenich. 8/23/2017. CHA8423/01/08.

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 9

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\BAP\AEP-Cardinal_BAP_GW_2017-05_May.mxd. MMuenich. 8/23/2017. CHA8423/01/08.

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.

250 125 0 250 Feet

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

C:\Users\mmuenich\Documents\local_projects\AEP_GIS\Cardinal\MXDs\BAP\AEP-Cardinal_BAP_GW_2017-07_July.mxd. MMuenich. 8/16/2017. CHA8423/01/08.

Bottom Ash Pond

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

Geosyntec Consultants, Inc.

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 1×10^{-1} to 1×10^{-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.

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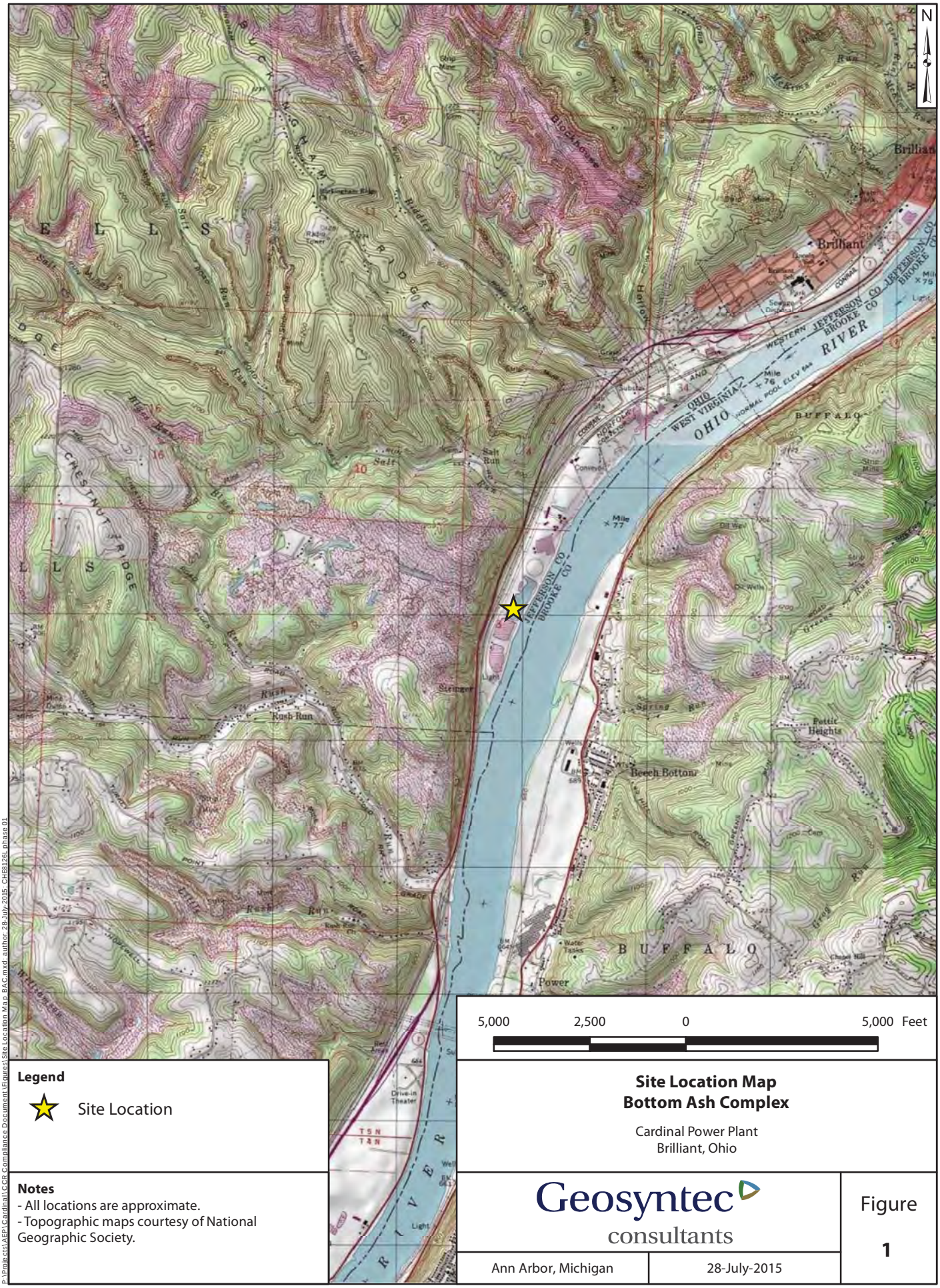
FIGURES



Site Location Map
Bottom Ash Complex

Cardinal Power Plant
Brilliant, Ohio

Geosyntec consultants

Ann Arbor, Michigan | 28-July-2015

Figure 1

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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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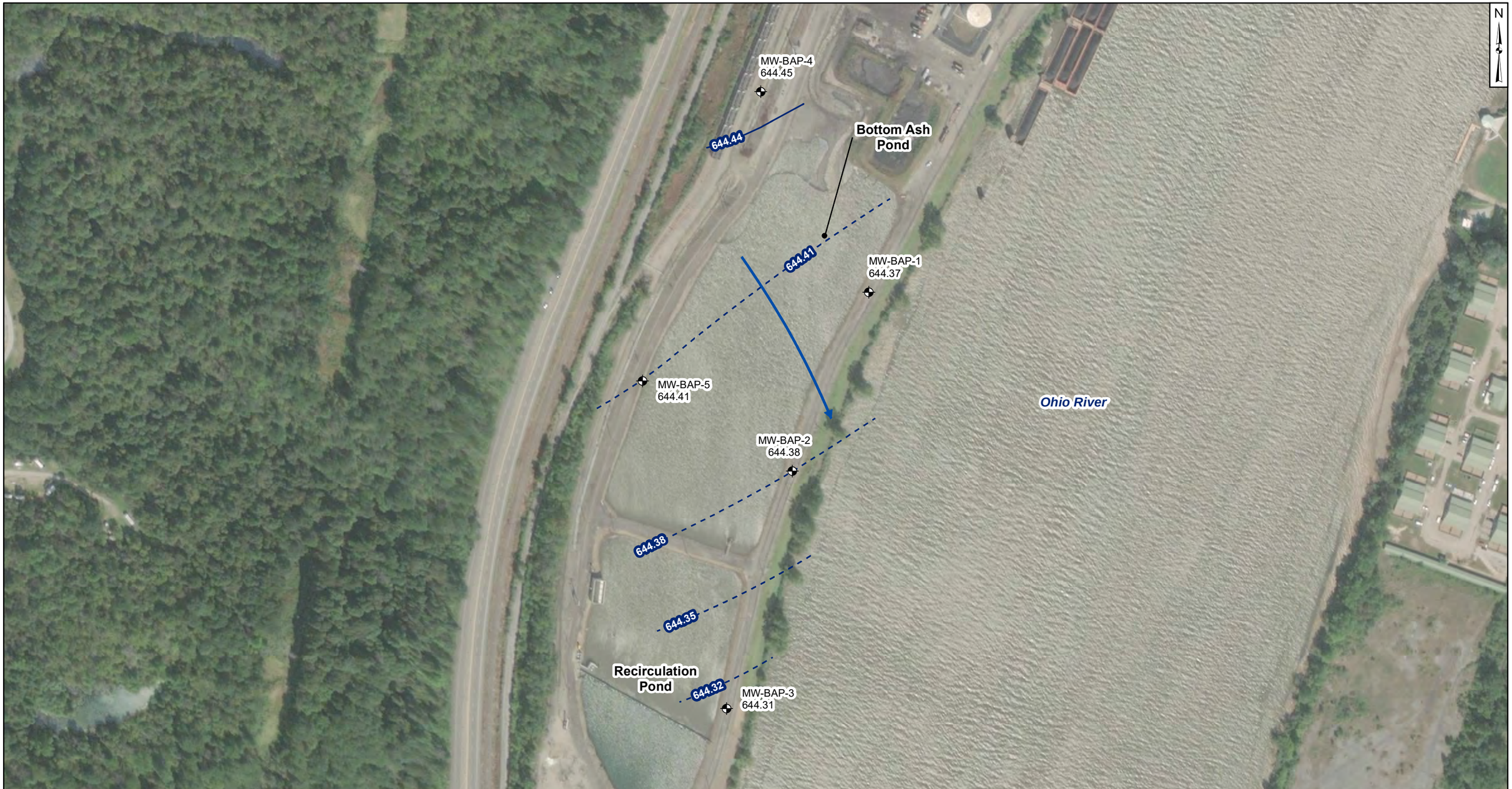

Legend

- 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

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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 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

P:\Projects\Buckeye Power\GIS\MXDs\BAP\Buckeye-Cardinal_BAP_GW_2019-10.mxd. ARevezzo. 12/31/2019. CHA8423/01/08.

TABLES

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

Geosyntec Consultants, Inc.

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

Bottom Ash Pond

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

A description 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).

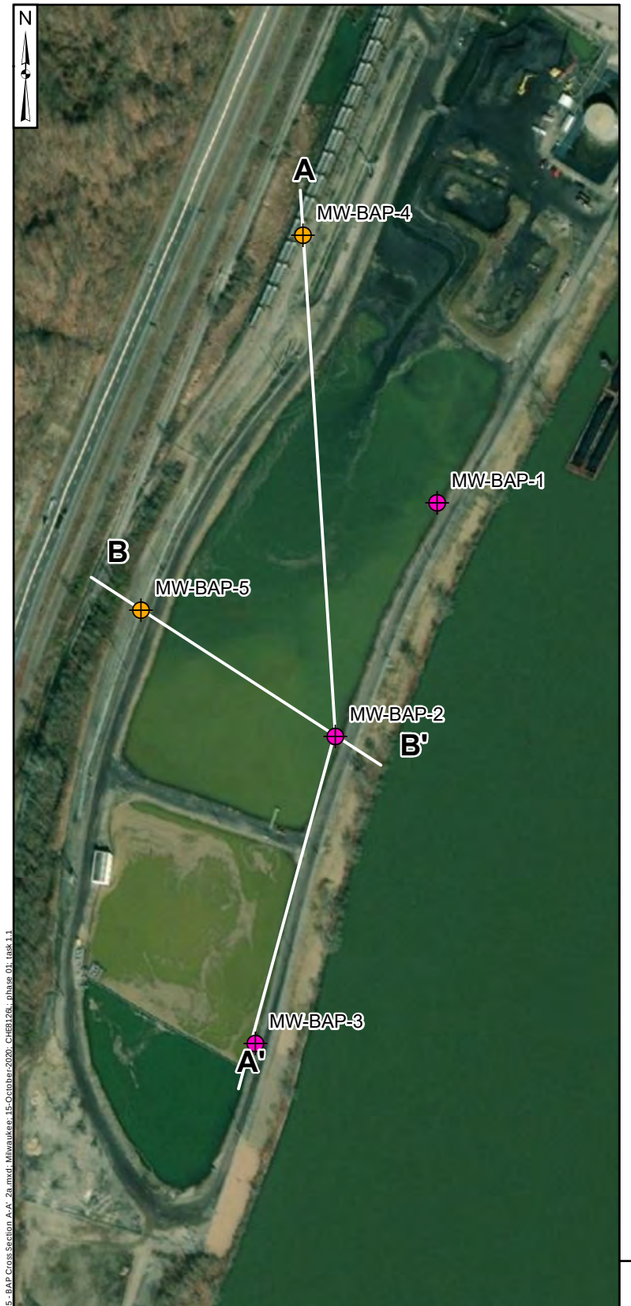
3.3 Review of Existing Monitoring Network

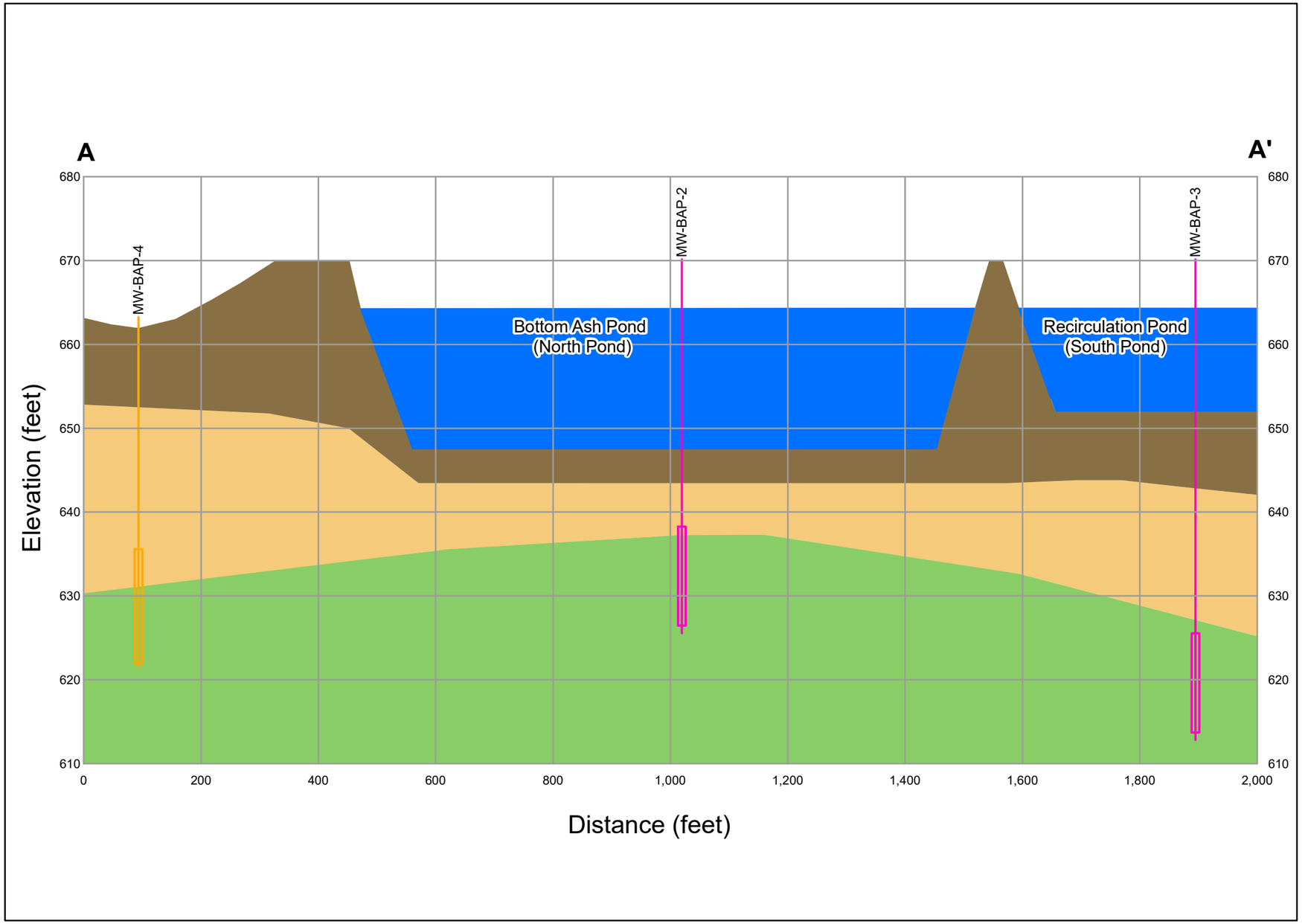
3.3.1 Overview

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

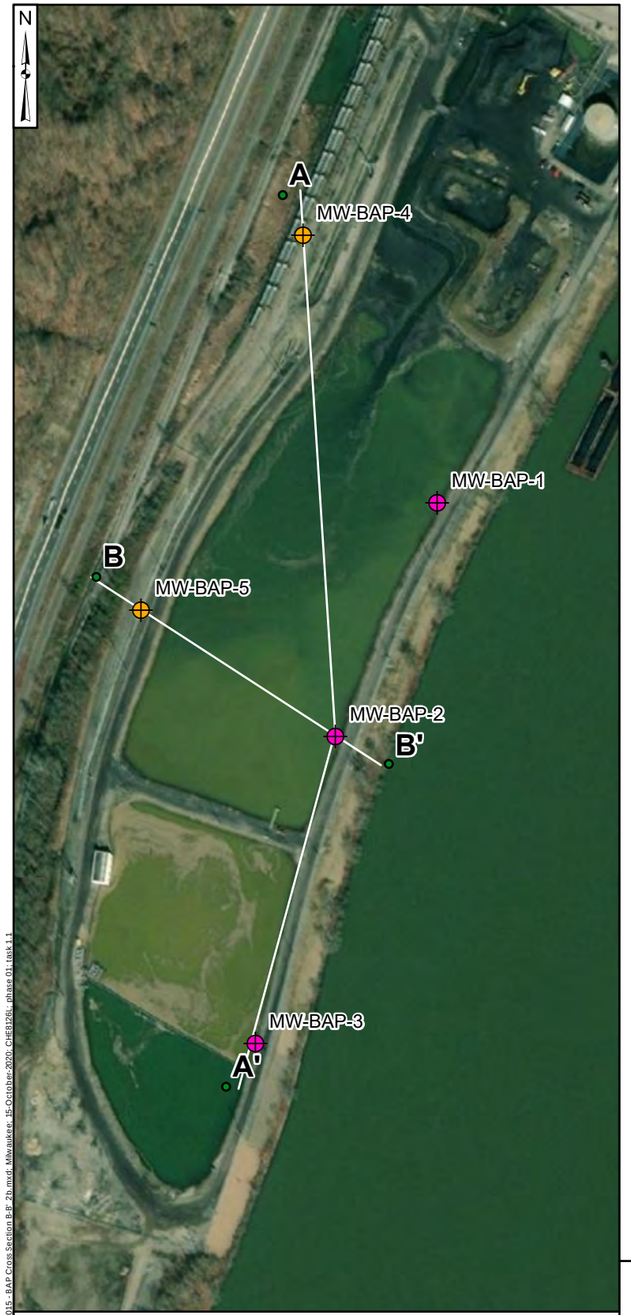
Cardinal BAP
Geologic Cross Section A - A'
Current Conditions
Cardinal Power Plant
Brilliant, Ohio

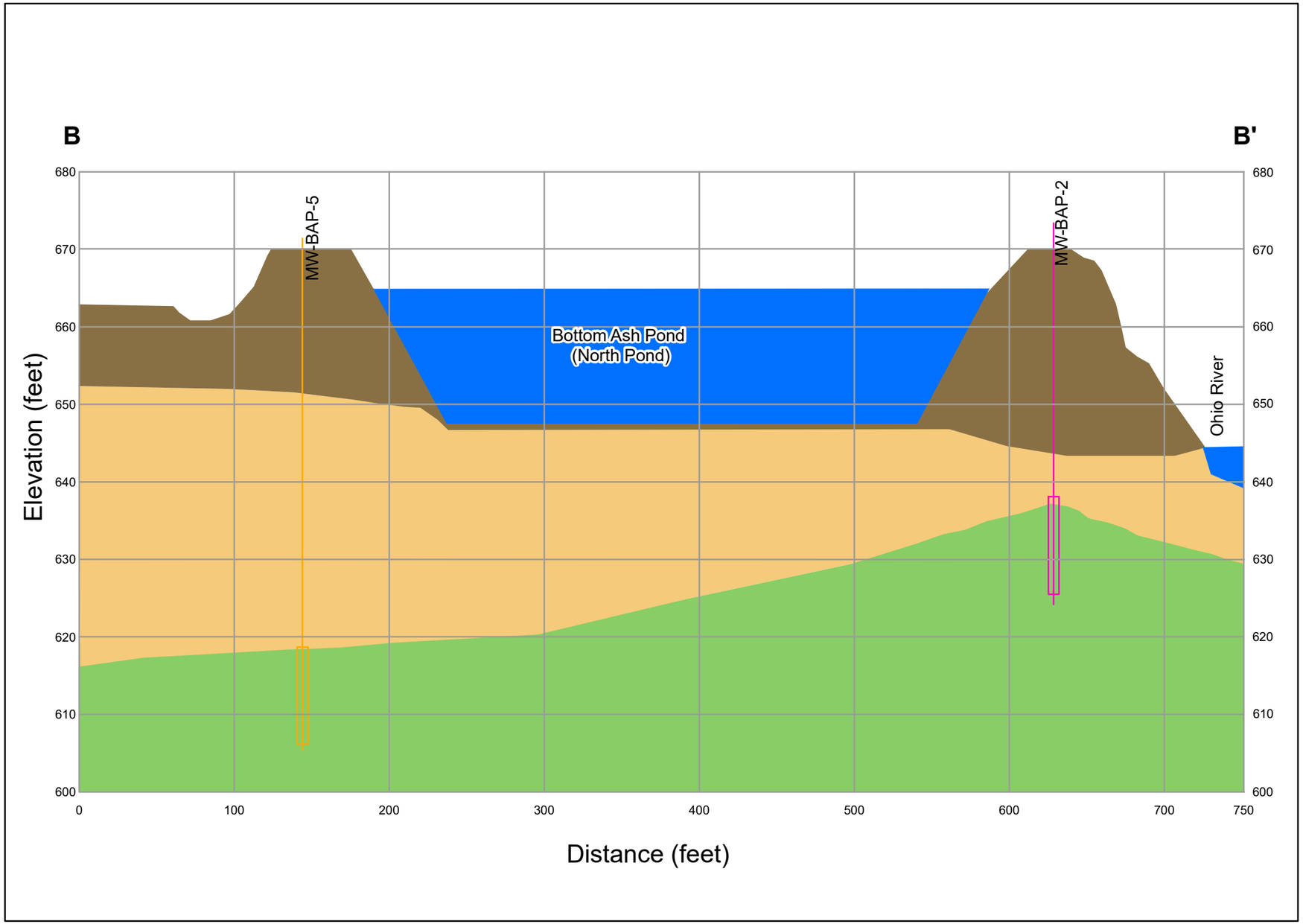
Geosyntec consultants

Columbus, Ohio | August 2020

Figure **Xa**

C:\Users\cchristenson\Desktop\MXDs\BAP\20200015 - BAP Cross Section A-A' 2a.mxd; Milwaukee; 15-October-2020; CHB126; 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**

C:\Users\cchristenson\Desktop\MXDs\BAP\20200015 - BAP Cross Section B-B' 2h.mxd, Milwaukee, 15-October-2020, CHE8326b, phase 01, task 1.1

Bottom Ash Pond

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.

Bottom Ash Pond

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.

Bottom Ash Pond

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

APPROVED BY 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)

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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	γ_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.

Bottom Ash Pond

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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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	γ_{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°	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
Granular Embankment Fill[(1)]	115	30°	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,

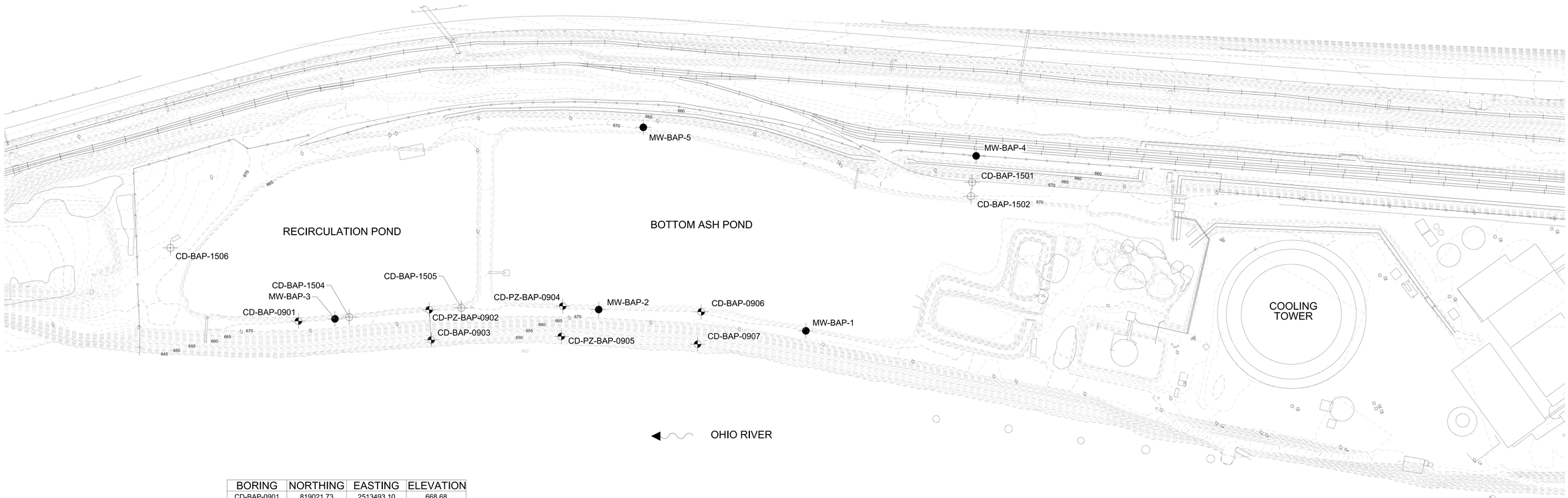
S&ME, Inc.

Michael T. Romanello, 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

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

SCALE IN FEET

0 100 200

REFERENCE: AEP CARDINAL DRAWING 94151038

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
6160 ENTERPRISE COURT
DUBLIN, OH 43016
(614) 793-0330
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:

DR:

CH:

ENGR:

PROJ. ENGR:

DATE:

CIVIL ENGINEERING

AEP AMERICAN ELECTRIC POWER

AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

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

DWG. NO. PLATE 2

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	N_{60}	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
656.5		9B						H=3.0-4.0
	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						- 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).	
	25							
	30							

NATURAL CONSISTENCY INDEX — NATURAL MOISTURE CONTENT — PLASTIC LIMIT — LIQUID LIMIT — 10 20 30 40

2010 NEW DEFAULT BORING LOG-W/ N60

DRAFT

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

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE	SAMPLE EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
	0						AGGREGATE - 12 INCHES	
670.0								
668.5		1		3/12/18	38	53	FILL: Dense brown and gray fine to coarse gravel, some fine to coarse sand, little silt, damp.	
667.2		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
	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
662.5		5		8/10/11	26	93		
	10	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
		7		11/15/18	41	53		H=4.5
657.5				P				
	15	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.	
654.0				P				
652.7		9		7/7/8	19	87	FILL: Medium-dense gray fine to coarse sand, some fine to coarse gravel, some clayey silt, wet.	G
	20	10		7/6/3	11	100	Stiff gray clayey silt, some fine to coarse sand, some fine gravel, moist.	H=1.25
649.2				P				H=1.25
		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
645.5	25	12		SH/SH/SH	0	33		H=1.25
		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
	30	14		2/4/	13	93		H=3.5

NATURAL CONSISTENCY INDEX — NATURAL MOISTURE CONTENT — PLASTIC LIMIT — LIQUID LIMIT — 10 20 30 40

2010 NEW DEFAULT BORING LOG-W/ N60

DRAFT

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

-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	SAMPLE EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
	30							
		15		3 / 5 / 6 / 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
638.5								
				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
636.5								
	35	16		1 / 3 / 3	8	100	Loose red-brown from to medium sand, trace coarse sand, "and" silt, damp.	
634.0								
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
							Very-loose brown fine to medium sand, "and" silt, damp.	
	40	18		2 / 2 / 2	5	67		G
629.5								
	45						- 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).	
	50							
	55							
	60							

NATURAL CONSISTENCY INDEX
NATURAL MOISTURE CONTENT
PLASTIC LIMIT — LIQUID LIMIT
10 20 30 40

DRAFT

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-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	N_{60}	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								
		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	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 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. - Encountered water at 16.5'. - Borehole converted to temporary piezometer 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).	
	25							
	30							

NATURAL CONSISTENCY INDEX
NATURAL MOISTURE CONTENT
PLASTIC LIMIT — LIQUID LIMIT
10 20 30 40

2010 NEW DEFAULT BORING LOG-W/ N60

DRAFT

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

JOB: 7217-15-007A

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	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT (PLASTIC LIMIT – LIQUID LIMIT; 10 20 30 40)	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.		
666.0		2		9/12/40	65	53			
	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			
661.5		5		8/9/13	28	80			
	10	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
659.2		7A		4/7/11	23	100		●	H=1.5
		7B					FILL: Medium-dense brown and gray fine to coarse sand, some fine to coarse gravel, little silty clay, dry.		
657.0		8		7/5/9	18	73			
		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
654.0	15	10		3/5/8	16	87		●	H=4.5 G
652.5		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
	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).

DRAFT

2010 NEW DEFAULT BORING LOG-W/ N60

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

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; 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		4		35 / 13 / 12	31	87	FILL: Very-soft brown and gray silty clay, "and" fine to coarse sand, little fine to coarse gravel.		
652.5		5		50-3"R		20	FILL: Dense bown fine to coarse sand, little fine to coarse gravel, "and" clayey silt, cobbles, moist.		
		6		2 / 3 / 4	9	87	Stiff to very-stiff dark-brown mottled with dark-gray silty clay, little fine to coarse sand, trace fine gravel, slightly organic, damp.		H=2.0-3.0
	10								
				P					H=1.25-2.5
	15								
643.8		7		3 / 5 / 6	14	87	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.		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

DRAFT

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

JOB: 7217-15-007B

-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

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'. - Encountered cobbles at 18.5'. - Borehole converted to monitoring well upon completion - See separate well log. - Boring elevation recorded with a hand held GPS unit. Elevation estimated from March 2015 survey. - Datum: Ohio State Plane South, NAD 27/NAVD 29 (Plant Grid).		
	45								
	50								

DRAFT

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

JOB: 7217-15-007B

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	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		4/6/10	20	100		
		10B		P			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.	
	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							

NATURAL CONSISTENCY INDEX — NATURAL MOISTURE CONTENT — PLASTIC LIMIT — LIQUID LIMIT — 10 20 30 40

2010 NEW DEFAULT BORING LOG-W/ N60

DRAFT

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

JOB: 7217-15-007B

-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	N_{60}	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT (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.		
				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
624.5	45								
		19		SH / SH / 1	0	100	Stiff gray mottled with brown and dark-gray silty clay, trace fine to coarse sand, slightly organic, damp.		H=0.75
622.0									
		20		SH / SH / SH	0	100	Medium-stiff to stiff gray and dark-gray organic clayey silt, trace fine to coarse sand, damp.		H=0.75-1.25
	50								

DRAFT

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

JOB: 7217-15-007B

-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	N_{60}	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									
	65						- Encountered water at 17.0'. - Borehole converted to monitoring well upon completion. See separate well log. - 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).		
	70								
	75								

DRAFT

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

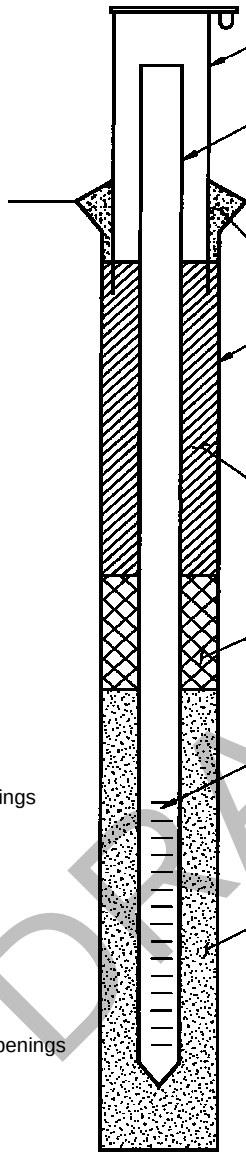
JOB: 7217-15-007B

2010 NEW DEFAULT BORING LOG-W/ N60

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



(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: **Bentonite pellets**

10 - Slot Screen

Filter Pack: **#5 quartz sand**

DRAFT

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

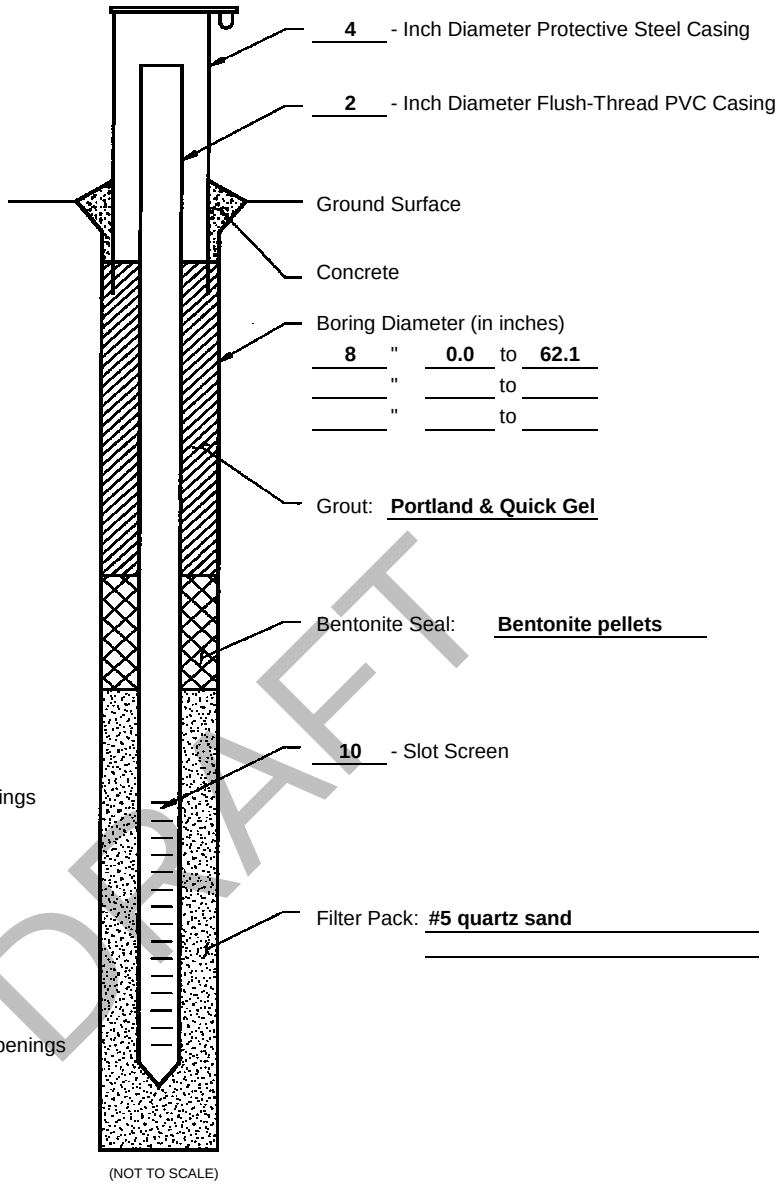
Boring Number:
MW-BAP-4

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



DRAFT

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

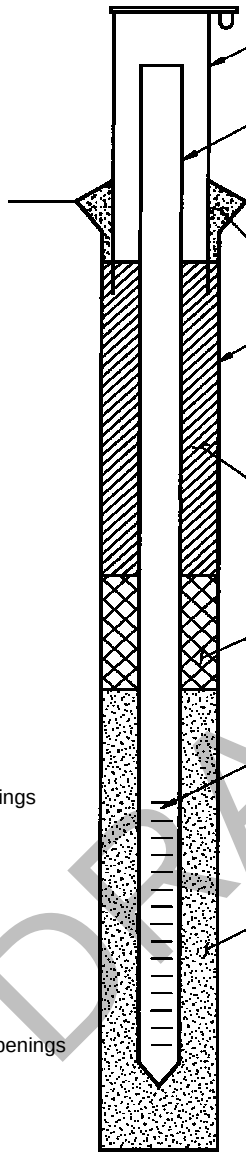
Project Location:
Cardinal Plant / Brilliant, Ohio

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**

DRAFT

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

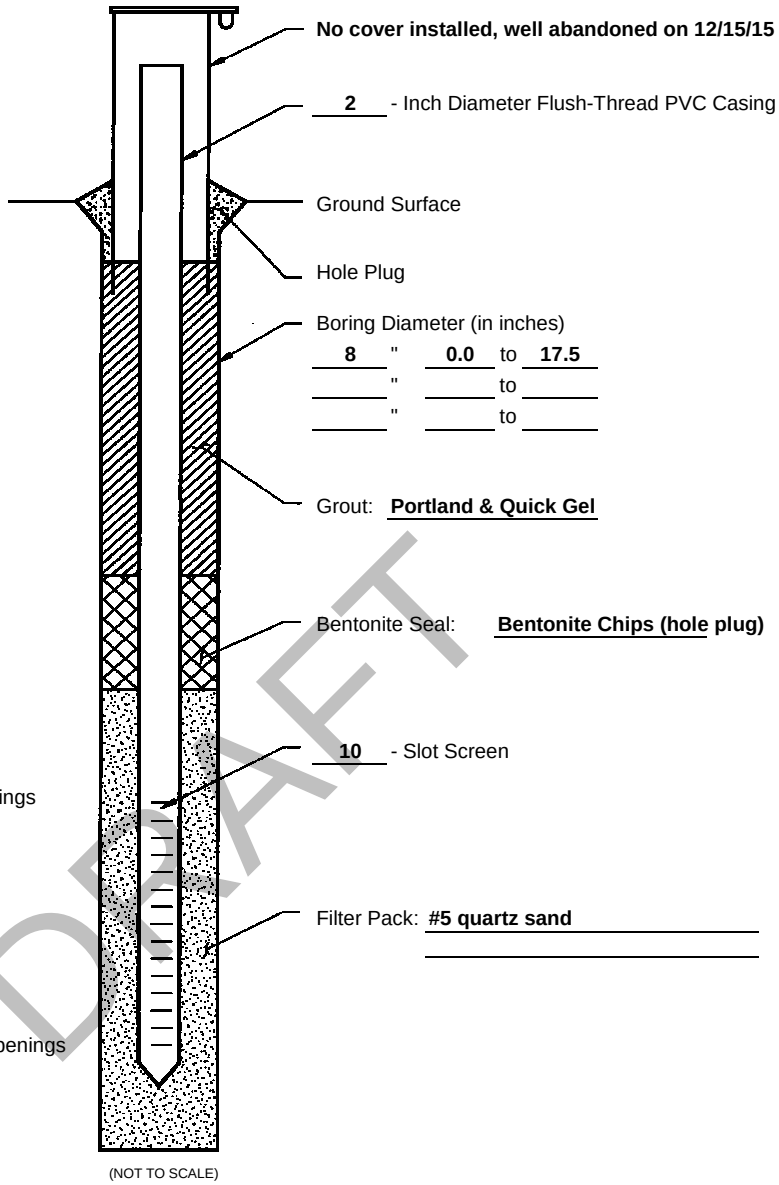
Project Location:
Cardinal Plant / Brilliant, Ohio

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



DRAFT

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

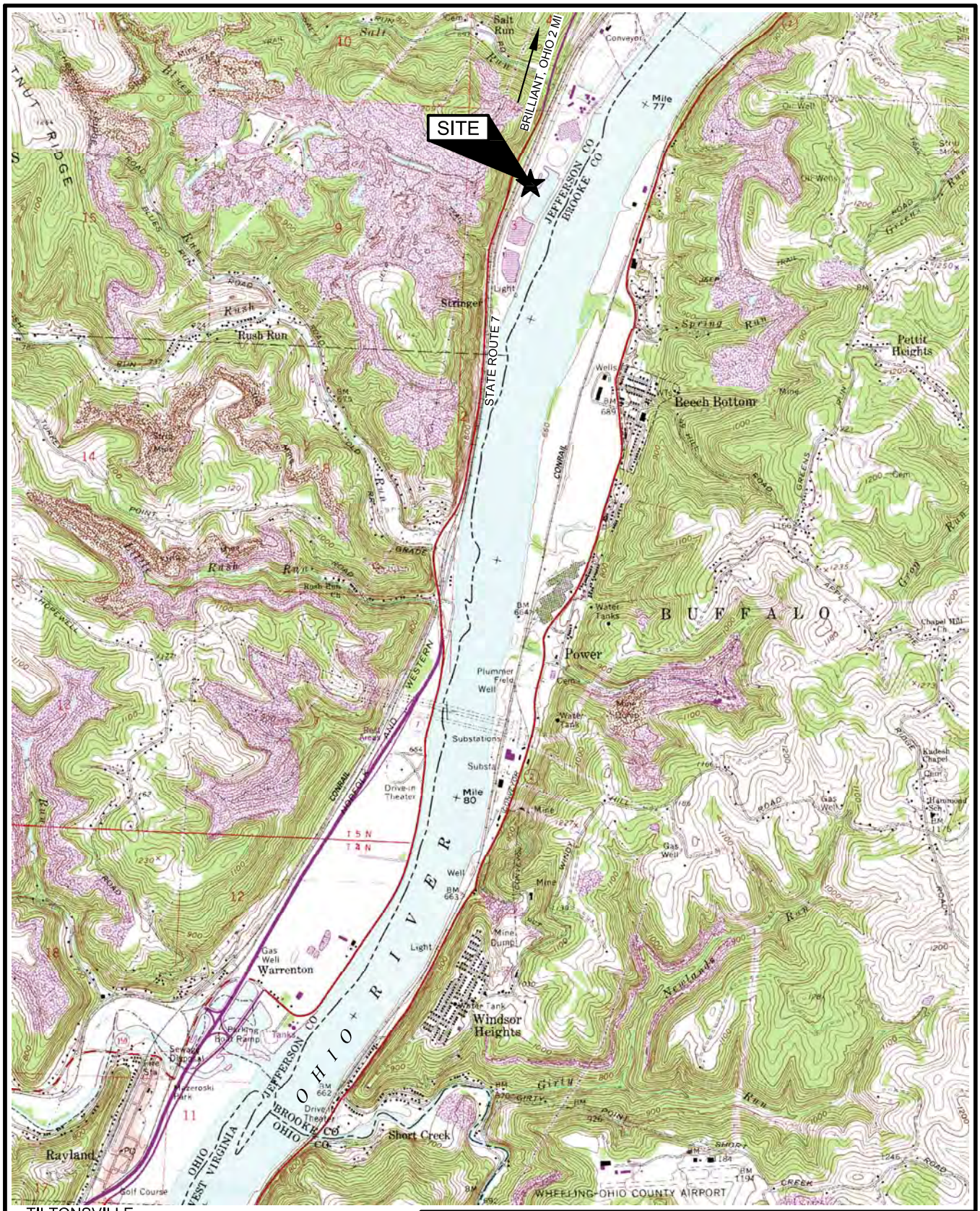
Project Location:
Cardinal Plant / Brilliant, Ohio

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

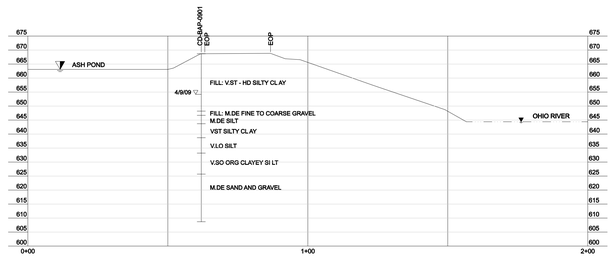
Project: 011-11497-013	Drawn By: MTR	
Drawing Date: 7-2-09	Approved By: MGR	
Last Updated: 7-6-2009	Scale: 1" = 3000'	1:1

BBCM
SOLUTIONS TO BUILD ON

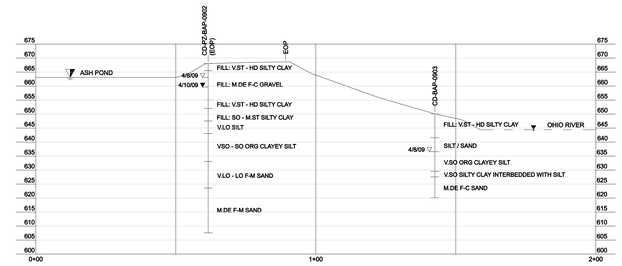
Columbus (614) 793-2226
Cleveland (216) 901-1000
Cincinnati (513) 771-8471
Dayton (937) 424-1011

PLATE 1

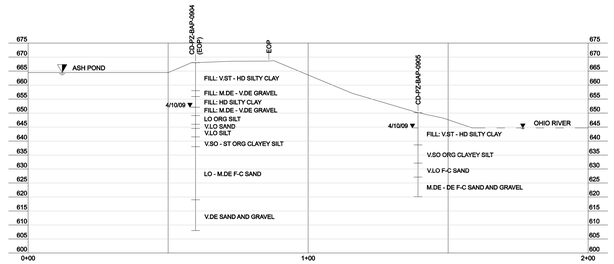
Images: ~Tiltonsville Ohio Quad Map.tif
Xrefs:
File Last Updated: Jul 06, 2009
Plot Info: 7-22-2009 @ 3:23pm By: MRomanello
BBC&M Filename: I:\DEPTS\CADD\Drawings\Projects\011-11497-013\VMap.dwg Layout: 8.5x11P



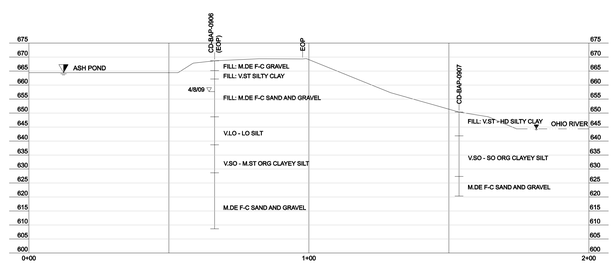
SECTION 'A'
Boring BAP-0901



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) 771-4471
Dayton (937) 424-1011

DATE	NO.	DESCRIPTION	APPD.
		REVISIONS	

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A.E.P.
CARDINAL PLANT
BRILLIANT OHIO

BOTTOM ASH POND
INVESTIGATION
SECTIONS

DWG. NO. PLATE 3

SCALE:
DR:
CH:
ENGR:
PROJ. ENGR:
DATE:
AB 03/01/2007

CIVIL ENGINEERING

AEP AMERICAN ELECTRIC POWER

AEP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

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

DWG. NO. PLATE 3

10S0694

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-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	N_{60}	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT (PLASTIC LIMIT – LIQUID LIMIT; 10 20 30 40)	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		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
	10	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
		16A	P						
643.7	25								

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 11149701 3.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**

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	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 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 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 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 G
		22		2/3/3	9	100			H=0.5-0.8 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

2008 NEW DEFAULT BORING LOG-W/N60 11149701 3.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**

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
	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									
		30	■	7/10/10	29	40	Medium-dense brown fine to medium sand, trace coarse sand, trace fine gravel, trace silt, wet.		
608.7	60						- Seepage encountered at 14.5'. - Borehole grouted upon completion. - 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 11149701 3.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**

ELEV.	DEPTH, FEET	SAMPLE NUMBER	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 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 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 G
647.5	20	13	1/SH/1	1	20		H=0.0-0.25 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 — 10 20 30 40

WATER LEVEL: 10.7 (Inside HSA, 4/8/09) 8.4 (Inside Well, 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 11149701 3.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**

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	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%; >>H=0.0-0.1; G
		19		SH/1/2	4	100			MC=54; H=0.0; G
	30	20		SH/1/1	3	73			G
633.1		21A		2/3/3	9				
	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									
		24		2/3/10	19	100	Medium-dense brown fine to medium sand, trace coarse sand, trace silt, trace to some fine gravel, trace coarse gravel, trace silt, wet.		G
	45	25A / 25B		5/7/11	26				
		26		6/10/13	33	67			
	50	27		10/15/13	40	33			

WATER LEVEL: 10.7 (Inside HSA, 4/8/09) ; 8.4 (Inside Well, 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 11149701 3.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**

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
	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			
		29	■	1 / 2 / 9	16	67			
	55								
		30	■	3 / 3 / 7	14	67			
		31	■	4 / 3 / 7	14				
607.9	60						- Cobbles encountered from 4.0' to 7.0'. - Seepage encountered at 5.5'. - Groundwater encountered at 13.0'. - Borehole converted to observation well upon completion. See separate well log. - 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

2008 NEW DEFAULT BORING LOG-W/ N60 11149701 3.GPJ BBCM.GDT 8/4/09

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
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
		2		4 / 6 / 6	16	53			H=3.3-4.5 G
646.1									
	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
		4		8 / 11 / 13	33	80			H=4.5
643.1									
		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 G
641.8									
		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 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 G
	15								
		8		SH / 1 / 1	3	67			H=0.0 G
		9		SH / 1 / 1	3	73			H=0.0 G
629.6	20								
		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 G
627.6									
		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

2008 NEW DEFAULT BORING LOG-W/ N60 11149701 3.GPJ BBCM.GDT 8/4/09

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								
		12	■	6 / 10 / 12	30	33	Medium-dense brown and gray fine to coarse gravel, some fine to coarse sand, trace silt, wet.		
		13	■	7 / 7 / 7	19	47			
620.1	30						- Seepage encountered at 13.5'. - Groundwater encountered at 22.5'. - At 26.0', 1.8' heave, shook augers to sample. - Borehole grouted upon completion. - 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 11149701 3.GPJ BBCM.GDT 8/4/09

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**

ELEV.	DEPTH, FEET	SAMPLE NUMBER	SAMPLE EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	TEST RESULTS
	0					GRAVEL FILL - 1.0 FEET	
667.1							
		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		
		6	2/8/17	36	80		H=2.75-3.5 G
658.1	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.	
656.6							
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
	15	10	5/6/7	19	80		H=3.0-4.25
652.1							
		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
		14	2/3/4	10	47		
646.1							
		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
644.6							
		16	SH/SH/SH	0	53	Very-loose gray silt, little clay, little fine sand, wet.	
	25						

NATURAL CONSISTENCY INDEX — NATURAL MOISTURE CONTENT — PLASTIC LIMIT — LIQUID LIMIT — 10 20 30 40

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**

2008 NEW DEFAULT BORING LOG-W/N60 11149701 3.GPJ BBCM.GDT 8/4/09

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**

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								
		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 C
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 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 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								
621.4		25A 25B		4 / 11 / 17	40				
							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

2008 NEW DEFAULT BORING LOG-W/N60 11149701 3.GPJ BBCM.GDT 8/4/09

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**

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
	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'. - Groundwater encountered at 16.0'. - Borehole converted to observation well upon completion. See separate well log. - 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

2008 NEW DEFAULT BORING LOG-W/ N60 11149701 3.GPJ BBCM.GDT 8/4/09

LOG OF BORING NO. CD-PZ-BAP-0905
CARDINAL PLANT ASH POND INVESTIGATION
BRILLIANT, OHIO

BBCM

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	SAMPLE EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT (PLASTIC LIMIT – LIQUID LIMIT; 10 20 30 40)	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 G
		4		12 / 13 / 22	48	100			H=4.5+
		5		9 / 11 / 14	34	100			H=4.0-4.5+
		6A		6 / 5 / 10	21				H=3.5-4.5
640.4	10	6B							H=1.5-3.0 G
639.6							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.		
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
		8		SH / SH / SH	0	100	Very-soft gray mottled with dark-gray organic clayey silt, trace fine to coarse sand, trace fine gravel, moist becoming wet.		H=0.0 G
	15								LOI=8.4%
		9		SH / SH / SH	0	100			H=0.0 G
632.1									
		10		SH / SH / 2	3	33	Very-loose brown and gray fine to coarse gravel, some fine to coarse sand, little silt, contains decayed wood, wet.		H=0.5
629.6	20								
		11		6 / 7 / 5	16	27	Very-soft gray mottled with brown silty clay, little fine to medium sand, few seams of fine to medium sand, wet.		G
627.1									
		12		6 / 10 / 12	30	53	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.		
	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

2008 NEW DEFAULT BORING LOG-W/ N60 11149701 3.GPJ BBCM.GDT 8/4/09

LOG OF BORING NO. CD-PZ-BAP-0905
CARDINAL PLANT ASH POND INVESTIGATION
BRILLIANT, OHIO

BBCM

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	SAMPLE EFFORT	N_{60}	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT (PLASTIC LIMIT – LIQUID LIMIT; 10 20 30 40)	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'. - Encountered decayed wood at 18.5'. - Borehole converted to observation well upon completion. See separate well log. - 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.
} 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 11149701 3.GPJ BBCM.GDT 8/4/09

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	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.	
		1		8 / 12 / 17	42	20		
666.1								
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
	15	10		10 / 11 / 11	32	40		
652.1								
		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 G
650.6								
		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	1	67		
		15		1 / 1 / 1	3	100		
	25							

NATURAL CONSISTENCY INDEX — NATURAL MOISTURE CONTENT — PLASTIC LIMIT — LIQUID LIMIT — 10 20 30 40

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 11149701 3.GPJ BBCM.GDT 8/4/09

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	N_{60}	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'.	
		16		3/4/5	13	67		G
		17		3/1/2	4	80		G
		18		2/2/2	6	67		G
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 G
		20		2/2/3	7	60		H=0.0-0.25 G LOI=7.9%
	35							
		21		2/2/3	7	47		H=0.0 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							

NATURAL CONSISTENCY INDEX — NATURAL MOISTURE CONTENT — PLASTIC LIMIT — LIQUID LIMIT — 10 20 30 40

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 11149701 3.GPJ BBCM.GDT 8/4/09

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	N_{60}	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'. - Cobbles encountered throughout the borehole. - Borehole grouted upon completion. - 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 11149701 3.GPJ BBCM.GDT 8/4/09

LOG OF BORING NO. CD-BAP-0907
CARDINAL PLANT ASH POND INVESTIGATION
BRILLIANT, OHIO

BBCM

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	N_{60}	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT (PLASTIC LIMIT – LIQUID LIMIT; 10 20 30 40)	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							FILL: Hard brown, gray and dark-gray silty clay intermixed with organic silt, little fine to coarse sand, trace fine gravel, damp.		
640.6		6A		P					H=4.5 G
	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 G
		8		SH / SH / SH	0	73			H=0.0 G
	15	9		SH / SH / SH	0	67			H=0.0-0.25 G
		10		SH / SH / SH	0	73			H=0.0-0.25 G
	20	11		SH / SH / 3	4	67			H=0.0-0.50 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

2008 NEW DEFAULT BORING LOG-W/N60 11149701 3.GPJ BBCM.GDT 8/4/09

LOG OF BORING NO. CD-BAP-0907
CARDINAL PLANT ASH POND INVESTIGATION
BRILLIANT, OHIO

BBCM

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	N_{60}	SAMPLE REC-%	DESCRIPTION	NATURAL CONSISTENCY INDEX / NATURAL MOISTURE CONTENT (PLASTIC LIMIT – LIQUID LIMIT; 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'. - Groundwater encountered at 23.0'. - Borehole grouted upon completion. - Boring location and elevation surveyed by AEP.		
	35								
	40								
	45								
	50								

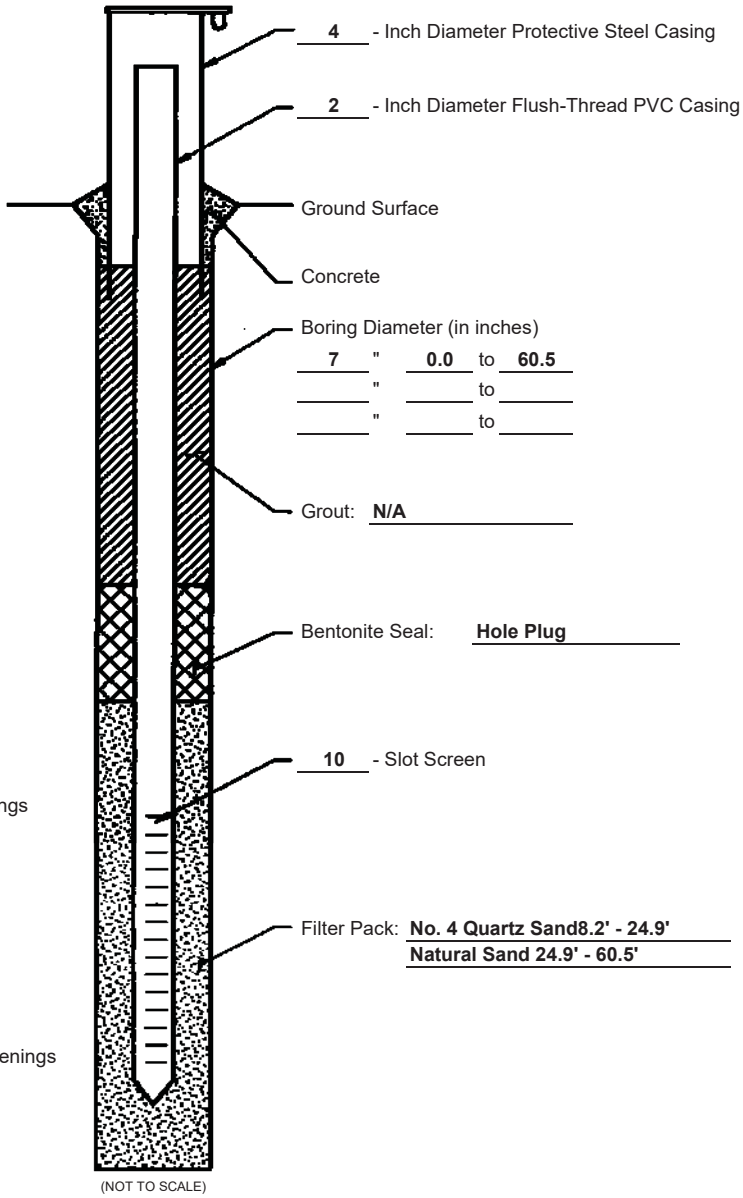
WATER LEVEL: ▽ **16.3** ▼
WATER NOTE: **Inside HSA**
DATE: **4/8/09**

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 11149701 3.GPJ BBCM.GDT 8/4/09

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



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

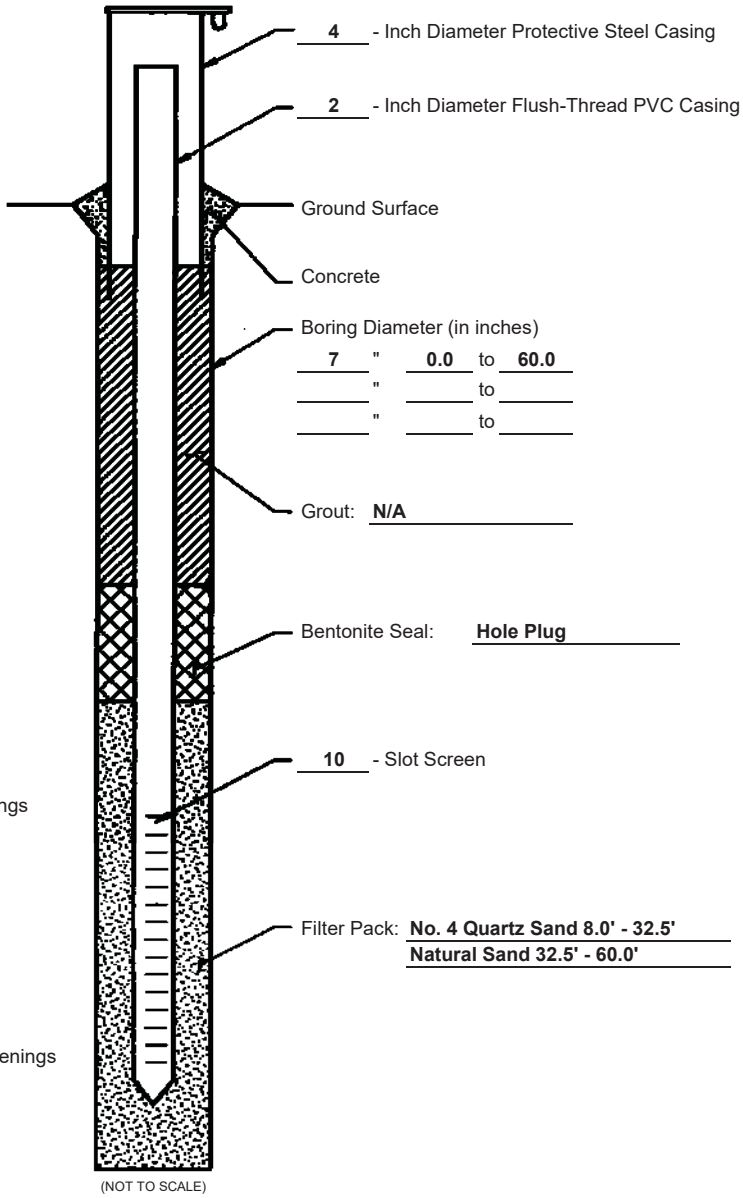
Project Number:
011-11497-013

Boring Number:
CD-PZ-BAP-0902

Date Well Installed:
4/8/2009

PLATE 23

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



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

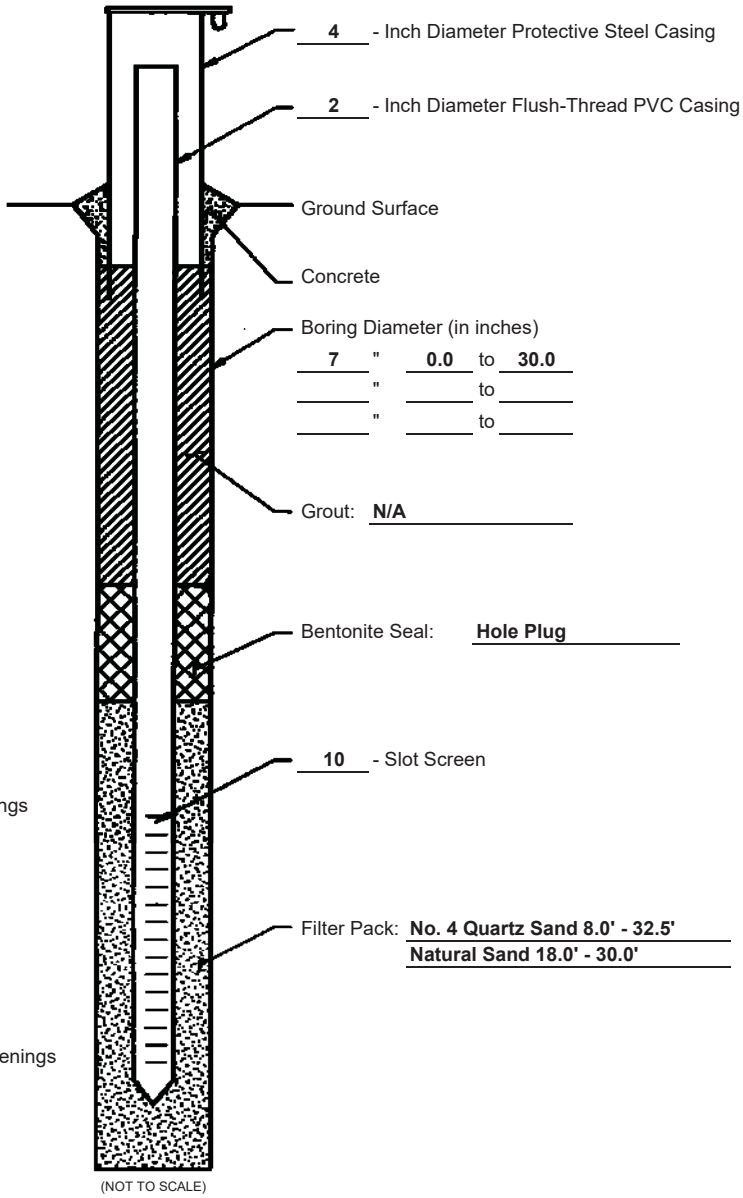
Project Number:
011-11497-013

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



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 WEIGHT DRY	REMOLDED	PERMEABILITY				RELATIVE DENSITY	LOI	ROCK CORE	SHELBY TUBE	Slake Index
							Hydrometer																									
						sieve	short	long	standard	modified	unconsn.	undrain consolid	undrain w/ pores	drained	drained	undrain	residual							cohesive	non/cohes	rigid	flexible					
		%	%	%	%	* 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				*																										

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

SUM REG

PLATE 1

SUMMARY OF LABORATORY TEST RESULTS

BORING	G'int Id.	MC	LL	PL	PI	GRADATION			COMPACTION		TRIAXIAL				DIRECT SHEAR			UNCONFIN COMPRESS	CONSOLID.	SPECIFIC GRAVITY	UNIT WEIGHT DRY	REMOLDED	PERMEABILITY				RELATIVE DENSITY	LOI	ROCK CORE	SHELBY TUBE	Slake Index
							Hydrometer																								
						sieve	short	long	standard	modified	unconsn.	undrain consolid	undrain w/ pores	drained	drained	undrain	residual						cohesive	non/cohes	rigid wall	flexible wall					
		%	%	%	%	* 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

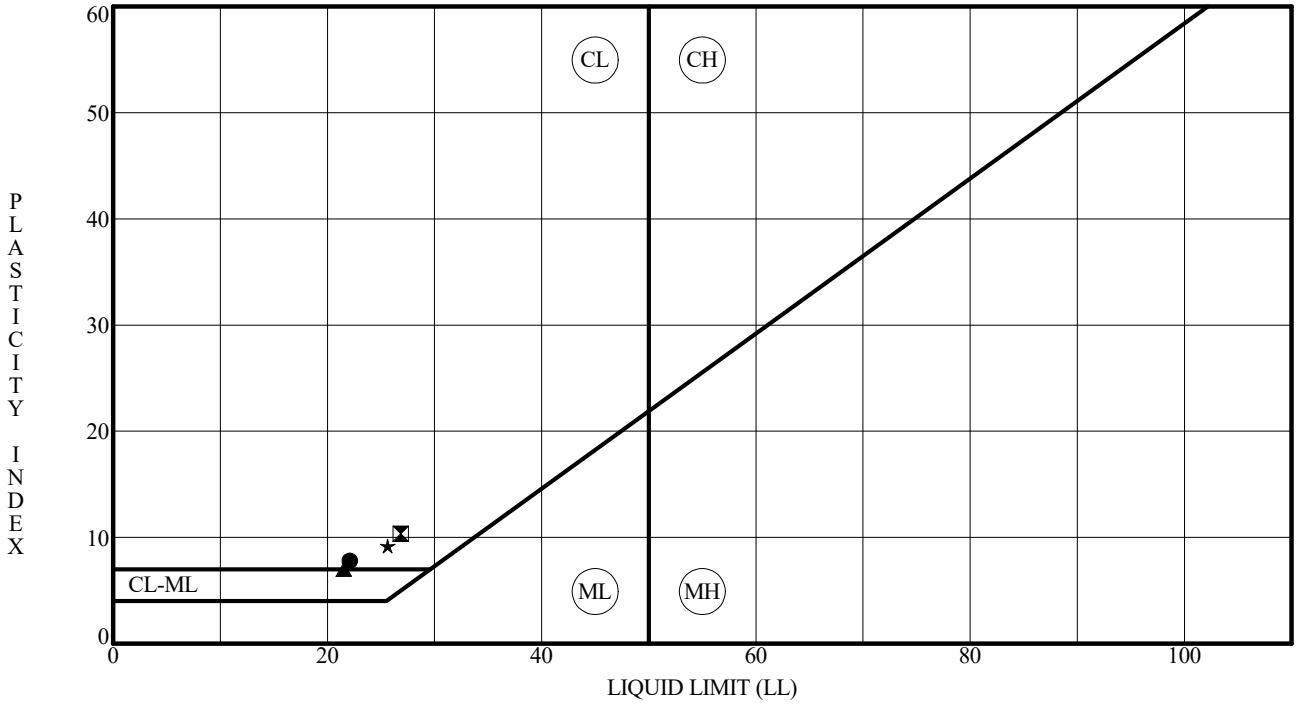
TESTING SUMMARY - STANDARD

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A DATE 12/30/15

SUM REG

PLATE 2

ATTERBERG LIMITS' RESULTS - ASTM D4318

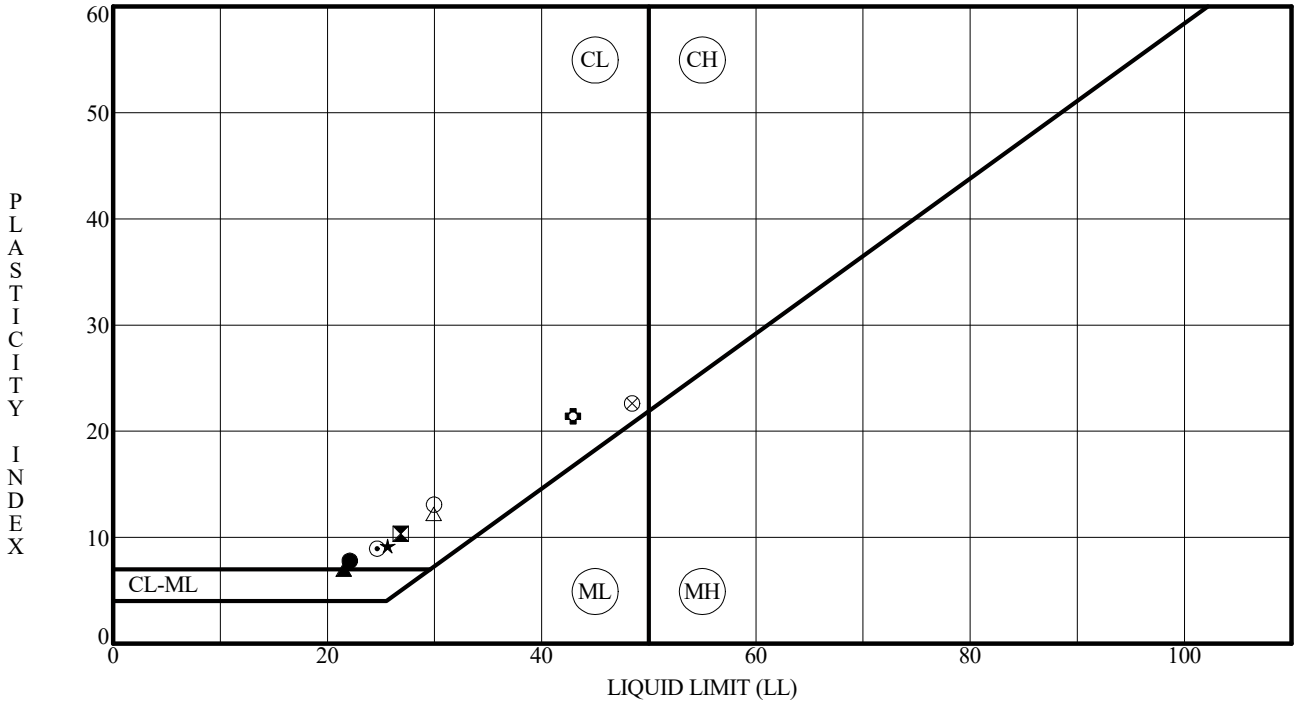


Specimen Id.	Depth	MC	LL	PL	PI	Fines	ASTM Classification
● CD-BAP-1501	12.25	14	22	14	8		
⧗ CD-BAP-1502	6.25	9	27	16	11	28.6	CLAYEY SAND with GRAVEL SC
▲ CD-BAP-1502	11.25	9	21	14	7		
★ CD-BAP-1502	17.75	13	26	16	10	27.9	CLAYEY SAND with GRAVEL SC

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A **DATE** 12/30/15

ALPI-REG

ATTERBERG LIMITS' RESULTS - ASTM D4318

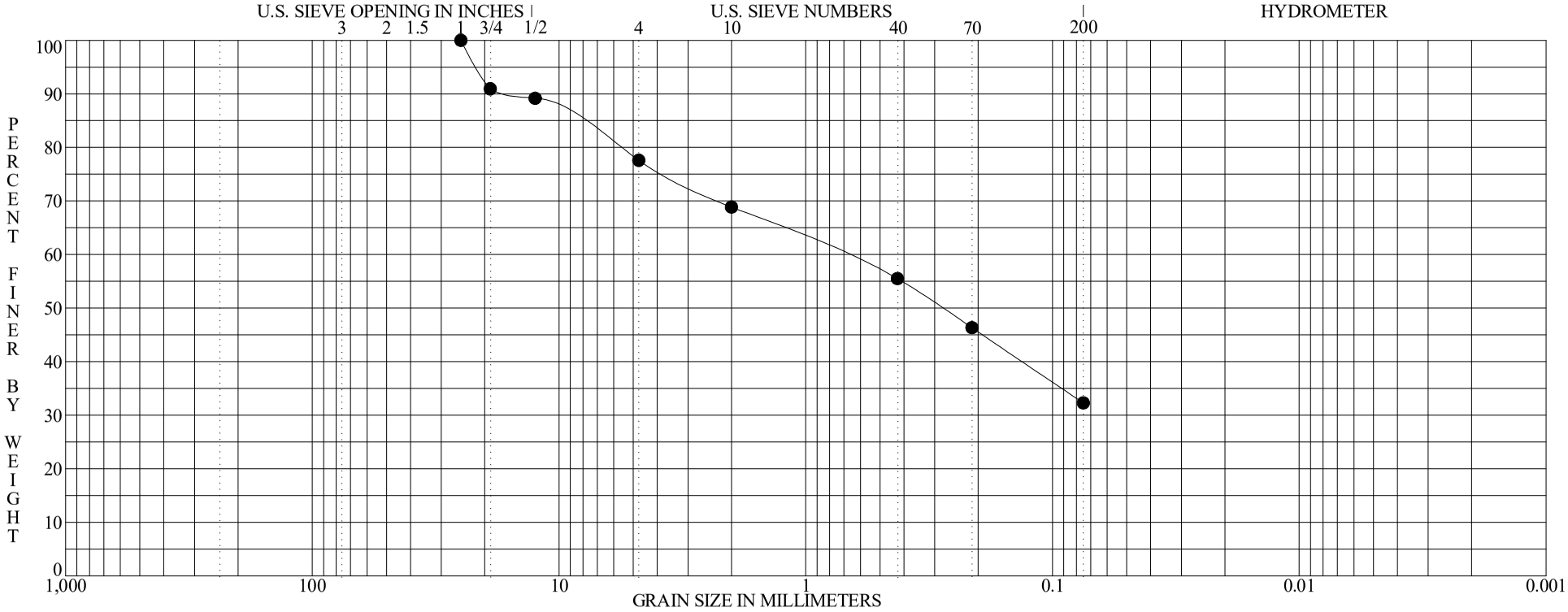


	Specimen Id.	Depth	MC	LL	PL	PI	Fines	ASTM Classification
●	CD-BAP-1501	12.25	14	22	14	8		
⧗	CD-BAP-1502	6.25	9	27	16	11	28.6	CLAYEY SAND with GRAVEL SC
▲	CD-BAP-1502	11.25	9	21	14	7		
★	CD-BAP-1502	17.75	13	26	16	10	27.9	CLAYEY SAND with GRAVEL SC
⊙	MW-BAP-4	6.25	15	25	16	9	41.2	CLAYEY SAND SC
✿	MW-BAP-4	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

ALPI-REG

GRN-REG W/ASTM DESC.



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

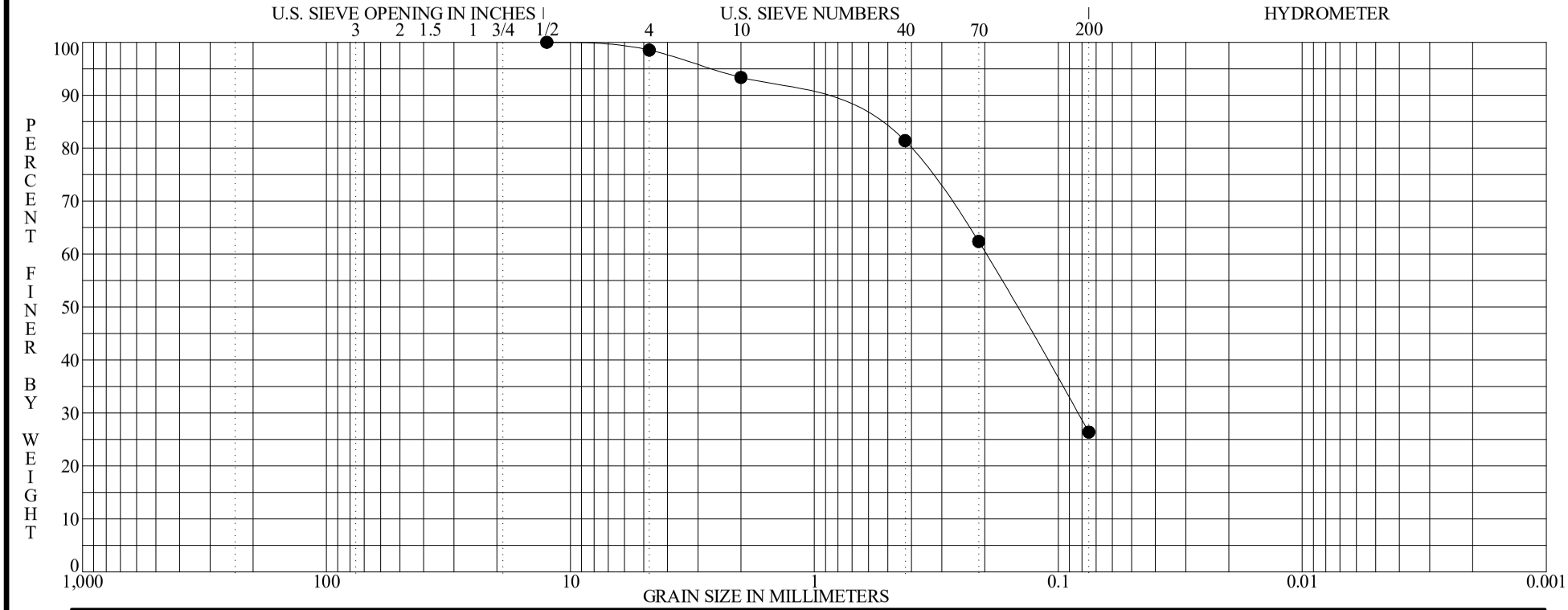
	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-1501 S-3 4.0' to 4.8'**	**Gray and brown fine to coarse sand, some fine to coarse gravel, some silt.**						

	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

GRN-REG W/ASTM DESC.



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

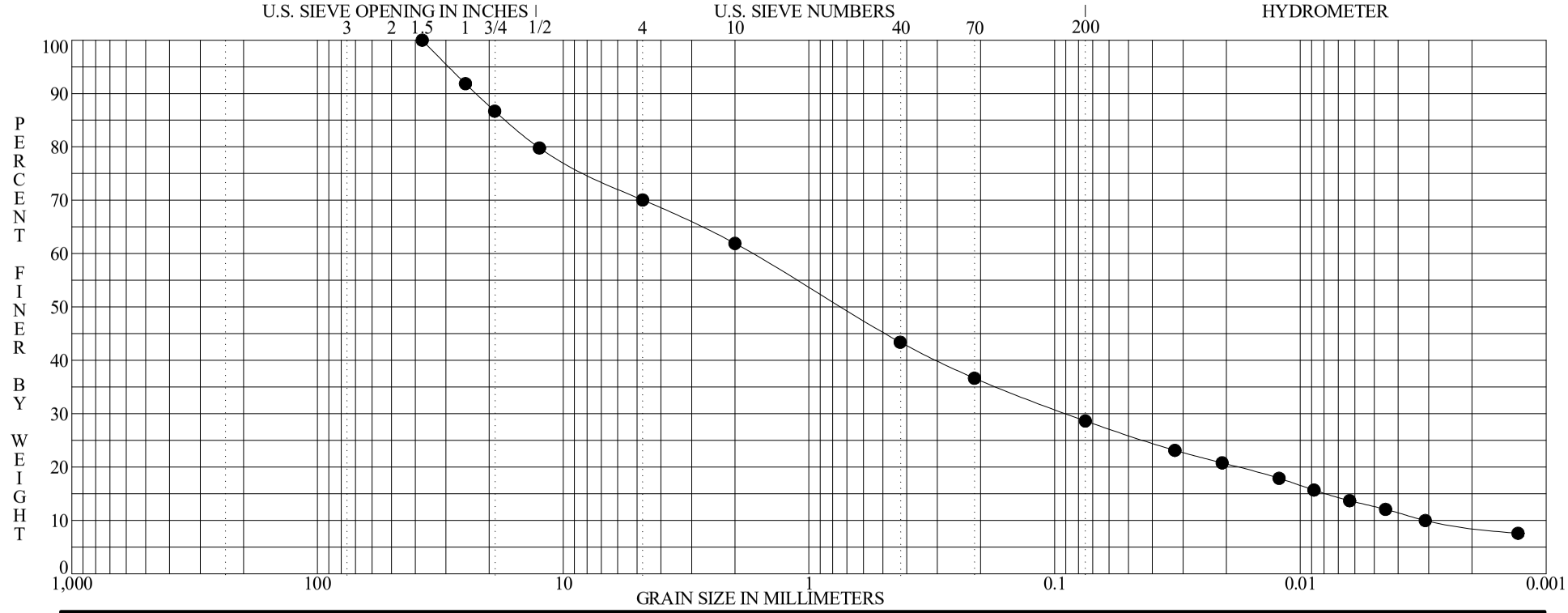
Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-BAP-1501 S-6 8.5' to 9.7'**	**Red-brown and gray fine to coarse sand, trace fine gravel, some silt.**						

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.



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	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.**	**9**	**27**	**16**	**11**	**1.508**	**547.388**
		CLAYEY SAND with GRAVEL SC						

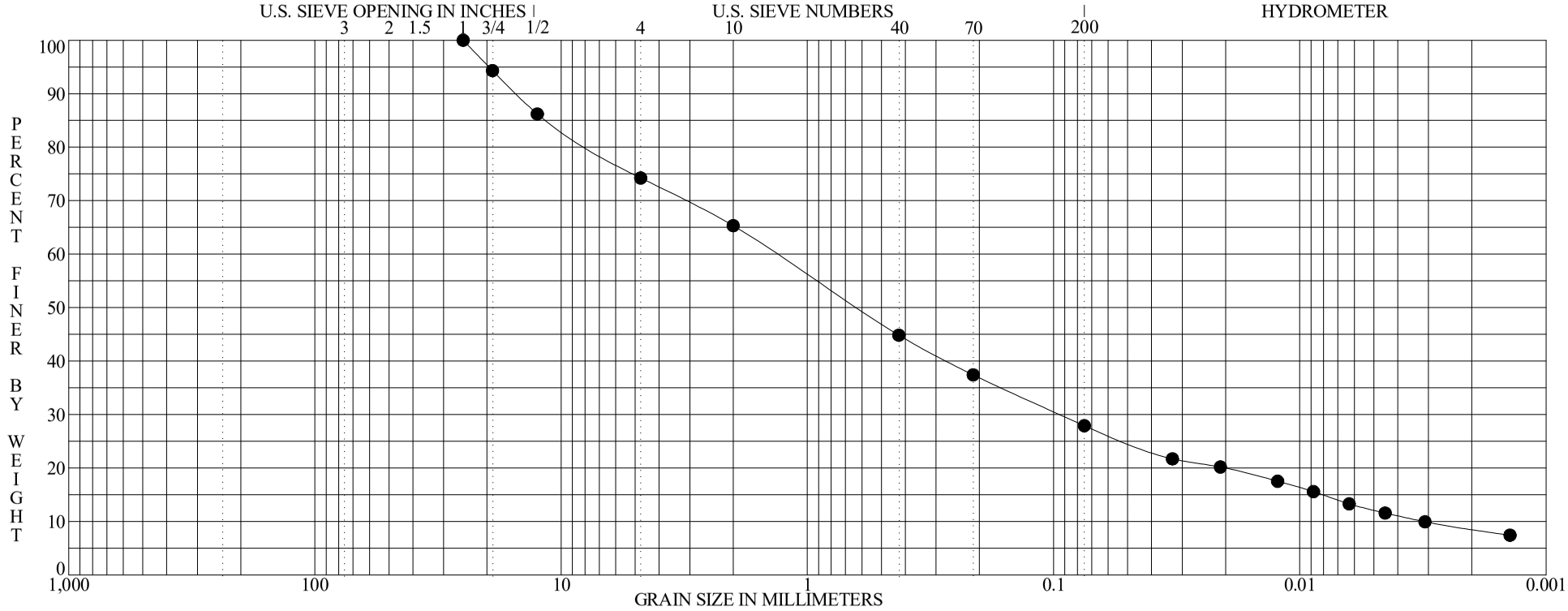
	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-1502 S-4 5.5' to 6.7'**	**37.5000**	**29.2411**	**1.7048**	**0.7385**	**0.0031**	**29.9**	**41.4**	**16.1**	**12.6**

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.



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

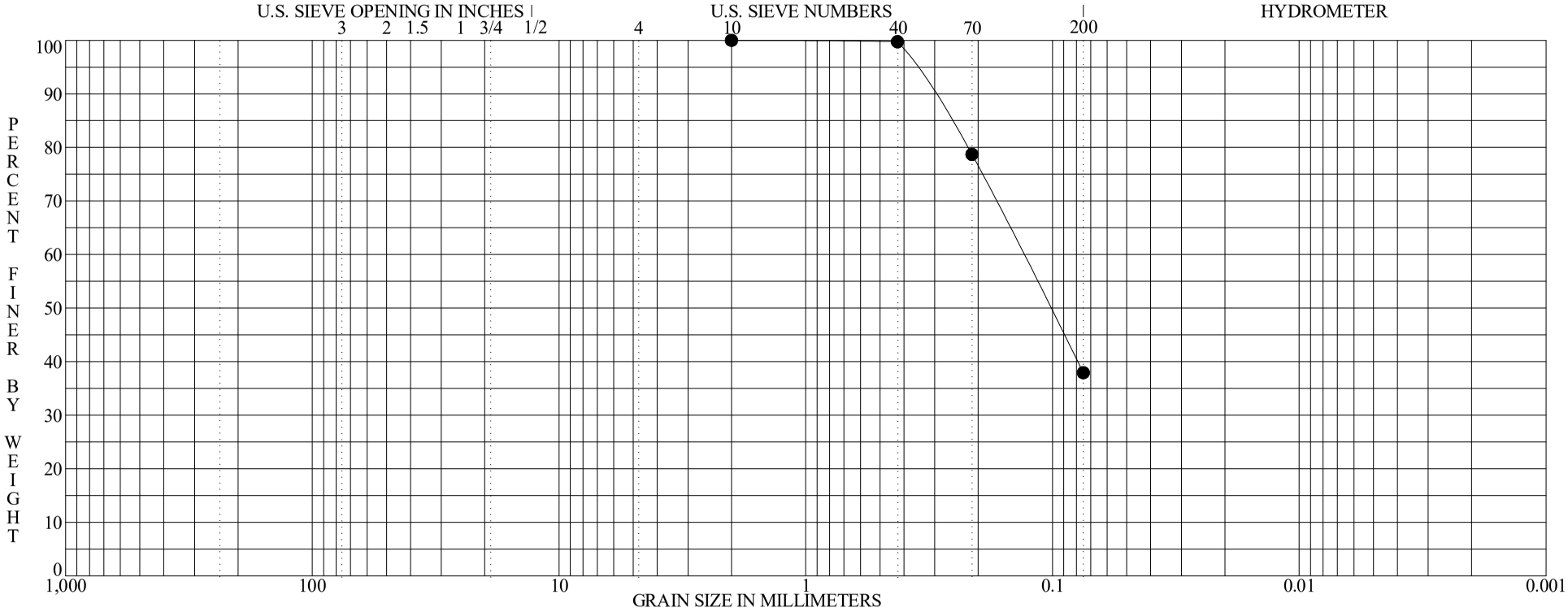
	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-1502 S-9 17.0' to 18.3**	**Gray fine to coarse sand, some fine to coarse gravel, some clayey silt.**	**13**	**26**	**16**	**10**	**2.113**	**425.827**
		CLAYEY SAND with GRAVEL SC						

	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.



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

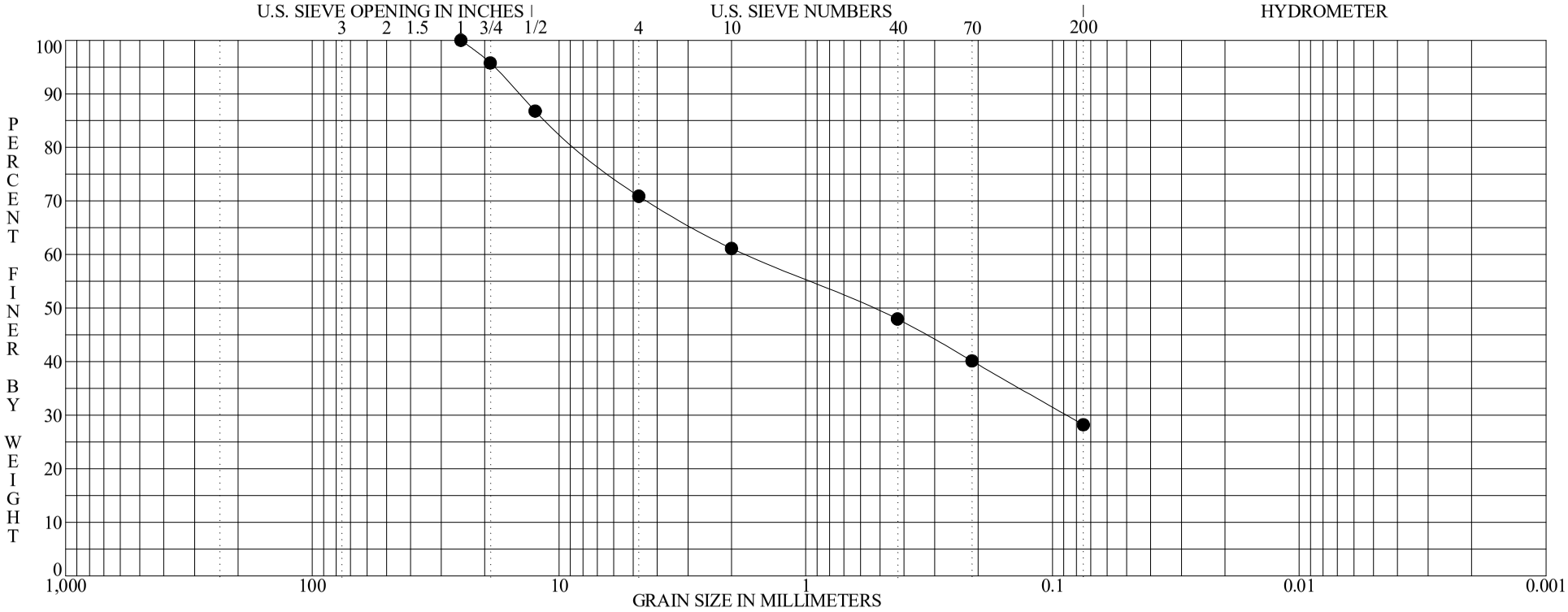
	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-1502 S-18 40.0' to 41.0'**	**Brown fine to medium sand, "and" silt.**						

	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.



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

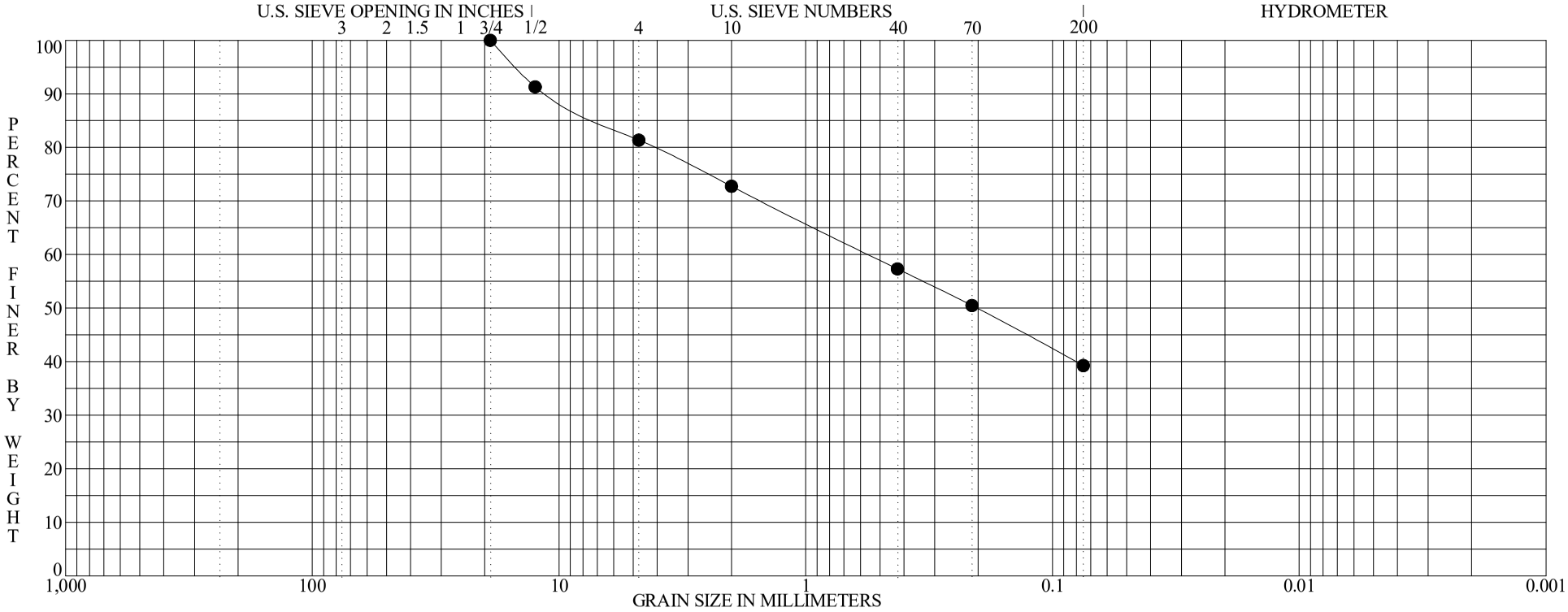
	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-1504 S-7 10.0' to 11.0'**	**Dark-gray fine to coarse sand, some fine to coarse gravel (sandstone fragments), some silty clay.**						

	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**					

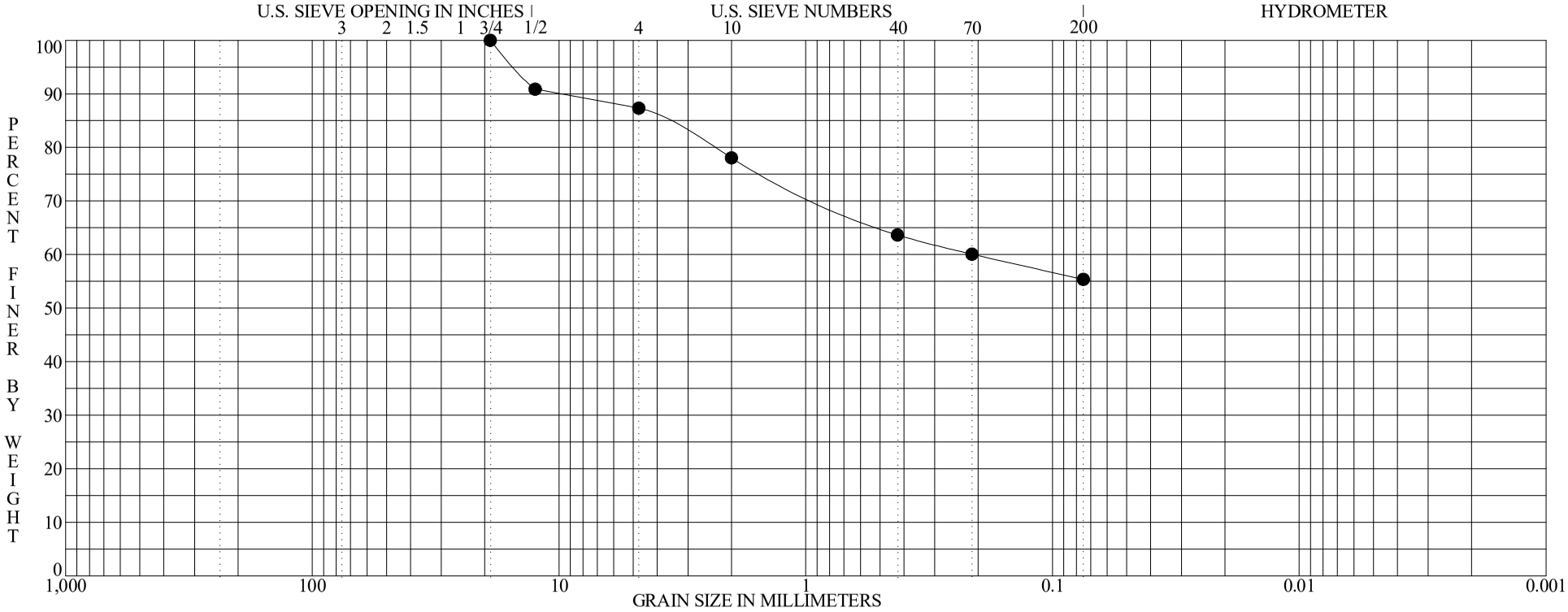
	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-1504 S-8 11.5' to 11.9'**	**19.0000**	**14.9354**	**0.5566**	**0.2026**		**18.6**	**42.1**	**39.3**	

ASTM D422 | **GRADATION CURVE**

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A **DATE** 12/30/15

PLATE 11

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-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**	

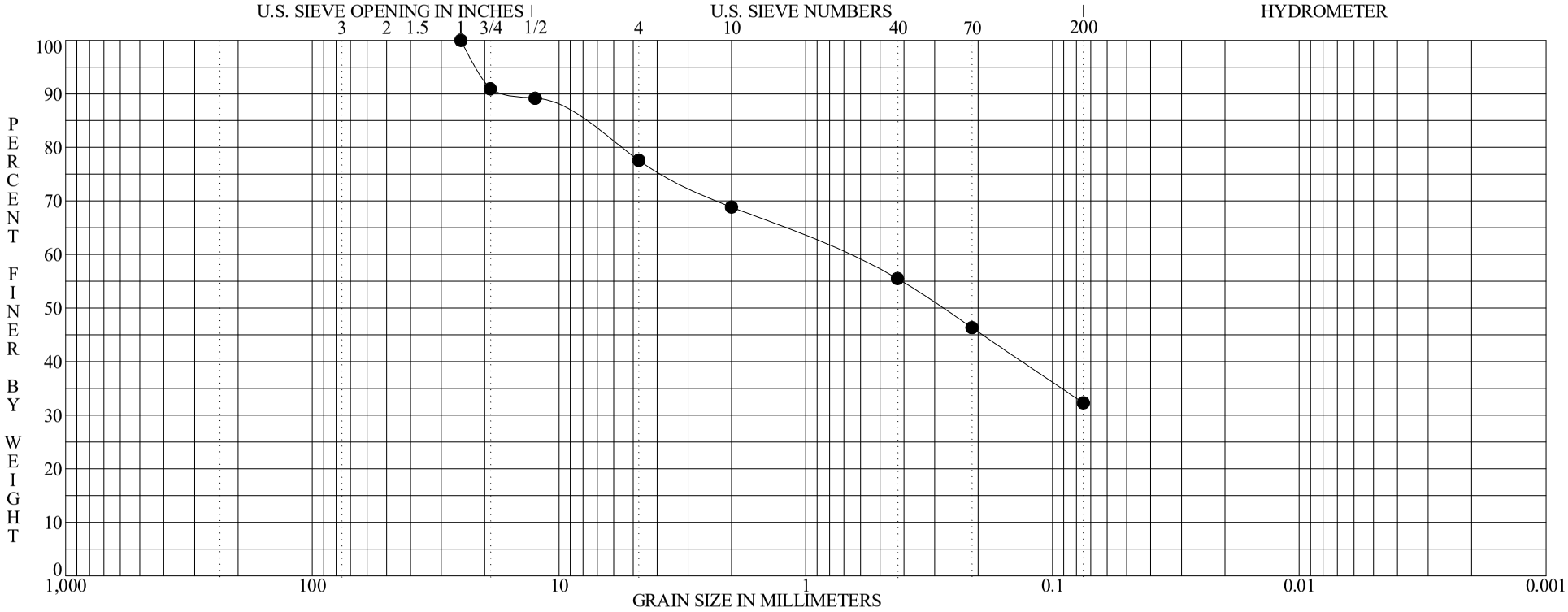
ASTM D422

GRADATION CURVE

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A **DATE** 12/30/15

PLATE 12

GRN-REG W/ASTM DESC.



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

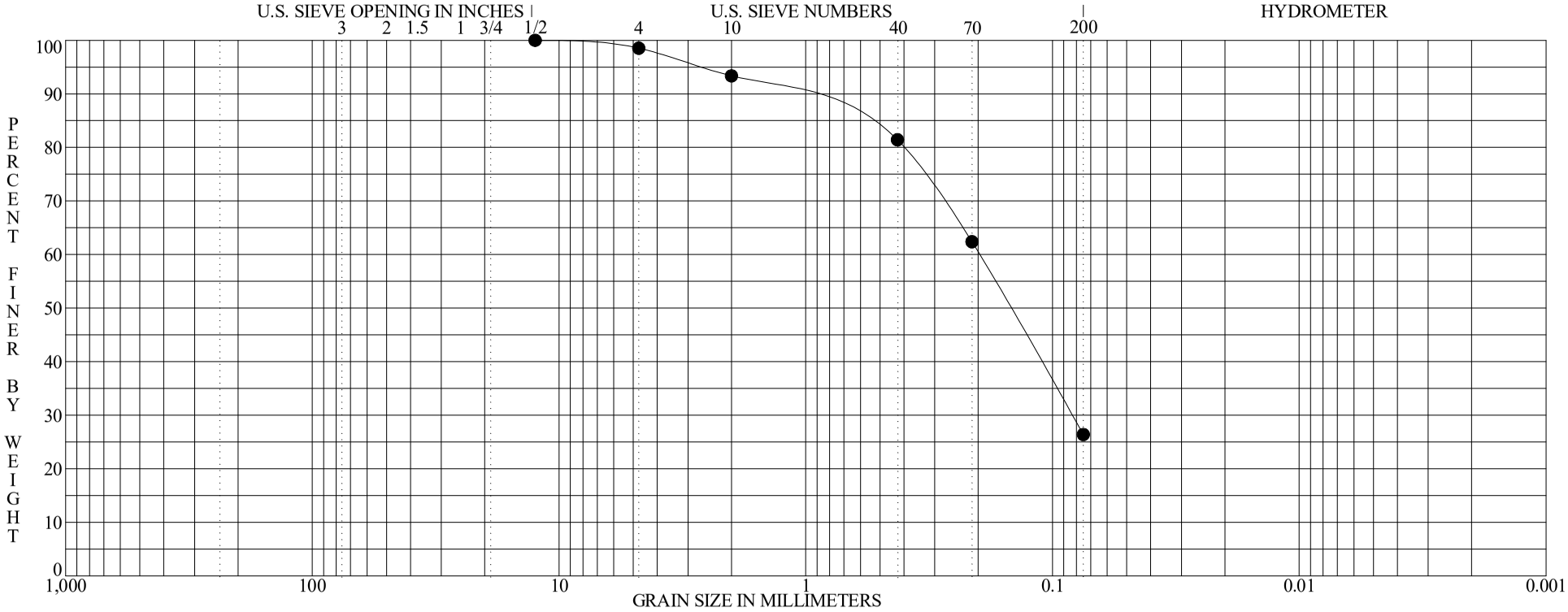
Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **CD-BAP-1501 S-3 4.0' to 4.8'**	**Gray and brown fine to coarse sand, some fine to coarse gravel, some silt.**						

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

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-1501 S-6 8.5' to 9.7'**	**Red-brown and gray fine to coarse sand, trace fine gravel, some silt.**						

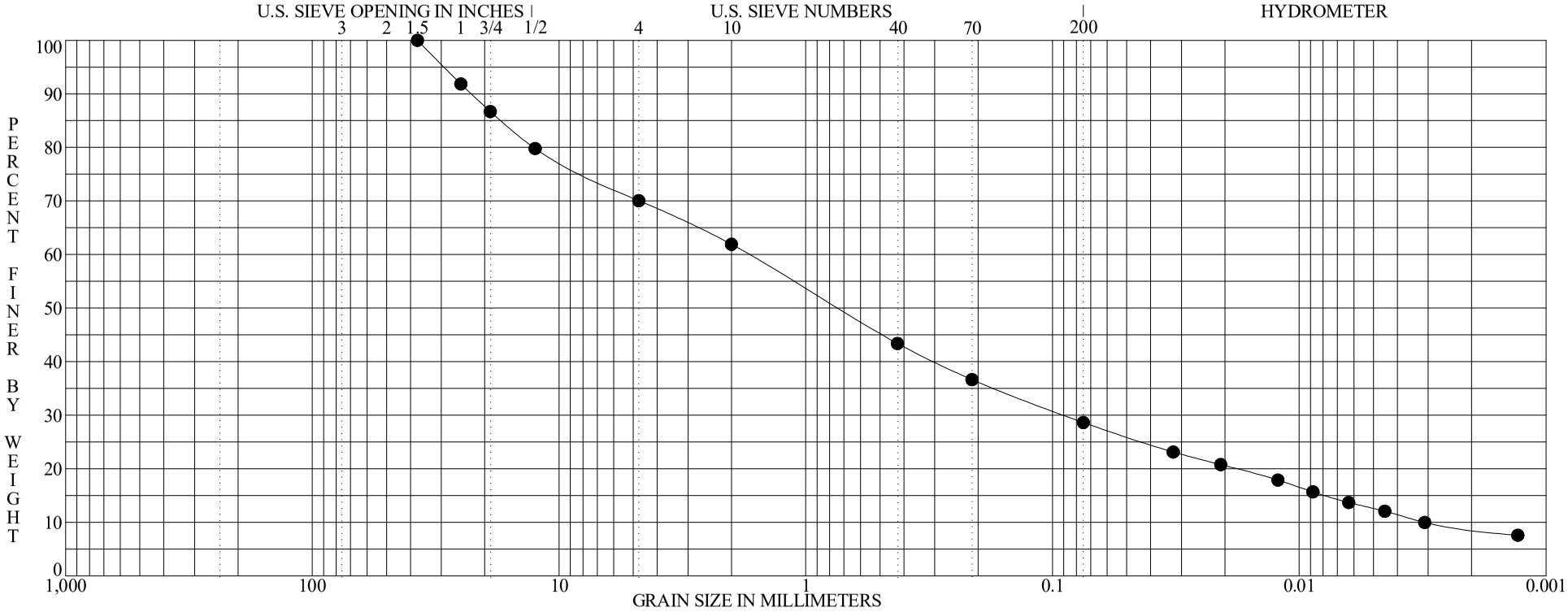
Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
● **CD-BAP-1501 S-6 8.5' to 9.7'**	**12.5000**	**2.6291**	**0.1978**	**0.1482**		**1.5**	**72.1**	**26.4**	

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.



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

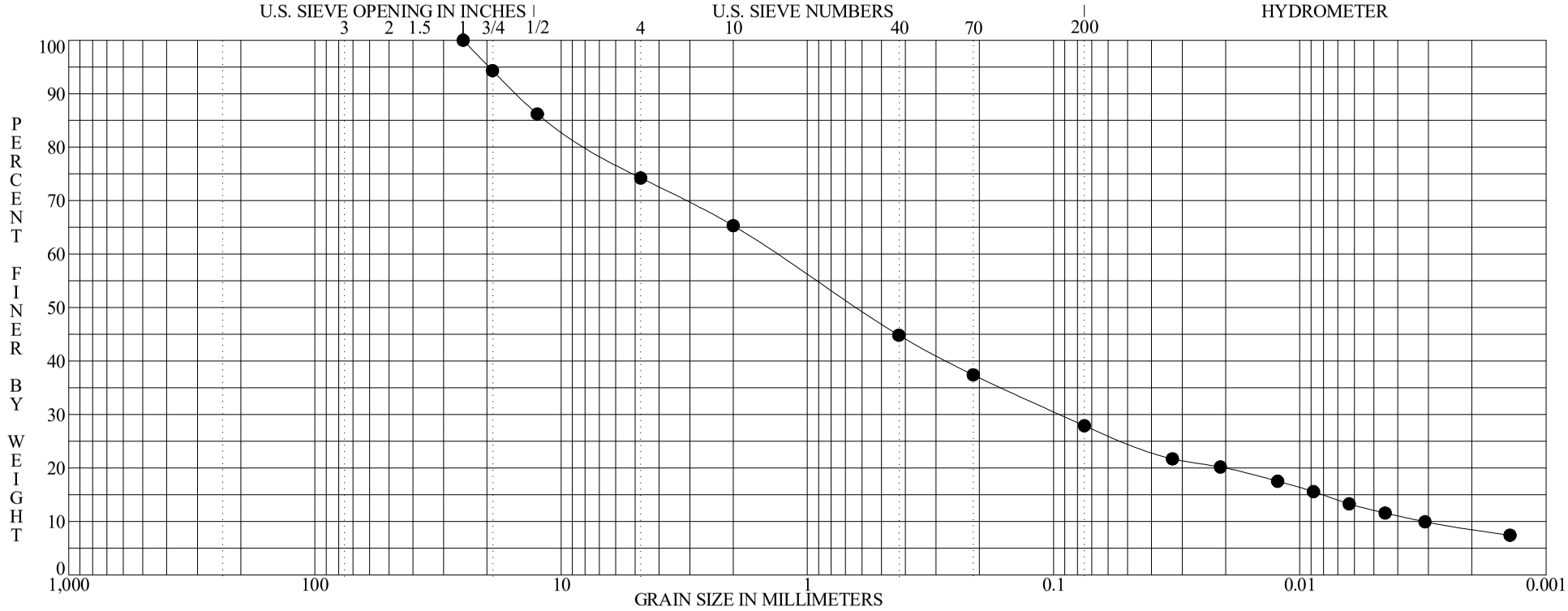
	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-1502 S-4 5.5' to 6.7'**	**Gray and brown fine to coarse sand, some fine to coarse gravel, some silty clay.**	**9**	**27**	**16**	**11**	**1.508**	**547.388**
		CLAYEY SAND with GRAVEL SC						

	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

GRN-REG W/ASTM DESC.



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

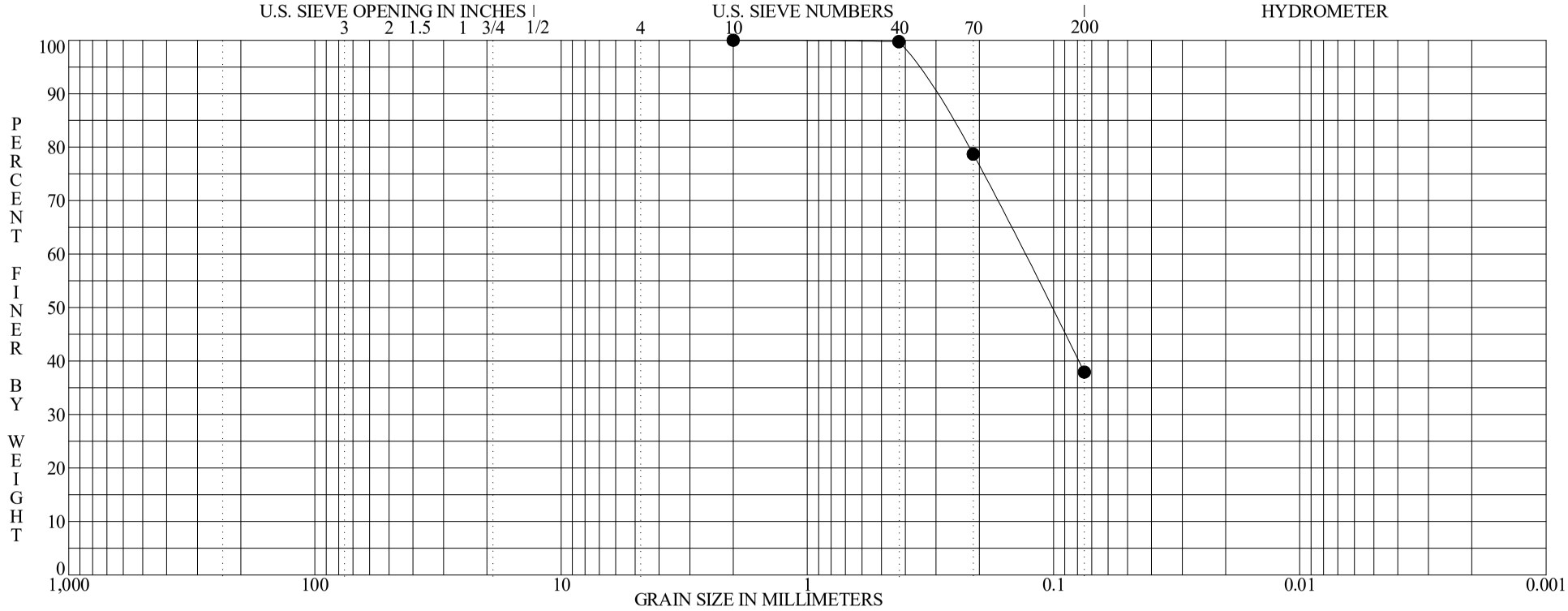
	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-1502 S-9 17.0' to 18.3**	**Gray fine to coarse sand, some fine to coarse gravel, some clayey silt.**	**13**	**26**	**16**	**10**	**2.113**	**425.827**
		CLAYEY SAND with GRAVEL SC						

	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.



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

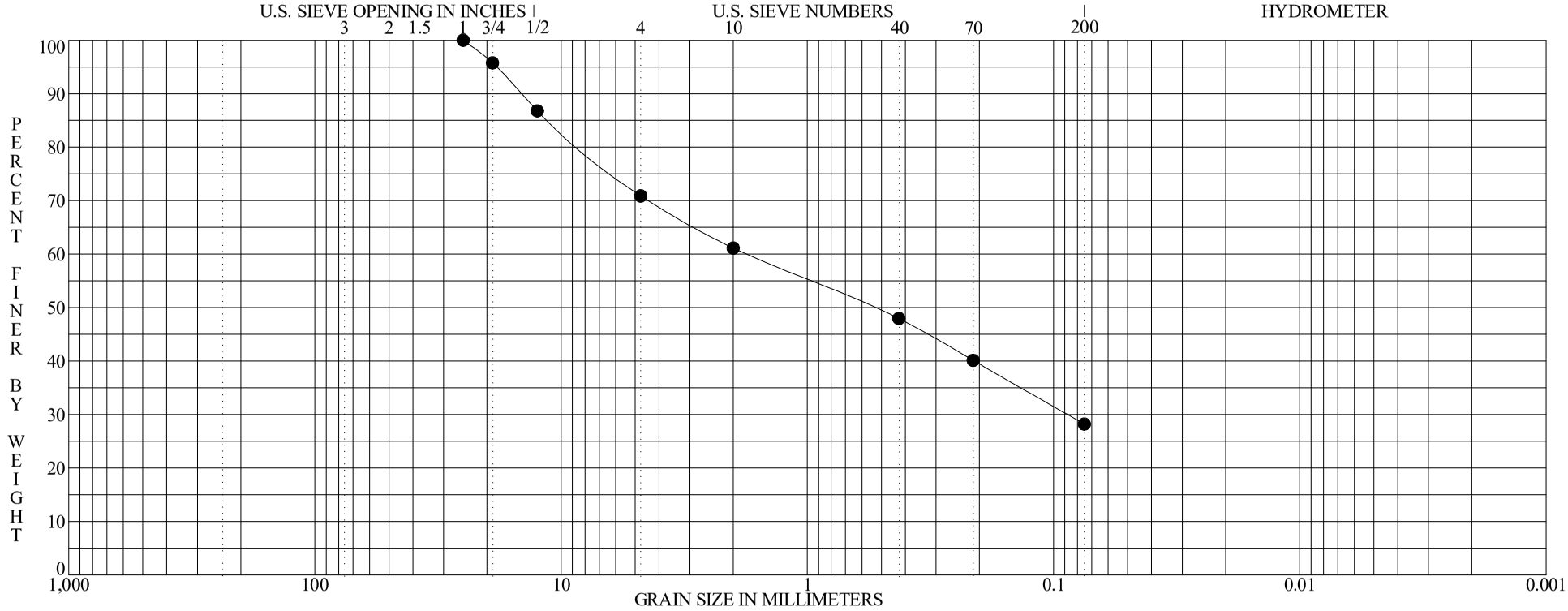
	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-1502 S-18 40.0' to 41.0'**	**Brown fine to medium sand, "and" silt.**						

	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.



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

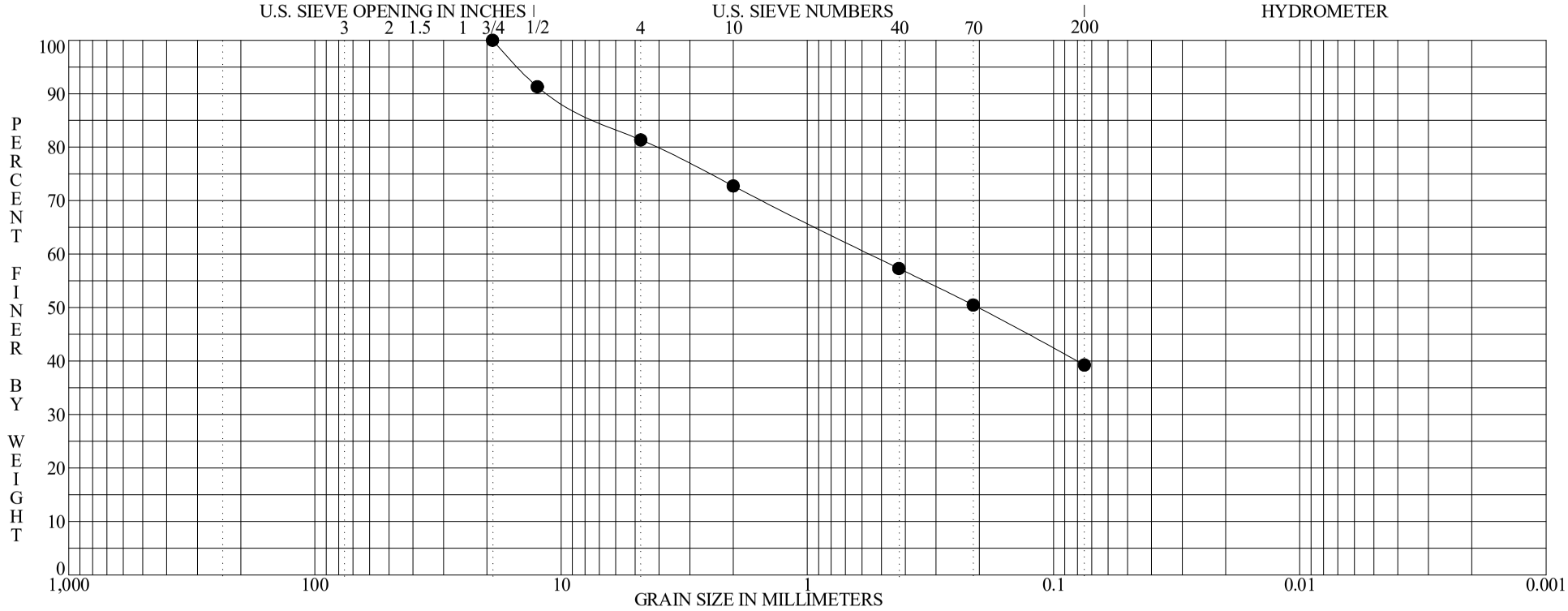
	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-1504 S-7 10.0' to 11.0'**	**Dark-gray fine to coarse sand, some fine to coarse gravel (sandstone fragments), some silty clay.**						

	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**					

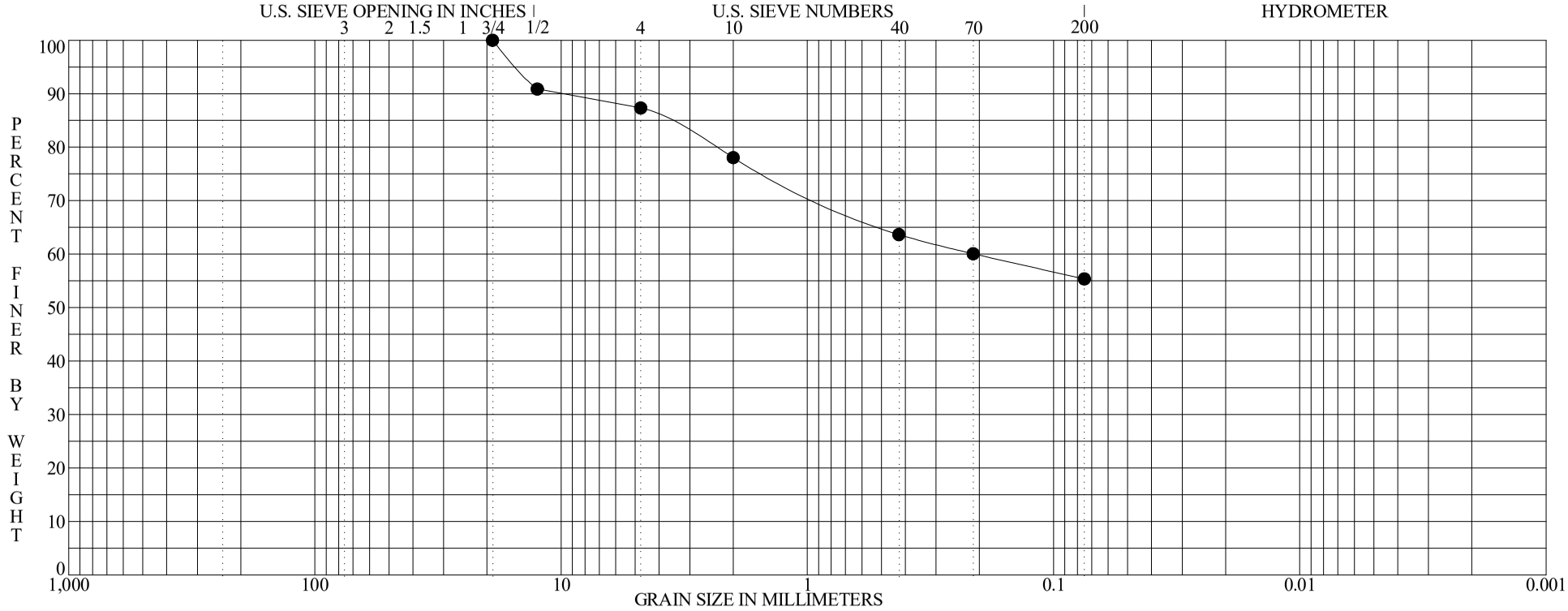
	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-1504 S-8 11.5' to 11.9'**	**19.0000**	**14.9354**	**0.5566**	**0.2026**		**18.6**	**42.1**	**39.3**	

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.



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	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**	

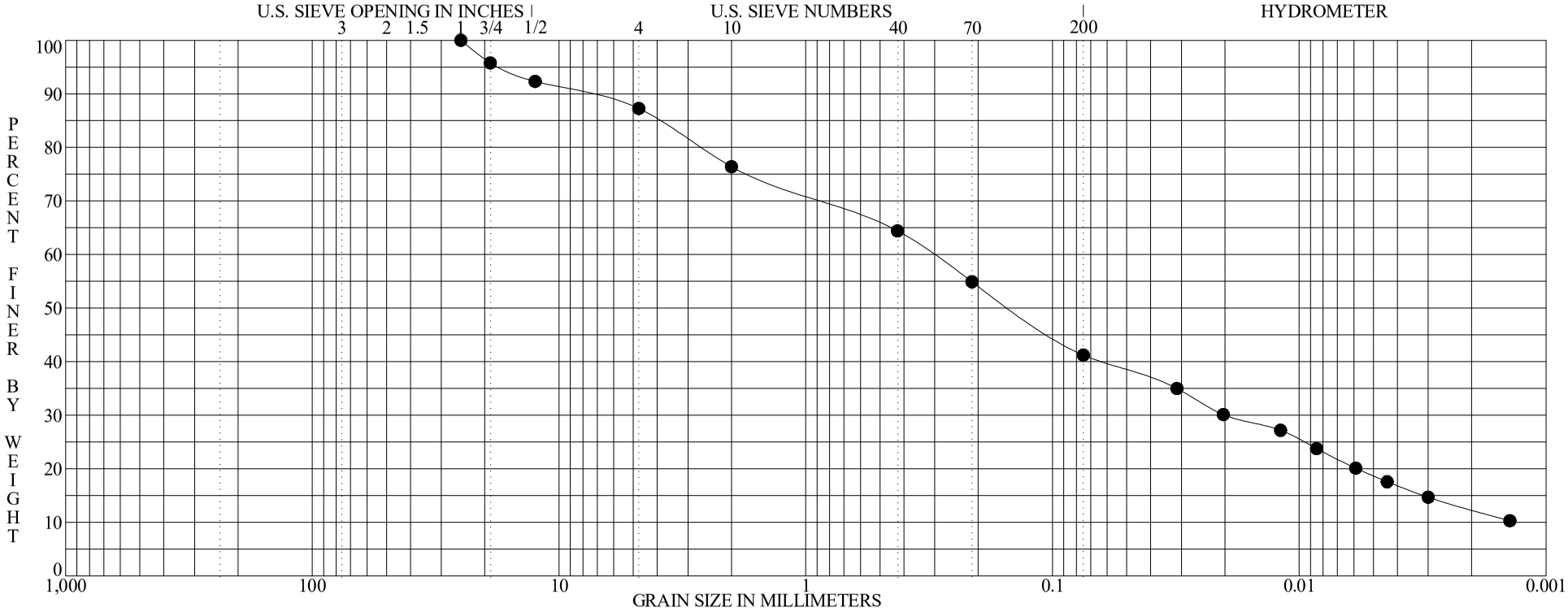
ASTM D422

GRADATION CURVE

PROJECT BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION
LOCATION CARDINAL PLANT, BRILLIANT, OH
JOB NO. 7217-15-007A **DATE** 12/30/15

PLATE 20

GRN-REG W/ASTM DESC.



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

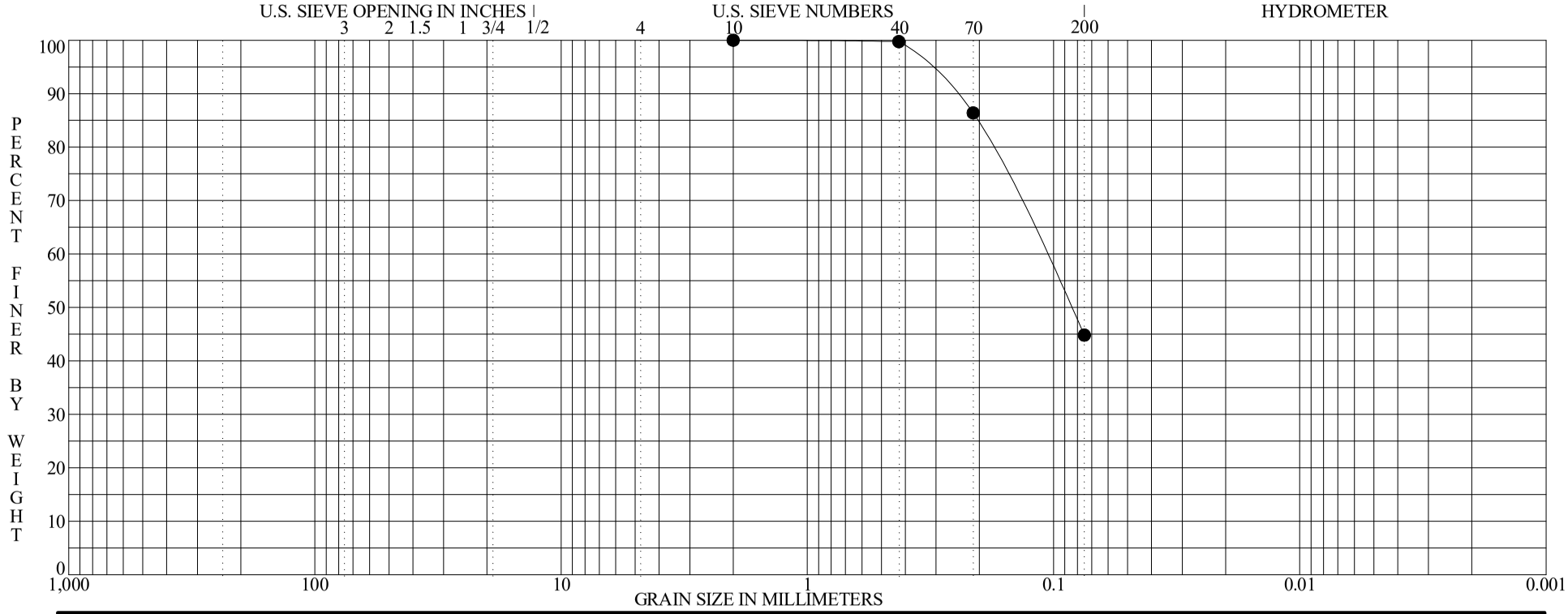
Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
● **MW-BAP-4 S-4 5.5' to 6.8'**	**Brown fine to coarse sand, little fine to coarse gravel, "and" clayey silt.**	**15**	**25**	**16**	**9**		
	CLAYEY SAND SC						

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.



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

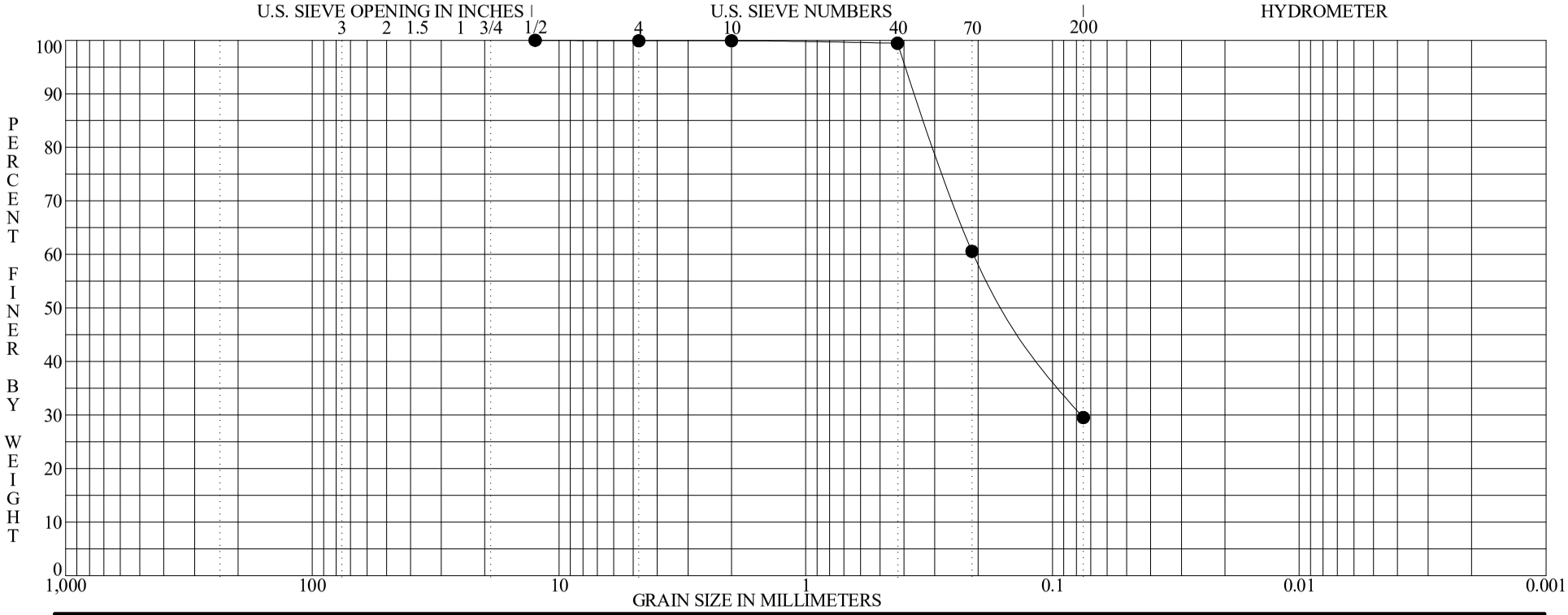
	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**MW-BAP-4 S-13 31.5' to 32.5'**	**Gray fine to medium sand, "and" silt.**						

	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

GRN-REG W/ASTM DESC.



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

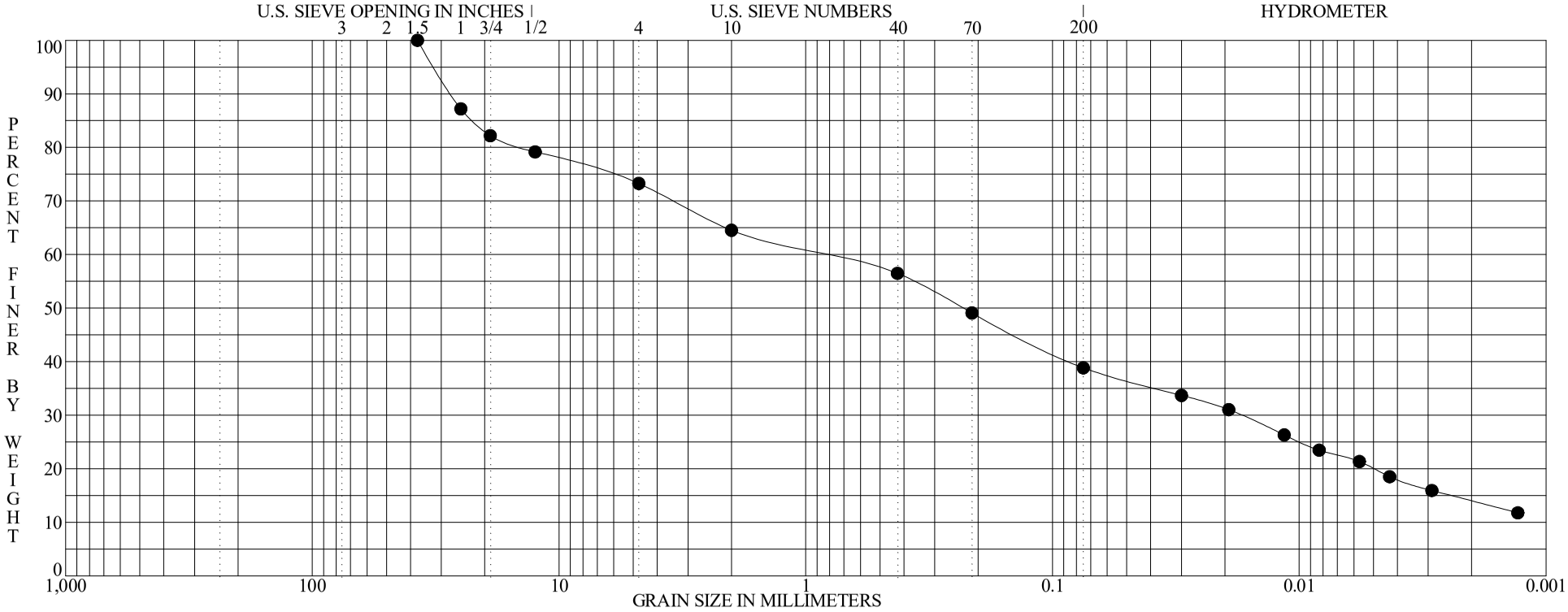
	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**MW-BAP-4 S-16 38.5' to 40.0'**	**Gray fine to coarse sand, trace fine gravel, some silt.**						

	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

GRN-REG W/ASTM DESC.



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

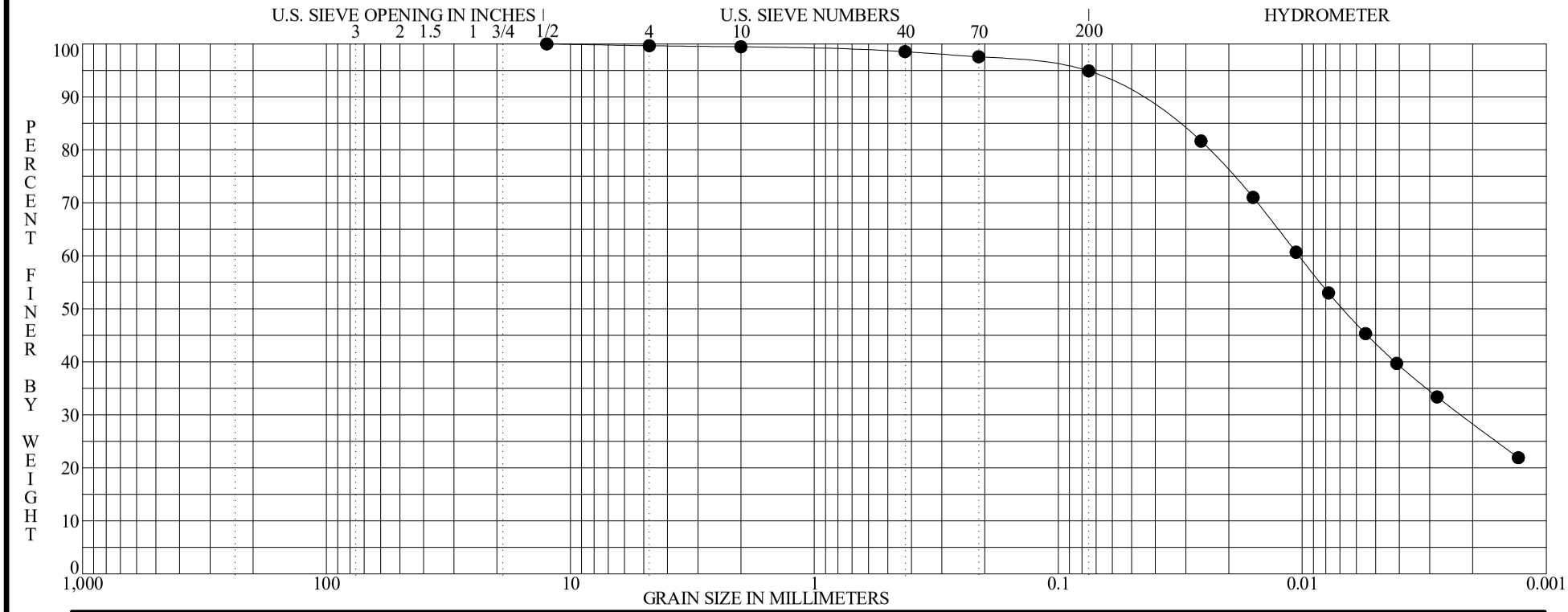
	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**MW-BAP-5 S-3 4.0' to 5.1'**	**Brown fine to coarse sand, some fine to coarse gravel, "and" silty clay.**	**13**	**30**	**17**	**13**		
		CLAYEY SAND with GRAVEL SC						

	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

GRN-REG W/ASTM DESC.



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

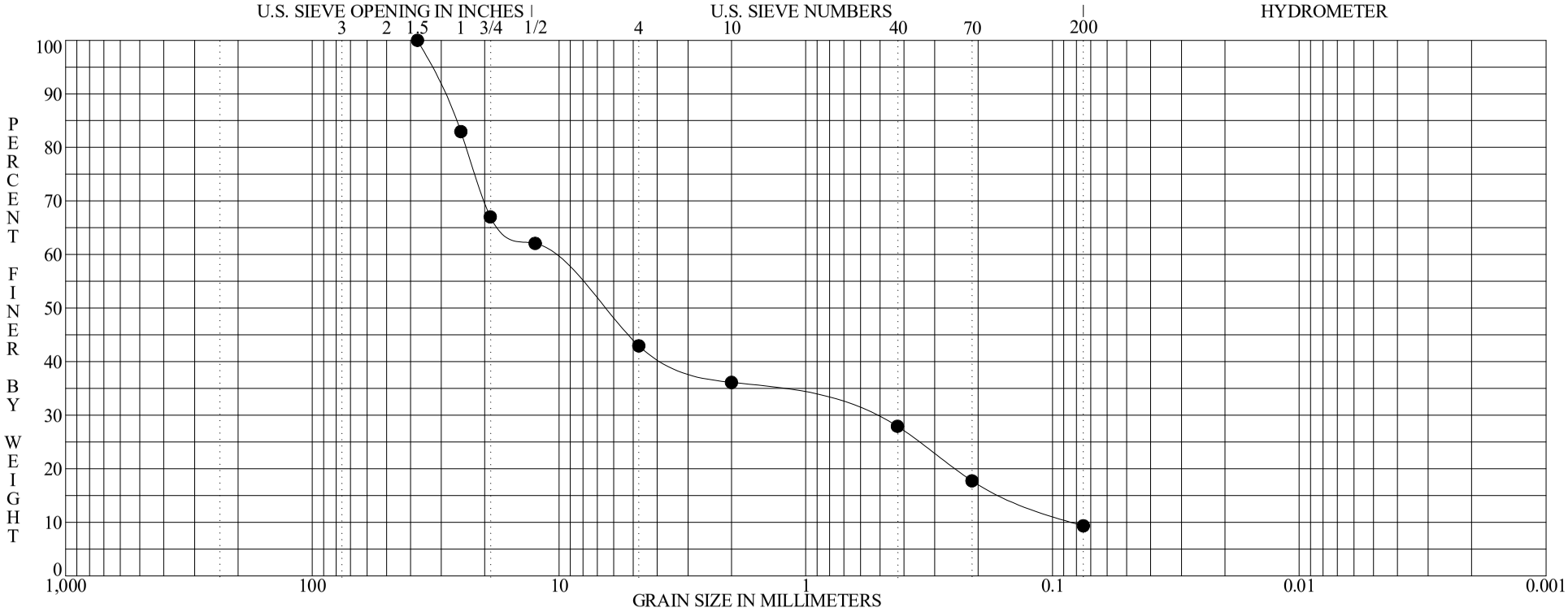
	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**MW-BAP-5 S-11 21.0' to 22.5'**	**Gray mottled with dark-gray and brown silty clay, trace fine to coarse sand, trace fine gravel, few roots and silt seams, slightly organic. LEAN CLAY CL**	**40**	**48**	**26**	**22**		

	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

GRN-REG W/ASTM DESC.



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

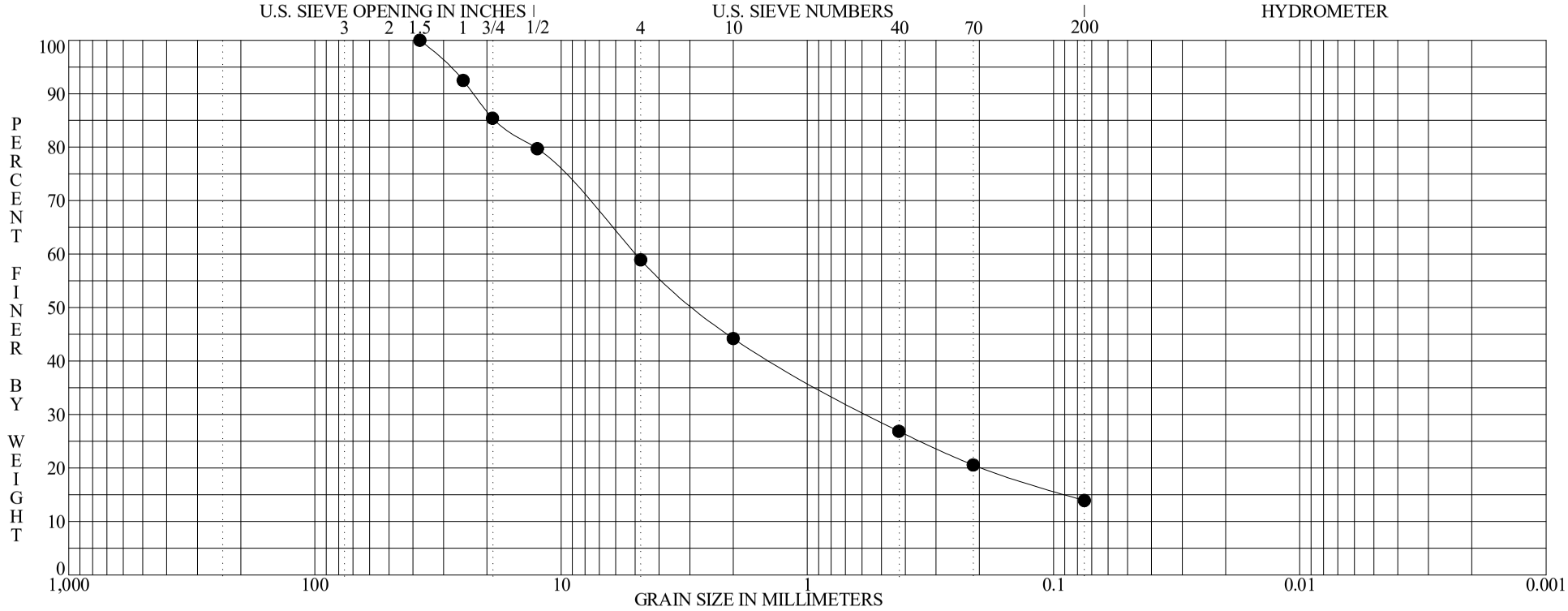
	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**MW-BAP-5 S-21 51.0' to 51.3'**	**Gray fine to coarse gravel, some fine to coarse sand, trace silt.**					**0.432**	**138.404**

	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.



BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	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

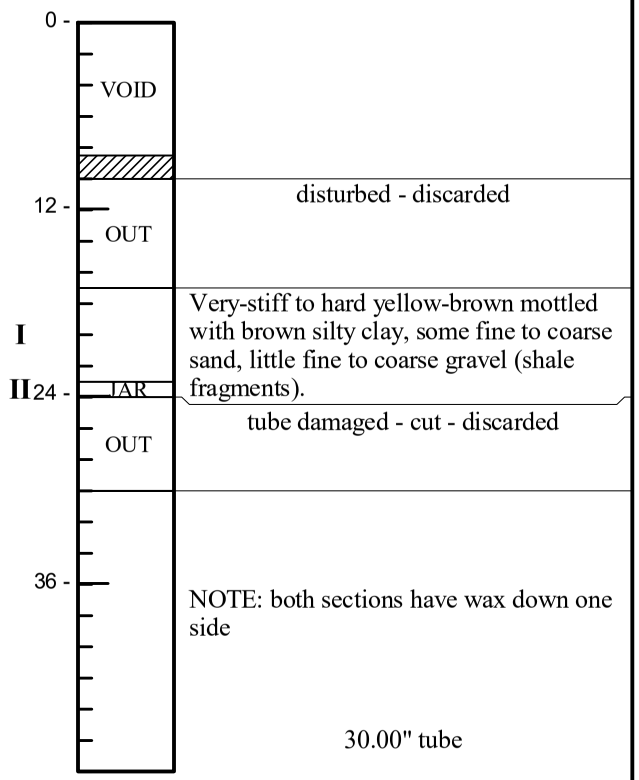
JOB NUMBER : **7217-15-007A**
PROJECT : **BOTTOM ASH POND SUPPLEMENTAL INVESTIGATION**
LOCATION : **CARDINAL PLANT, BRILLIANT, OH**

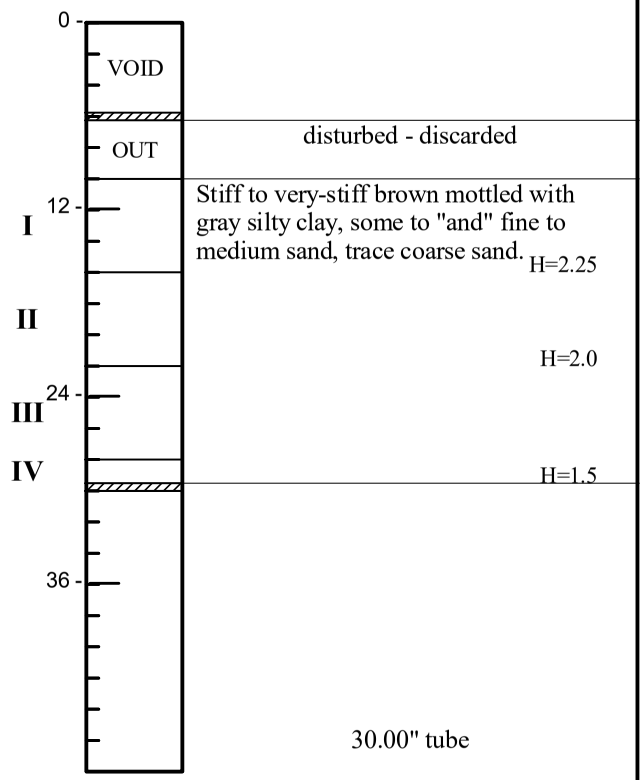
S&ME

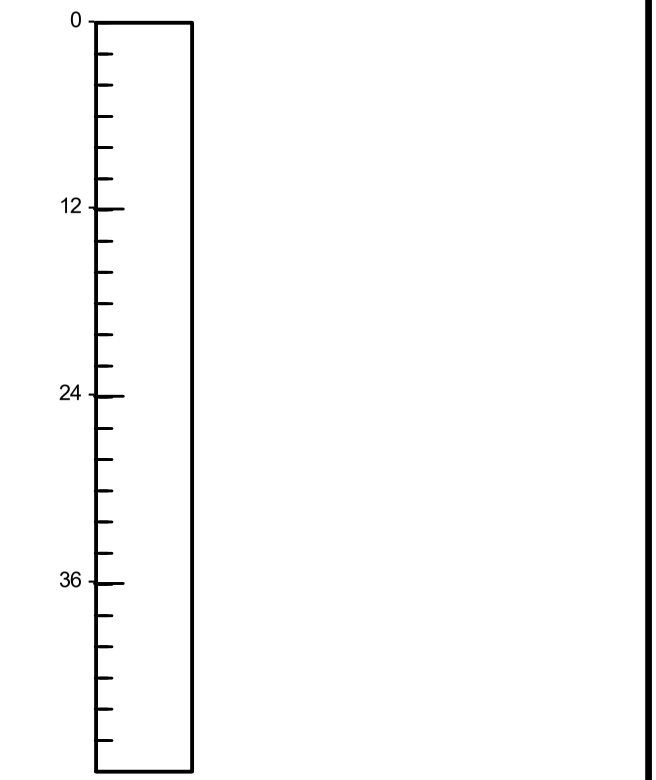
LABORATORY LOG OF SHELBY TUBES

SHELBY TUBE LOG

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 :







LEGEND

- Consolidation, Incremental
- Swelling, Test
- Wax
- C R S - Consolidation, C R S
- In/B Sa-Cl
- Unconfined Compression Test
- Triaxial Compression Test
- P P - Permeability, Vertical / Horizontal

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

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 WEIGHT DRY	REMOLDED	PERMEABILITY				RELATIVE DENSITY	LOI	ROCK CORE	SHELBY TUBE	CBR
						sieve	Hydrometer short	Hydrometer long	standard	modified	unconsn.	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

SUMMARY OF LABORATORY TEST RESULTS

BORING	G'int Id.	MC	LL	PL	PI	GRADATION			COMPACTION		TRIAXIAL					DIRECT SHEAR			UNCONFIN COMPRESS	CONSOLID.	SPECIFIC GRAVITY	UNIT WEIGHT DRY	REMOLDED	PERMEABILITY				RELATIVE DENSITY	LOI	ROCK CORE	SHELBY TUBE	CBR
						sieve	Hydrometer short	Hydrometer long	standard	modified	unconsn. undrain	consolid undrain	w/pores	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 WEIGHT DRY	REMOLDED	PERMEABILITY				RELATIVE DENSITY	LOI	ROCK CORE	SHELBY TUBE	CBR
						sieve	Hydrometer short	Hydrometer long	standard	modified	unconsn. undrain	consolid undrain	w/ pores	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

SUMMARY OF LABORATORY TEST RESULTS

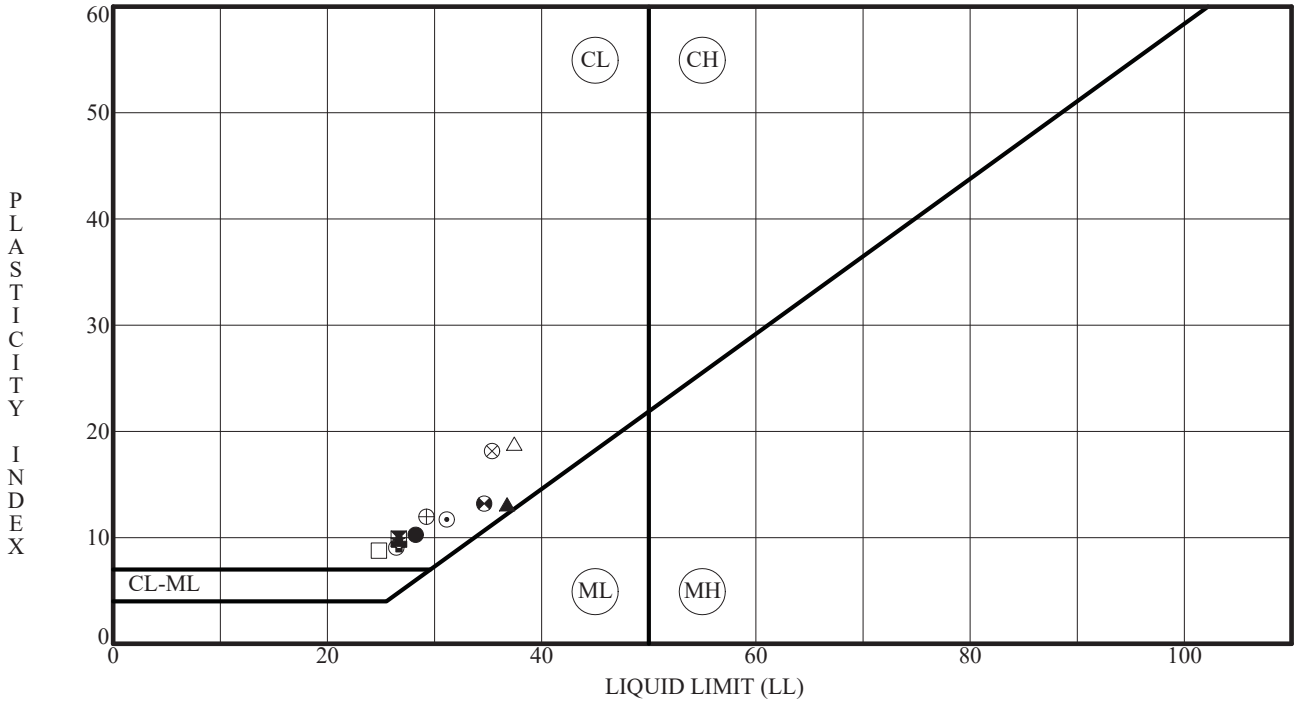
BORING	G'int Id.	MC	LL	PL	PI	GRADATION			COMPACTION		TRIAXIAL				DIRECT SHEAR			UNCONFIN COMPRESS	CONSOLID.	SPECIFIC GRAVITY	UNIT WEIGHT DRY	REMOLDED	PERMEABILITY				RELATIVE DENSITY	LOI	ROCK CORE	SHELBY TUBE	CBR
							Hydrometer																								
						sieve	short	long	standard	modified	unconsn.	undrain consolid	undrain w/pores	drained	drained	undrain	residual						cohesive	non/cohes	rigid	flexible					
		%	%	%	%	* 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

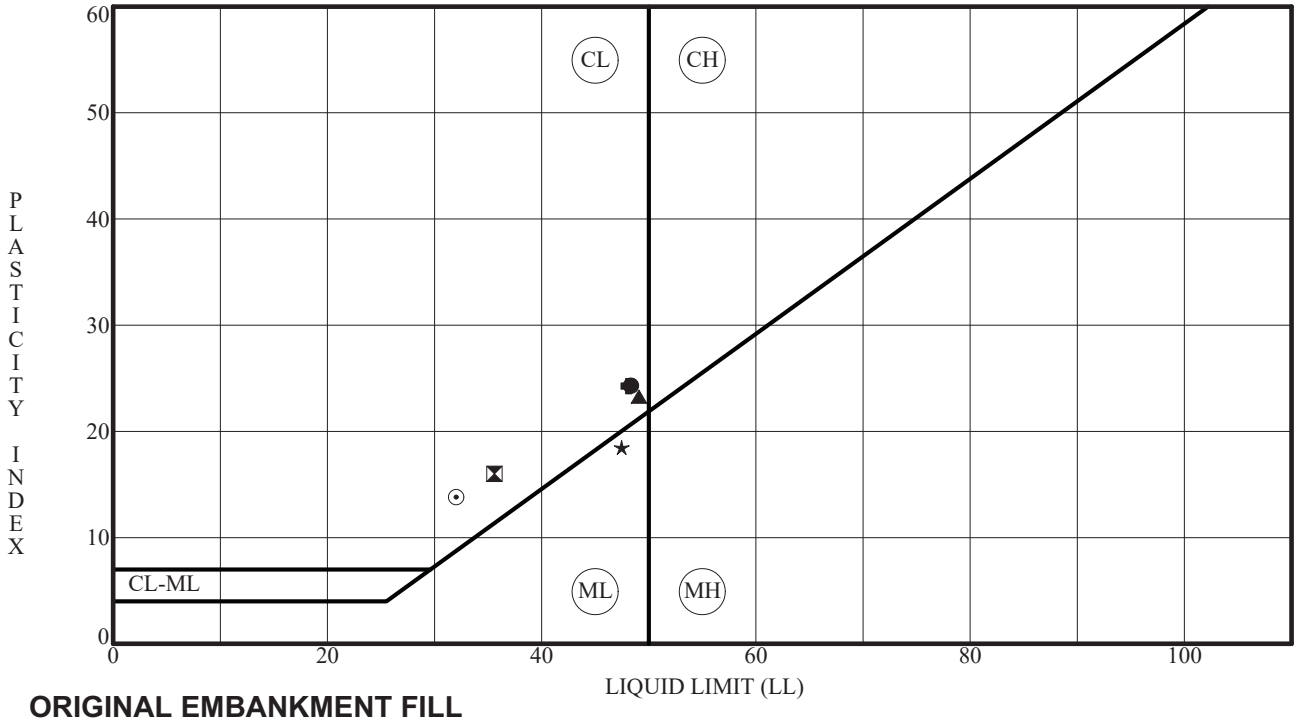


	Specimen Id.	Depth	MC	LL	PL	PI	Fines	ASTM Classification
●	BAP-0901	7.75	16	28	18	10		
⧗	BAP-0901	13.75	13	27	17	10		
▲	BAP-0901	18.25	14	37	24	13	60.6	SANDY LEAN CLAY CL
★	BAP-0906	4.75	15	27	17	10		
⊙	BAP-0906	17.25	14	31	19	12	38.0	CLAYEY SAND with GRAVEL SC
✿	BAP-0902	6.25	13	27	17	10	23.6	CLAYEY 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		

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

ATTERBERG LIMITS' RESULTS



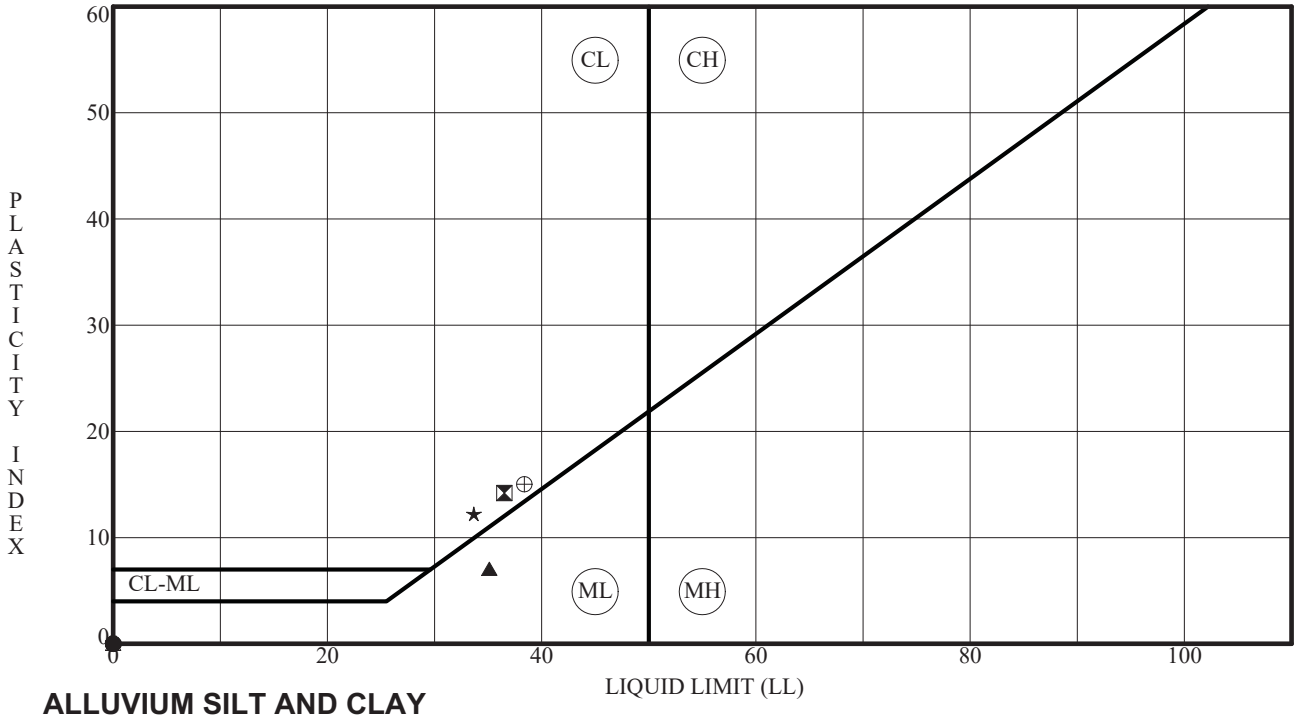
ORIGINAL EMBANKMENT FILL

	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

ALPI-REG 111497013.GPJ BBCM.GDT 7/6/09

ATTERBERG LIMITS' RESULTS



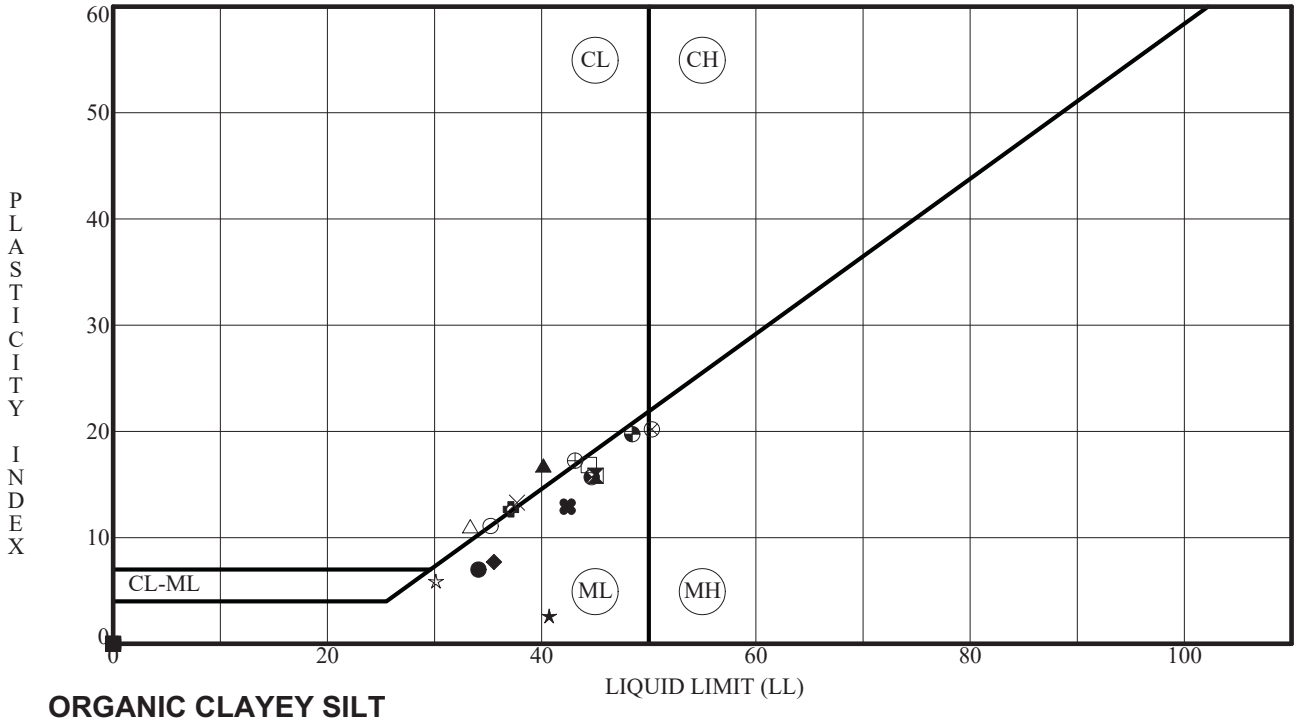
ALLUVIUM SILT AND CLAY

	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

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

ATTERBERG LIMITS' RESULTS



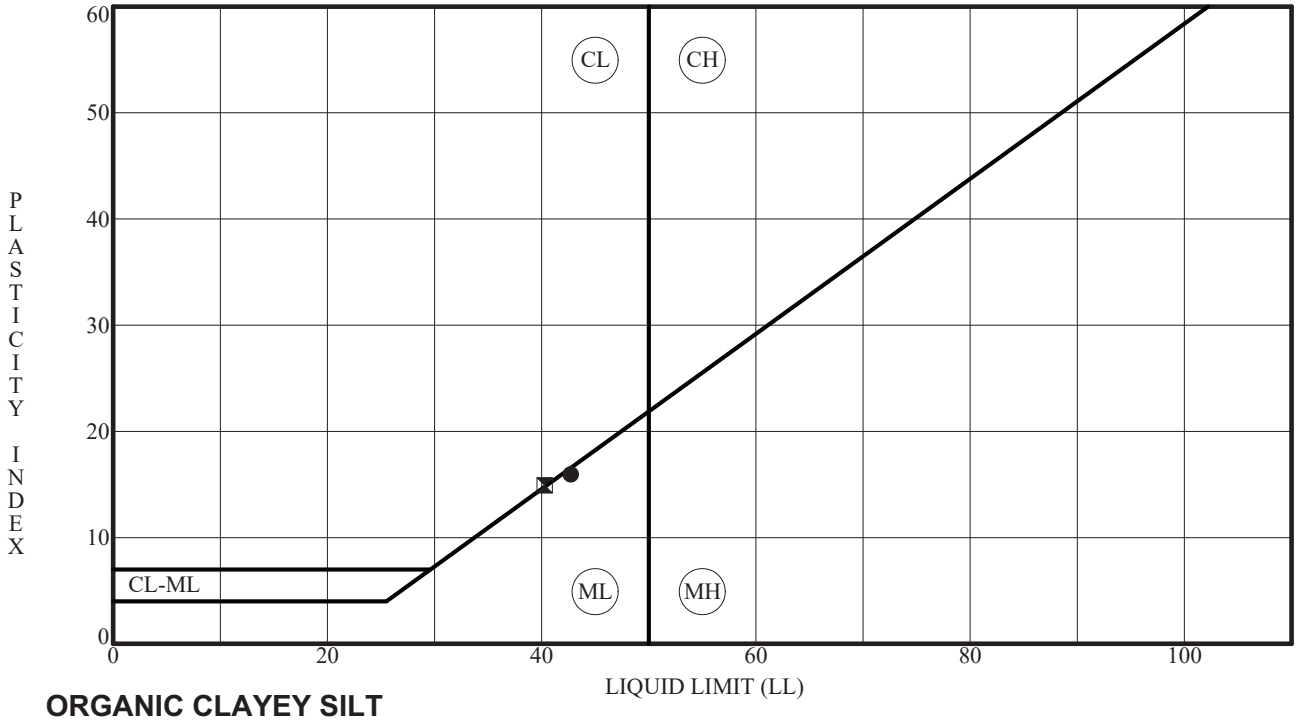
ORGANIC CLAYEY SILT

	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

ALPI-REG 111497013.GPJ BBCM.GDT 7/6/09

ATTERBERG LIMITS' RESULTS



ORGANIC CLAYEY SILT

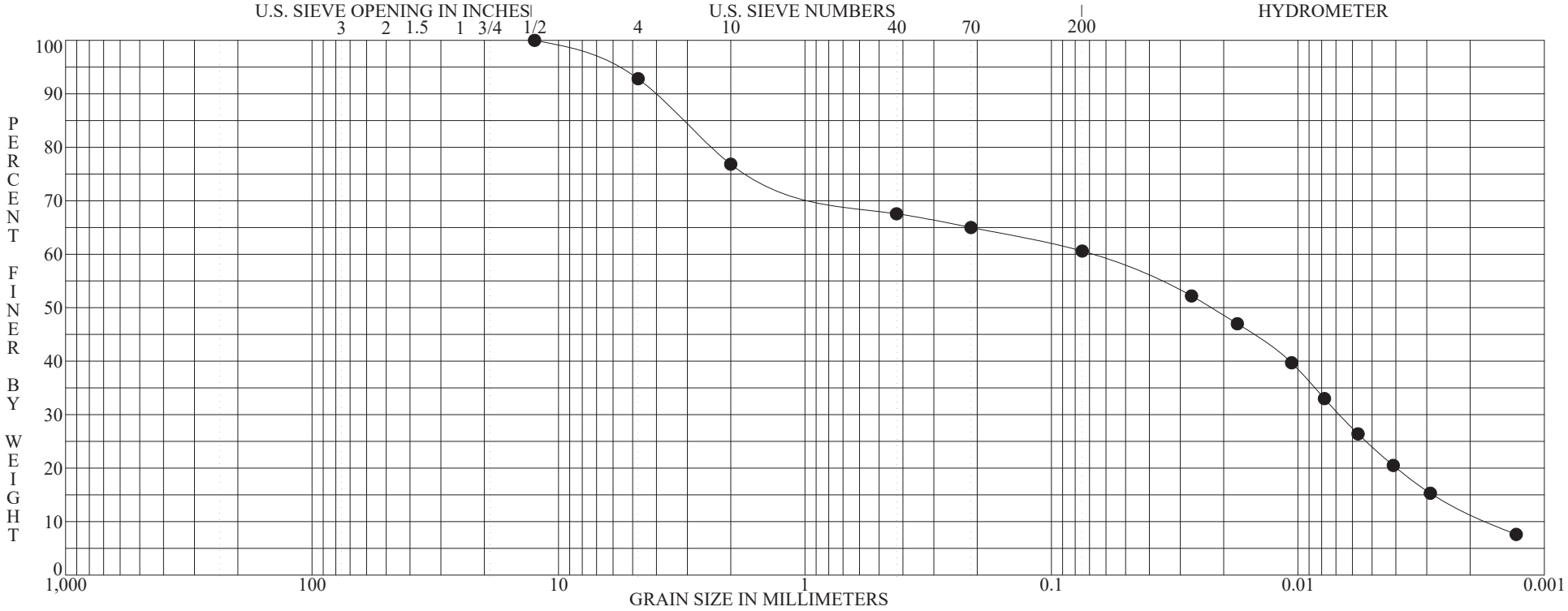
	Specimen Id.	Depth	MC	LL	PL	PI	Fines	ASTM Classification
●	**BAP-0905**	**14.25**	**45**	**43**	**27**	**16**	**80.5**	**ORGANIC SILT with SAND OL**
⧗	**BAP-0905**	**16.75**	**42**	**40**	**25**	**15**	**84.5**	**ORGANIC CLAY with SAND OL**

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

ALPI-REG 111497013.GPJ BBCM.GDT 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-0901 S-12 17.5' to 18.3'**	**FILL: Gray and brown silty clay, some fine to coarse sand, trace fine gravel(shale fragments).**	**14**	**37**	**24**	**13**	**0.393**	**41.763**
		SANDY LEAN CLAY CL						

	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

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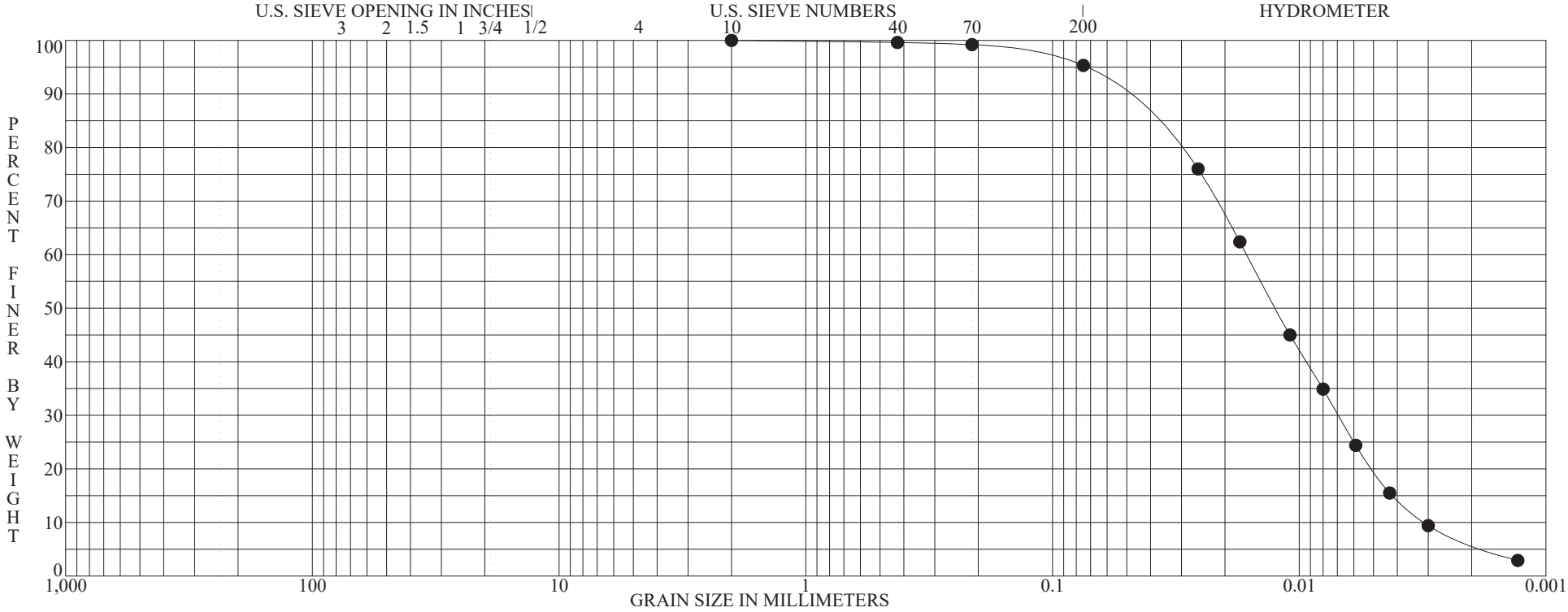

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0901 S-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

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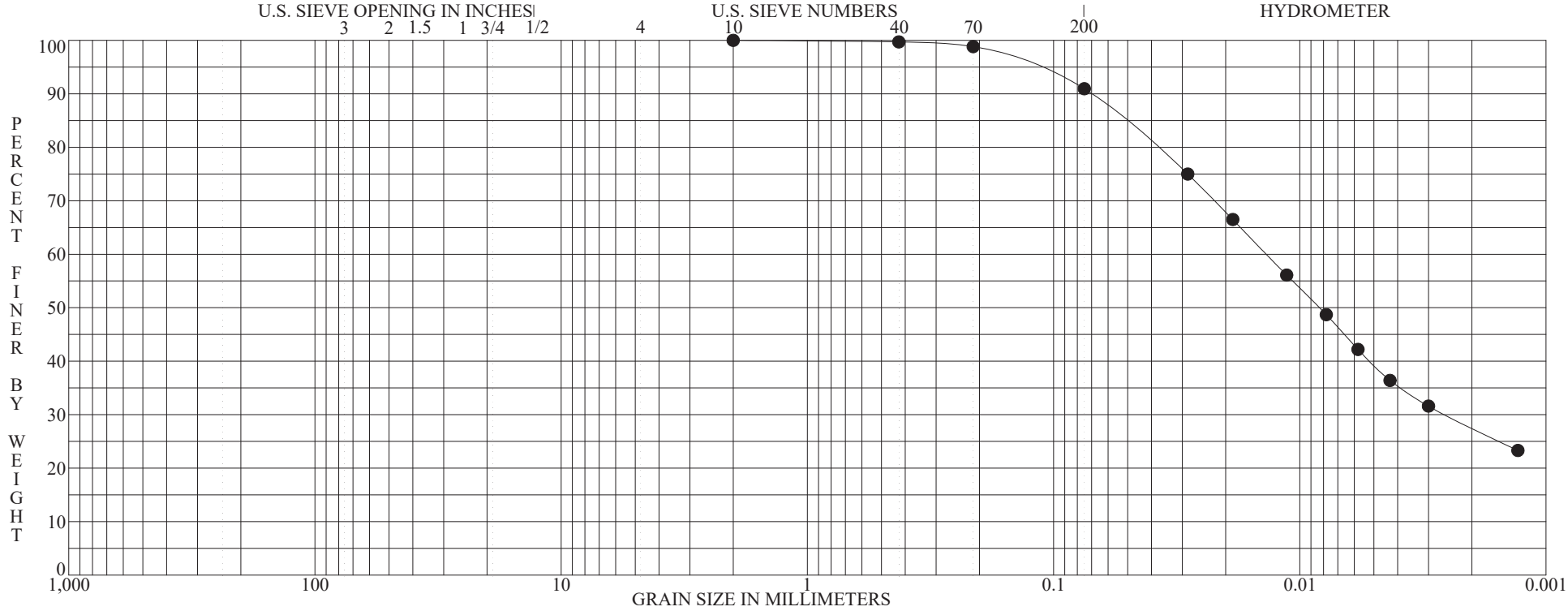

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0901 S-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.**	**27**	**37**	**22**	**15**		
		LEAN CLAY CL						

	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
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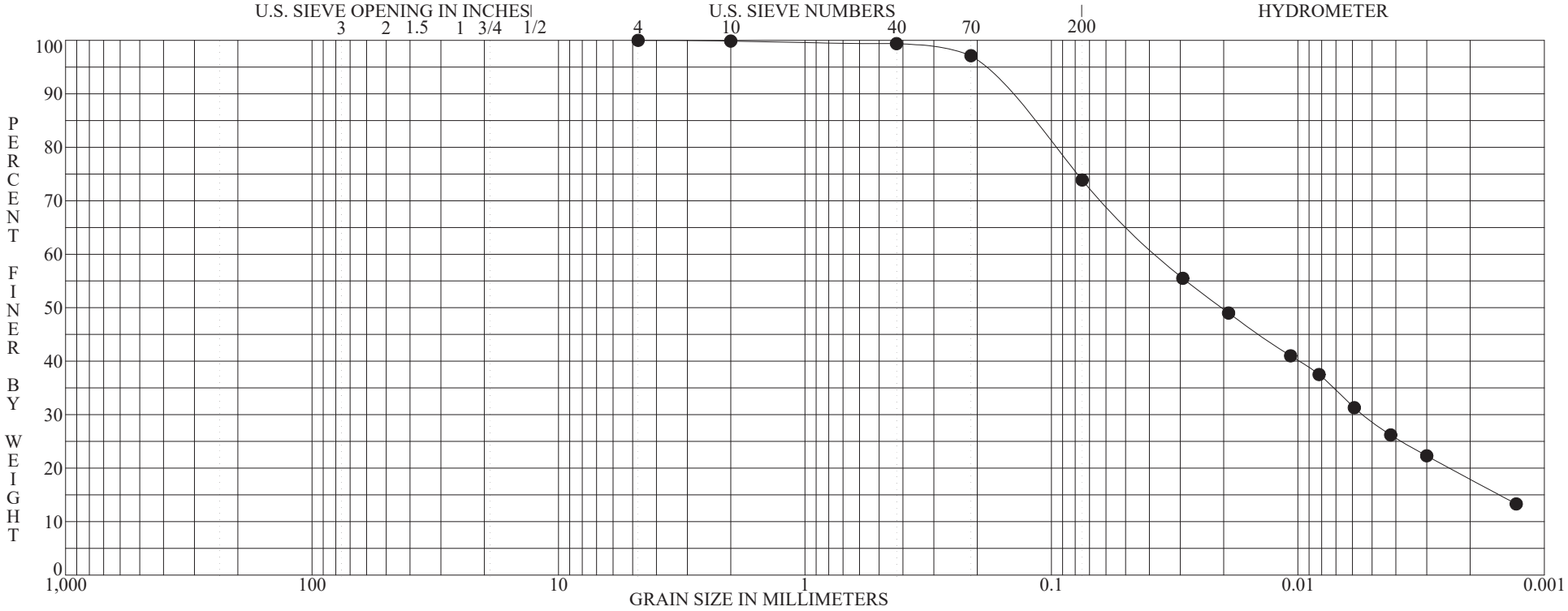

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0901 ST-19A II**	**Gray mottled with dark-gray and brown clayey silt, some**	**33**	**35**	**28**	**7**		
	31.0' to 32.8'	**fine sand, trace medium to coarse sand, few seams and lenses**						
		of silty clay and fine sand.						
		SILT with SAND ML						

	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0901 ST-19A II**	**4.7500**	**0.1927**	**0.0369**	**0.0204**		**0.00**	**26.12**	**55.95**	**17.94**
	31.0' to 32.8'									

ASTM D422 | **GRADATION CURVE**

PROJECT CARDINAL PLANT ASH POND INVESTIGATION
LOCATION BRILLIANT, OHIO
JOB NO. 011-11497-013 **DATE** 7/6/09

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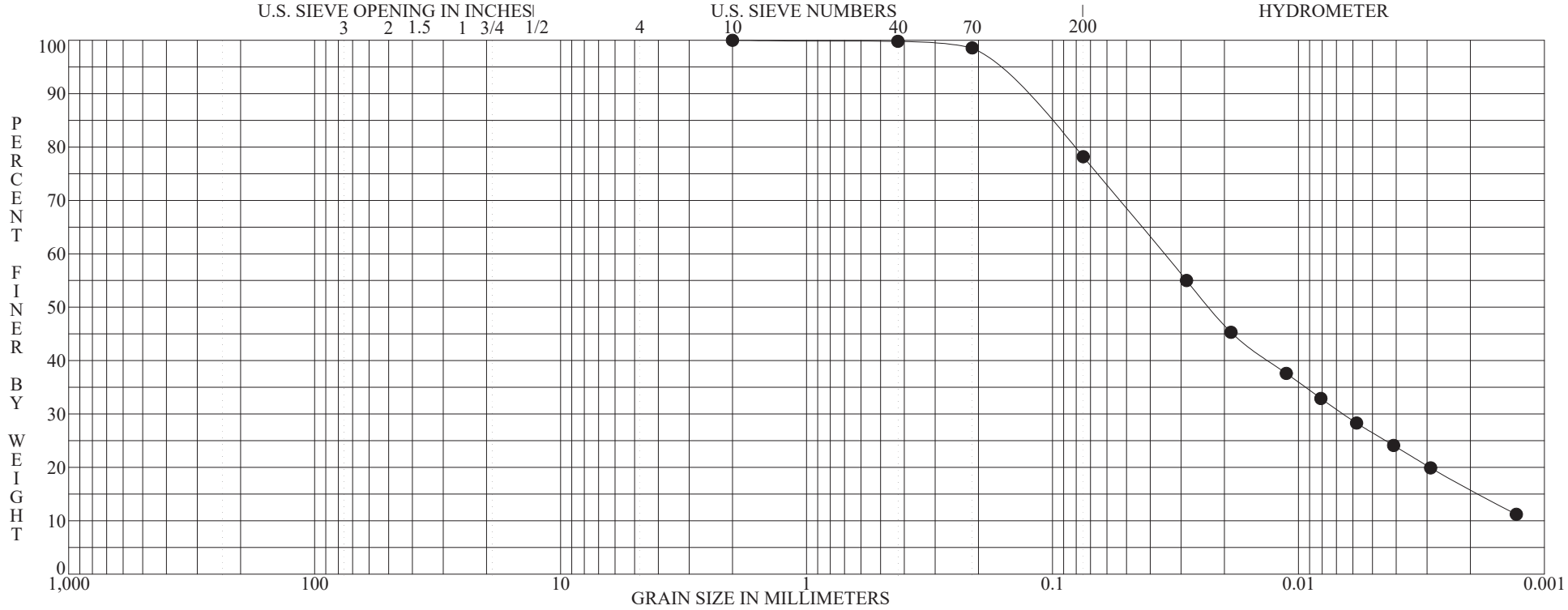

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0901 S-20 33.5' to 35.0'**	**Dark-gray organic clayey silt, some fine sand, trace medium sand.**	**42**	**34**	**27**	**7**		
		ORGANIC SILT with SAND OL						

	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
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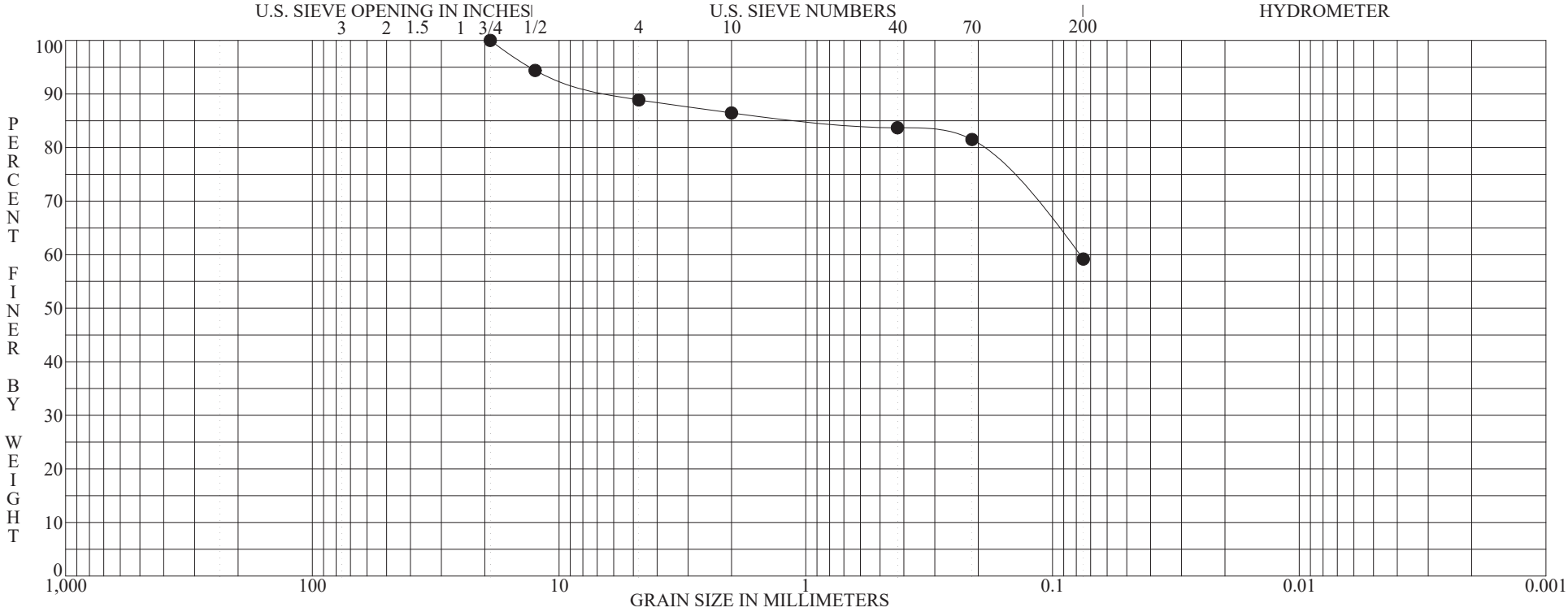

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	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.**	**40**	**45**	**29**	**16**		
		SANDY ORGANIC SILT OL						

	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**

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LOCATION: BRILLIANT, OHIO
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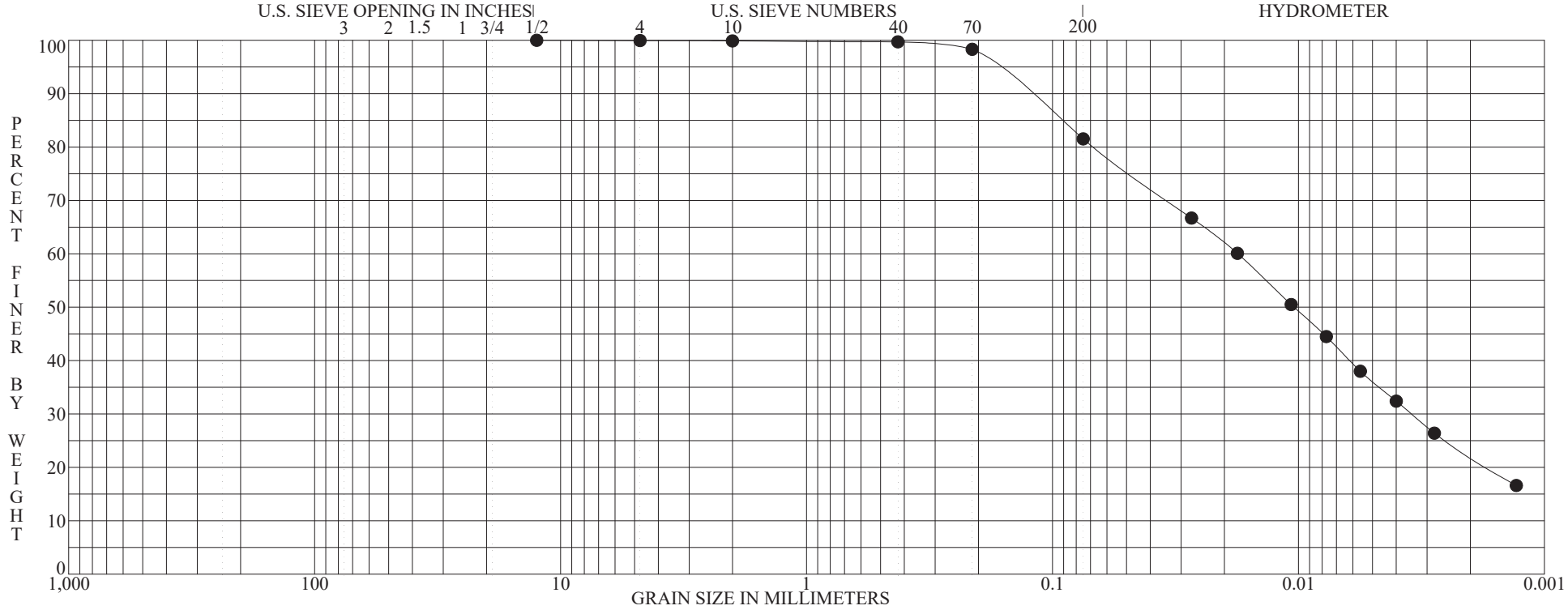

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0901 S-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.**	**42**	**40**	**23**	**17**		
		ORGANIC CLAY with SAND OL						

	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
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PLATE 16

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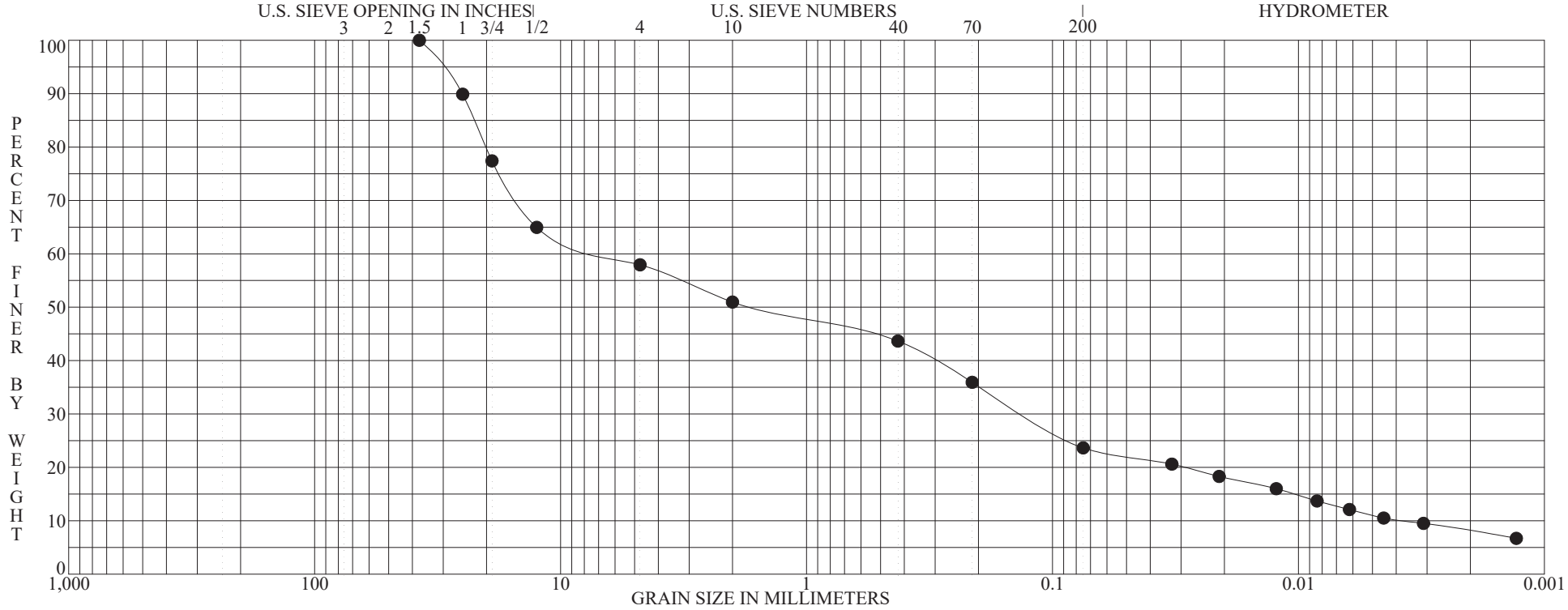

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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.**	**13**	**27**	**17**	**10**	**0.699**	**1690.044**
		CLAYEY GRAVEL with SAND GC						

	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

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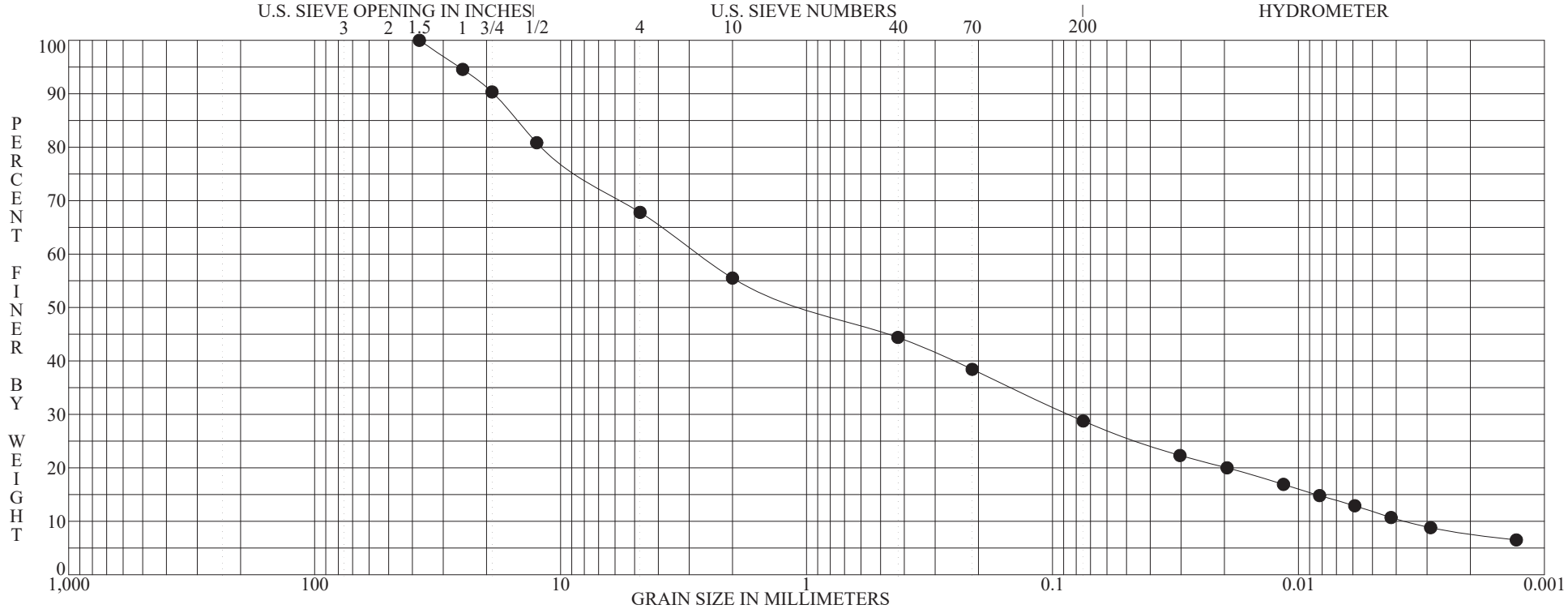

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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.**	**10**	**26**	**17**	**9**	**0.731**	**748.575**
		CLAYEY SAND with GRAVEL SC						

	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

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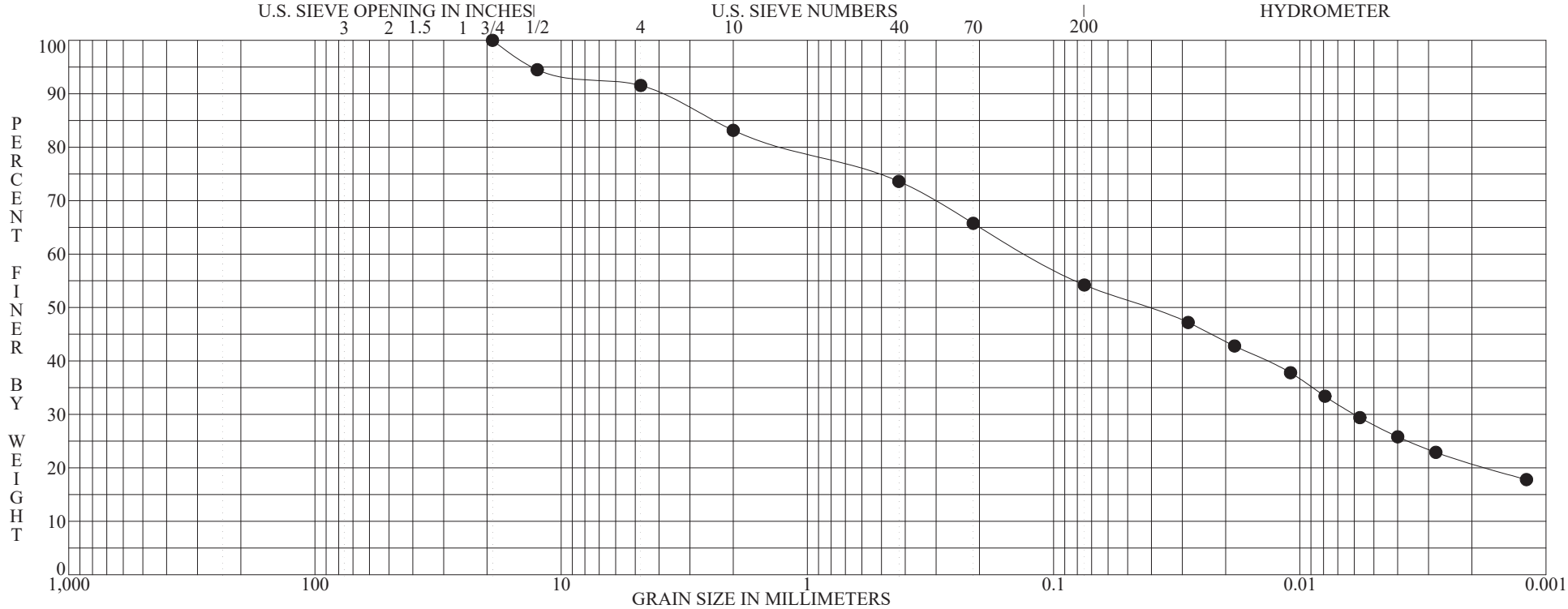

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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).**	**21**	**35**	**17**	**18**		
		SANDY LEAN CLAY CL						

	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

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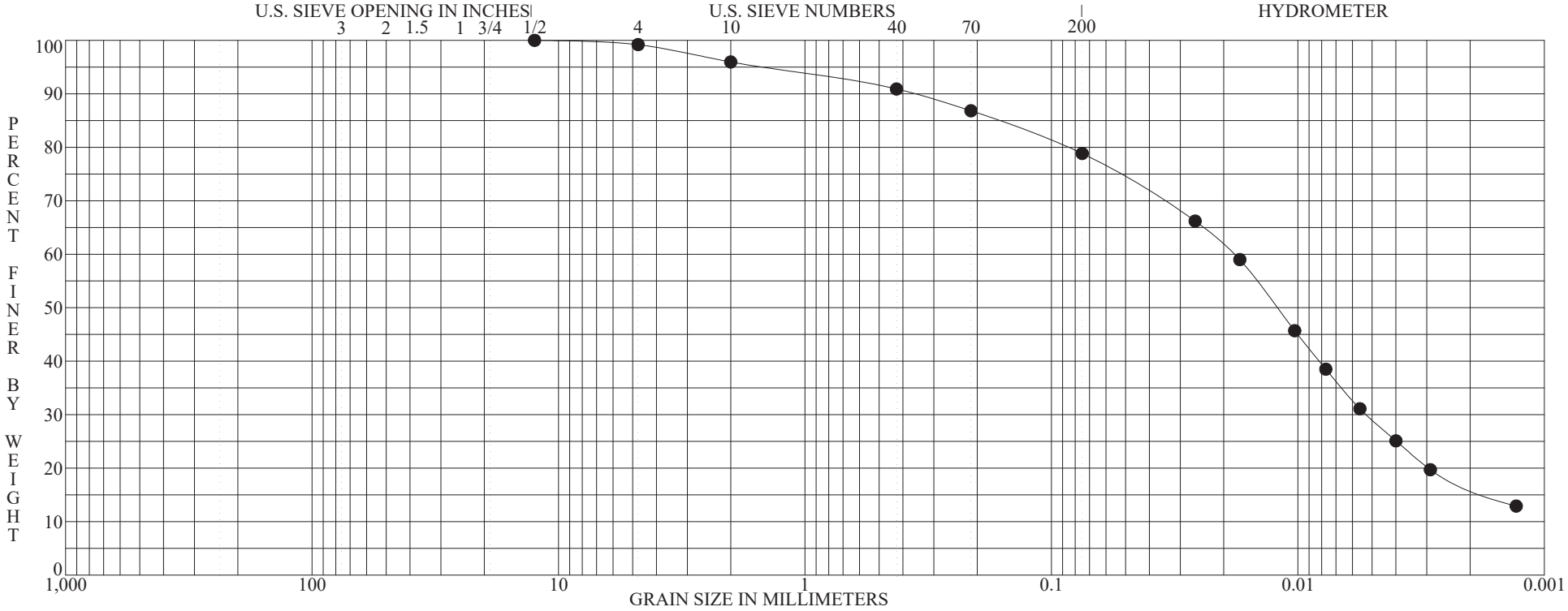

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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).**	**31**	**29**	**17**	**12**		
		LEAN CLAY with SAND CL						

	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**

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LOCATION: BRILLIANT, OHIO
JOB NO.: 011-11497-013 DATE: 7/6/09

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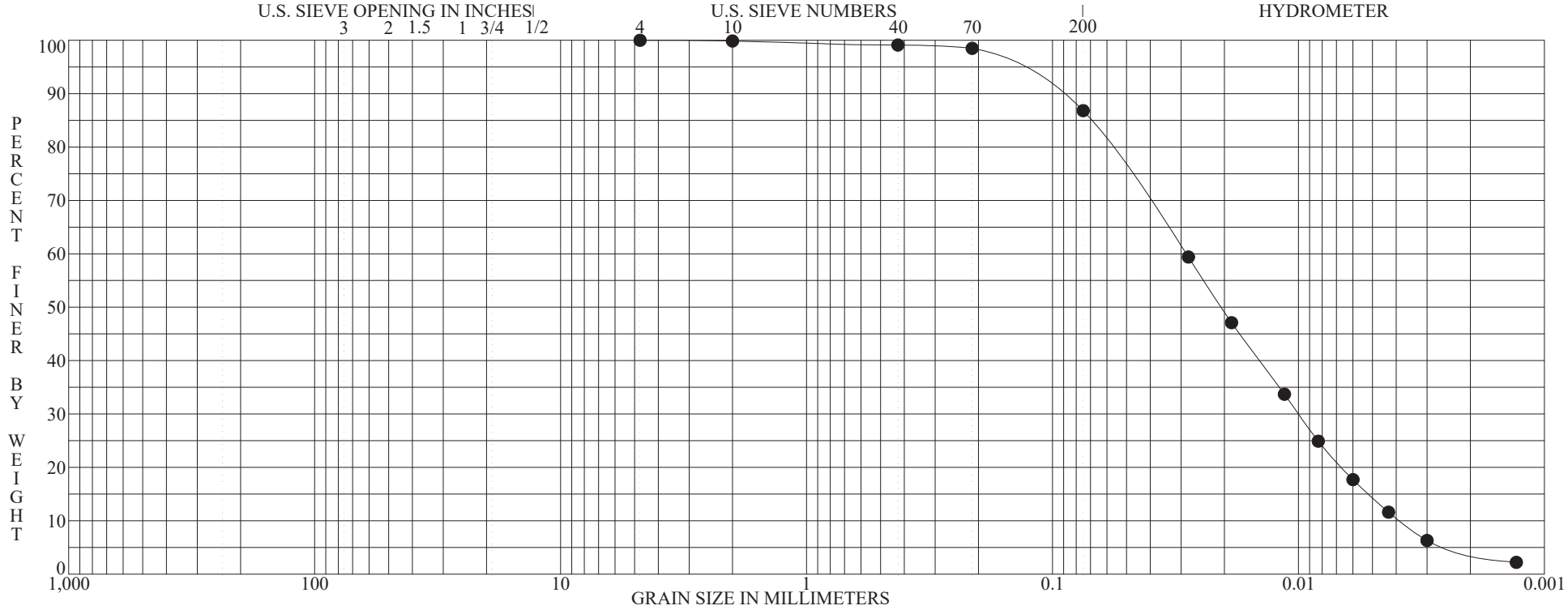

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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**

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LOCATION: BRILLIANT, OHIO
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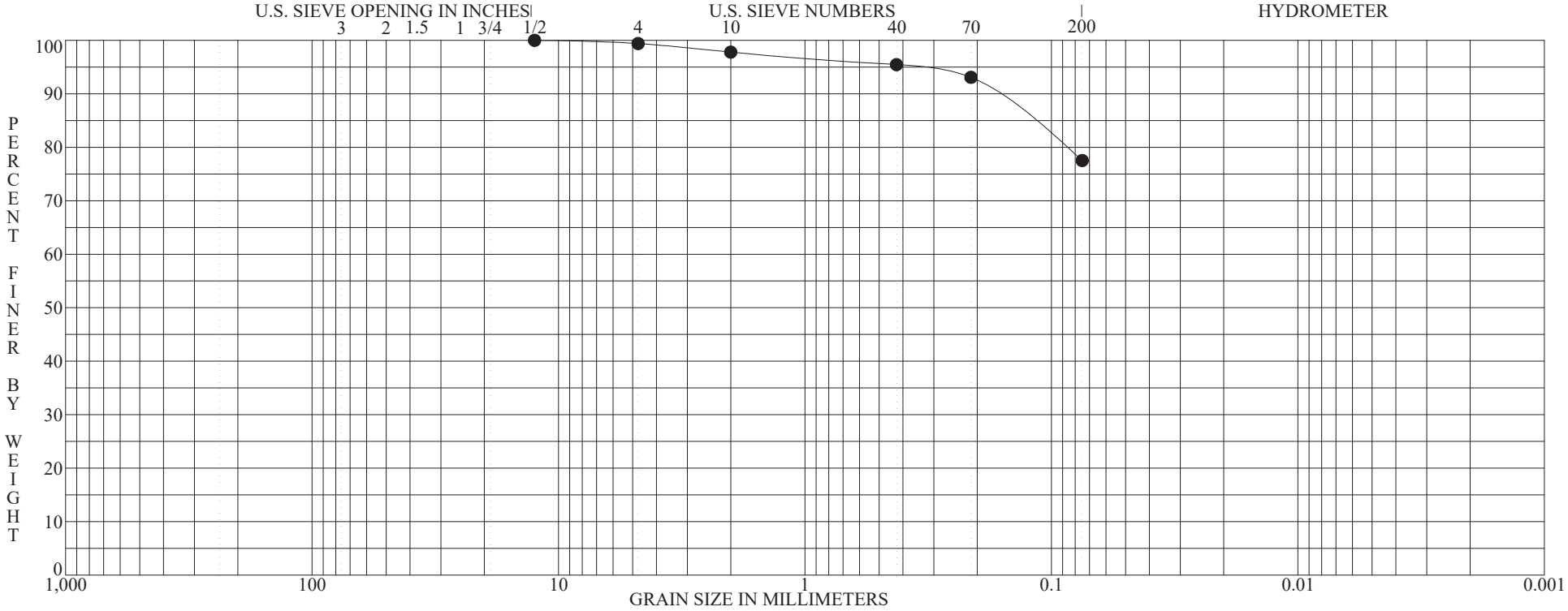

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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**

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LOCATION: BRILLIANT, OHIO
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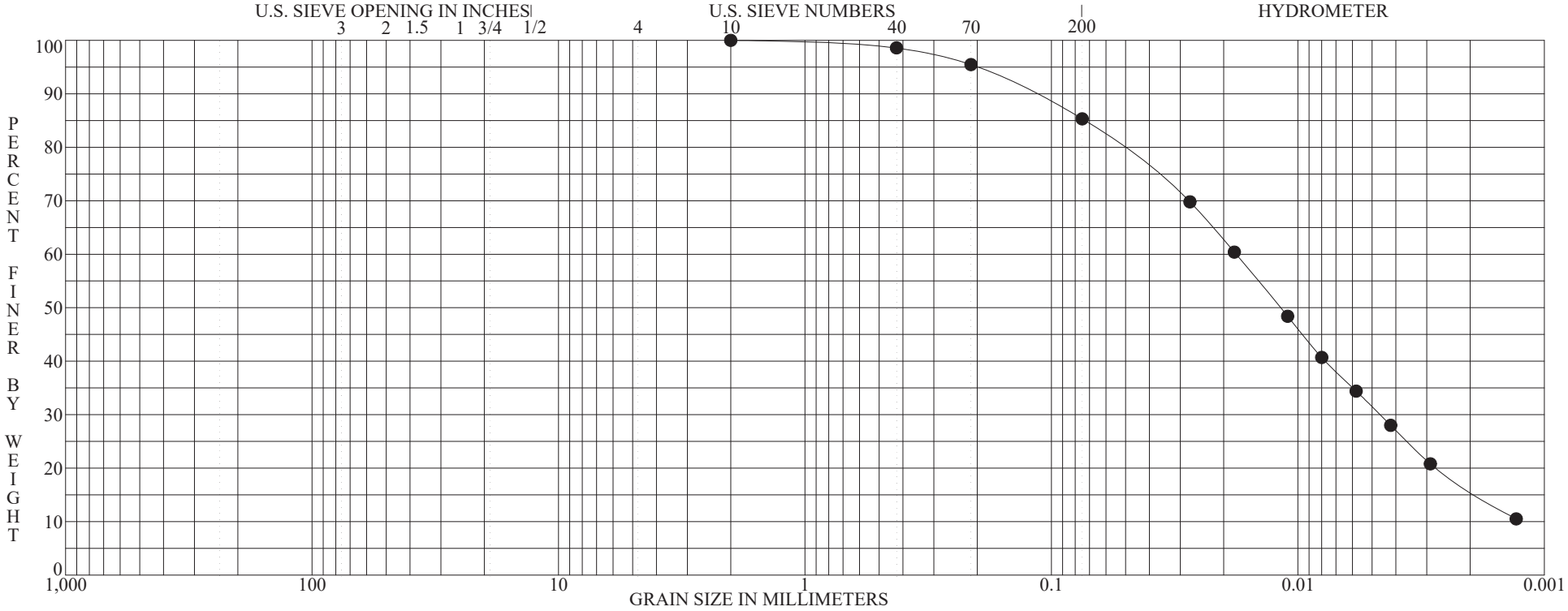

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-PZ-BAP-0902 S-18 26.5' to 27.7'**	**Gray mottled with dark-gray organic silt, little clay, little fine to medium sand.**	**54**	**NP**	**NP**	**NP**		
		ORGANIC SILT OL						

	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
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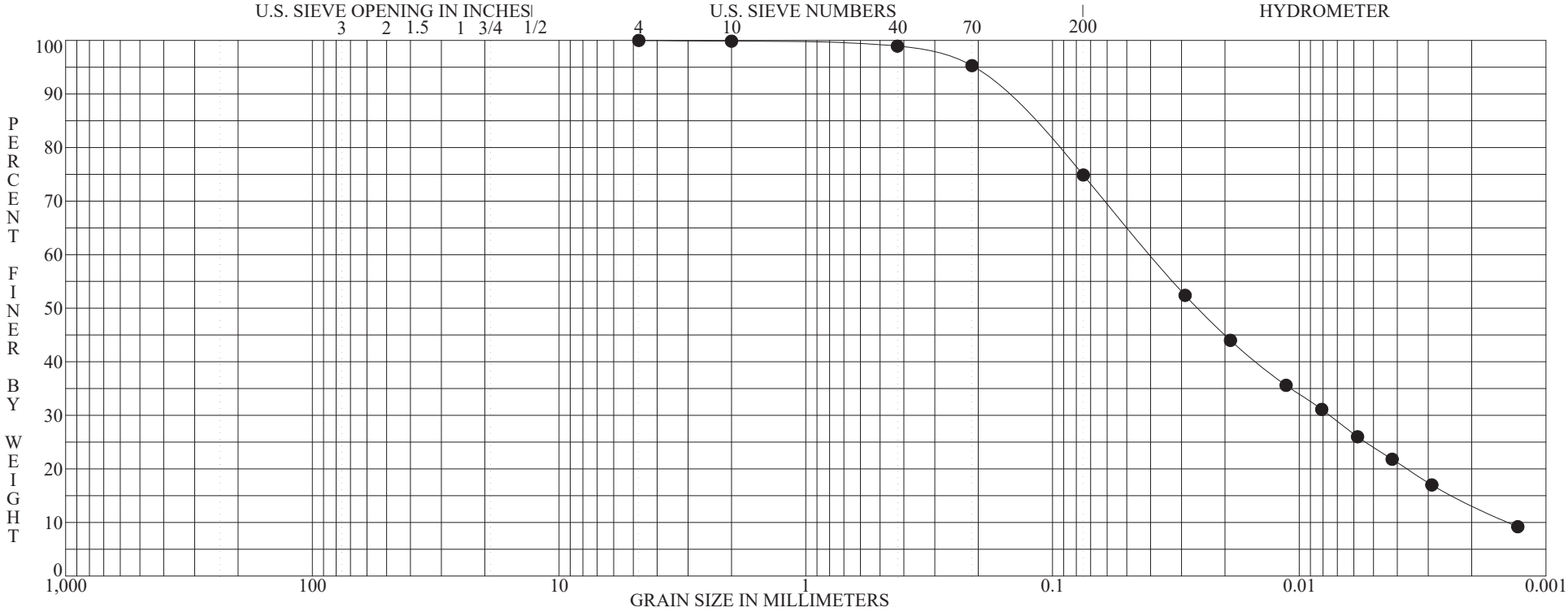

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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.**	**43**	**NP**	**NP**	**NP**	**1.006**	**28.333**
		ORGANIC SILT with SAND OL						

	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

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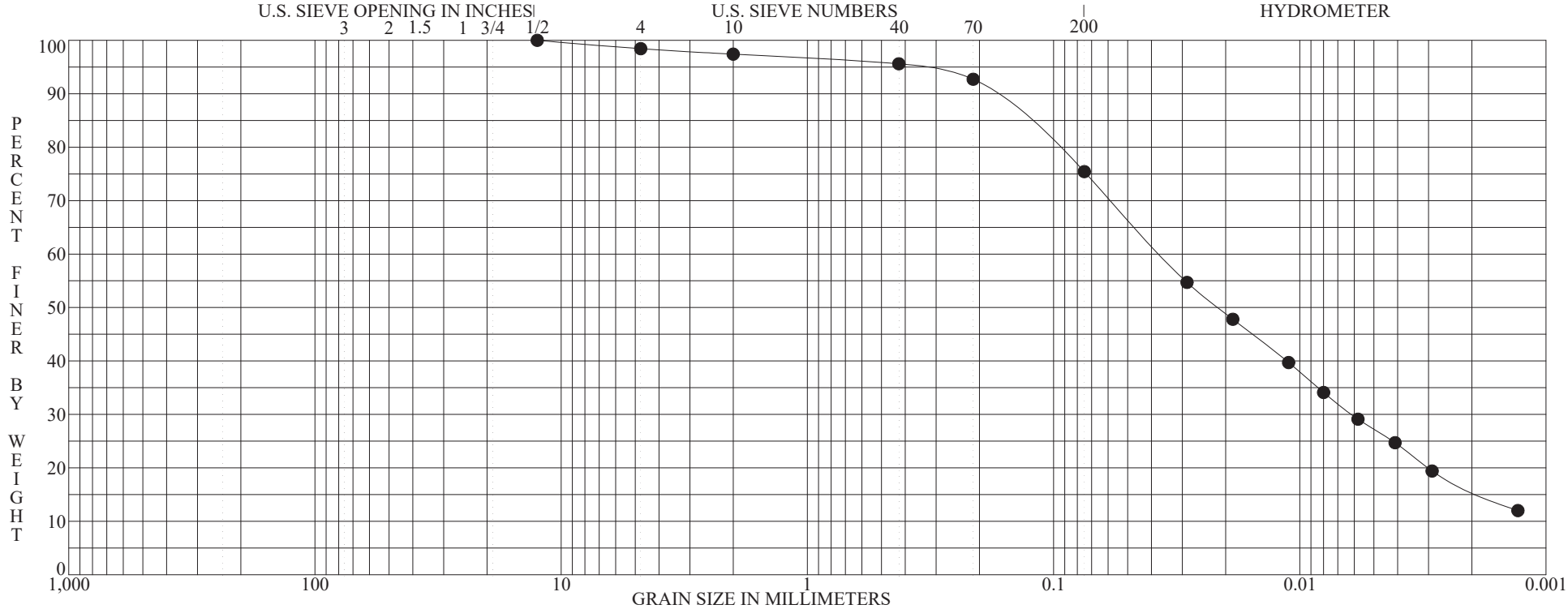

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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.**	**38**	**36**	**28**	**8**		
		ORGANIC SILT with SAND OL						

	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

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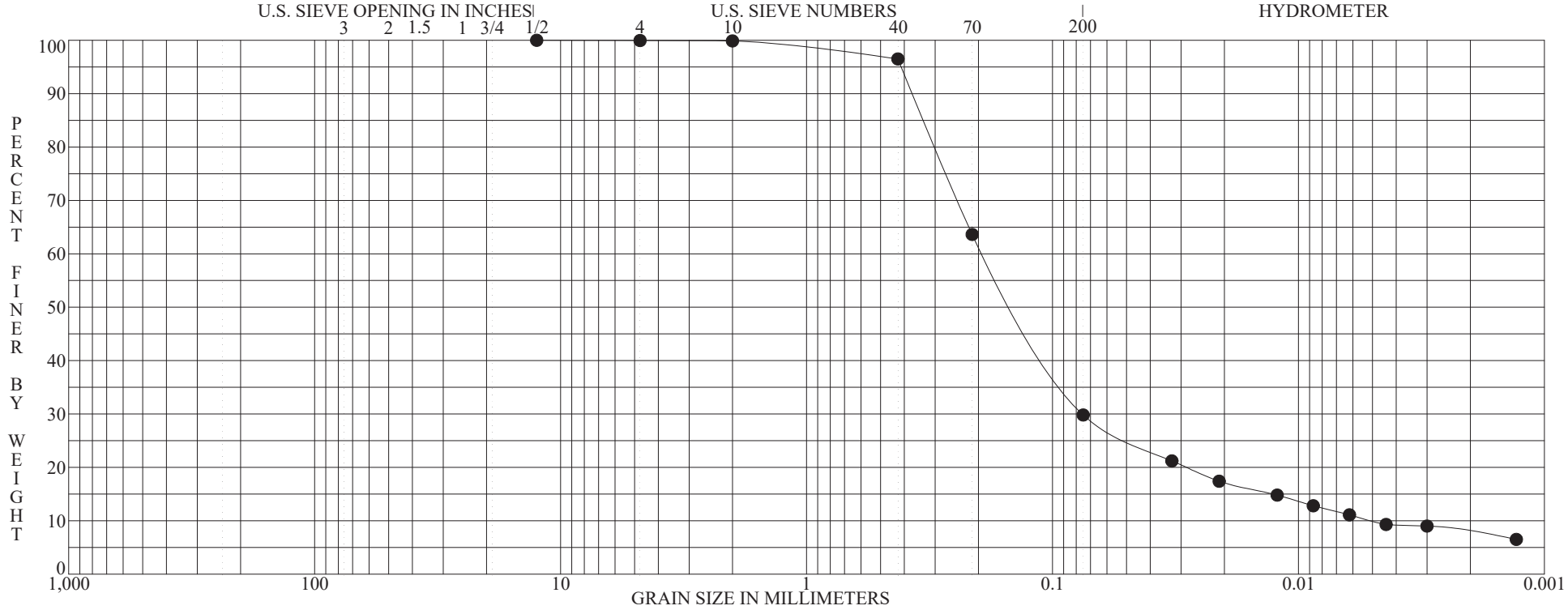

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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
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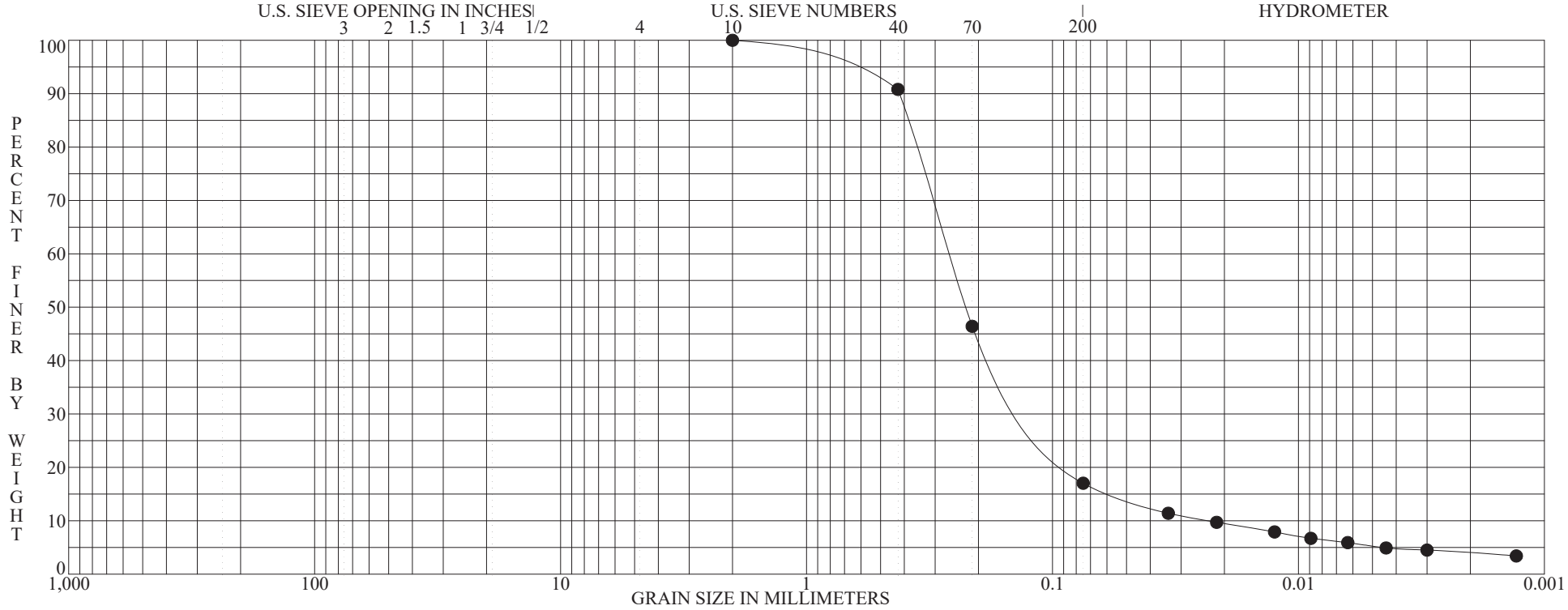

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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

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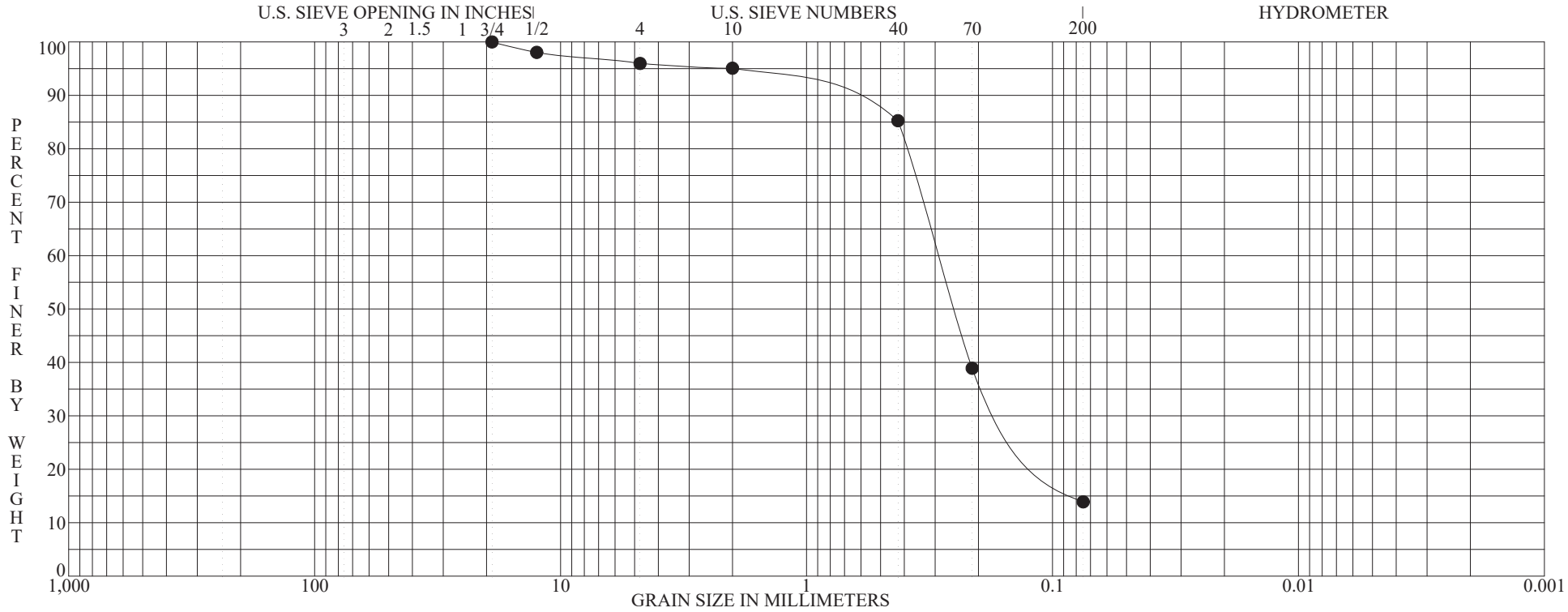

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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
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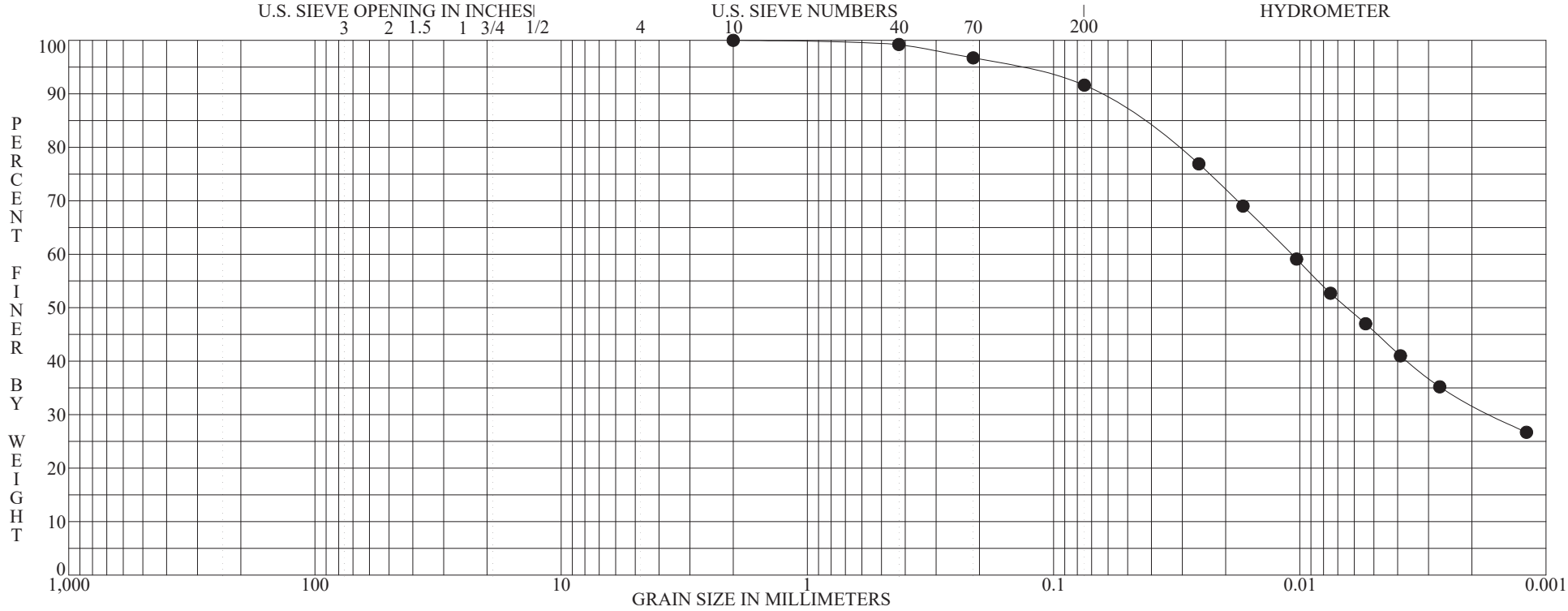

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0903 S-2 2.5' to 3.3'**	**FILL: Brown mottled with dark-brown and gray silty clay, trace fine to medium sand.**	**24**	**48**	**24**	**24**		
		LEAN CLAY CL						

	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

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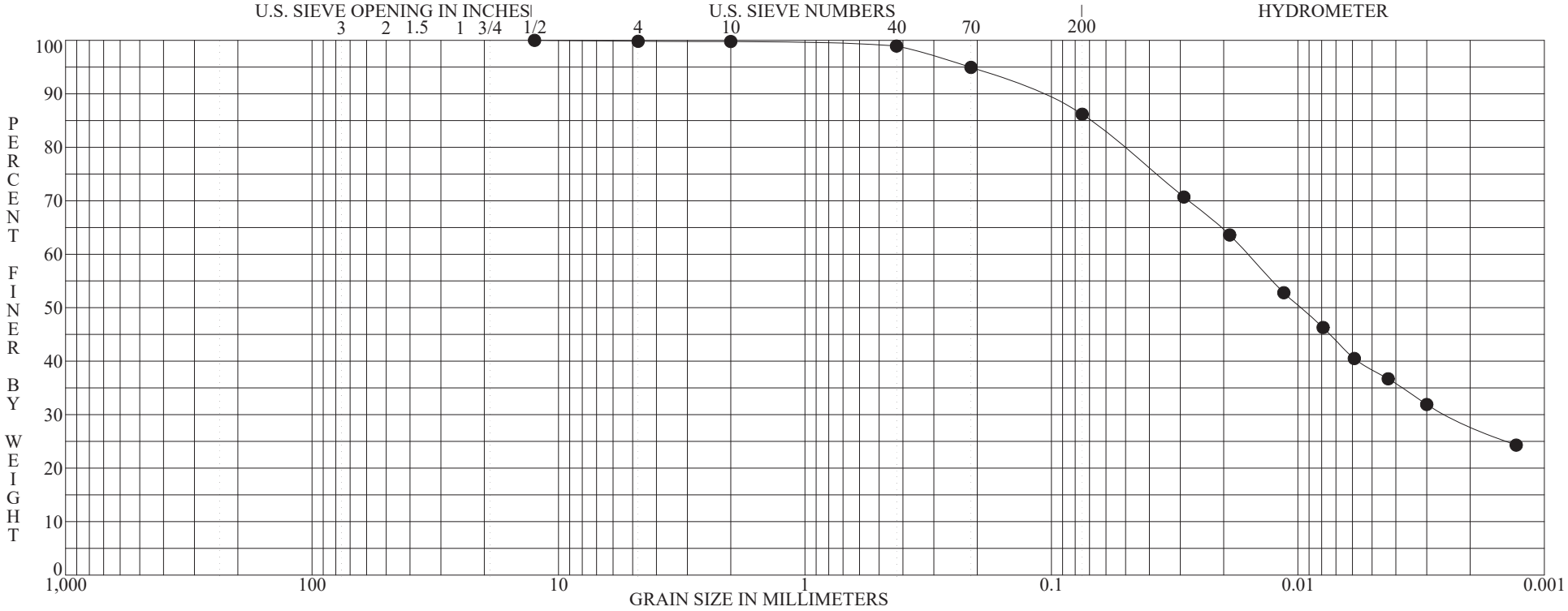

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-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.**	**20**	**36**	**20**	**16**		
		LEAN CLAY CL						

	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**

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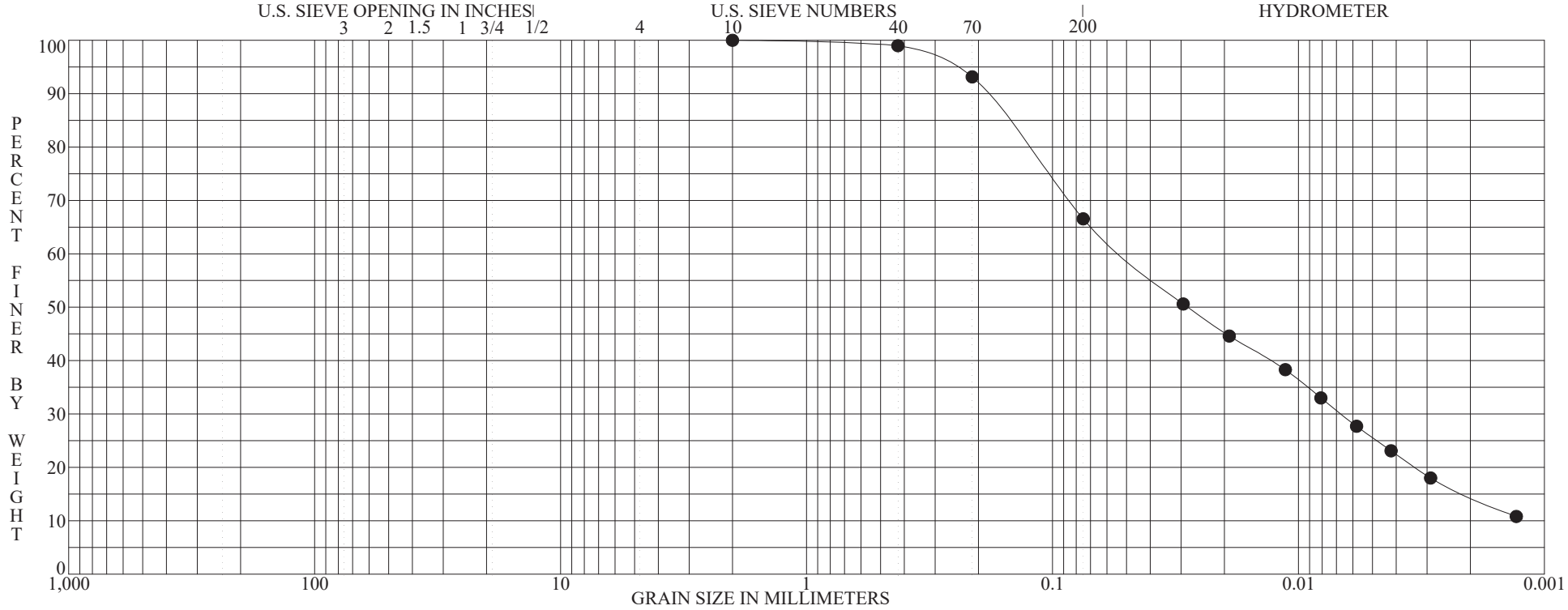

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-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**

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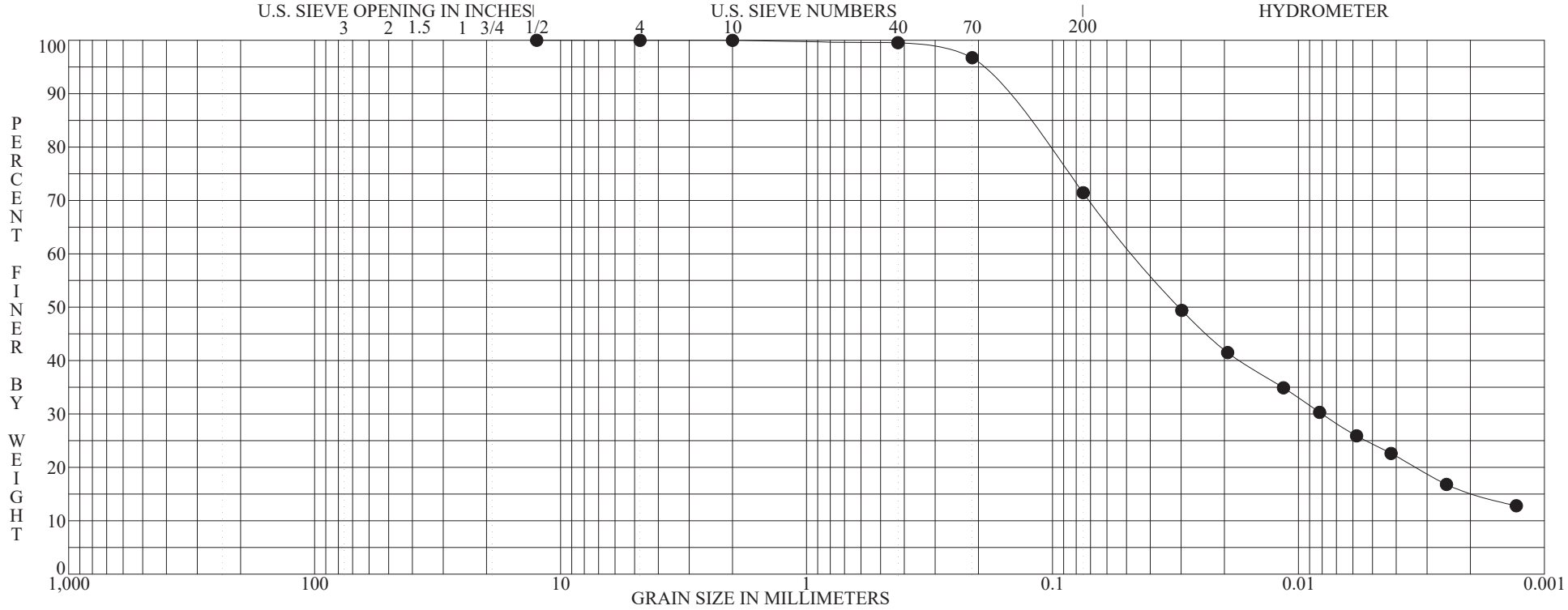

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-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.**	**43**	**NP**	**NP**	**NP**		
		ORGANIC SILT with SAND OL						

	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**

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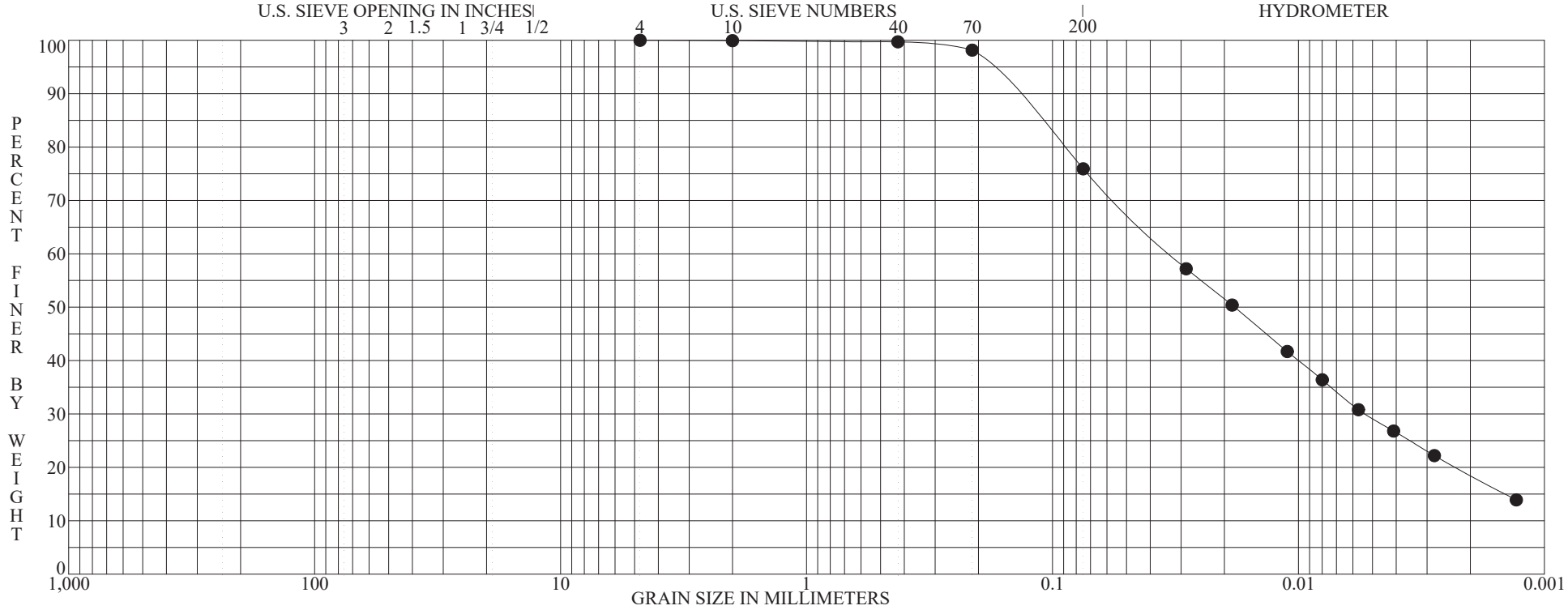

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-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.**	**43**	**37**	**24**	**13**		
		ORGANIC CLAY with SAND OL						

	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**

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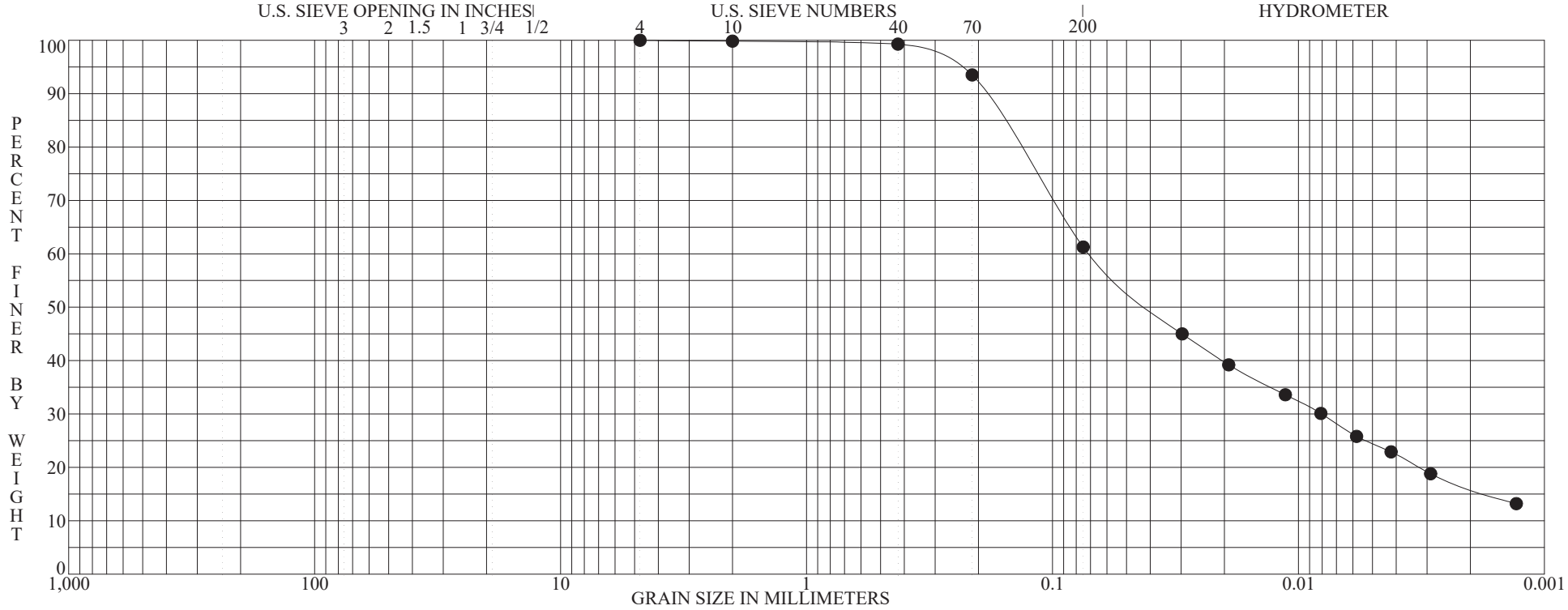

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-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.**	**44**	**35**	**24**	**11**		
		SANDY ORGANIC CLAY OL						

	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**

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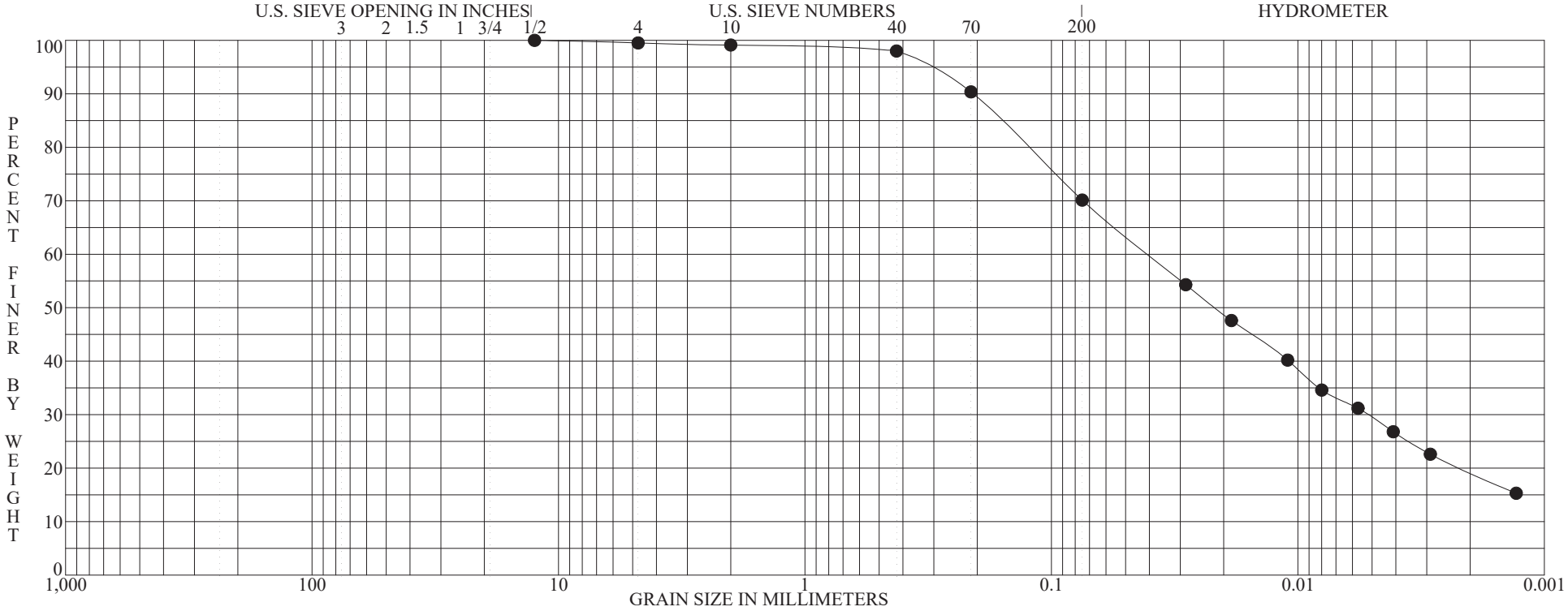

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-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.**	**35**	**34**	**21**	**13**		
		LEAN CLAY with SAND CL						

	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**

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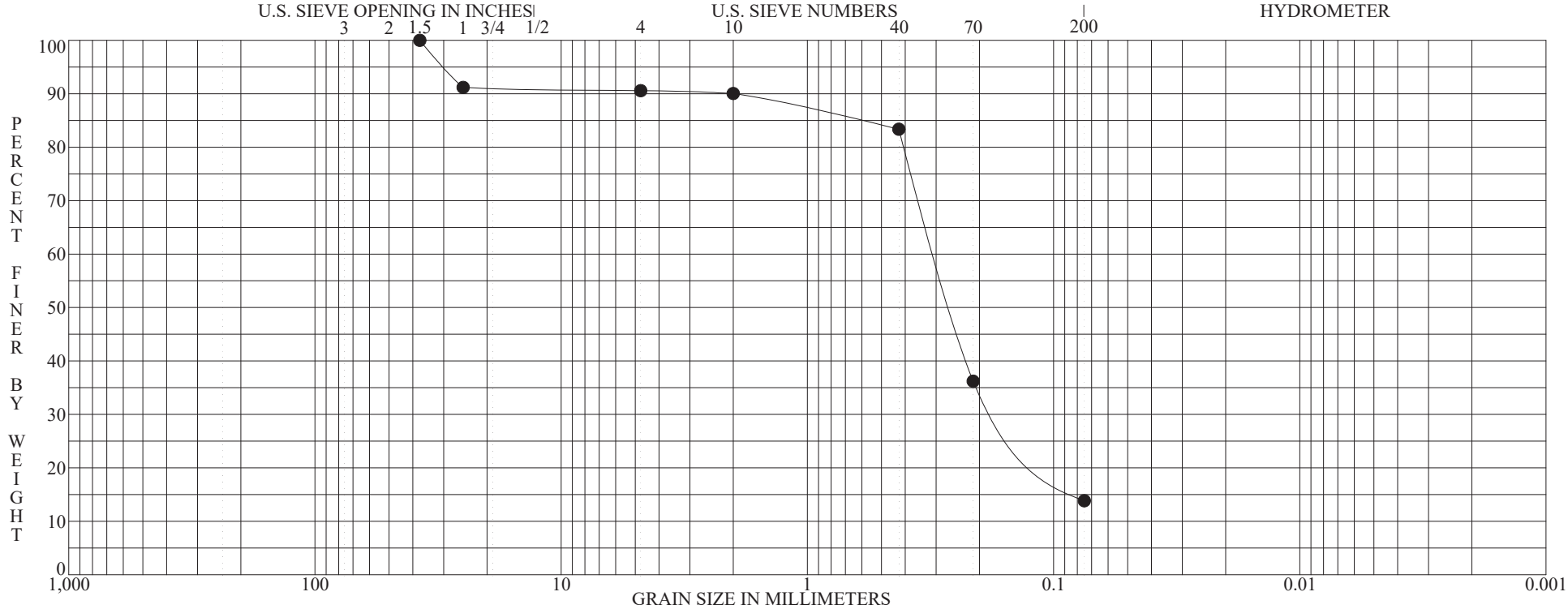

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-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**

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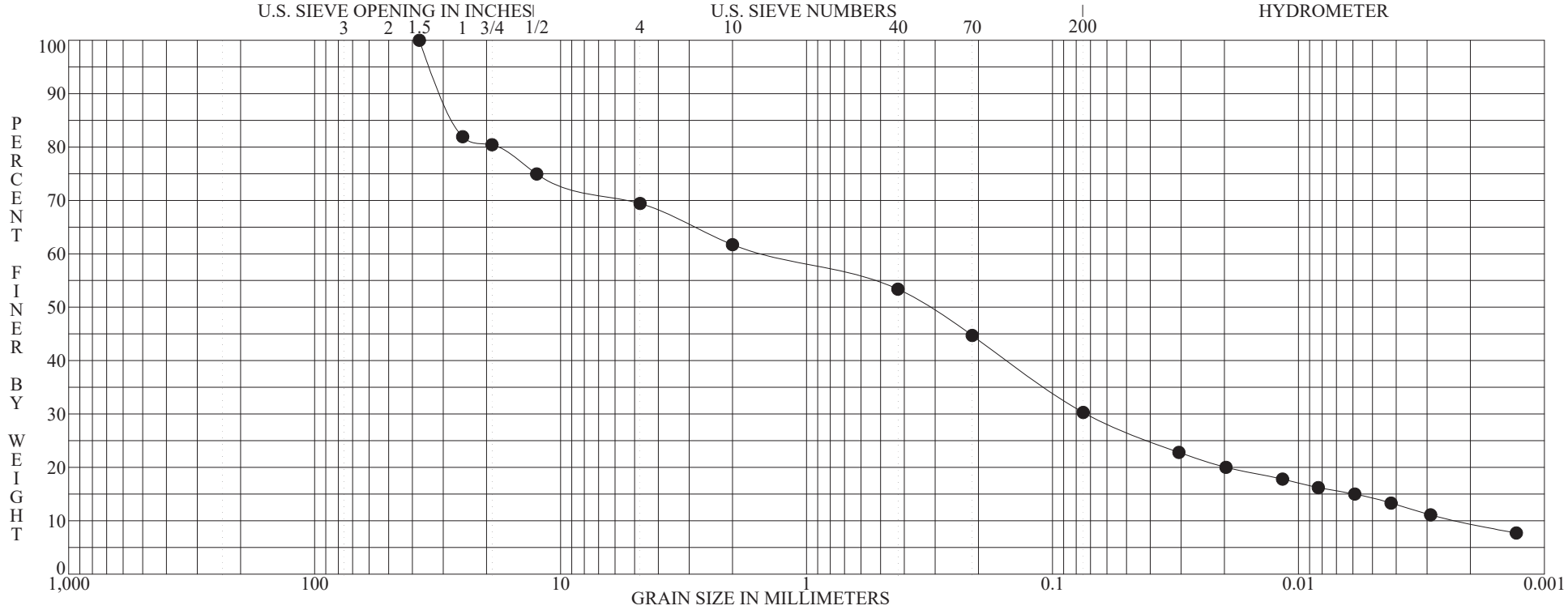

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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.**	**14**	**25**	**16**	**9**	**1.616**	**650.322**
		CLAYEY SAND with GRAVEL SC						

	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**

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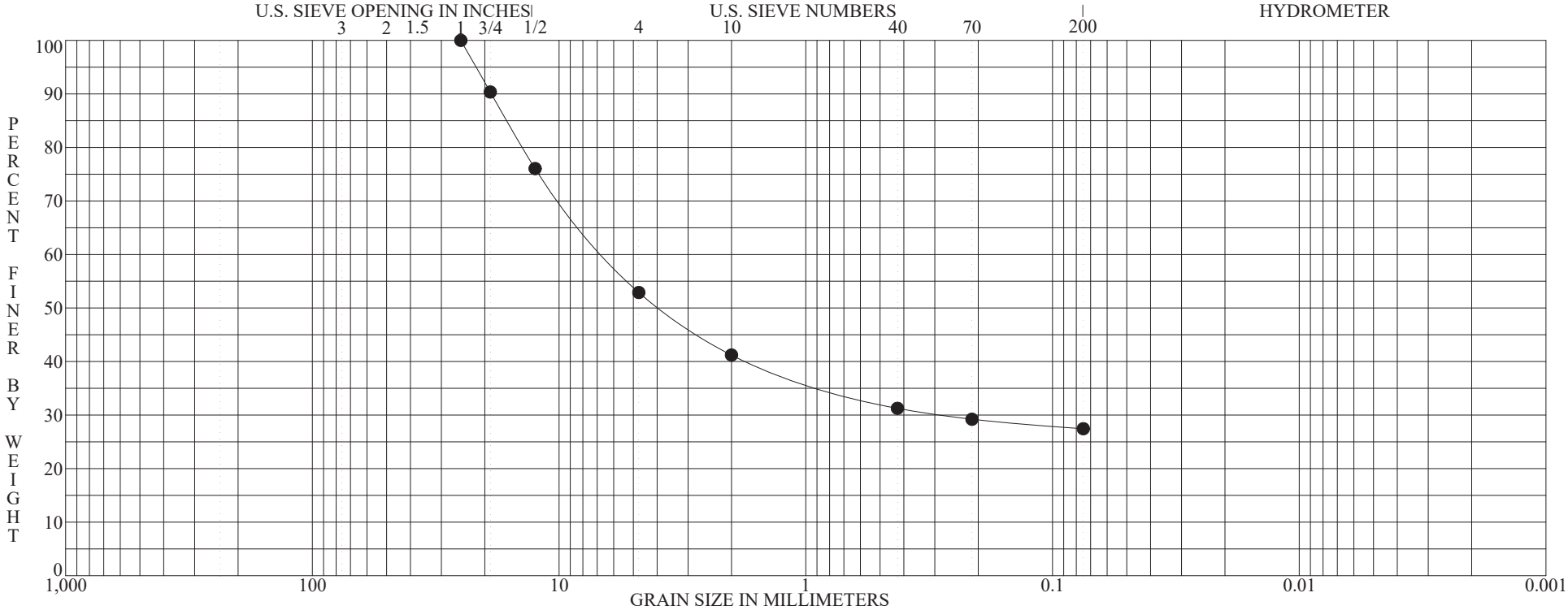

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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**

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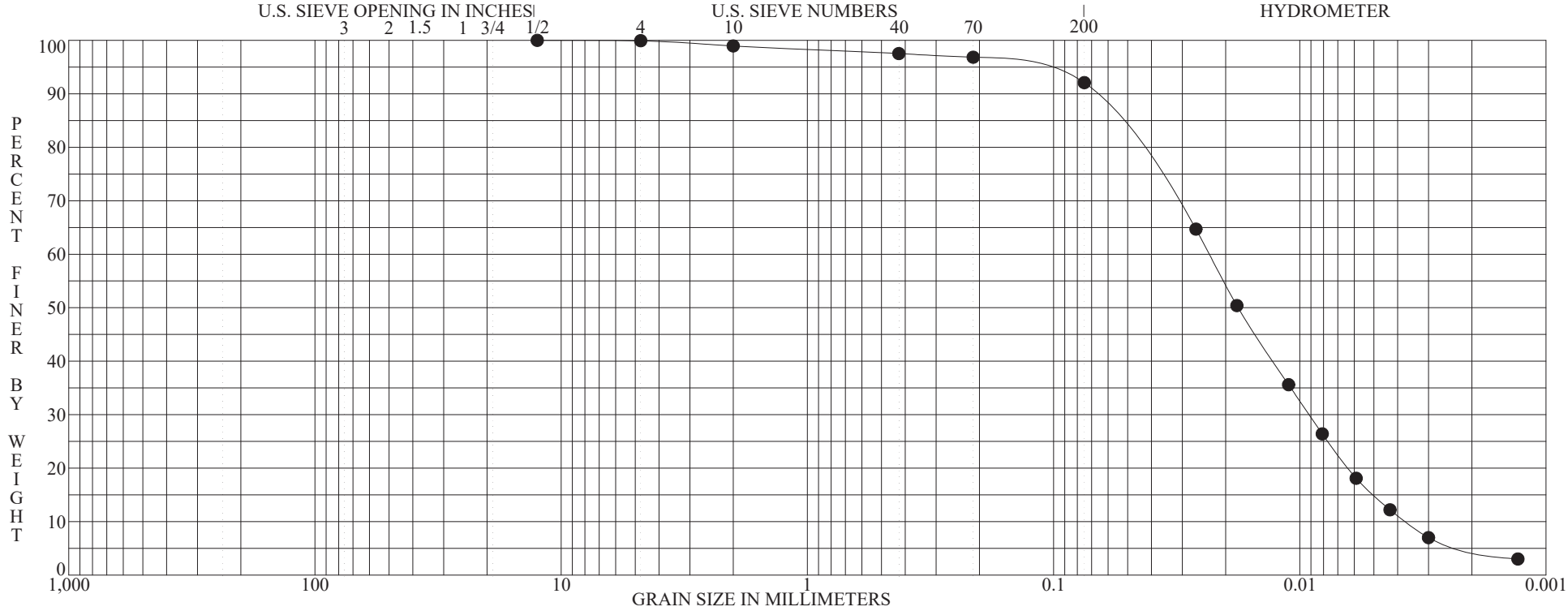

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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**

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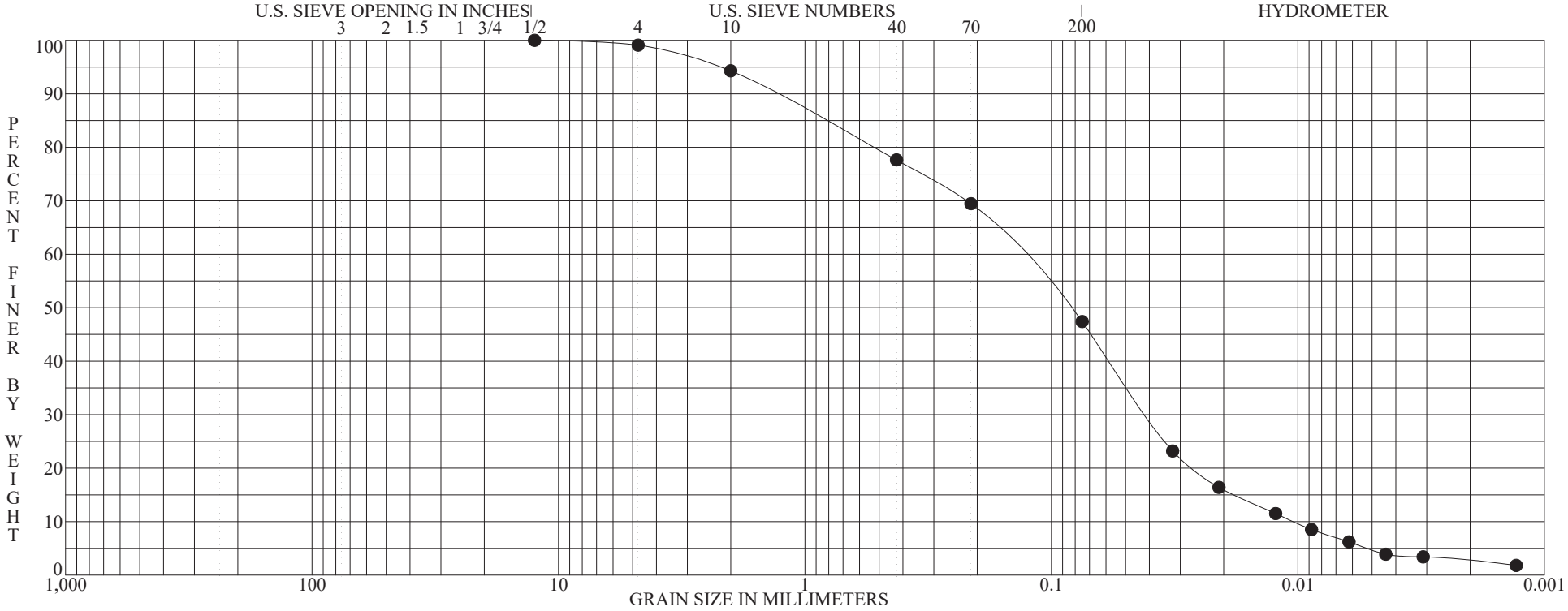

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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.**	**26**	**NP**	**NP**	**NP**	**1.180**	**13.048**
		SILTY SAND SM						

	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**

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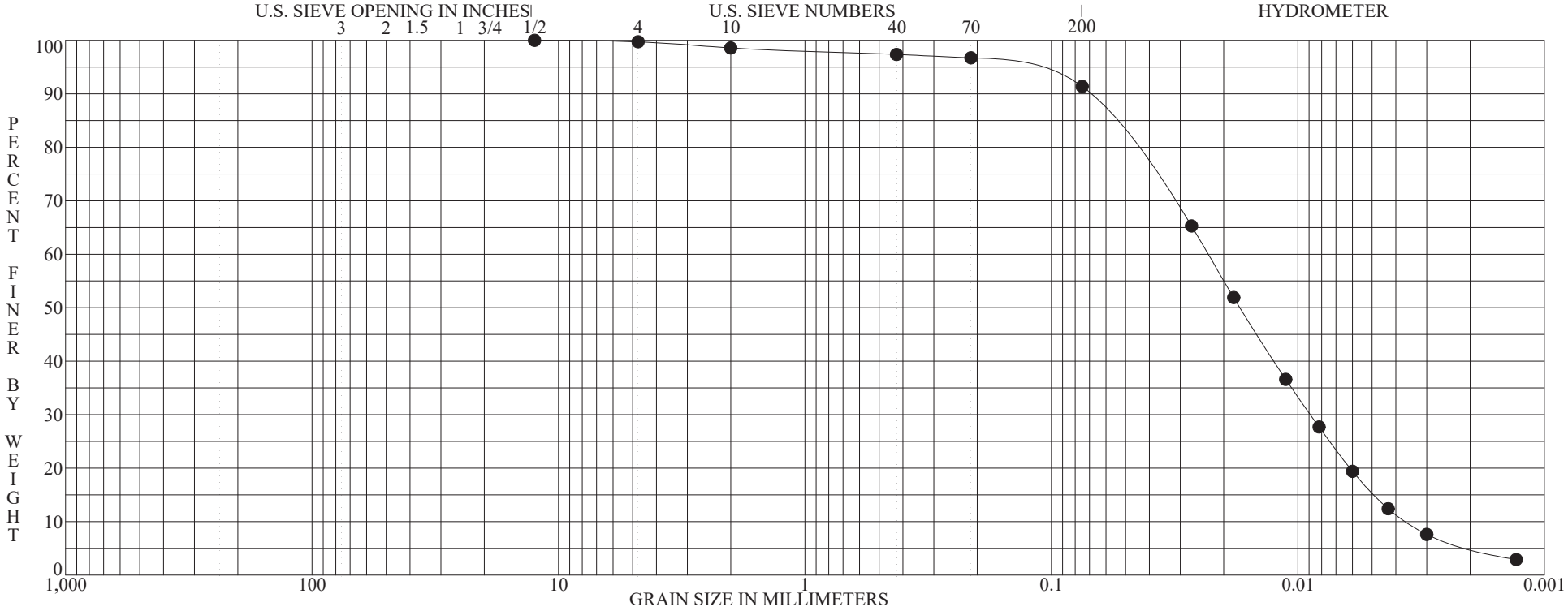

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-PZ-BAP-0904 S-17 25.0' to 25.8'**	**Gray silt, trace clay, trace fine to coarse sand, trace fine gravel.**	**22**	**NP**	**NP**	**NP**	**0.952**	**6.432**
		SILT ML						

	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**

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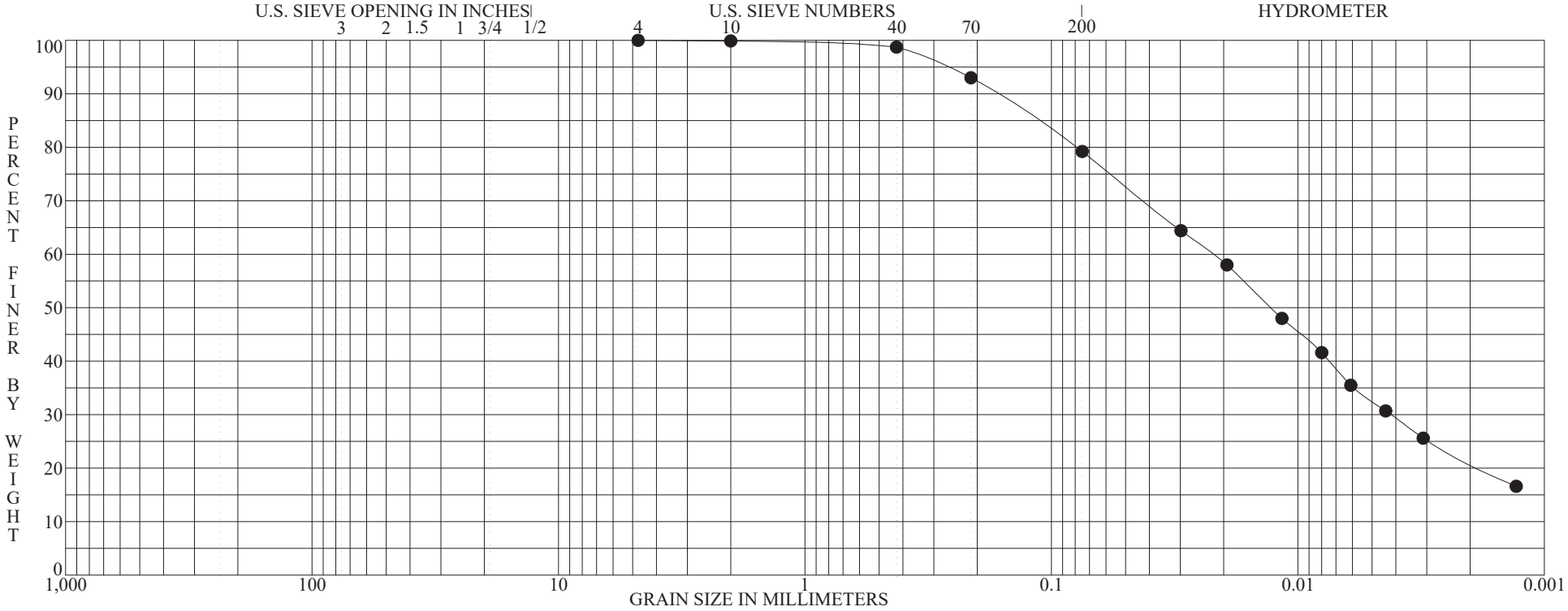

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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.**	**38**	**38**	**24**	**14**		
		ORGANIC CLAY with SAND OL						

	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**

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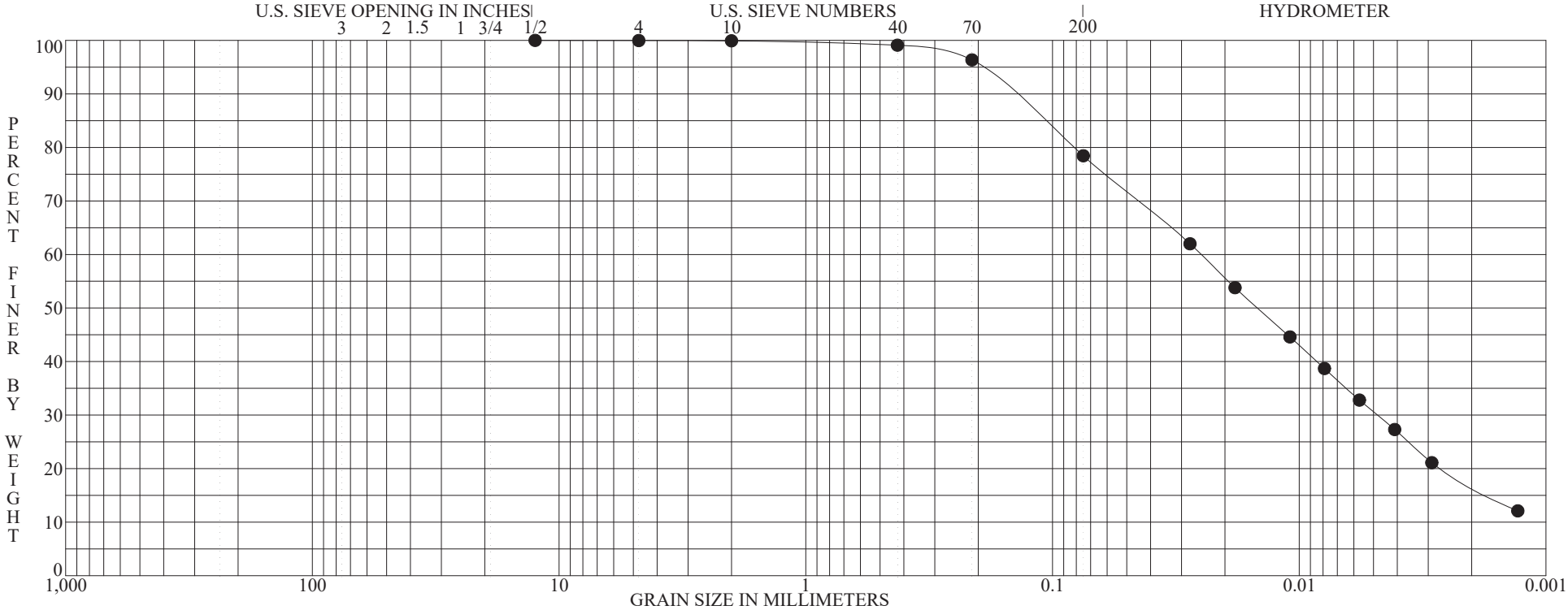

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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.**	**47**	**42**	**30**	**12**		
		ORGANIC SILT with SAND OL						

	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

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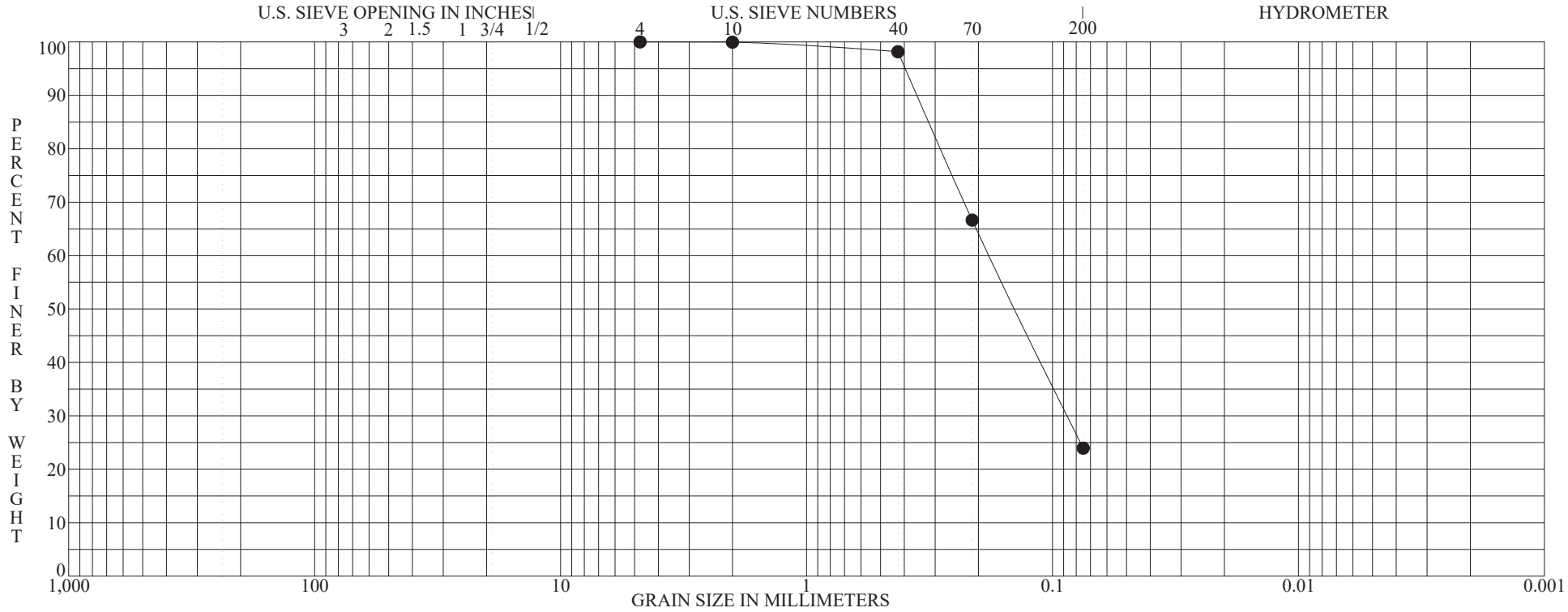

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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

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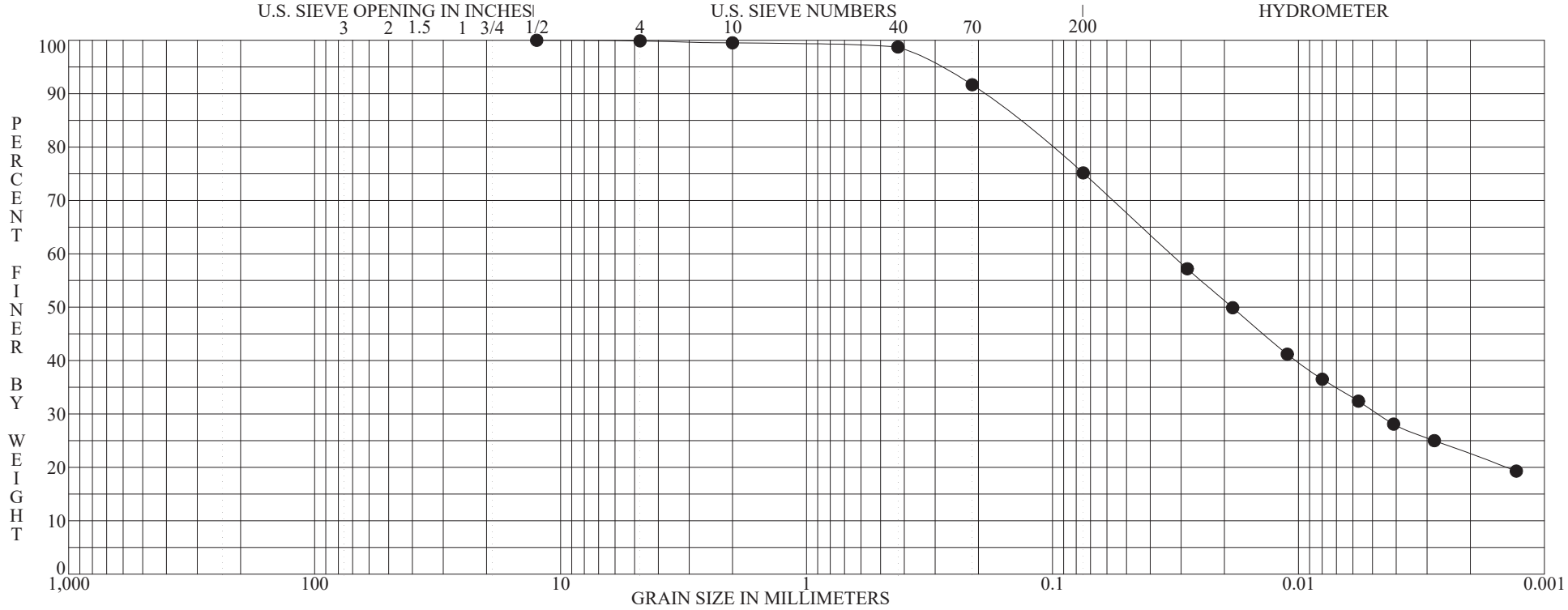

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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.**	**17**	**32**	**18**	**14**		
		LEAN CLAY with SAND CL						

	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

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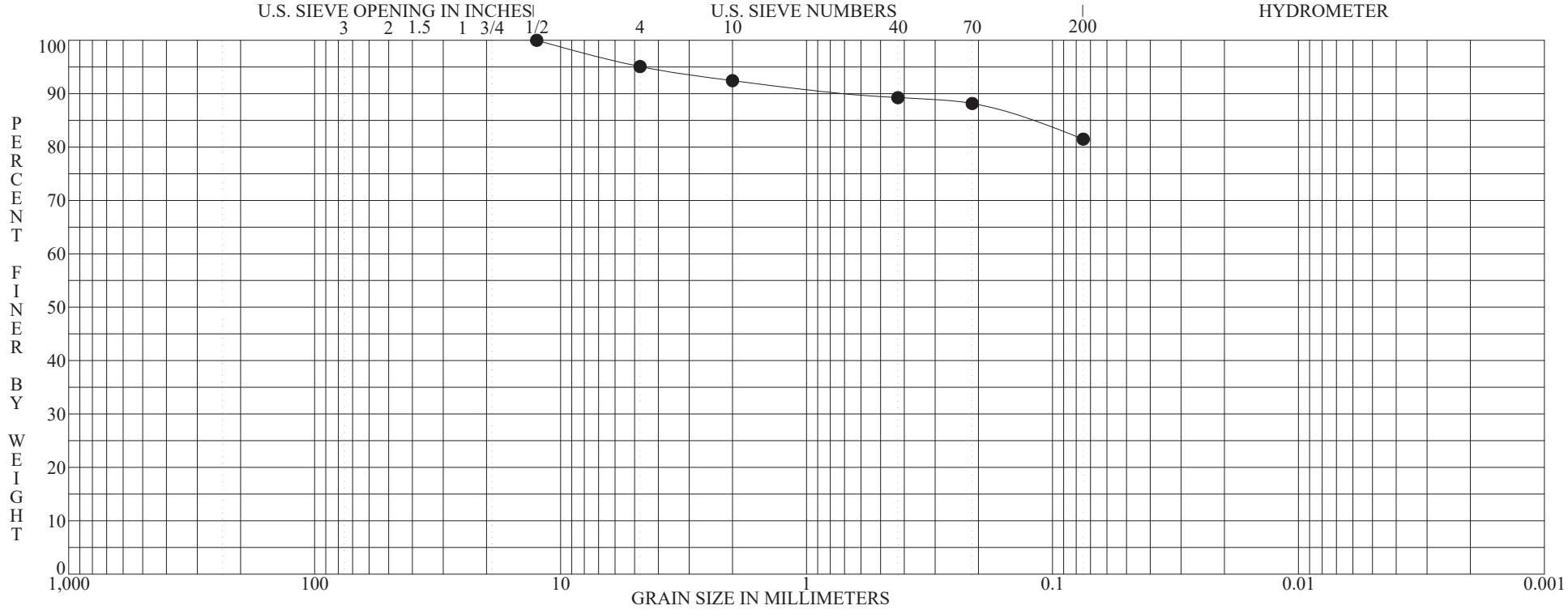

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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**

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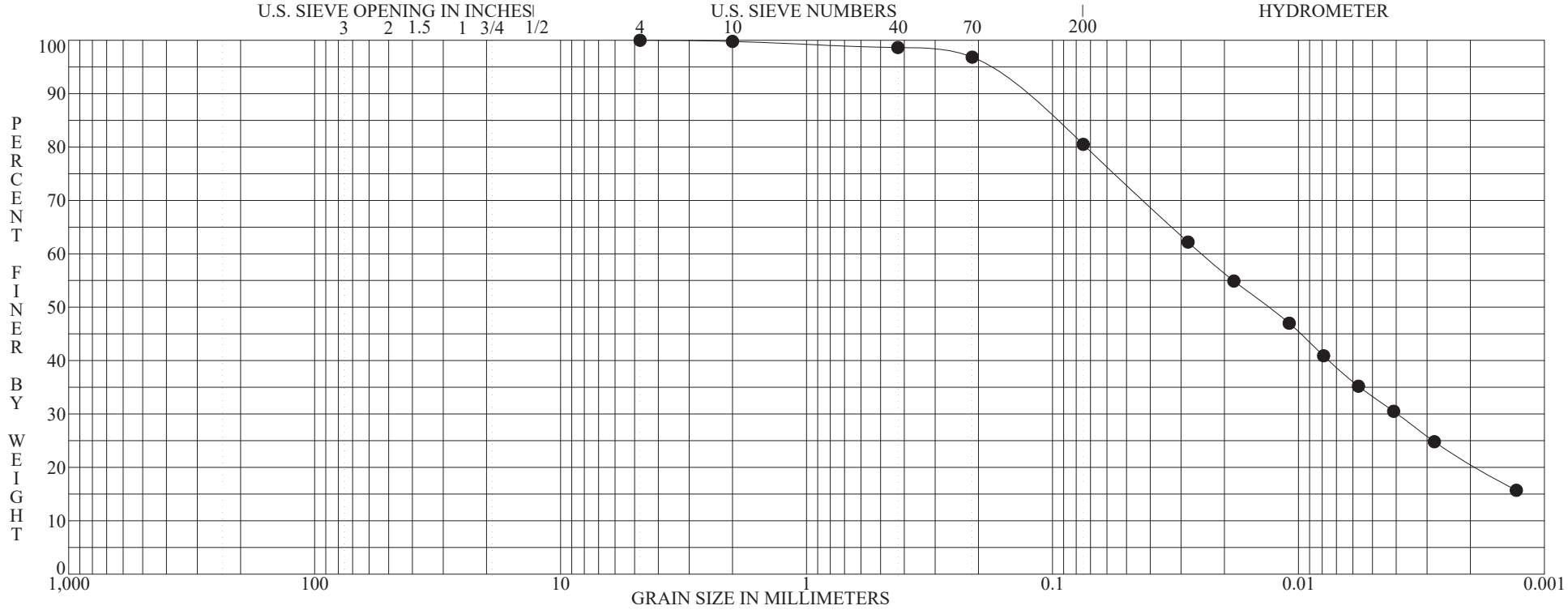

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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.**	**45**	**43**	**27**	**16**		
		ORGANIC SILT with SAND OL						

	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

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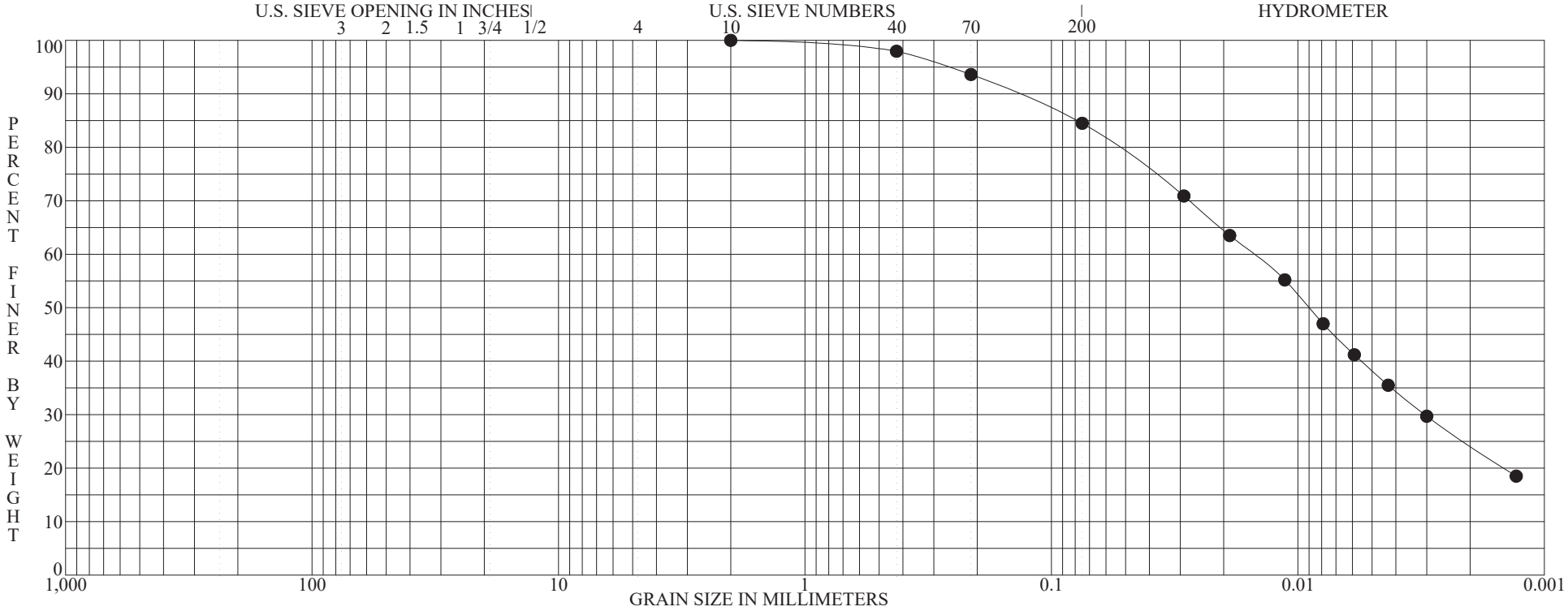

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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**

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LOCATION: BRILLIANT, OHIO
JOB NO.: 011-11497-013 DATE: 7/6/09

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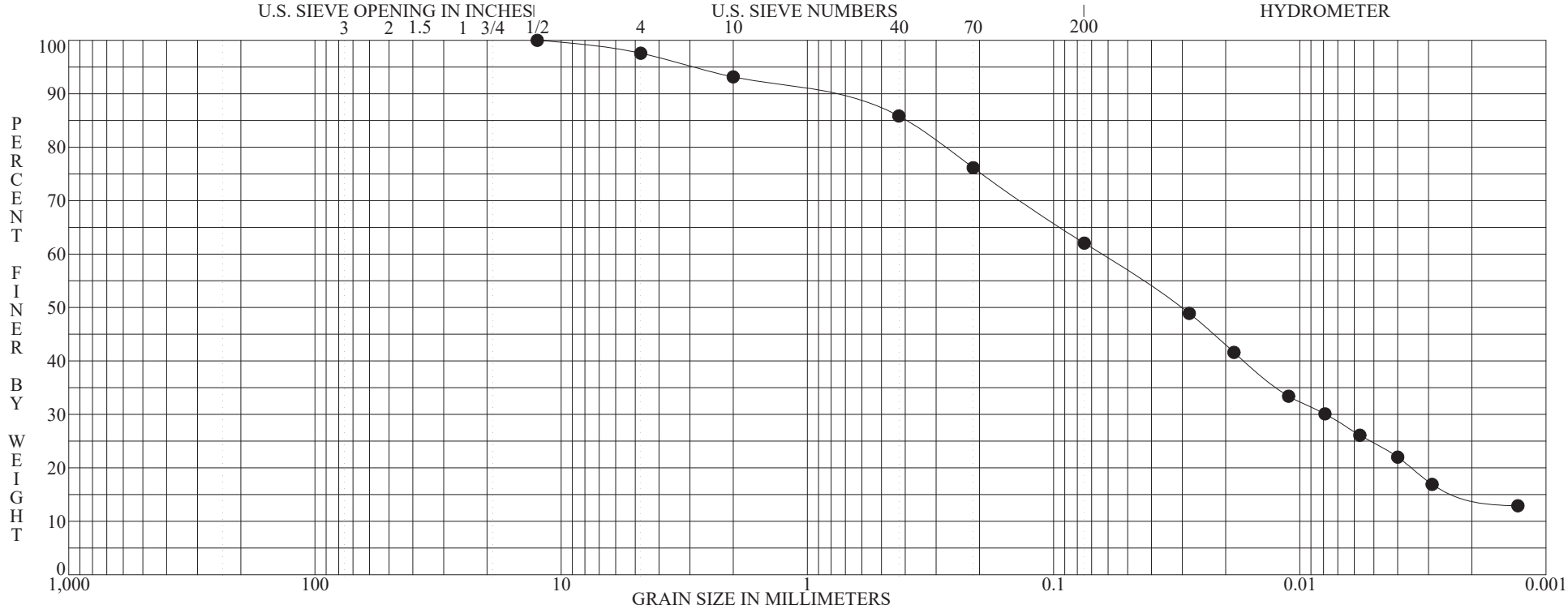

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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.**	**38**	**38**	**23**	**15**		
		SANDY LEAN CLAY CL						

	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

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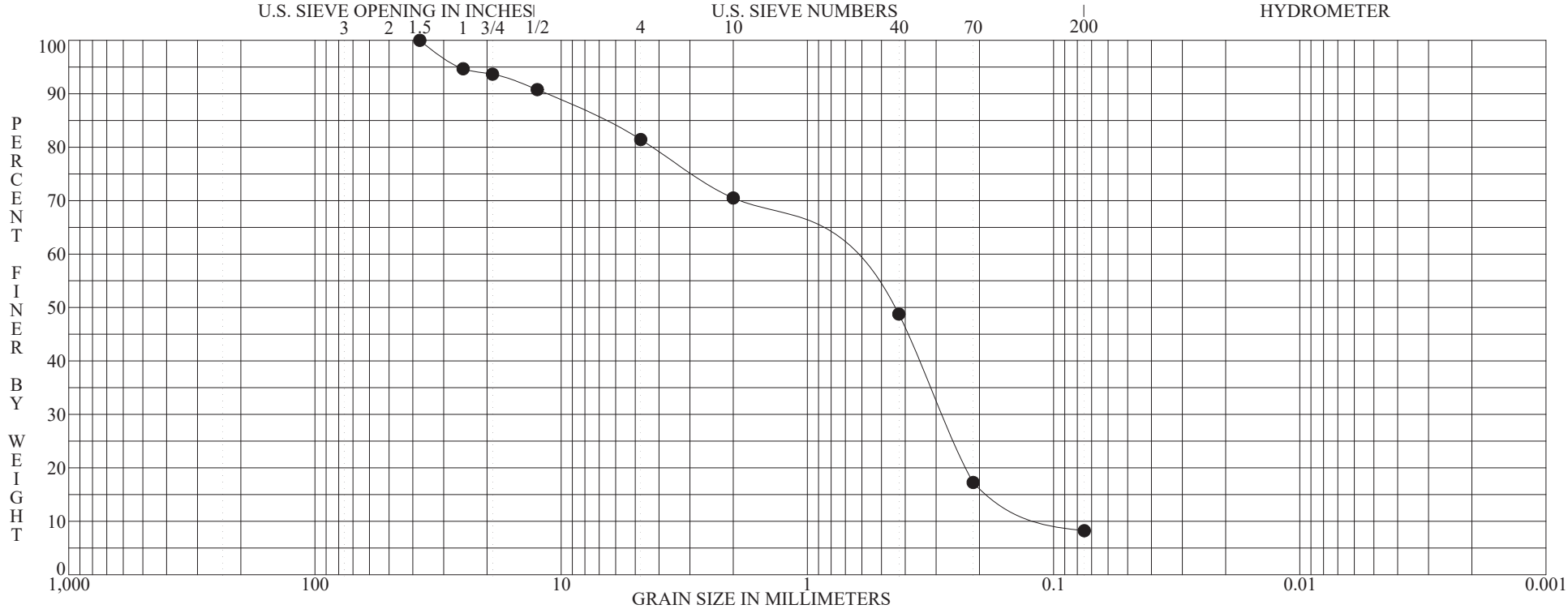

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-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

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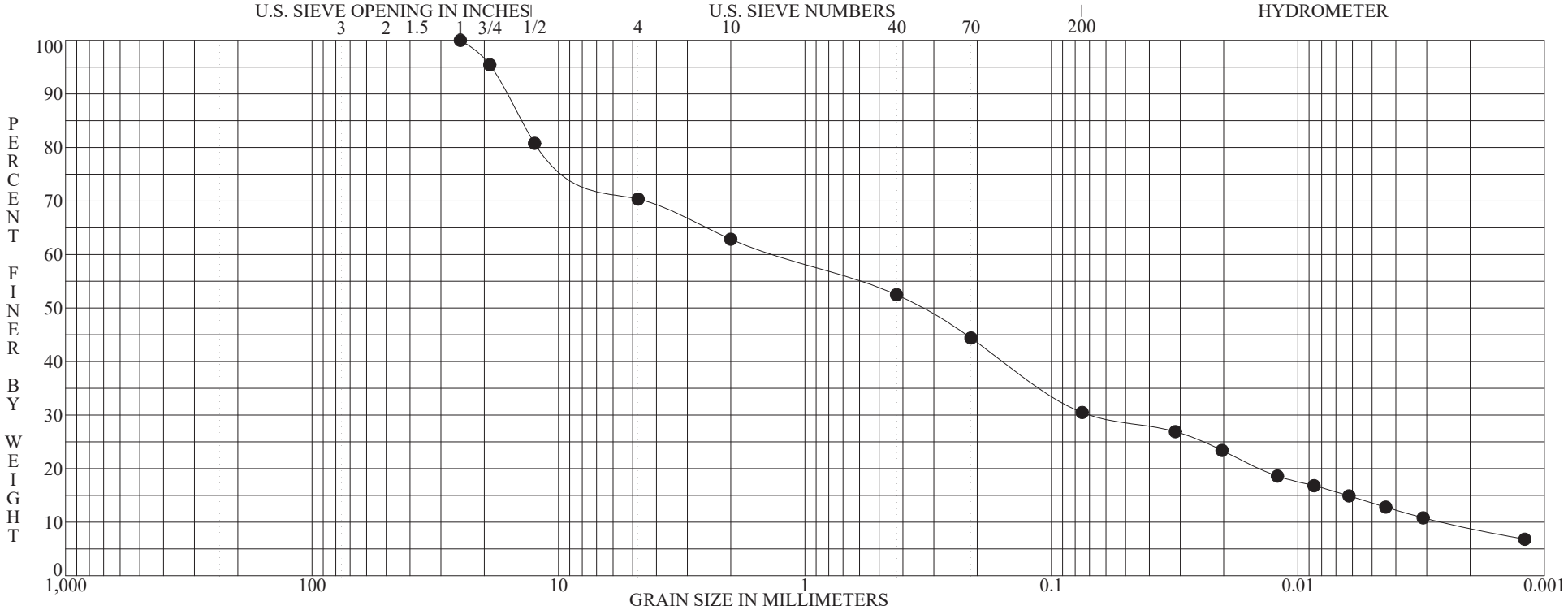

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-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**

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LOCATION: BRILLIANT, OHIO
JOB NO.: 011-11497-013 DATE: 7/6/09

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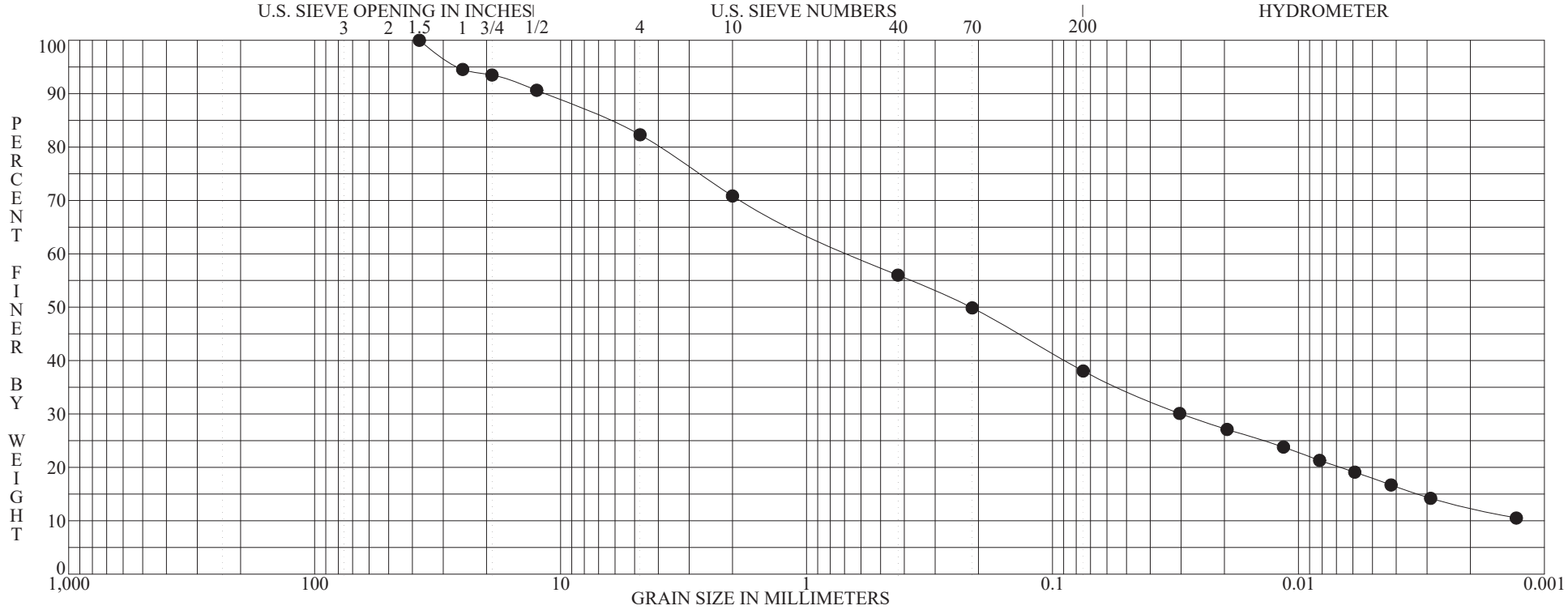

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0906 S-11 16.5' to 17.3'**	**FILL: Brown fine to coarse sand, little fine to coarse gravel, "and" silty clay.**	**14**	**31**	**19**	**12**		
		CLAYEY SAND with GRAVEL SC						

	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

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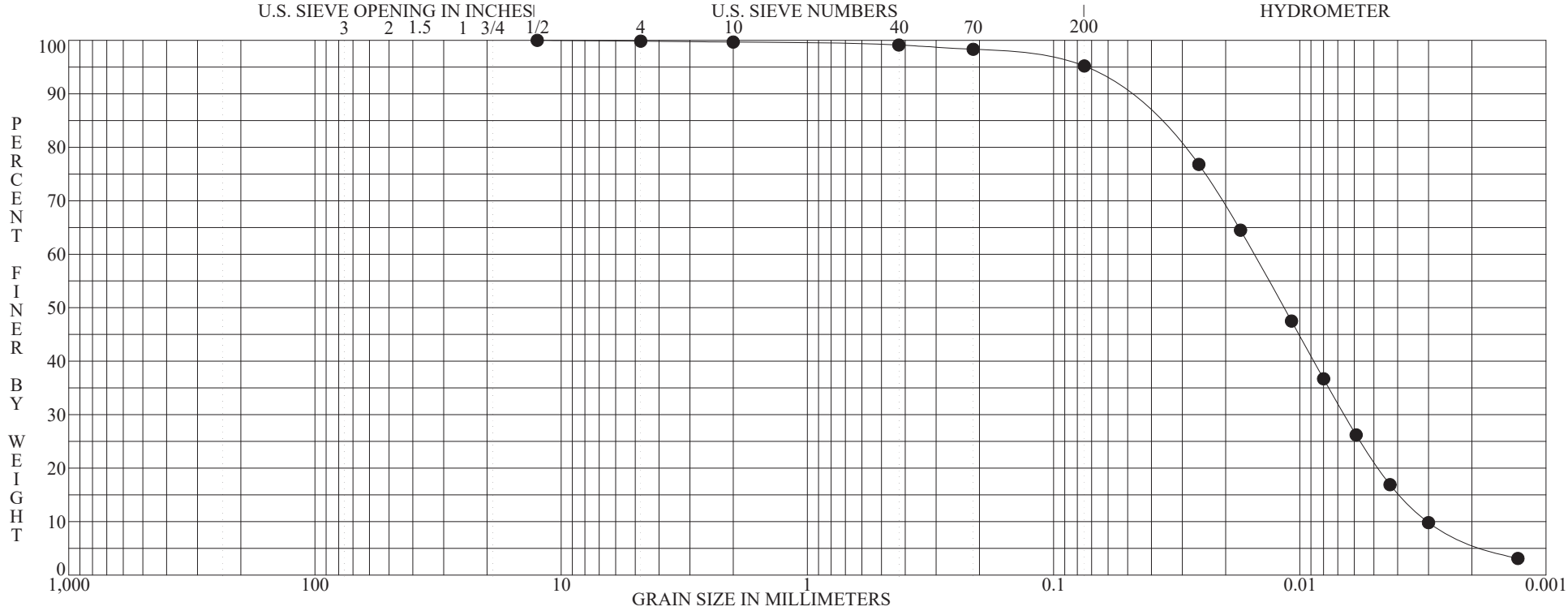

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0906 S-15 24.0' to 25.0'**	**Gray silt, trace clay, trace fine to coarse sand, trace fine gravel.**	**31**	**NP**	**NP**	**NP**	**0.934**	**5.061**
		SILT ML						

	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**

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LOCATION: BRILLIANT, OHIO
JOB NO.: 011-11497-013 DATE: 7/6/09

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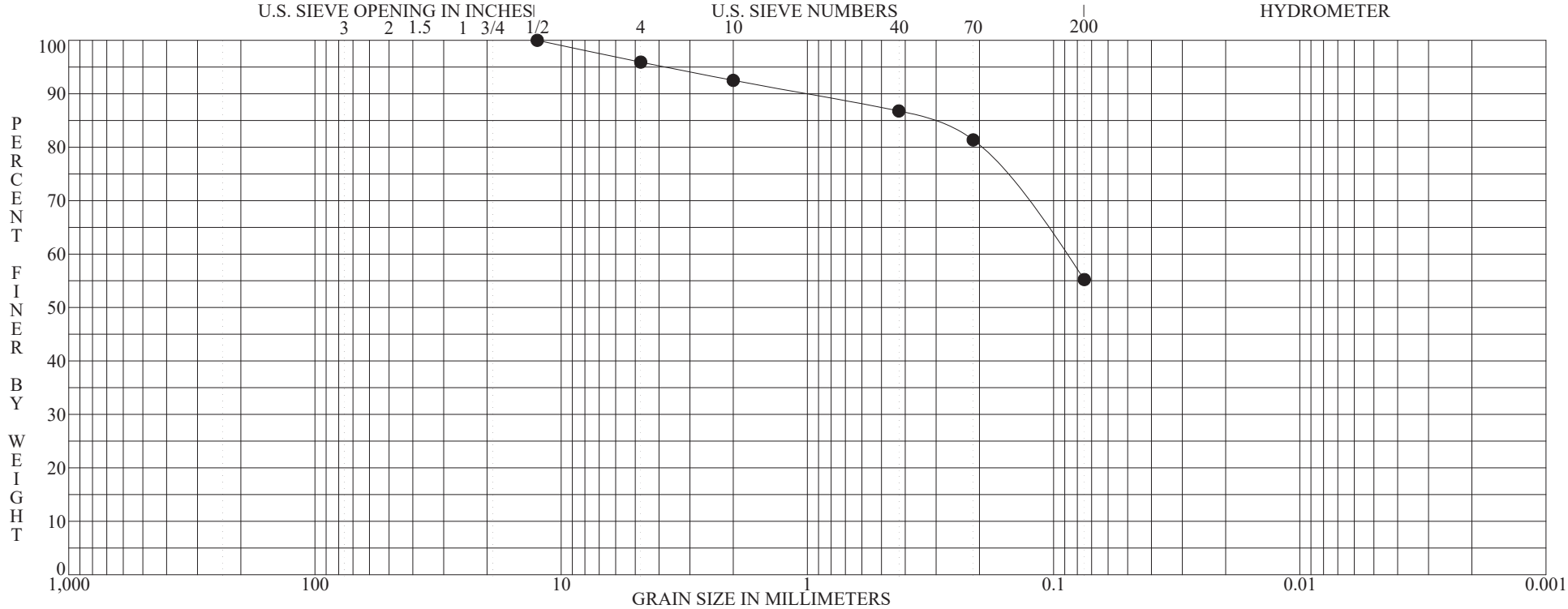

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-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**

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LOCATION: BRILLIANT, OHIO
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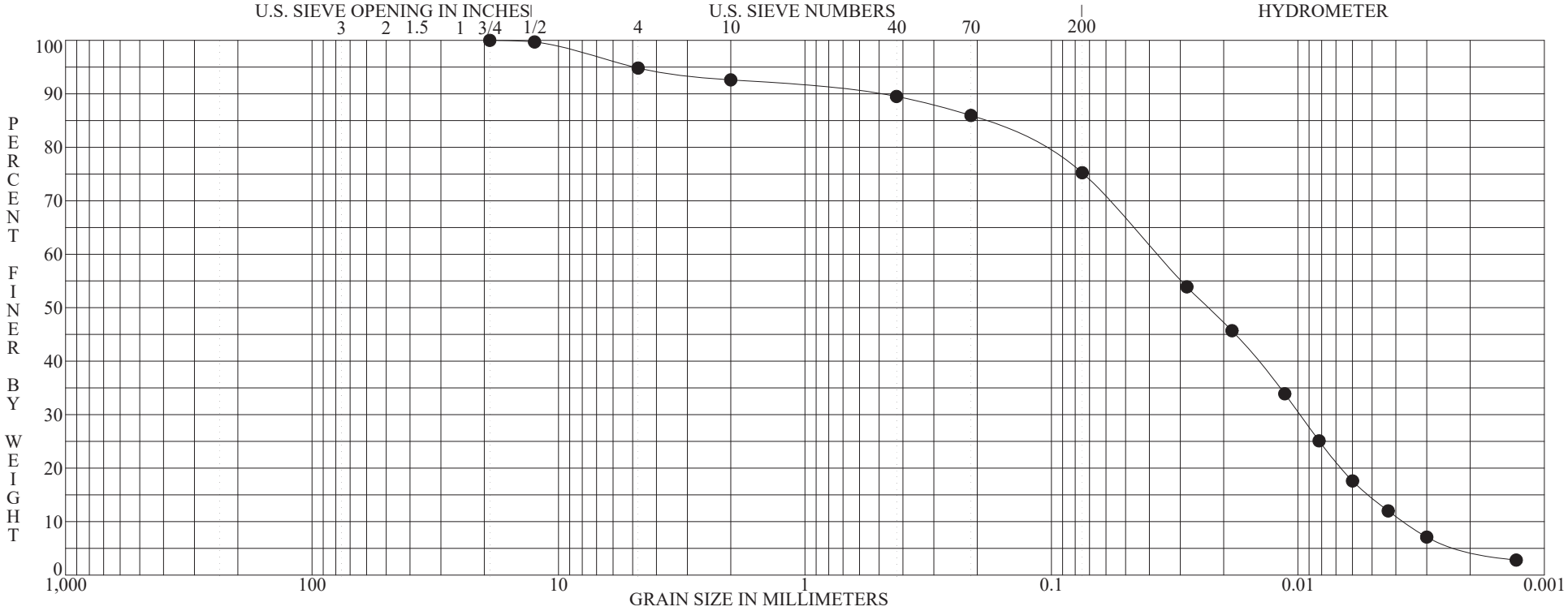

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-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**

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LOCATION: BRILLIANT, OHIO
JOB NO.: 011-11497-013 DATE: 7/6/09

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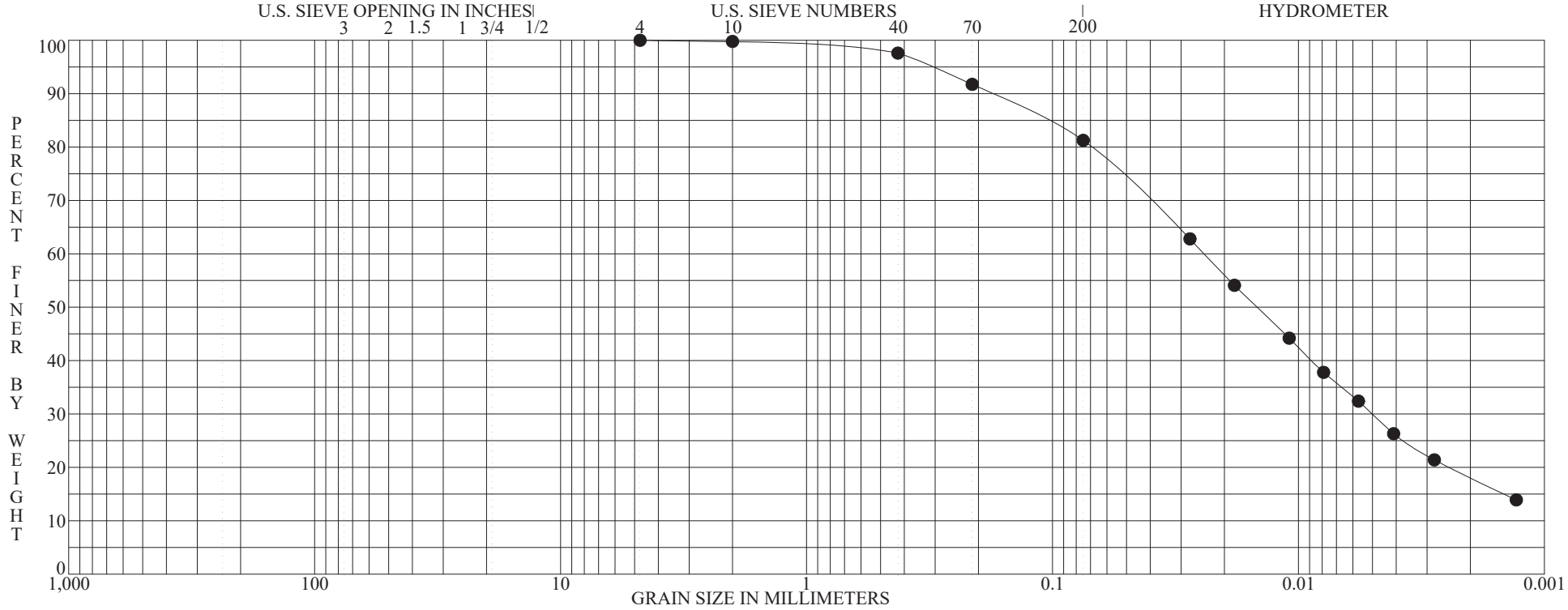

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-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.**	**34**	**33**	**22**	**11**		
		ORGANIC CLAY with SAND OL						

	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**

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LOCATION: BRILLIANT, OHIO
JOB NO.: 011-11497-013 DATE: 7/6/09

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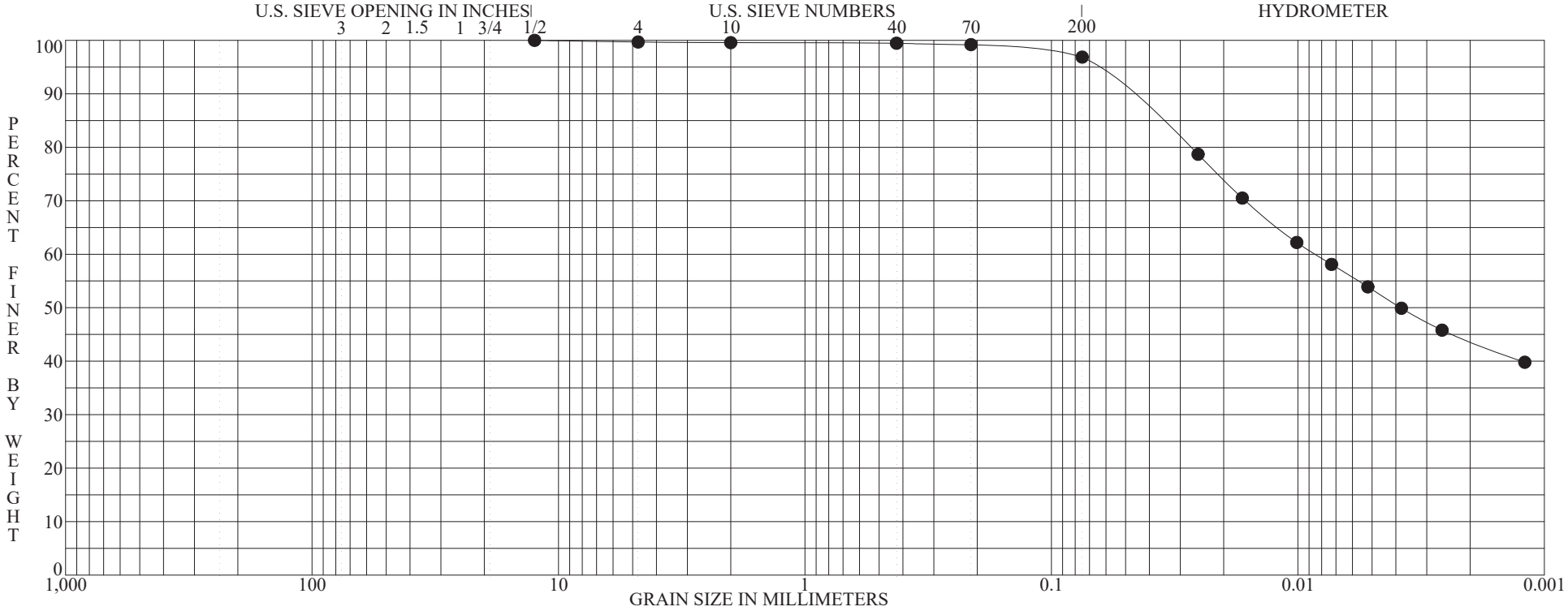

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0906 S-20 33.5' to 34.4'**	**Gray organic clayey silt, trace fine to coarse sand, trace fine gravel.**	**43**	**50**	**30**	**20**		
		ORGANIC SILT OH						

	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

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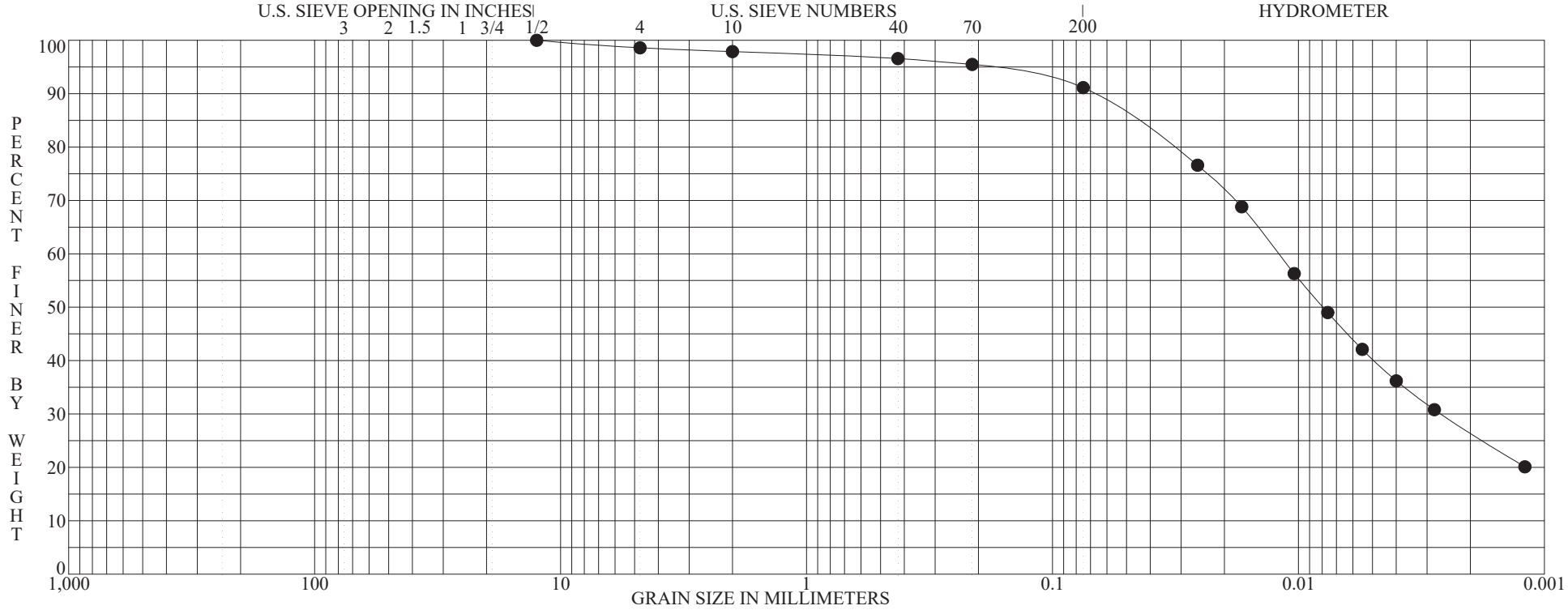

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0906 S-21 36.0' to 36.7'**	**Gray organic clayey silt, trace fine to coarse sand, trace fine gravel.**	**38**	**43**	**26**	**17**		
		ORGANIC CLAY OL						

	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**

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LOCATION: BRILLIANT, OHIO
JOB NO. 011-11497-013 DATE 7/6/09

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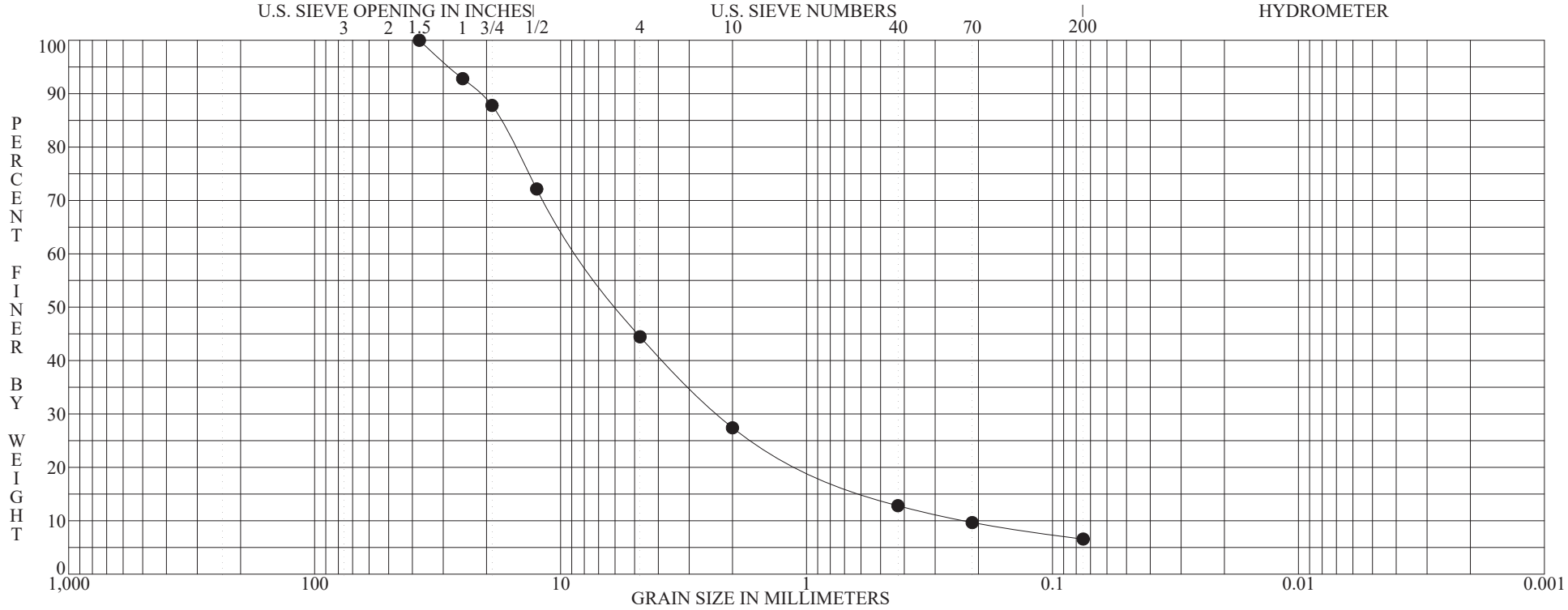


BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-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**	

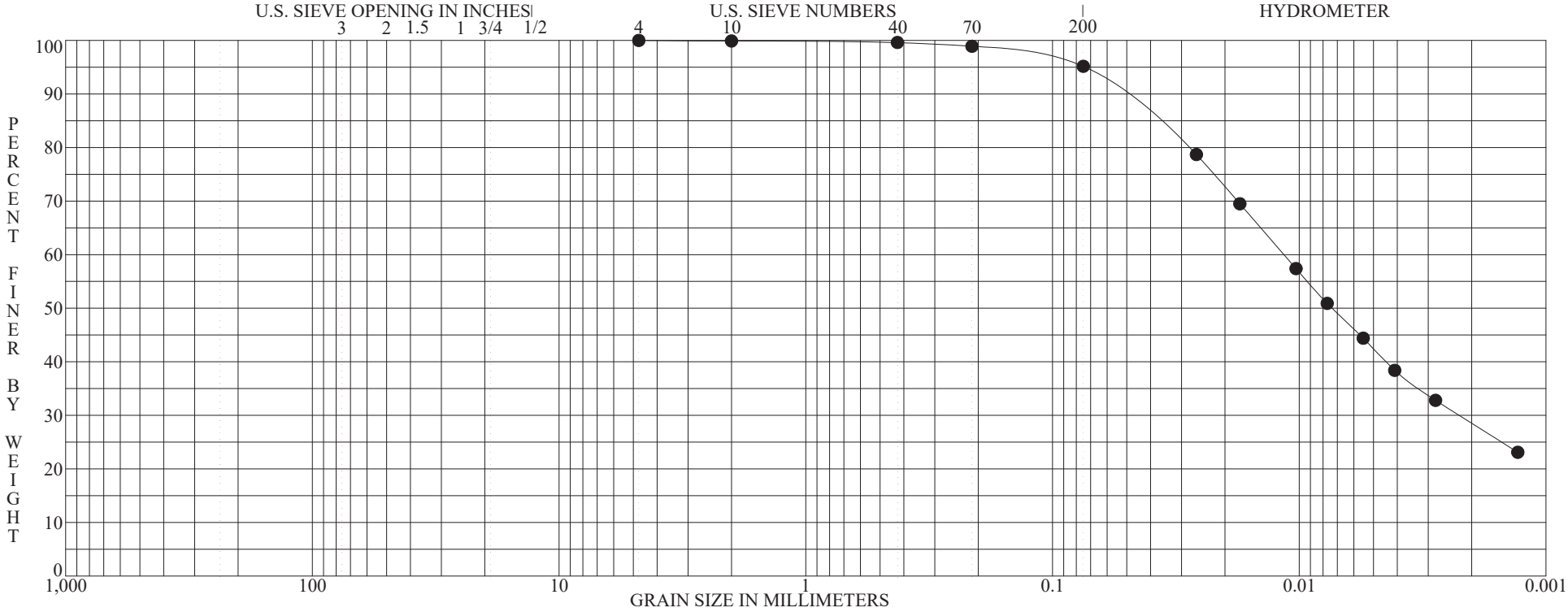
ASTM D422

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

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 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.**	**28**	**47**	**29**	**18**		
		SILT ML						

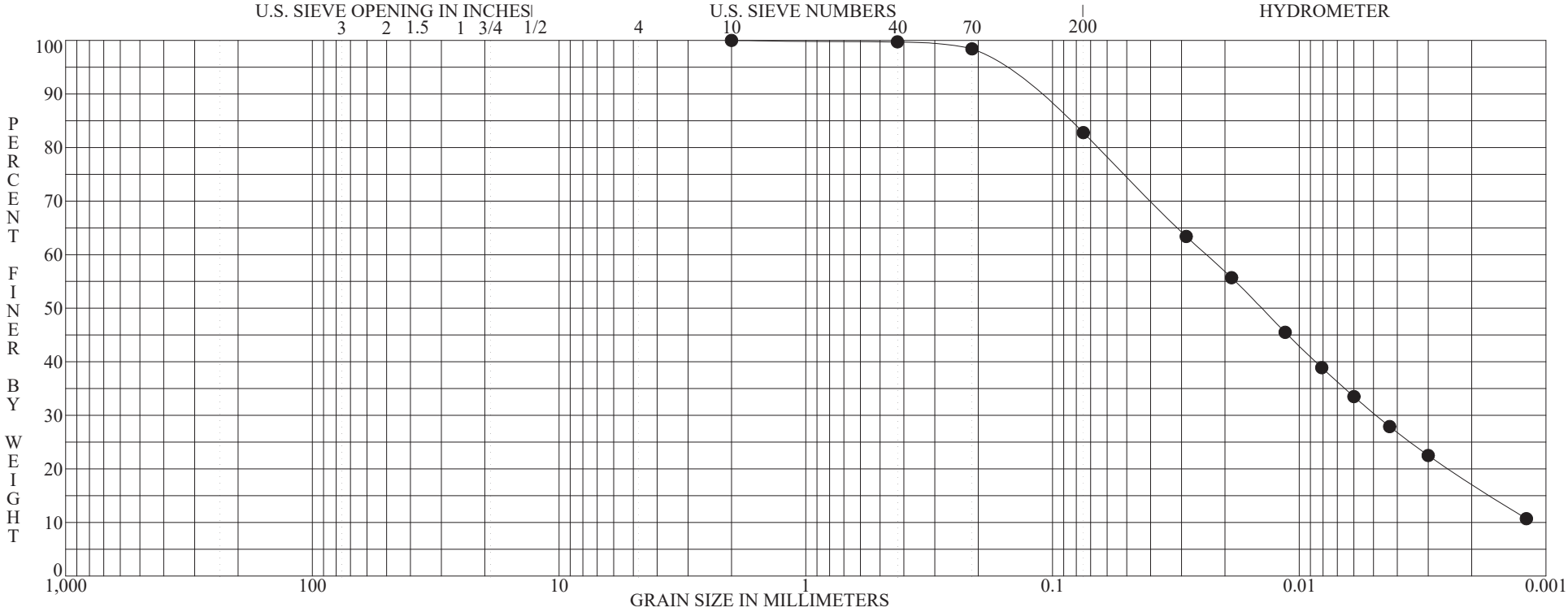
	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0907 ST-6A II 8.5' to 9.9'**	**4.7500**	**0.0742**	**0.0115**	**0.0073**		**0.00**	**4.83**	**66.62**	**28.55**

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

GRN-EPA W/ASTM-BBCM

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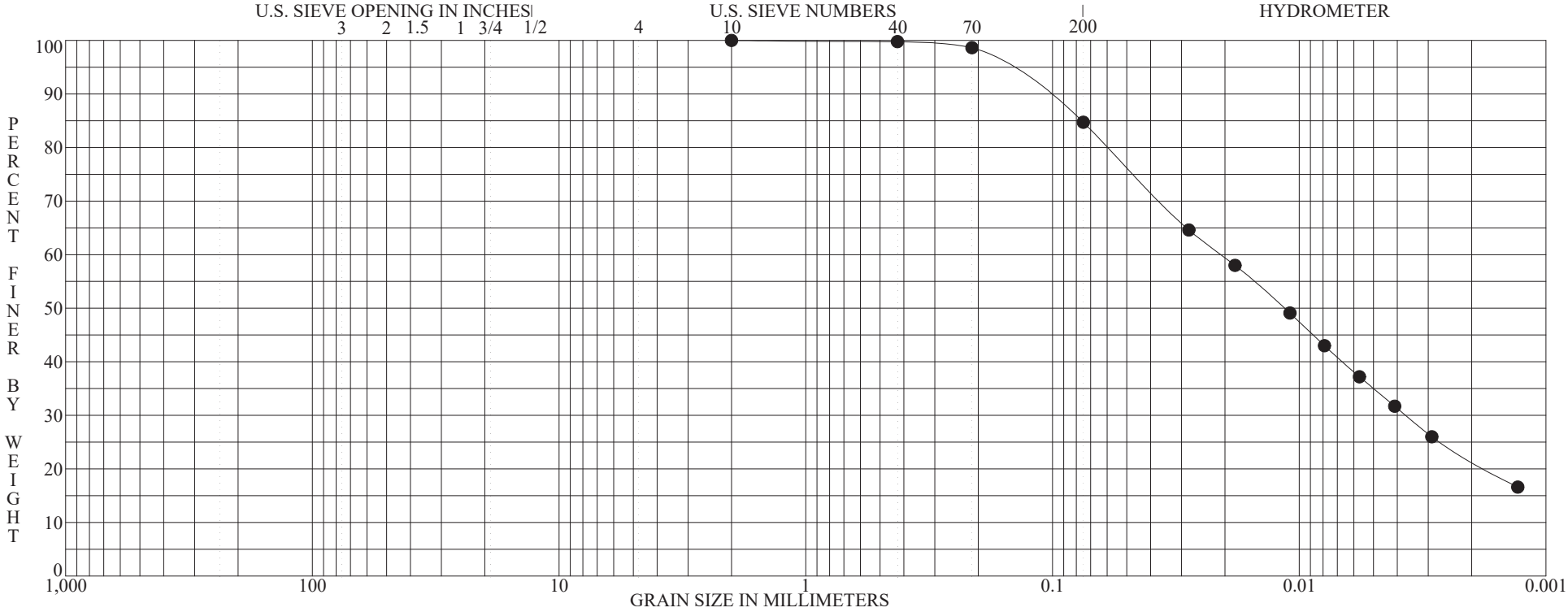


BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	

	Specimen Identification - Depth	Classification	MC%	LL	PL	PI	Cc	Cu
●	**CD-BAP-0907 S-8 13.5' to 14.6'**	**Gray organic clayey silt, little fine to medium sand, few seams of fine sand.**	**43**	**44**	**28**	**16**		
		ORGANIC SILT with SAND OL						

	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**

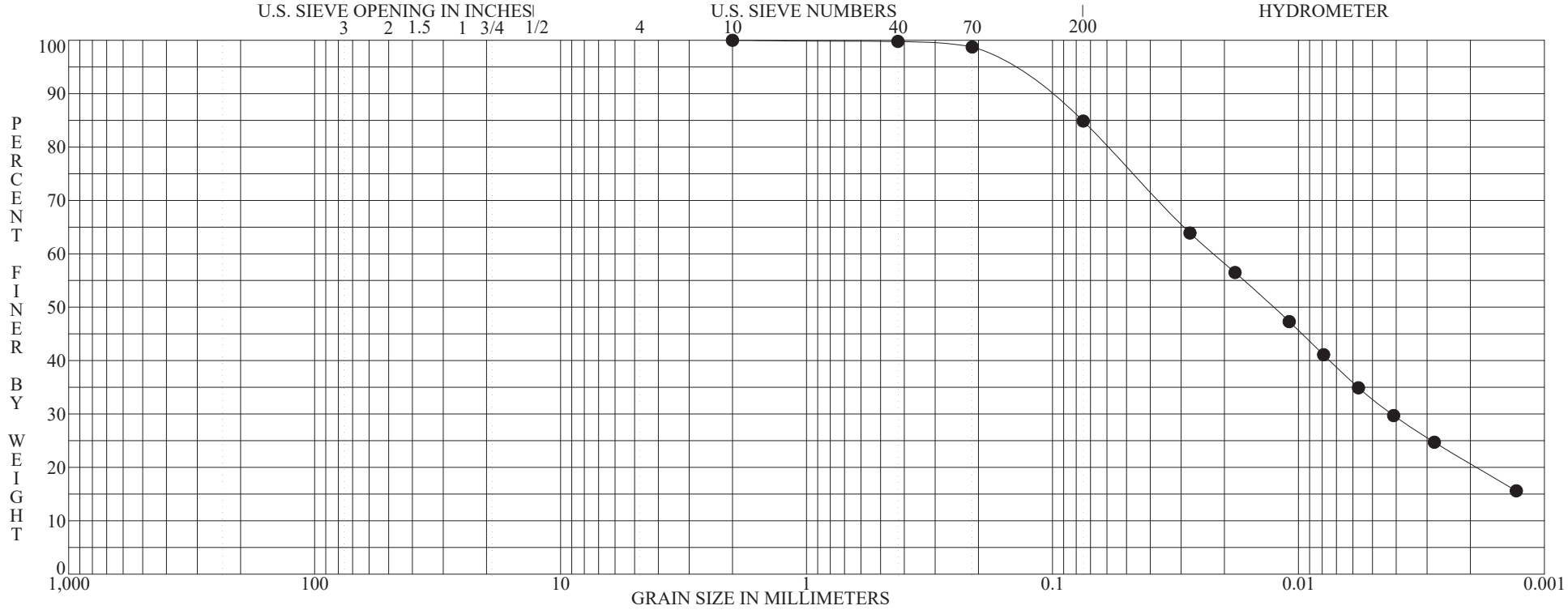
ASTM D422 | **GRADATION CURVE**

PROJECT: CARDINAL PLANT ASH POND INVESTIGATION
LOCATION: BRILLIANT, OHIO
JOB NO.: 011-11497-013 DATE: 7/6/09

PLATE 62

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-9 16.0' to 17.0'**	**Gray organic clayey silt, little fine sand, trace medium sand.**	**44**	**45**	**29**	**16**		
		ORGANIC SILT with SAND OL						

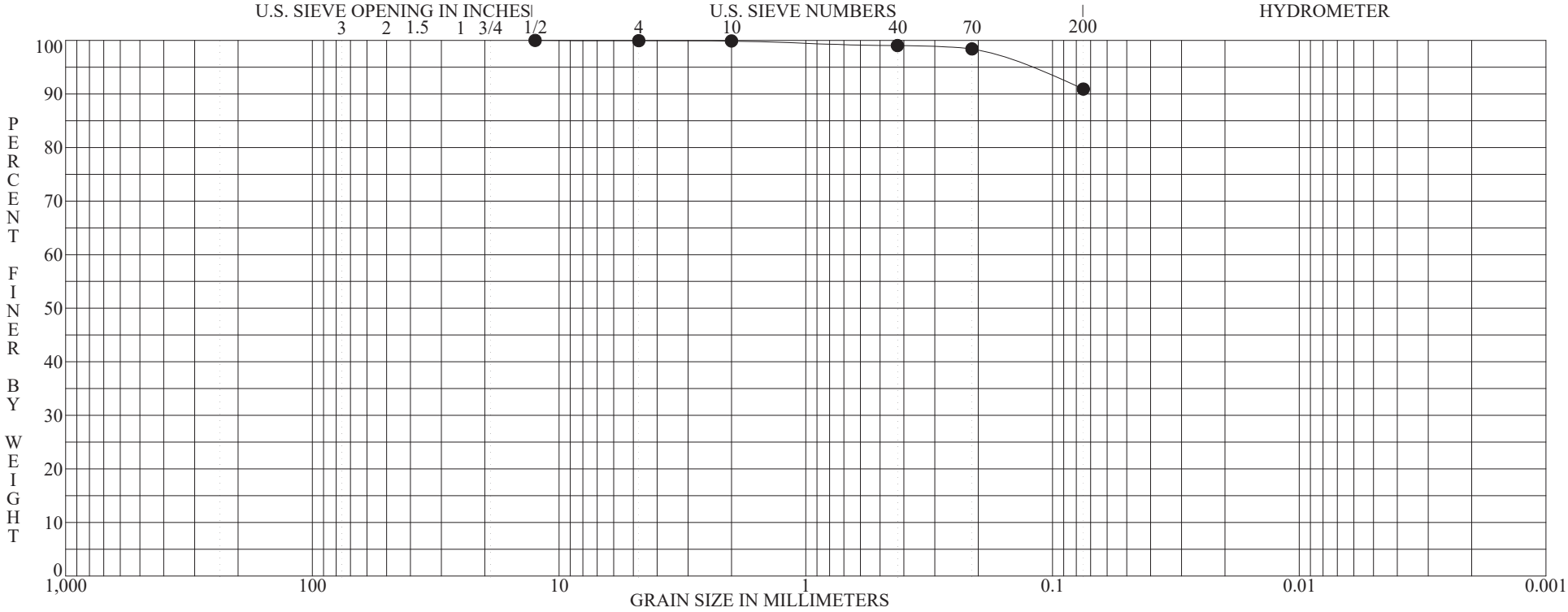
	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0907 S-9 16.0' to 17.0'**	**2.0000**	**0.1601**	**0.0221**	**0.0126**		**0.00**	**15.12**	**64.17**	**20.71**

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



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-10 18.5' to 19.6'**	**Gray organic clayey silt, trace fine to coarse sand, trace fine gravel.**	**40**	**48**	**29**	**19**		
		ORGANIC SILT OL						

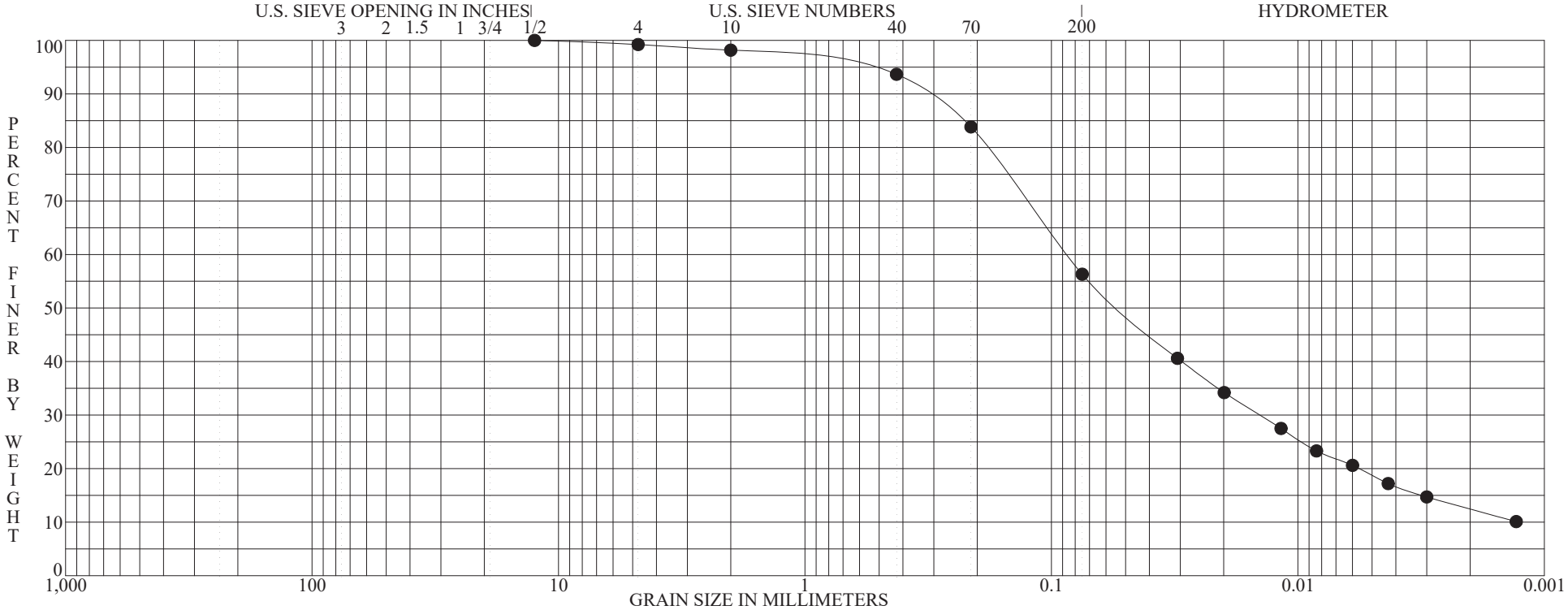
	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0907 S-10 18.5' to 19.6'**	**12.5000**	**0.1321**				**0.05**	**9.03**	**90.92**	

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



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-11 21.0' to 22.0'**	**Gray organic silt, little clay, "and" fine sand, trace medium to coarse sand, trace fine gravel.**	**39**	**30**	**24**	**6**		
		SANDY ORGANIC SILT OL						

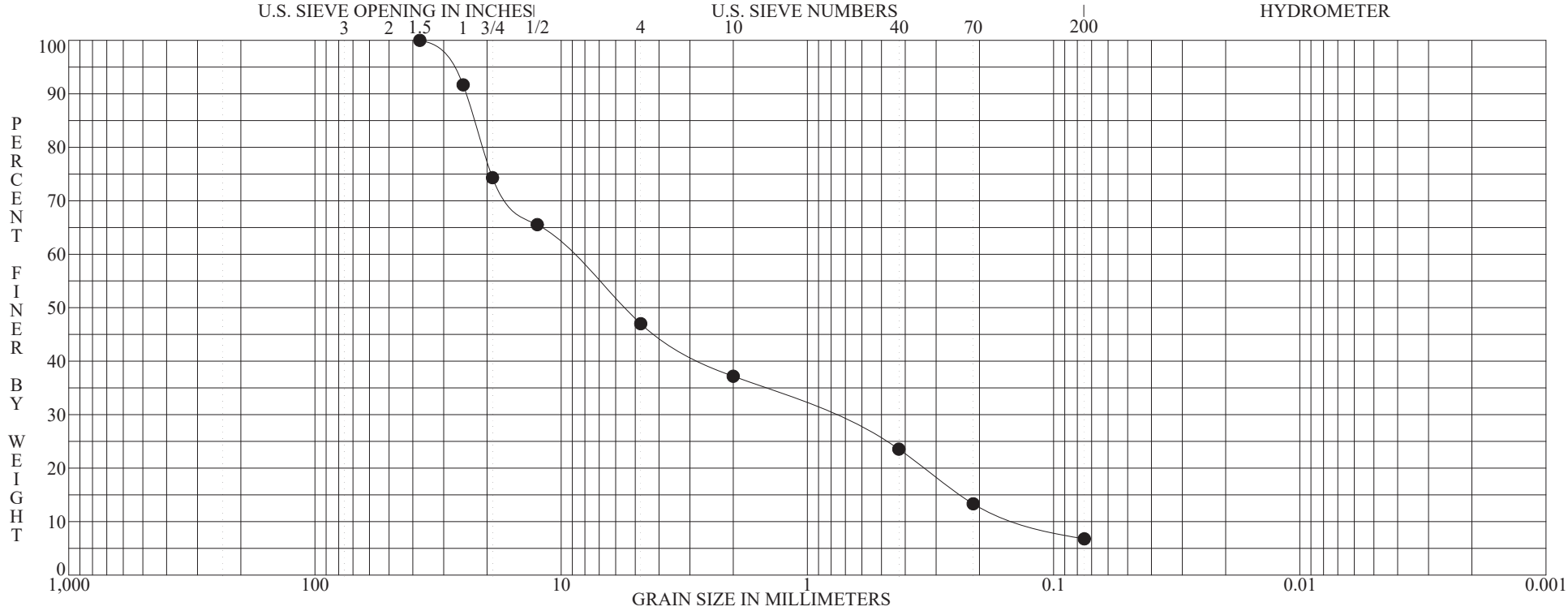
	Specimen Identification - Depth	D100	D95	D60	D50	D10	%Gravel	%Sand	%Silt	%Clay
●	**CD-BAP-0907 S-11 21.0' to 22.0'**	**12.5000**	**0.6714**	**0.0862**	**0.0525**		**0.77**	**42.92**	**43.85**	**12.47**

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

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-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**

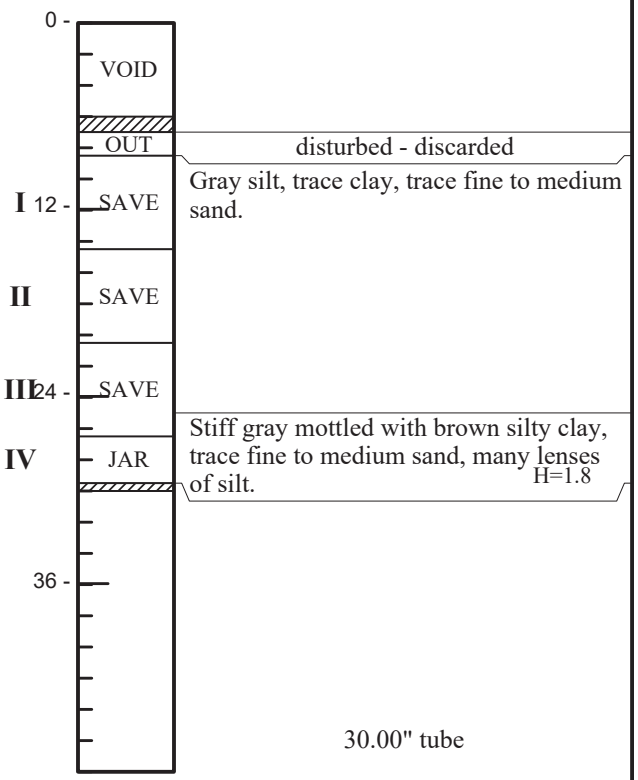
PROJECT: CARDINAL PLANT ASH POND INVESTIGATION
LOCATION: BRILLIANT, OHIO
JOB NO.: 011-11497-013 DATE: 7/6/09

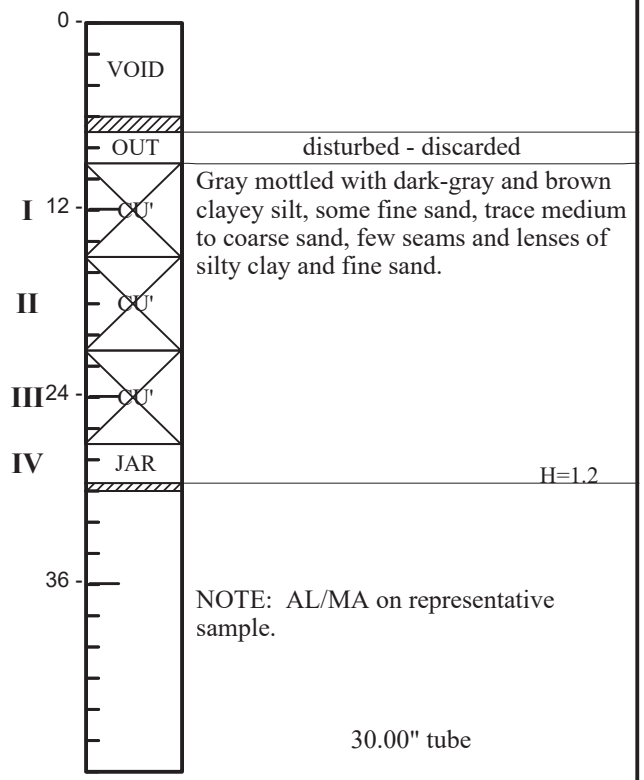
JOB NUMBER : **011-11497-013**
PROJECT : **CARDINAL PLANT ASH POND INVESTIGATION**
LOCATION : **BRILLIANT, OHIO**

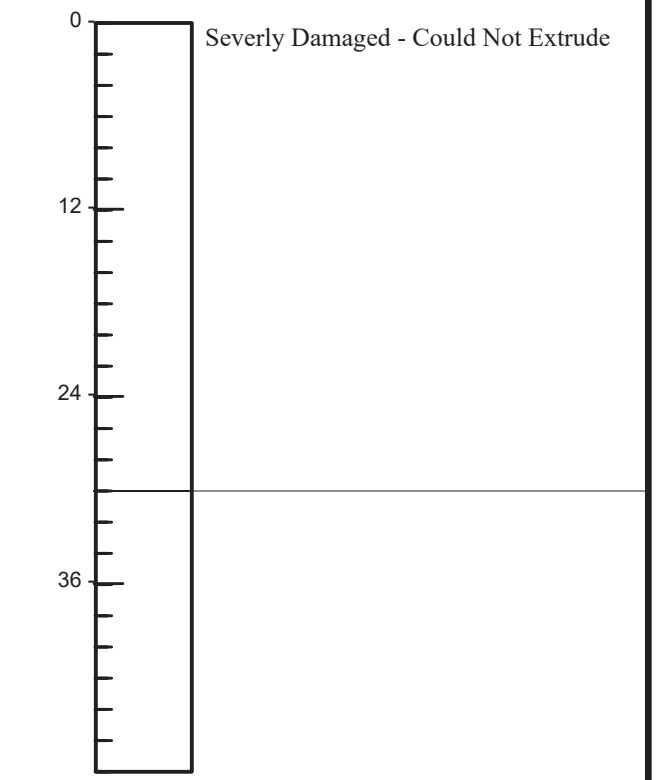
BBCM

LABORATORY LOG OF SHELBY TUBES

Boring : CD-PZ-BAP-0901	Sample : 16A	Boring : CD-PZ-BAP-0901	Sample : 19A	Boring : CD-PZ-BAP-0906	Sample : 6A
Depth : 23.5' to 25.3'	Recovery : 21.00"	Depth : 31.0' to 32.8'	Recovery : 20.50"	Depth : 8.5' to 9.4'	Recovery : 0.00"







LEGEND

- Consolidation, Incremental
- Swelling, Test
- Wax
- C R S - 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

SHELBY TUBE LOG 111497013.GPJ BBCM.GDT 6/16/09

JOB NUMBER : **011-11497-013**
PROJECT : **CARDINAL PLANT ASH POND INVESTIGATION**
LOCATION : **BRILLIANT, OHIO**

BBCM

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 :

Boring CD-PZ-BAP-0906

0 - 12 - 24 - 36 -

Severly Damaged - Could Not Extrude

Boring CD-PZ-BAP-0907

0 - 12 - 24 - 36 -

VOID

OUT — disturbed - discarded

I — SAVE — FILL : Hard brown, gray and dark-gray silty clay inter-mixed with organic silt, trace fine to coarse sand.

II — P — H=4.5+ — Dark-gray organic silt, little fine to medium sand, few lenses of fine sand.

III — JAR — H=2.2

NOTE: AL/MA on Section II

30.00" tube

Boring

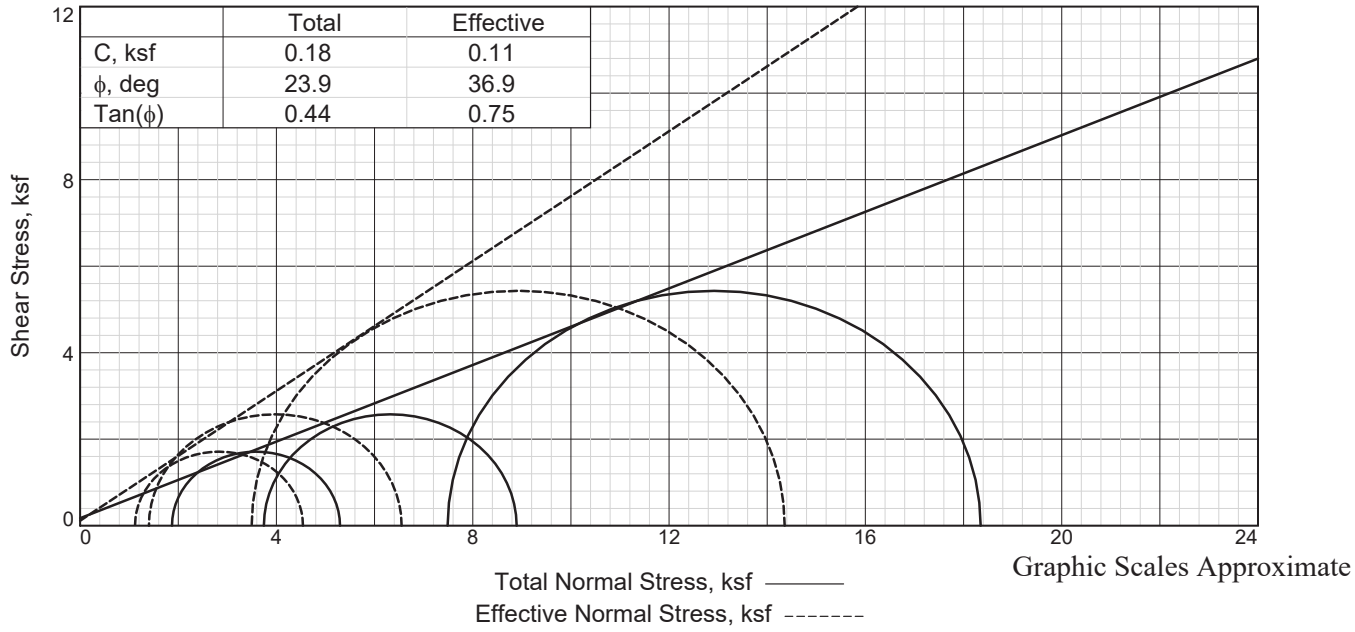
0 - 12 - 24 - 36 -

LEGEND

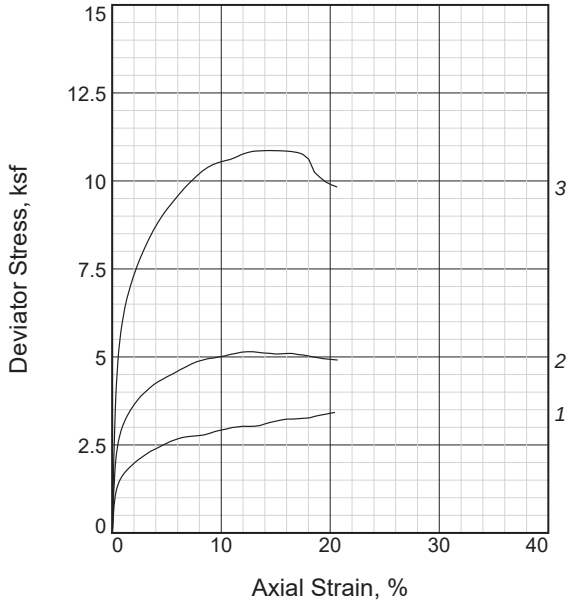
- Consolidation, Incremental
- Swelling, Test
- Wax
- C R S — Consolidation, C R S
- P P — Permeability, Vertical / Horizontal
- Unconfined Compression Test
- Triaxial Compression Test

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

SHELBY TUBE LOG 11497013.GPJ BBCM.GDT 6/16/09



	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

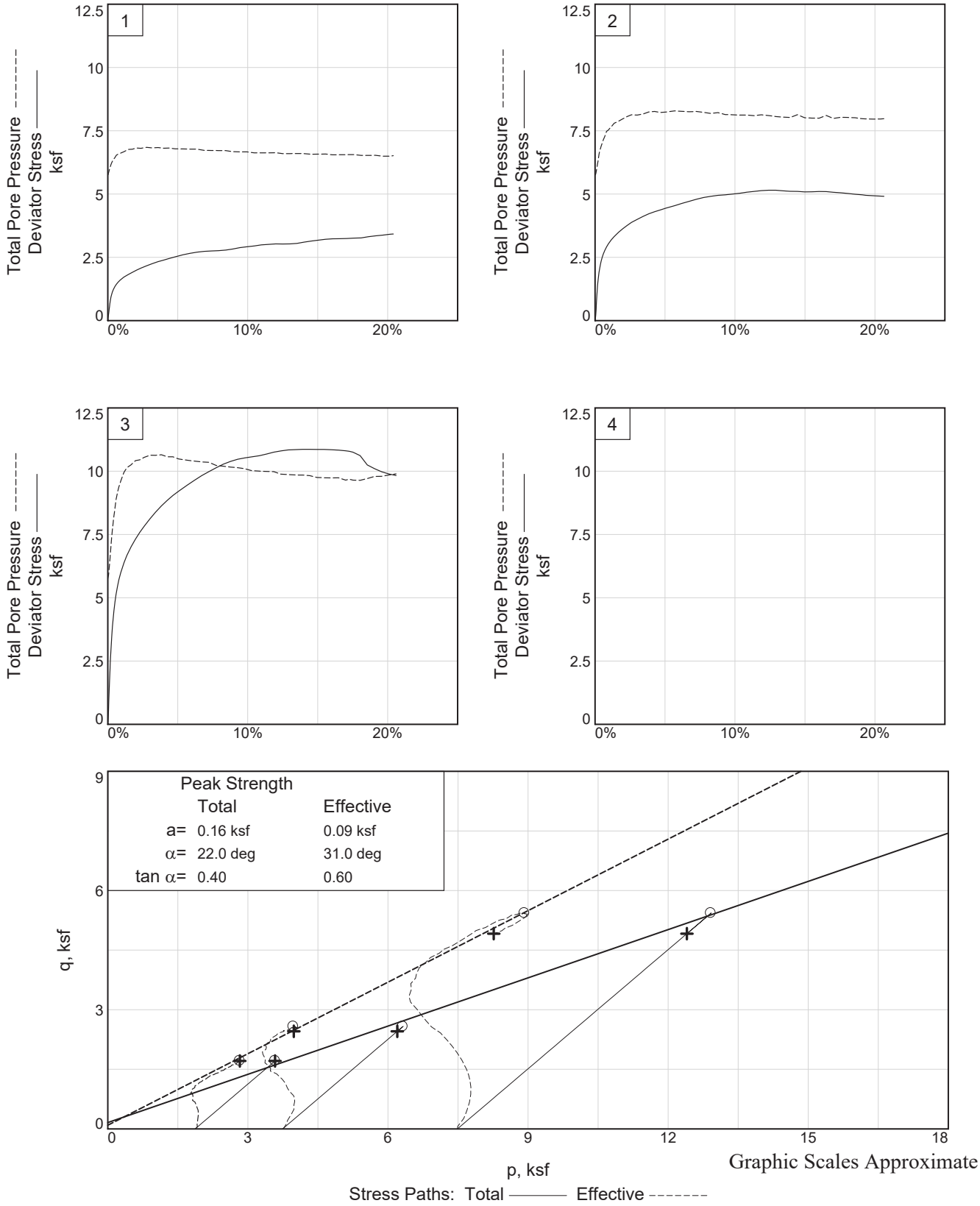
Client:

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



Client:

Project: Cardinal Plant Ash Pond Investigation

Location: CD-PZ-BAP-0901 **Depth:** 31.0' to 32.8' **Sample Number:** ST-19A

Project No.: 011.11497.013

2

BBC&M Engineering, Inc.

Tested By: PJM **Checked By:** JJ

PERMEABILITY TEST DATA AND COMPUTATION SHEET

((ASTM D-5084) FALLING HEAD, METHOD C)

BBCM SOLUTIONS TO BUILD ON

Job Number:	011.11497.013	Date:	5/6-7/2009	Maximum Dry Density:	
Project Name:	Cardinal Ash Pond Investigation	Boring:	CD-PZ-BAP-0907	Optimum Moisture Content:	
Project Location:	Brilliant, Ohio	Sample:	ST-6A Sec. II	% Compaction.:	
Tested By:	PJM	Depth:	8.5' to 9.9'	Optimum +/-:	
Remarks:				Natural:	X
Material:	FILL : Hard brown, gray and dark-gray silty clay inter-mixed with organic silt, trace fine to coarse sand.			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:

$$k = \frac{a \cdot L}{2 \cdot A \cdot \Delta t} \ln\left(\frac{h_1}{h_2}\right)$$

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

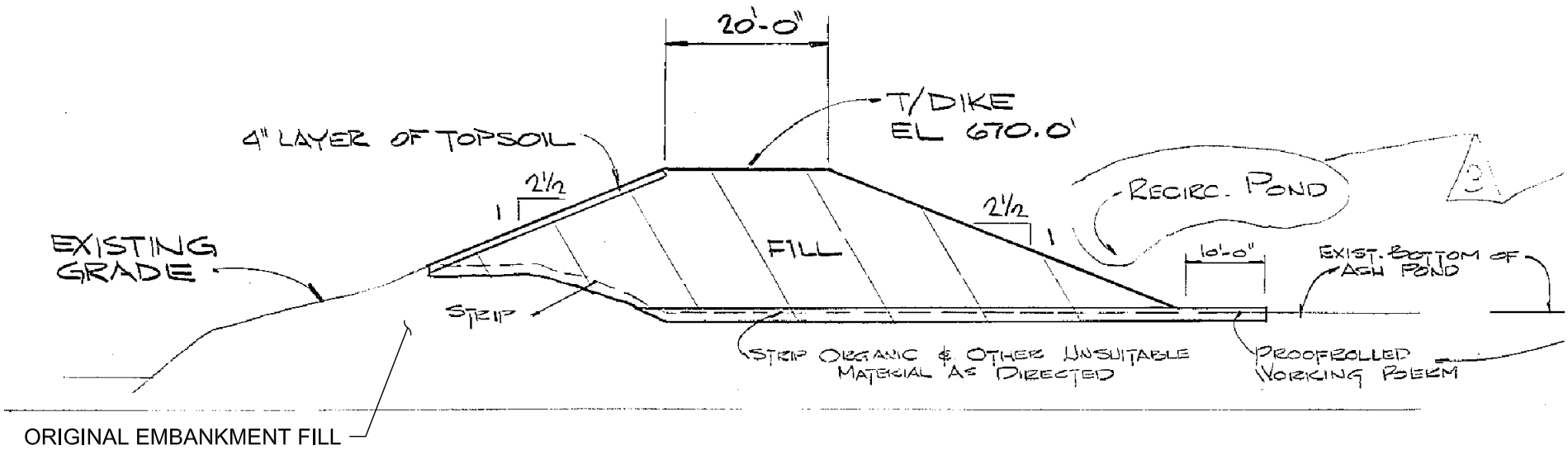
ln = Natural Logarithm (Base e = 2.71828)

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	$\ell n (h_1/h_2)$	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**

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

0 20 40
APPROX.SCALE IN FEET

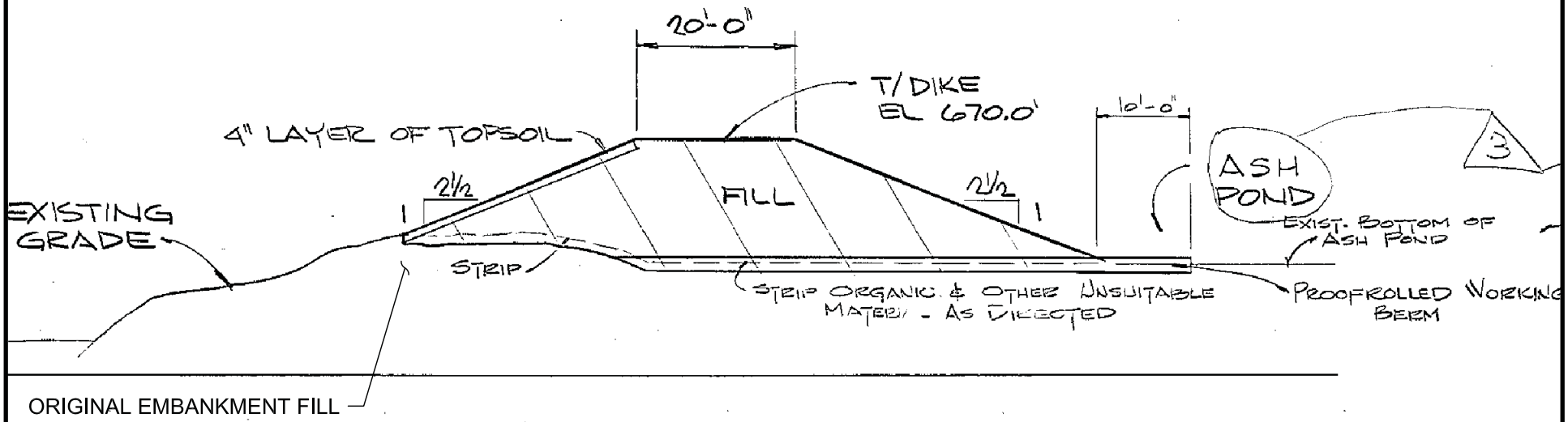
REFERENCE: SITE DEVELOPMENT PLANS - ASH STORAGE AREA SECTIONS, 1973
DRAWING NO. 3-3027-3

HISTORIC SECTION A-A		
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

PLATE 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

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
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PLATE 2

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

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

PLATE 4

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

PLATE 5

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

PLATE 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

PLATE 7

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, ϕ' 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 ϕ' 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 $\phi'_{NC} = 36 - 0.2665$ (% 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 ϕ' BASED ON SPT CORRELATIONS AND GRAIN SIZE ANALYSIS

1) $\phi' = \sqrt{15.4\,(N_{60})} + 20°$ (HANTAMAKA 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	γ_{MOIST} (PCF)	*Approximate Relative Density, %*	*N_{60} Standard Penetration Resistance*	*Approximate Angle of Friction of Soil ϕ, 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

+ 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 $K = (100\ D_{10})^2$ μsec (cm x10^{-4}/sec)

  (HAZEN)

  ALSO USE d_{15} VALUE AND COMPARE TYPICAL RANGE OF PERMEABILITY BASED ON GRAIN SIZE (GEOSYNTEC, 1991)

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 ϕ'_{vo} = 50 KPa AND 100 KPa TO ACCOUNT FOR PROBABLE DEPTH OF FAILURE SURFACE.
     - RESULTS: $\phi'_{FS} = 31°$ (SEE CORRELATIONS THIS APPENDIX)

  2) GRAPH OF ϕ' 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, $\phi' = 31°$	5×10^{-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 $K_V = 1\times10^{-5}$ cm/sec. SEE CORRELATION THIS APPENDIX. ADJUST K_V/K_H RATIO DURING ANALYSIS TO MATCH FIELD CONDITIONS

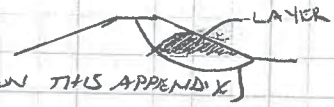
LAYER: ORIGINAL EMBANKMENT FILL (OLDER FILL)

- 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 ϕ'_{vo} = 50 kPa BASED ON RELATION OF THIS LAYER TO THE FAILURE PLANE.
- RESULTS: ϕ'_{FS} = 30°



(SEE CORRELATION THIS APPENDIX)

2) ϕ' VRS PI
- RESULTS: FOR PI = 24, ϕ' = 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 ϕ' = 28°	> 10^{-7}

DESIGN STRENGTH PARAMETER: c' = 100 psf, ϕ' = 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.

=> K_v ADJUSTED TO 5×10^{-8} cm/sec WITH $K_H/K_V = 5$ DURING SEEPAGE ANALYSIS

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 ϕ'_{vo} = 100 kPa AND 400 kPa WITH TENDANCY TOWARD 100 kPa
   - RESULTS: ϕ'_{FS} = 30° (SEE CORRELATION THIS APPENDIX)

2) ϕ' VRS PI
   - RESULTS: FOR PI = 15, ϕ' = 31.5° (SEE CHART THIS APPENDIX)

3) HALL'S THESIS
   ϕ'_{NC} = 36 - 0.2665 (% CLAY)
   FOR CF = 10.9, ϕ'_{NC} = 33°

4) N/A FOR NATURAL SOILS - USE TABLE 3.28 - COMMON PROPERTIES OF COHESIONLESS SOILS (SOURCE)
   - FOR 'LOOSE INORGANIC SILTS' ϕ' = 27°

Design Strength Parameter: Use ϕ'_{NC} = 30°, c' = 0 psf

- Permeability: Based on soil description.

$k_v = 1 \times 10^{-5}$ cm/s (typical published value)

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 ϕ_{vo}' = 100 kPa AND 400 kPa WITH TENDANCY TOWARD 100 kPa
   - RESULTS: ϕ'_{FS} = 26° (SEE CORRELATION THIS APPENDIX)

2) ϕ' VRS PI
   - RESULTS: FOR PI = 16, ϕ' = 31° (SEE CHART THIS APPENDIX)

3) HALL'S THESIS
   ϕ'_{NC} = 36 - 0.2665 (% CLAY)
   FOR CF = 16, ϕ'_{NC} = 31.7°

5) CU TRIAXIAL TEST - SAMPLE WAS NOT DESCRIBED AS 'ORGANIC', BUT DESCRIPTION BEST MATCHES THIS LAYER
   RESULTS: ϕ' = 36.9°, c' = 110 psf

- PERMEABILITY: D_{15} - LOW = 0.0015, HIGH = 0.005, AVG = 0.0023 } K_v = 5 x 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: ϕ' = 30°, c' = 0 psf

+ 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:

		ϕ' EQN 7.2	ϕ' 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:

		ϕ' EQN 7.2	ϕ' 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)

Use $k_v = 1 \times 10^{-3}$ cm/s (Geosyntec, 1991)

- 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

- ASSUME 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	φ	
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, φ = 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 τ_{ff} vs. σ'_{fc} Strength Envelopes

Soil no.	Description and reference	Index properties	c' (psf)	ϕ' (deg)	c_R (psf)	ϕ_R (deg)	d^a (psf)	ψ^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 Liquid limit: 45 Plasticity index: 23	0	45	60	23	64	24.4
			ORIGINAL EMBANKMENT FILL USE C=50 psf & ϕ=22° LL=48, PI=24					
2	Brown sandy clay from dam site in Rio Blanco, Colorado (Wong et al., 1983)	Percent minus No. 200: 25 Liquid limit: 34 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 Liquid limit: 45 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 Liquid limit: 32.4 Plastic limit: 19.4	0	35	1400	22.5	1716	26.9

[a]Intercept of τ_{ff} vs. σ'_{fc} envelope—can be calculated knowing c', ϕ', c_R, and ϕ_R.
[b]Slope of τ_{ff} vs. σ'_{fc} envelope—can be calculated knowing c', ϕ', c_R, and ϕ_R.

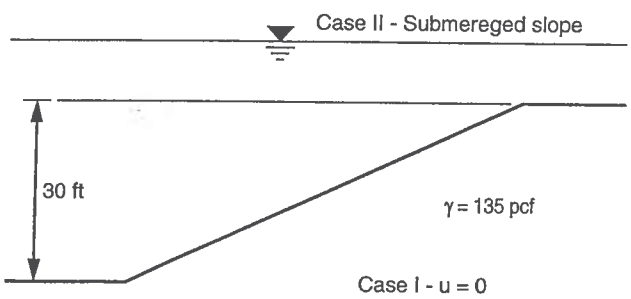


Figure 10.6 Slope used to compare simple, single-stage and rigorous, two-stage pseudostatic analyses.

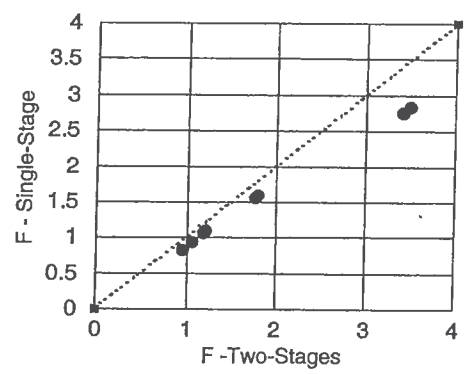


Figure 10.7 Comparison of factors of safety by simplified single-stage pseudostatic and more rigorous two-stage pseudostatic analyses.

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

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-

BBCM SOLUTIONS TO BUILD ON	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

Soil Layer: Newer Embankment Fill

LL_{BM} = 35.4

CF_{BM} = 22.2

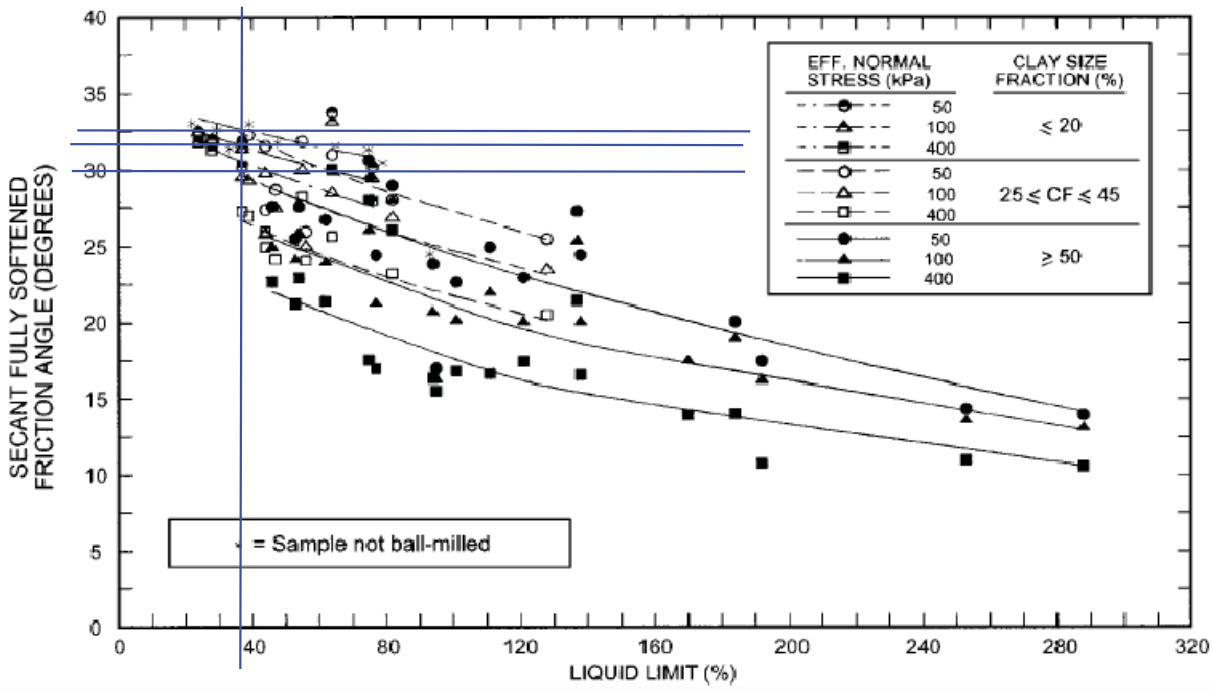


Fig. 5. Secant fully softened friction angle relationships with liquid limit, clay-size fraction, and effective normal stress

Secant Fully Softened Friction Angle

Clay Sized Fraction, %	Effective Normal Stress: *50 kPa*	*100 kPa*
CF ≤ 20	32.5°	31.5°
25 ≤ CF ≤ 45	32.5°	30°

Design Friction Angle Value	31°

BBCM SOLUTIONS TO BUILD ON	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

$$\frac{\textit{ball-milled derived LL}}{\textit{ASTM derived LL}} = .003\,(\textit{ASTM derived LL}) + 1.23$$

LL_{ASTM} = 48
LL_{BM} = 66.0

$$\frac{\textit{ball-milled derived CF}}{\textit{ASTM derived CF}} = 0.0003\,(\textit{ASTM derived CF})2 - 0.037(\textit{ASTM derived CF}) + 2.254$$

CF_{ASTM} = 28
CF_{BM} = 40.7

where: LL = Liquid Limit
CF = Clay-sized Fraction

PLATE 19

Soil Layer: Original Embankment Fill

LL_{BM} = 66.0

CF_{BM} = 40.7

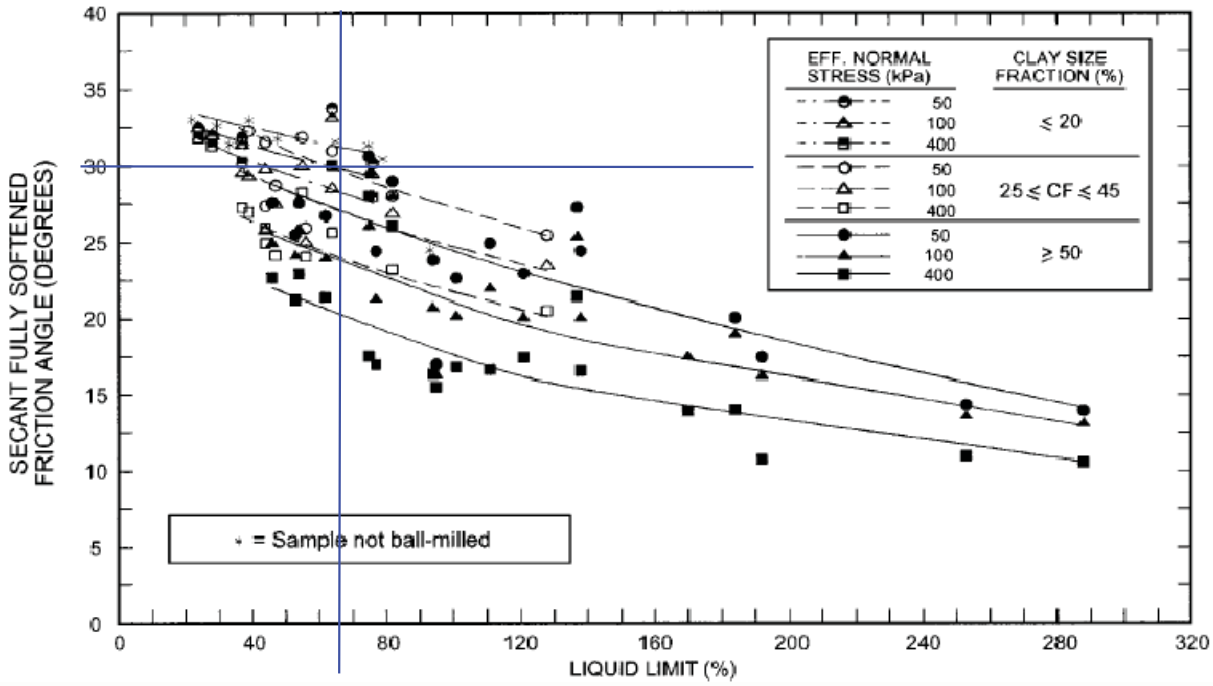


Fig. 5. Secant fully softened friction angle relationships with liquid limit, clay-size fraction, and effective normal stress

Effective Normal Stress, kPa	50
Secant Fully Softened Friction Angle	**30°**

BBCM SOLUTIONS TO BUILD ON	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

Soil Layer: Organic Clayey Silt

LL_{BM} = 61.4

CF_{BM} = 32.7

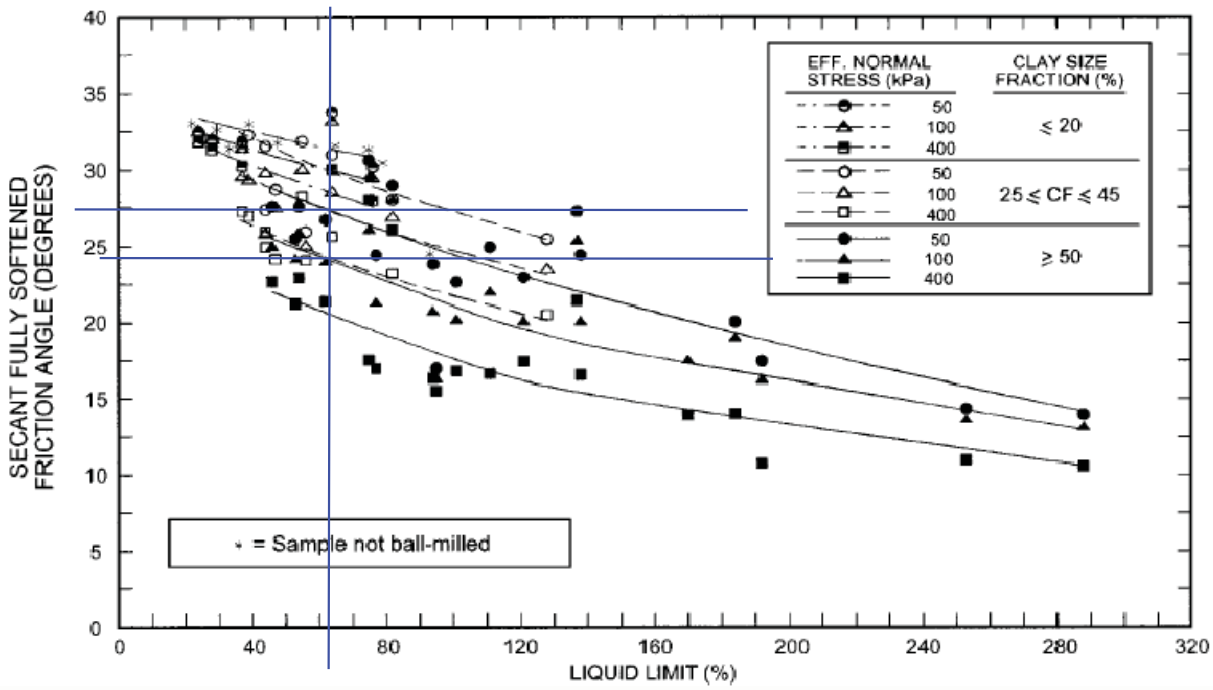


Fig. 5. Secant fully softened friction angle relationships with liquid limit, clay-size fraction, and effective normal stress

Secant Fully Softened Friction Angle

Clay Sized Fraction, %	Effective Normal Stress: *100 kPa*	*400 kPa*
CF ≤ 20	27.5°	24°
25 ≤ CF ≤ 45	-	-

Design Friction Angle Value	26°

BBCM SOLUTIONS TO BUILD ON

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

$$\frac{\textit{ball-milled derived LL}}{\textit{ASTM derived LL}} = .003\,(\textit{ASTM derived LL}) + 1.23$$

LL_{ASTM} = 36
LL_{BM} = 48.2

$$\frac{\textit{ball-milled derived CF}}{\textit{ASTM derived CF}} = 0.0003\,(\textit{ASTM derived CF})2 - 0.037(\textit{ASTM derived CF}) + 2.254$$

CF_{ASTM} = 10.0
CF_{BM} = 19.1

where: LL = Liquid Limit
CF = Clay-sized Fraction

PLATE 23

Soil Layer: Alluvium Silt and Clay

LL_{BM} = 48.2

CF_{BM} = 19.1

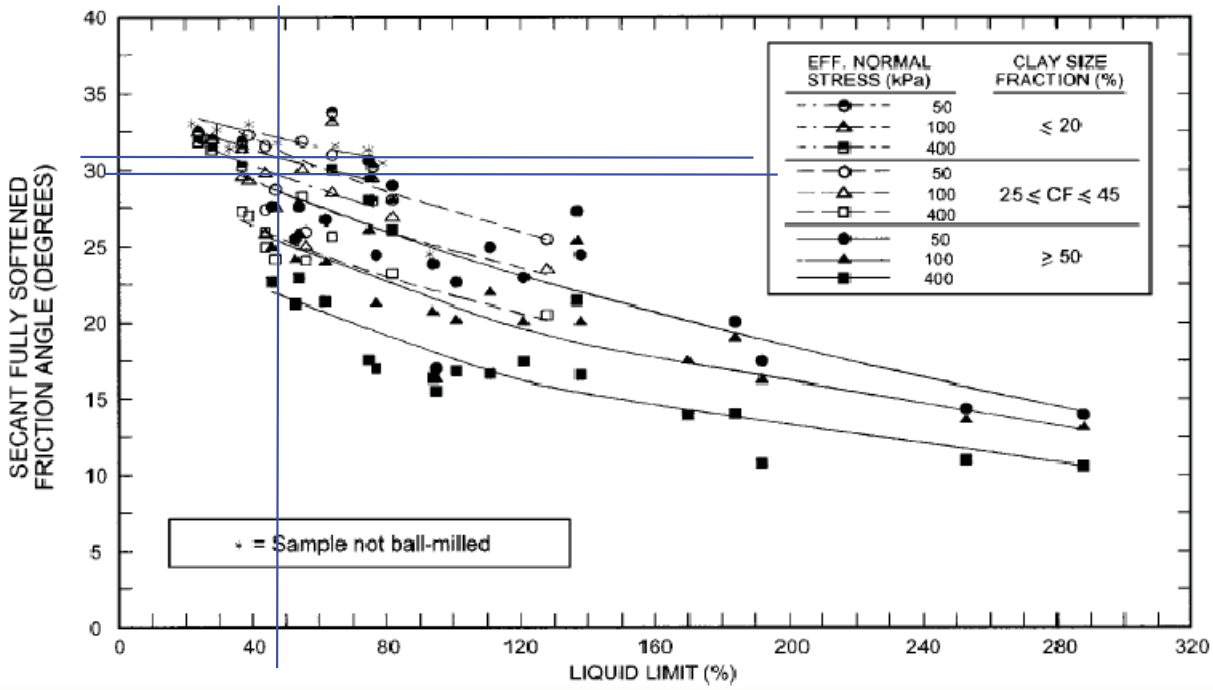


Fig. 5. Secant fully softened friction angle relationships with liquid limit, clay-size fraction, and effective normal stress

Secant Fully Softened Friction Angle

Clay Sized Fraction, %	Effective Normal Stress: *100 kPa*	*400 kPa*
CF ≤ 20	31°	29.5°
25 ≤ CF ≤ 45	-	-

Design Friction Angle Value	30°

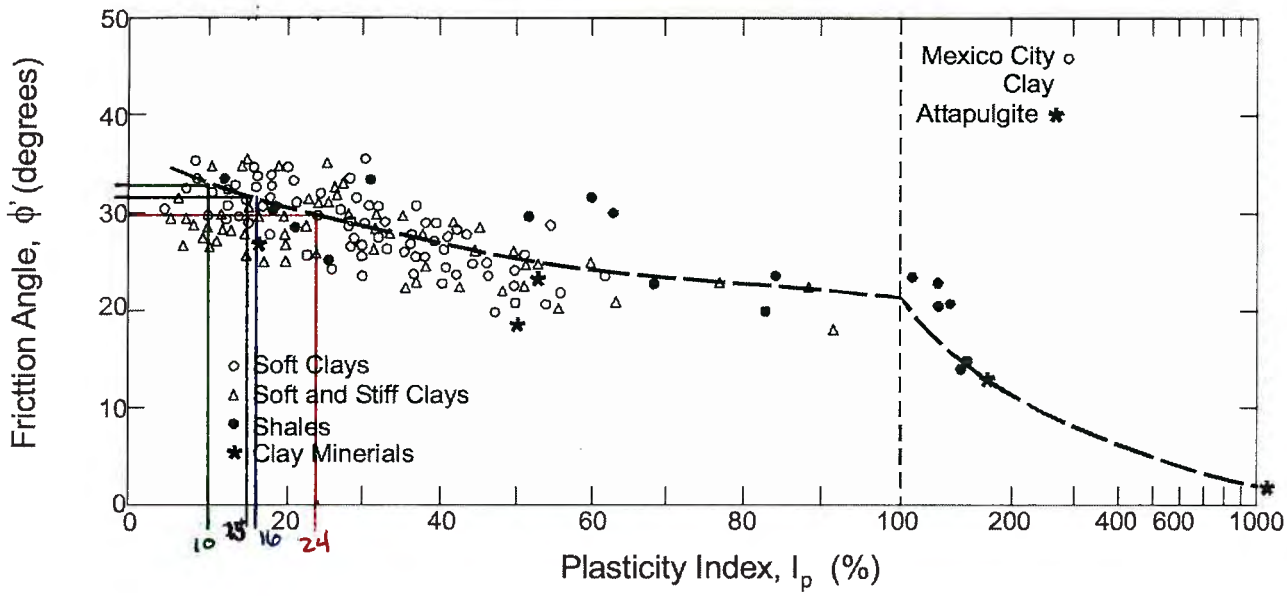


Figure 74. Relationship between ϕ′ and PI (Terzaghi, Peck, and Mesri, 1996).

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*	γ dry,† g/cm³	γ dry (pcf)	Void ratio e	γ_{SAT} (pcf)	Strength‡ φ
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	139.5	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 φ depends on mineral type, normal stress, and grain angularity as well as D_R and gradation (see Fig. 3.63).

$1\ g/cm^3 = 9.81\ kN/m^3$

$$\gamma_{SAT} = \frac{(G_s + e)\gamma_w}{1 + e}$$

$$\gamma_{SAT} = \gamma_d + \frac{e\gamma_w}{(1 + e)}$$

D_{15} Range = 0.002 - 0.080

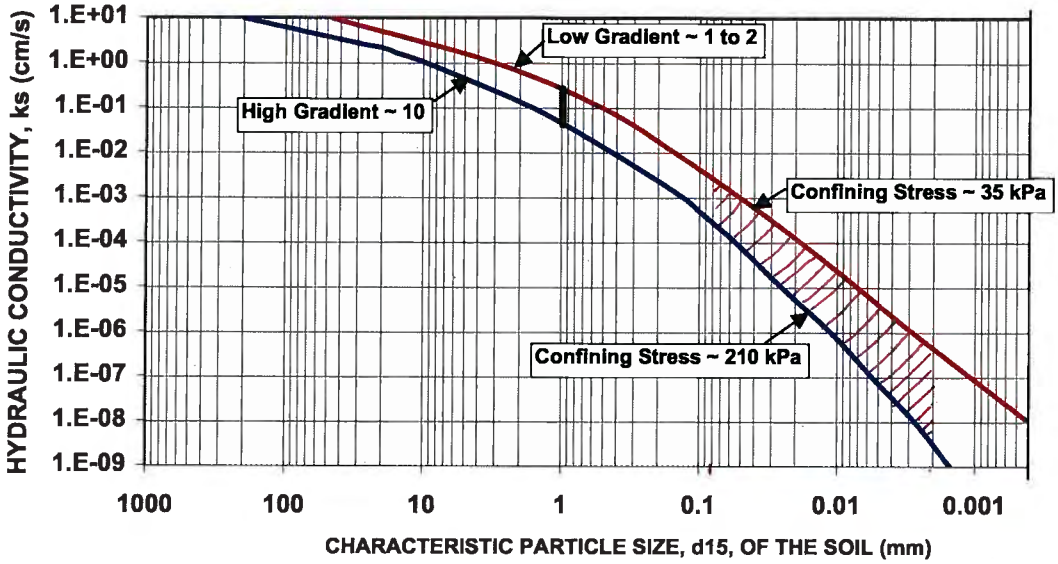


Figure 91. Range of hydraulic conductivity based on grain size (after GeoSyntec, 1991).

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: $1 \times 10^{-8} - 1 \times 10^{-3}$ cm/s

Geotechnical Engineering Circular No. 5
Evaluation of Soil and Rock Properties

Glacial outwash sand and gravel.

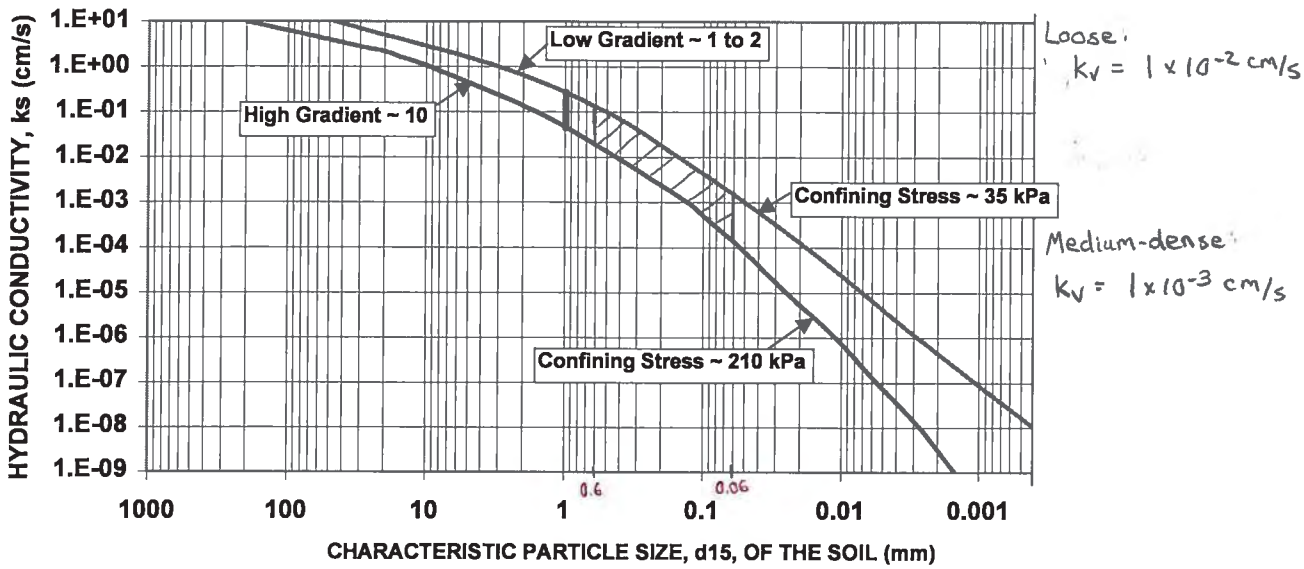


Figure 91. Range of hydraulic conductivity based on grain size (after GeoSyntec, 1991).

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

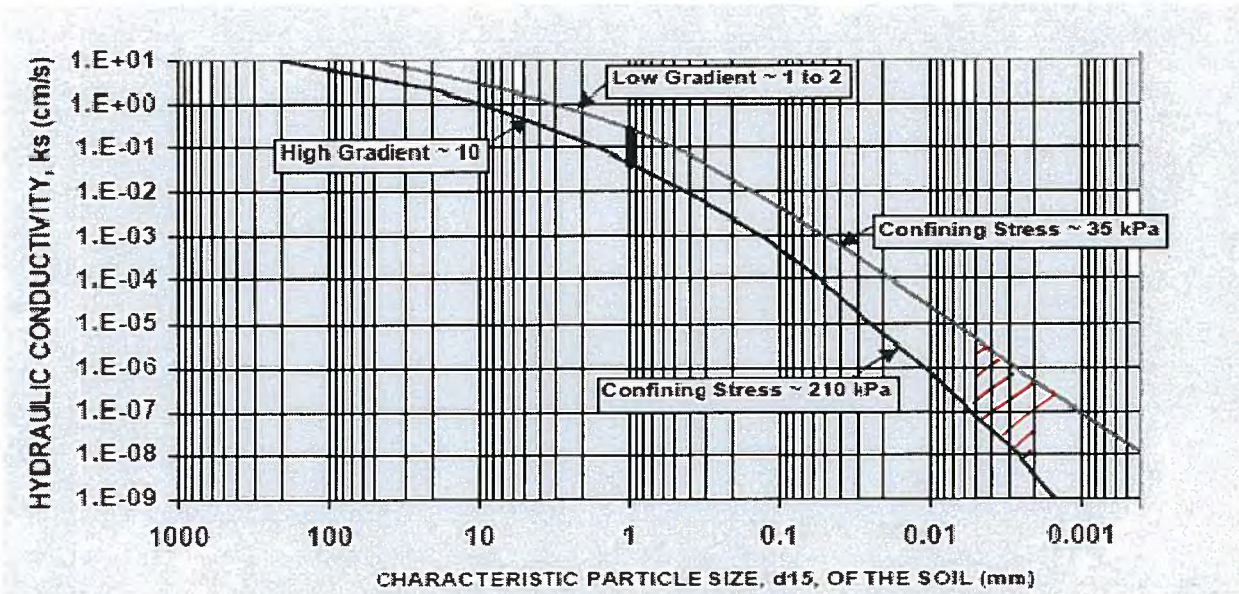


Figure 91. Range of hydraulic conductivity based on grain size after GeoSyntec, 1991).

LAYER: ORGANIC CLAYEY SILT

d_{15} RANGE = 0.0015 mm - 0.005 mm

AVG d_{15} = 0.002 mm

USE K_v = 5×10^{-6} cm/SEC BASED ON INCLUSIONS OF SILT SEAMS

PERMEABILITY TEST DATA AND COMPUTATION SHEET

((ASTM D-5084) FALLING HEAD, METHOD C)

BBCM SOLUTIONS TO BUILD ON

Job Number:	011.11497.013	Date:	5/6-7/2009	Maximum Dry Density:	
Project Name:	Cardinal Ash Pond Investigation	Boring:	CD-PZ-BAP-0907	Optimum Moisture Content:	
Project Location:	Brilliant, Ohio	Sample:	ST-6A Sec. II	% Compaction.:	
Tested By:	PJM	Depth:	8.5' to 9.9'	Optimum +/-:	
Remarks:				Natural:	X
Material:	FILL : Hard brown, gray and dark-gray silty clay inter-mixed with organic silt, trace fine to coarse sand.			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:

$$k = \frac{a \cdot L}{2 \cdot A \cdot \Delta t} \ln\left(\frac{h_1}{h_2}\right)$$

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)

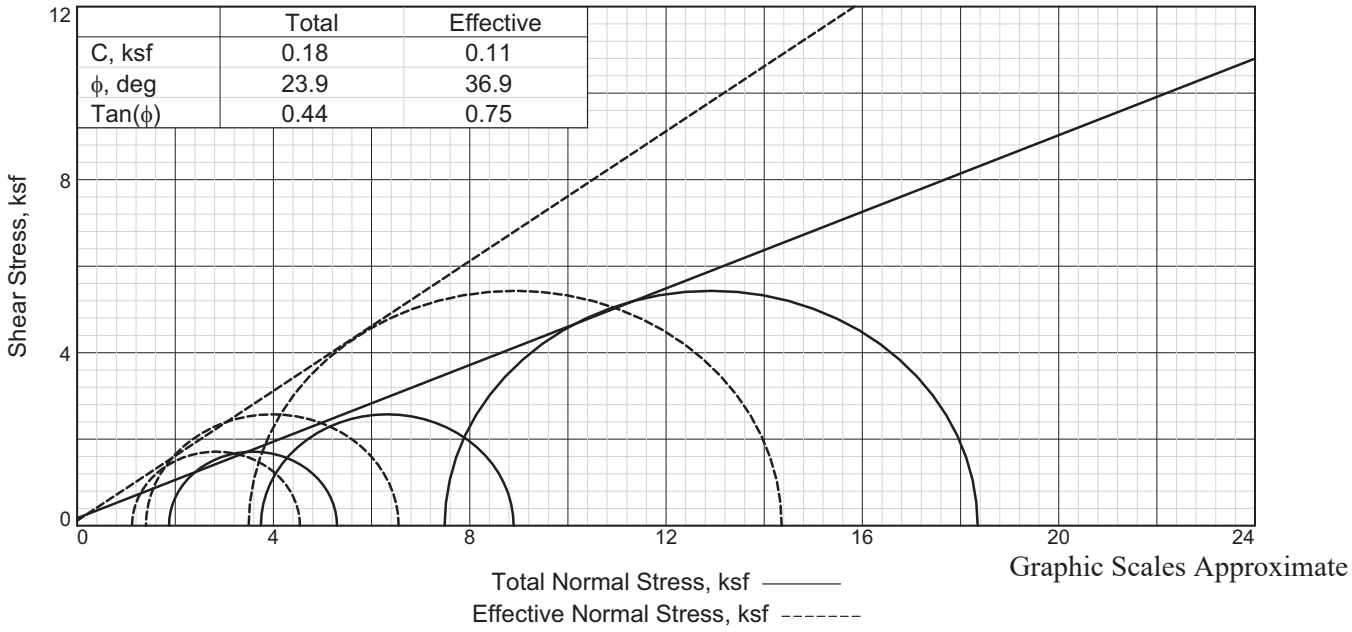
h_1 = Head Loss Across Permeameter/Specimen at t_1

h_2 = Head Loss Across Permeameter/Specimen at t_2

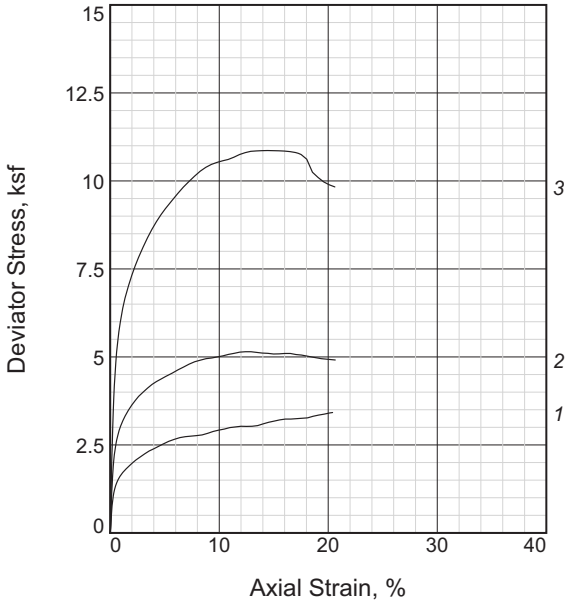
ln = Natural Logarithm (Base e = 2.71828)

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	$\ell n (h_1/h_2)$	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



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

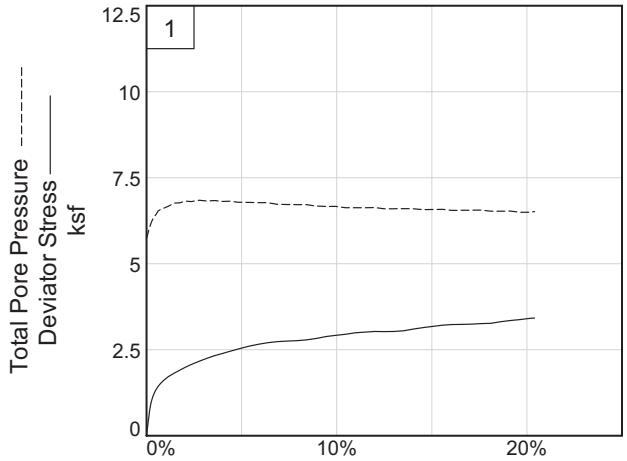
Client:

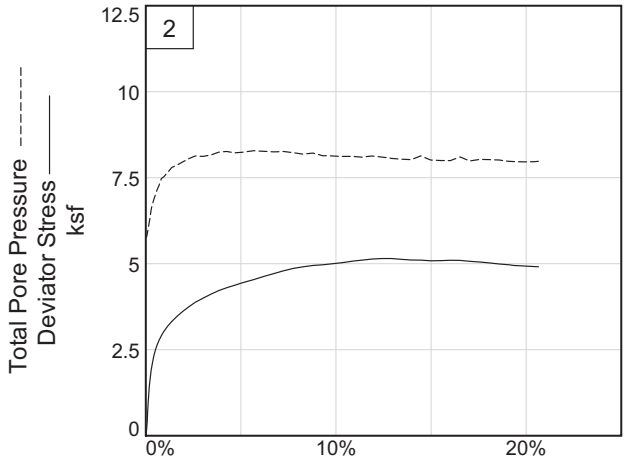
Project: Cardinal Plant Ash Pond Investigation
Brilliant, Ohio
Location: CD-PZ-BAP-0901
Sample Number: ST-19A **Depth:** 31.0' to 32.8'
Proj. No.: 011.11497.013 **Date Sampled:** 5/1/09

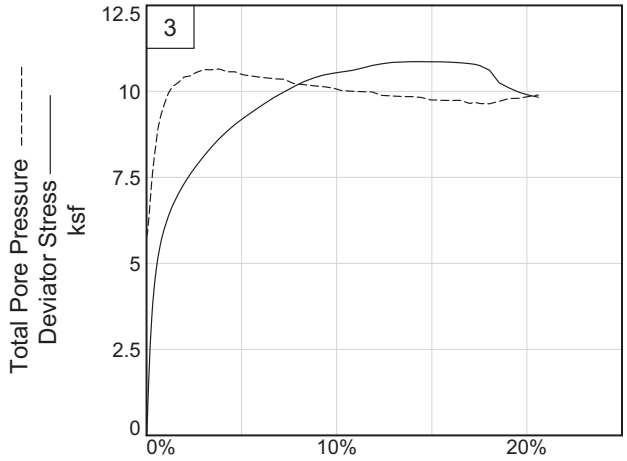
TRIAXIAL SHEAR TEST REPORT

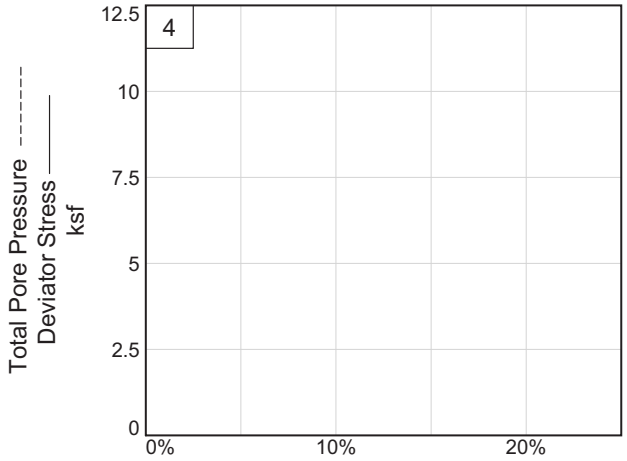
BBC&M Engineering, Inc.

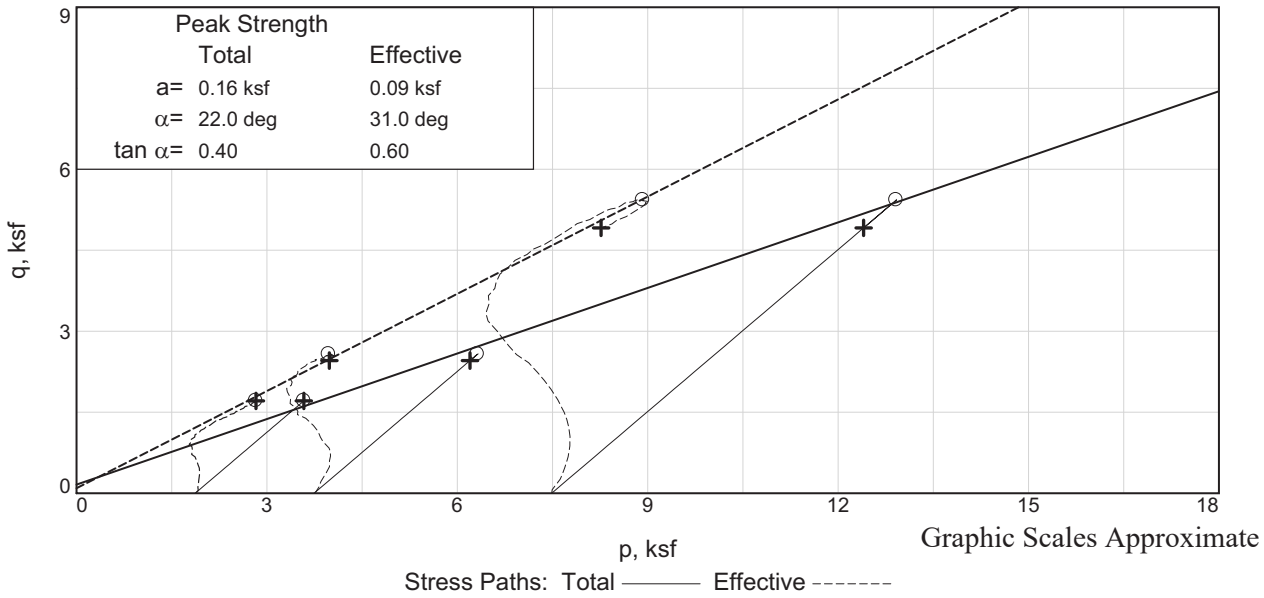
Tested By: PJM **Checked By:** JJ **PLATE 31**











Client:

Project: Cardinal Plant Ash Pond Investigation

Location: CD-PZ-BAP-0901 **Depth:** 31.0' to 32.8' **Sample Number:** ST-19A

Project No.: 011.11497.013

2

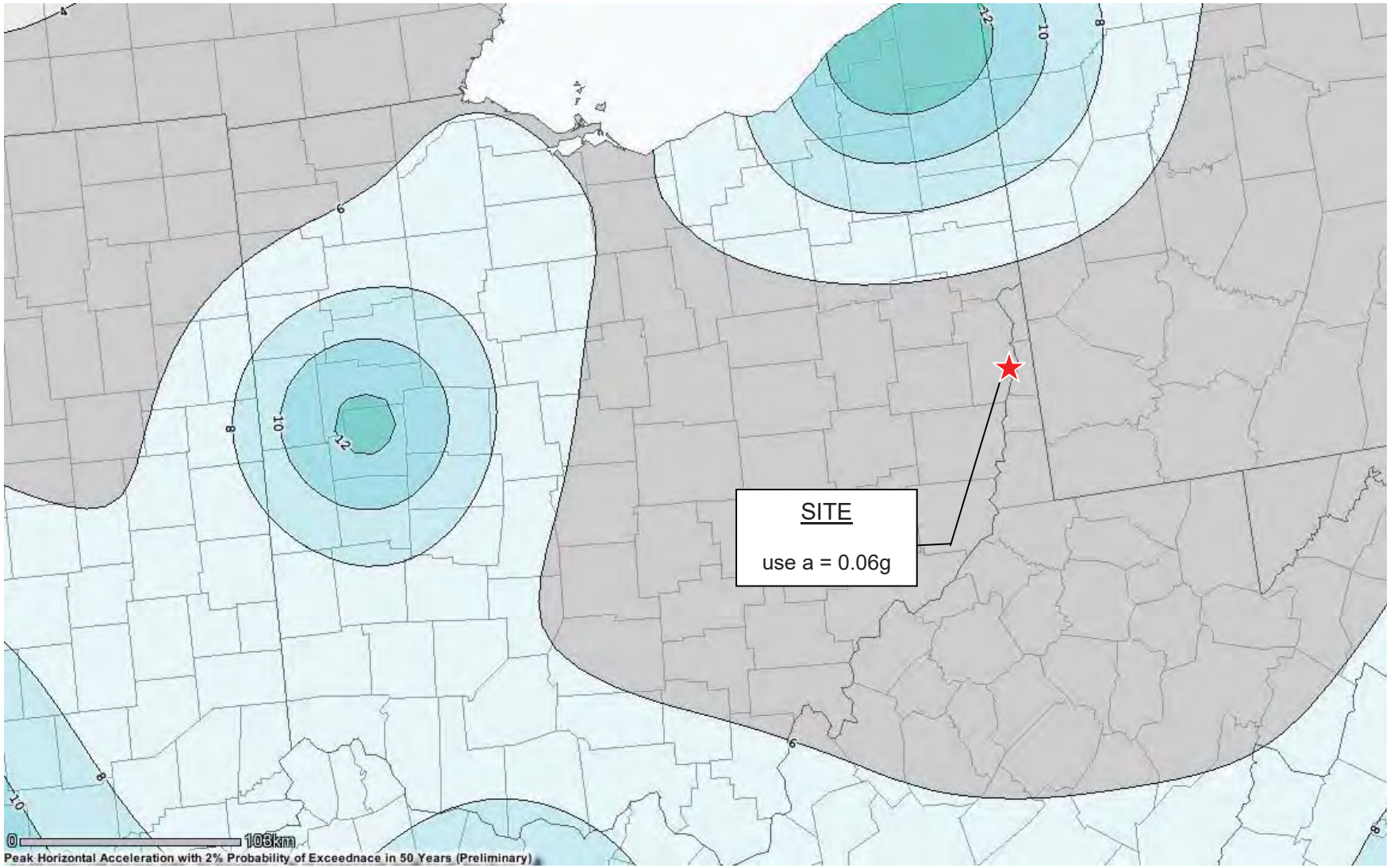
BBC&M Engineering, Inc.

Tested By: PJM **Checked By:** JJ

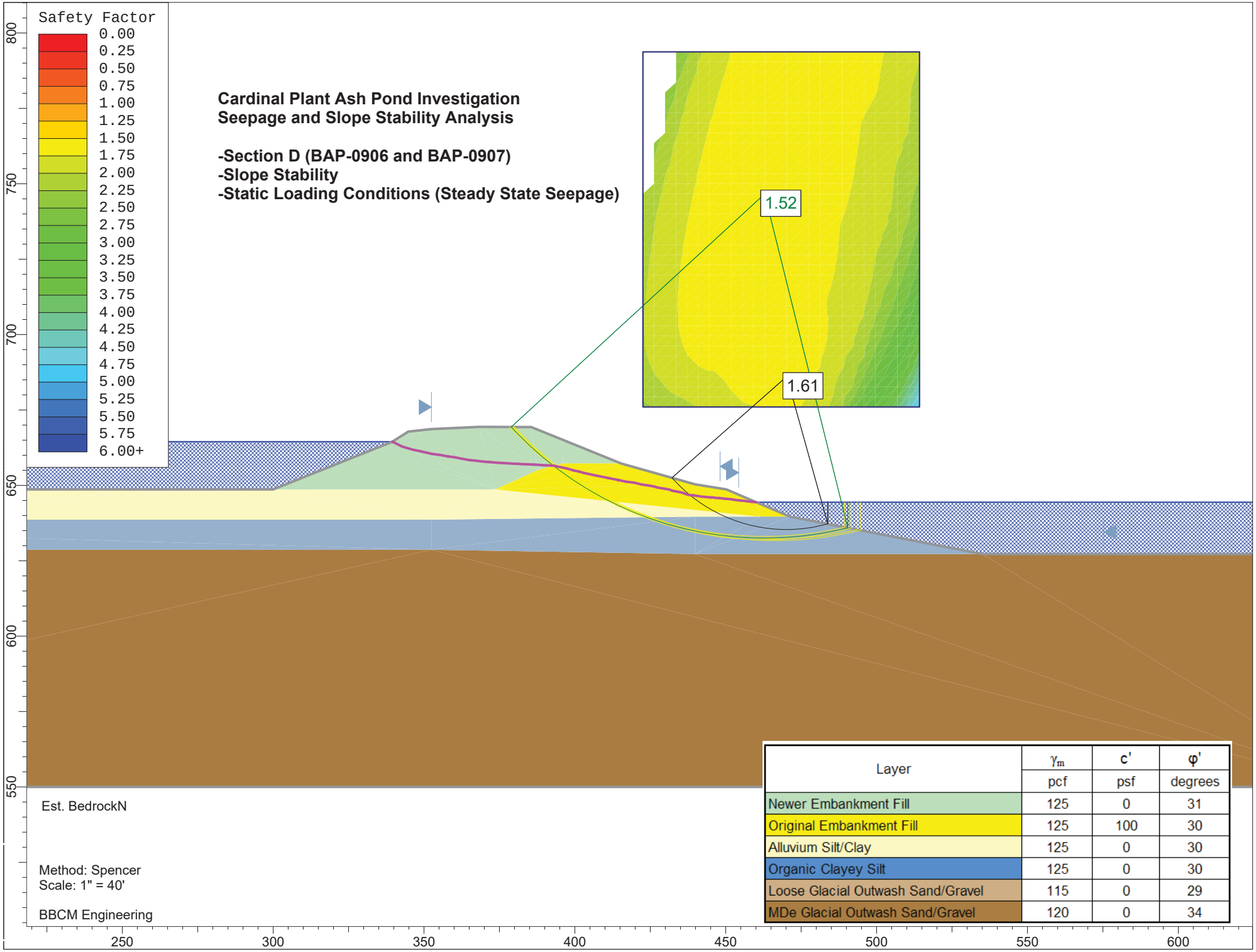
PLATE 32

USGS National Seismic Hazard Maps - 2008

Peak Horizontal Acceleration with 2% Probability of Exceedence in 50 Years

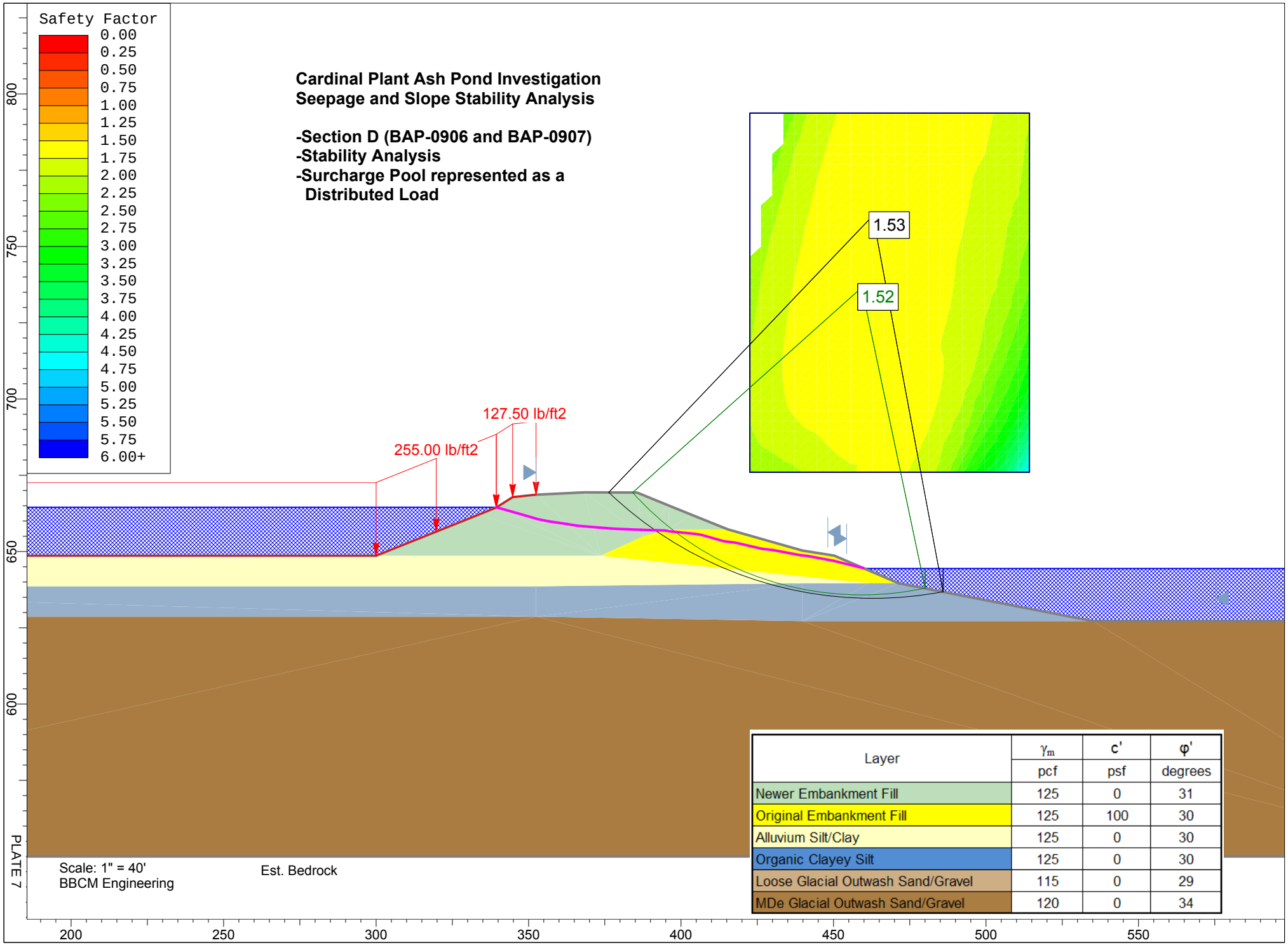


Appendix IV – Limit Equilibrium Analysis

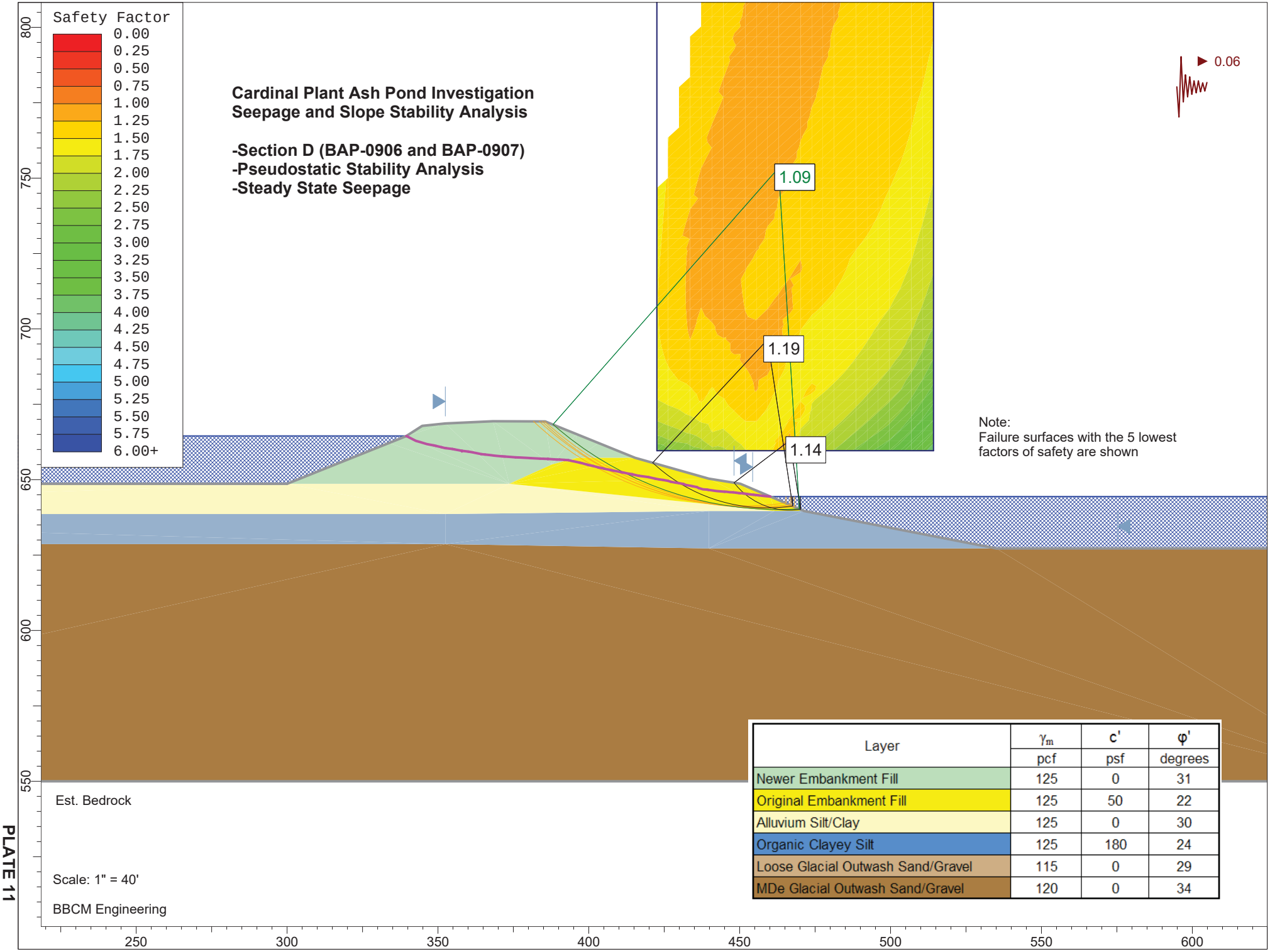


Layer	γ_m	c'	φ'
	pcf	psf	degrees
Newer Embankment Fill	125	0	31
Original Embankment Fill	125	100	30
Alluvium Silt/Clay	125	0	30
Organic Clayey Silt	125	0	30
Loose Glacial Outwash Sand/Gravel	115	0	29
MDe Glacial Outwash Sand/Gravel	120	0	34

PLATE 10

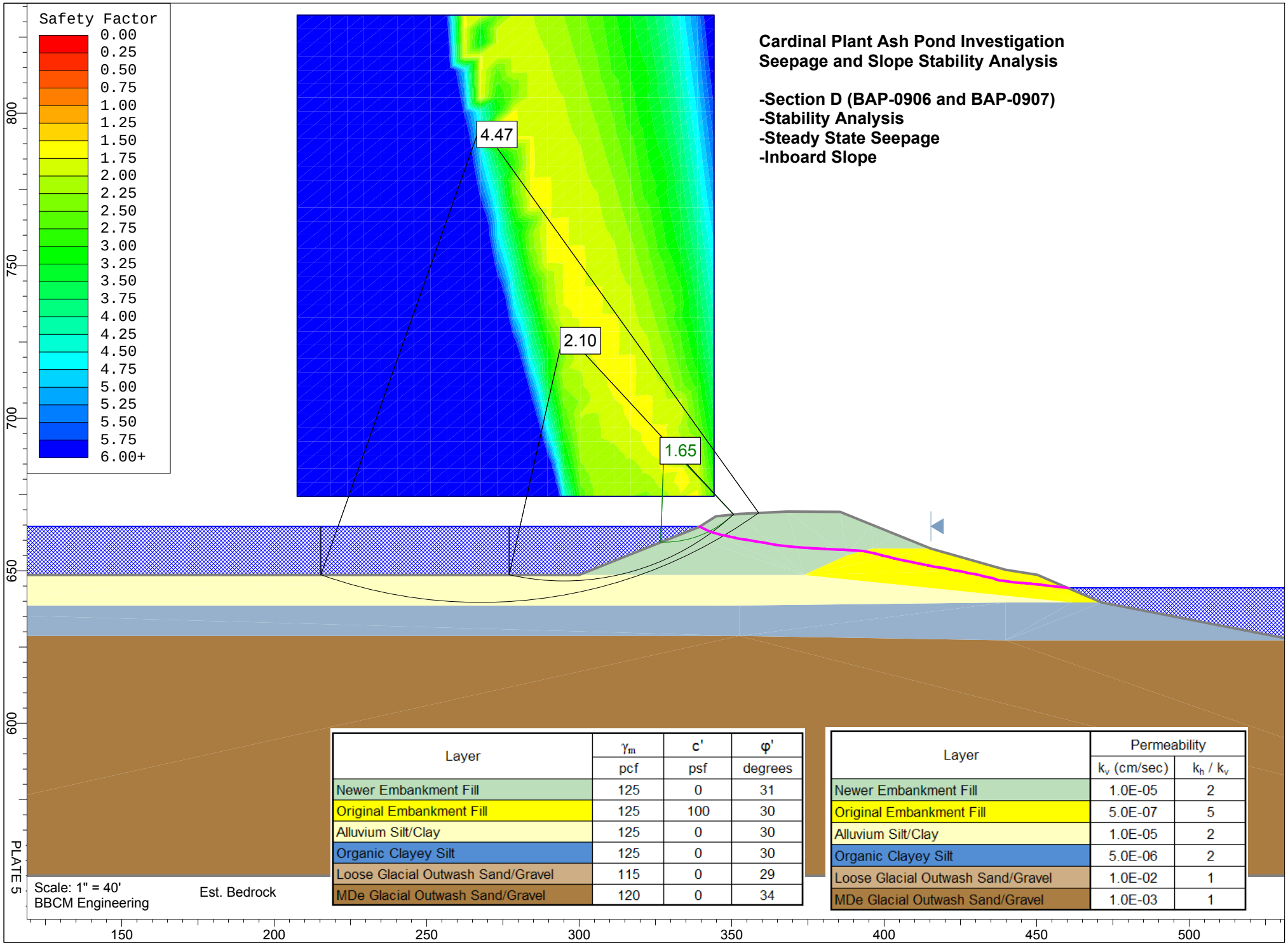


Layer	γ_m	c'	φ'
	pcf	psf	degrees
Newer Embankment Fill	125	0	31
Original Embankment Fill	125	100	30
Alluvium Silt/Clay	125	0	30
Organic Clayey Silt	125	0	30
Loose Glacial Outwash Sand/Gravel	115	0	29
MDe Glacial Outwash Sand/Gravel	120	0	34



Layer	γ_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

PLATE 11

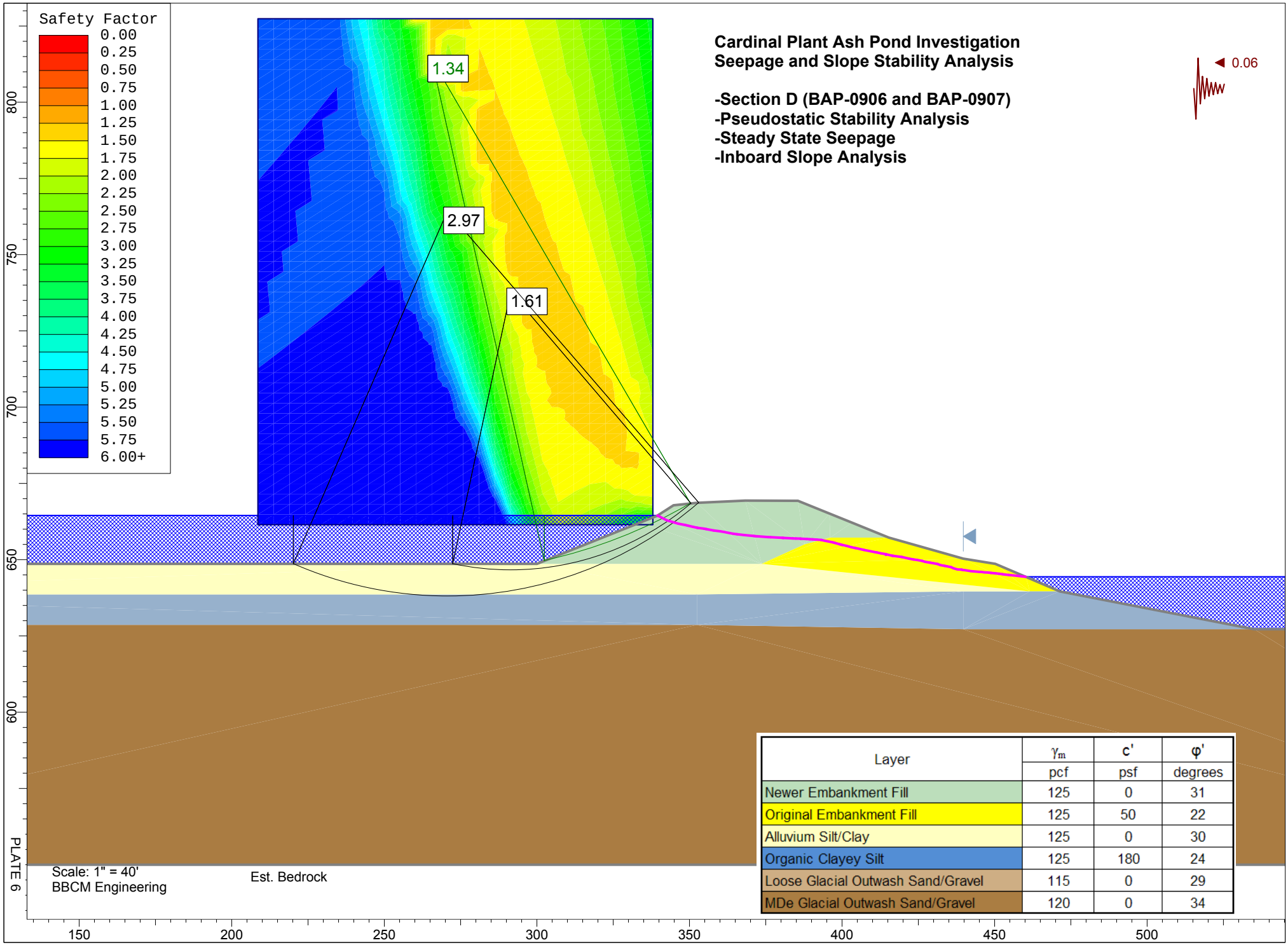


Cardinal Plant Ash Pond Investigation
Seepage and Slope Stability Analysis

-Section D (BAP-0906 and BAP-0907)
-Stability Analysis
-Steady State Seepage
-Inboard Slope

Layer	γ_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

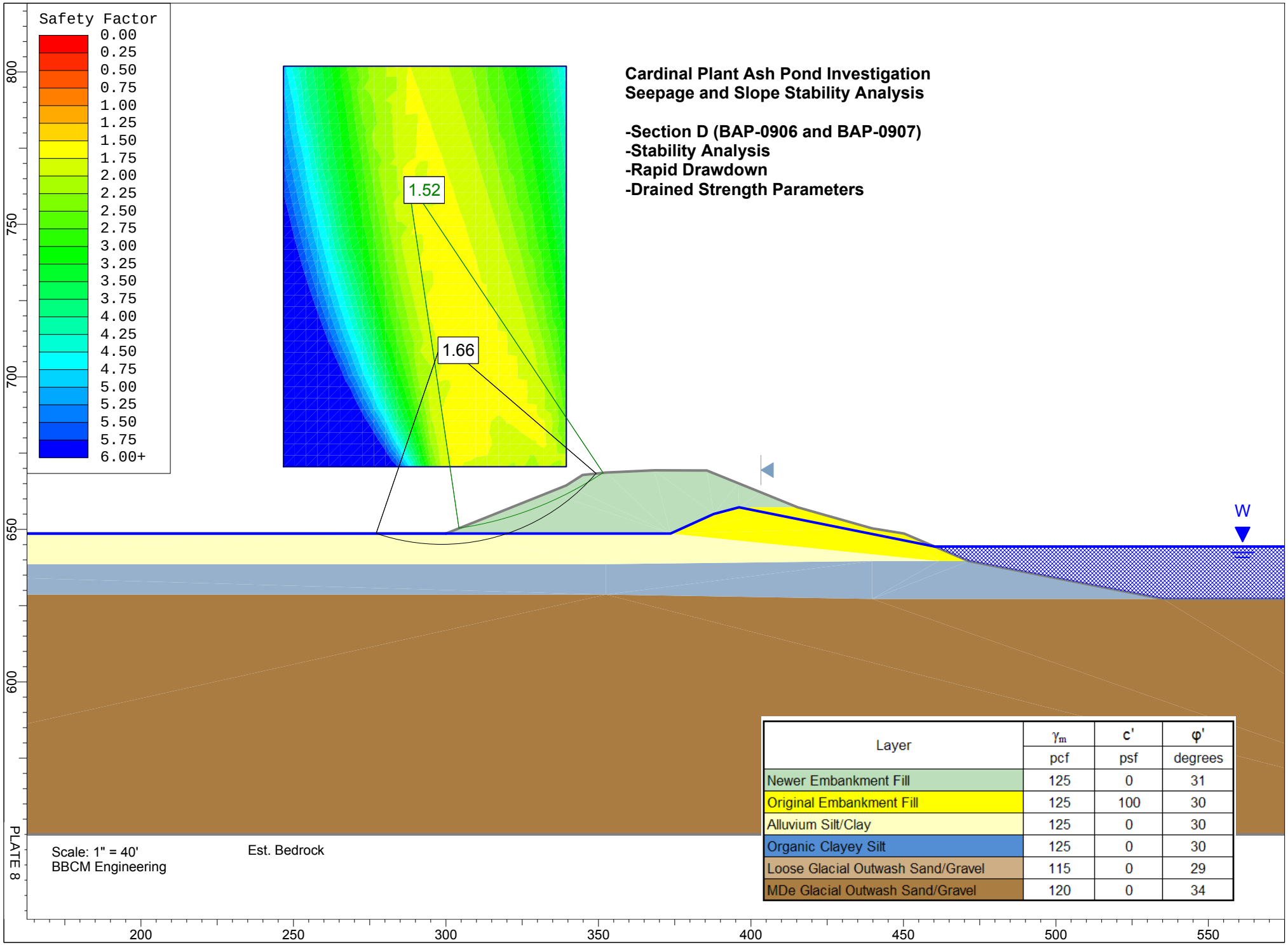
Layer	Permeability	
	k_v (cm/sec)	k_h / k_v
Newer Embankment Fill	1.0E-05	2
Original Embankment Fill	5.0E-07	5
Alluvium Silt/Clay	1.0E-05	2
Organic Clayey Silt	5.0E-06	2
Loose Glacial Outwash Sand/Gravel	1.0E-02	1
MDe Glacial Outwash Sand/Gravel	1.0E-03	1



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	γ_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



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	γ_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

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	Fines Content and Plasticity Index Screening			Is Soil Sample Liquefiable (meets all three criteria)
														LL < 35	% Passing 0.005 < 15	WC < 0.9LL	
BAP-0901	S-5	7.75	16	28	18	10								Yes	-	Yes	-
BAP-0901	S-9	13.75	13	27	17	10								Yes	-	Yes	-
BAP-0901	S-12	18.25	14	37	24	13	7	32	49	23	12	61	SANDY LEAN CLAY CL	No	No	Yes	No
BAP-0902	S-11	16.75	24	37	19	18								No	-	Yes	No
BAP-0902	S-12	18.25	21	35	17	18	8	37	33	28	21	54	SANDY LEAN CLAY CL	No	No	Yes	No
BAP-0902	S-13	19.75	31	29	17	12	1	20	62	28	17	79	LEAN CLAY with SAND CL	Yes	No	No	No
BAP-0904	S-9	13.75	16	35	21	14								No	-	Yes	No
BAP-0906	S-3	4.75	15	27	17	10								Yes	-	Yes	-
BAP-0906	S-8	12.75					30	40	22	13	9	31		-	Yes	-	-
BAP-0906	S-11	17.25	14	31	19	12	18	44	26	18	12	38	CLAYEY SAND with GRAVEL SC	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	Fines Content and Plasticity Index Screening			Is Soil Sample Liquefiable (meets all three criteria)
														LL < 35	% Passing 0.005 < 15	WC < 0.9LL	
BAP-0903	S-2	3.25	24	48	24	24	0	8	60	45	32	92	LEAN CLAY CL	No	No	Yes	No
BAP-0903	S-5	7.75	20	36	20	16	0	14	58	38	28	86	LEAN CLAY CL	No	No	Yes	No
BAP-0905	S-3	4.75	17	32	18	14	0	25	53	30	23	76	LEAN CLAY with SAND CL	Yes	No	Yes	No
BAP-0905	S-5	7.75	22	48	24	24								No	-	Yes	No
BAP-0907	S-5	7.75	23	49	26	23								No	-	Yes	No
BAP-0907	S-6A	9.25	28	47	29	18	0	5	67	43	29	96	SILT ML	No	No	Yes	No

Appendix V – 2009 Investigation Report Text

August 4, 2009
011-11497-013

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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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 7.4×10^{-8} cm/sec. The design value for permeability was increased to 5×10^{-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	1×10^{-5}	2	Grain Size Correlation
Original Embankment Fill	5×10^{-7}	5	Permeability Test
Alluvium Silt and Clay	1×10^{-5}	2	Typical Published Values
Organic Clayey Silt	5×10^{-6}	2	Typical Published Values
Loose to Med Dense Glacial Outwash Sand and Gravel	1×10^{-2}	1	Grain Size Correlation
Med Dense - Dense Glacial Outwash Sand and Gravel	1×10^{-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	γ_{wet} (pcf)	Strength		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°	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	γ_{wet} (pcf)	Strength		Reference
		ϕ	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.

FAR I RSW Landfill

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

Maps of Groundwater monitoring well locations in relation to CCR Unit

Monitoring Well Network

- Background Sampling Location
- Compliance Sampling Location
- Residual Solid Waste (RSW) Landfill

Notes
- Monitoring well coordinates provided by Buckeye Power.
- Site features based on information available in Groundwater Monitoring Network Evaluation -Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by Buckeye Power.

1,000 500 0 1,000 Feet

Site Layout
Residual Solid Waste Landfill

Buckeye Power Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2019/01/16

Figure 2

P:\Projects\AEP\Groundwater Statistical Evaluation - CHA8423\Groundwater Mapping\GIS Files\Mike's GIS Files\Cardinal\MXDs\FAR_I\AEP-Cardinal_RSW_Site_Layout.mxd. ARevezzo. 1/16/2019. CHA8423/01/08.

FAR I RSW Landfill

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

Well construction diagrams and drilling logs for all groundwater monitoring wells

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0623A

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 836,291.1 E 2,514,223.8**

GROUND ELEVATION **1159.2** SYSTEM

Water Level, ft			
TIME			
DATE			

BORING NO. **CA-0622** DATE **7/17/15** SHEET **1** OF **16**

BORING START **4/10/06** BORING FINISH **6/1/06**

PIEZOMETER TYPE WELL TYPE

HGT. RISER ABOVE GROUND **2.281** DIA

DEPTH TO TOP OF WELL SCREEN **354.9** BOTTOM **359.9**

WELL DEVELOPMENT BACKFILL

FIELD PARTY **DLB / MCR / MWJ** RIG **D-120**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
		0.0	10.0									**GROUNDING PROCEDURES NOT IN USE ON THIS BORING. BLIND DRILLED FROM GRADE TO 10' WITH 3 7/8" ROLLER BIT & SET 3" PVC CASING. STARTED CORING AT 10.0'**
							5					
1	NQ	10.0	13.9		3.3		10			**HARD N8 VERY LIGHT GRAY LIMESTONE** w/ 1/2" clay bands in bottom 0.3'		
2	NQ	13.9	18.9		5.0					**HARD N8 VERY LIGHT GRAY LIMESTONE**		
							15			**SOFT 5G 6/1 GREENISH GRAY SHALE**		
3	NQ	18.9	23.9		4.7					**HARD 5R 4/2 GRAYISH RED SHALE**		

TYPE OF CASING USED

	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0623A

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **2** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										5G 6/1 GREENISH GRAY LIMESTONE fractured throughout		
										5GY 6/1 GREENISH GRAY SHALE		
4	NQ	23.9	33.9		9.7					**5B 5/1 MEDIUM BLUISH GRAY SHALE** fractured		
							25			**N7 LIGHT GRAY LIMESTONE**		
										5G 6/1 GREENISH GRAY SHALE		
										5G 6/1 GREENISH GRAY LIMESTONE fractured		
							30			**5G 6/1 GREENISH GRAY SHALE**		
										HARD 5B 5/1 MEDIUM BLUISH GRAY SHALEY LIMESTONE		
5	NQ	33.9	43.9		9.8					**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALEY LIMESTONE** fractured in bottom 1.5'		
							35					
							40					
6	NQ	43.9	46.9		3.0					**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALEY LIMESTONE**		
							45					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0623A

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **3** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
7	NQ	46.9	53.9		7.0		50					
										5B 5/1 MEDIUM BLUISH GRAY SHALE		
8	NQ	53.9	63.9		9.6		55			**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALEY LIMESTONE**		
										HARD N5 MEDIUM GRAY SHALEY LIMESTONE		
9	NQ	63.9	73.9		10.0		60					
							65			**HARD 5B 5/1 MEDIUM BLUISH GRAY to N6 MEDIUM LIGHT GRAY SHALE**		
							70			**HARD N4 MEDIUM DARK GRAY SHALE** small coal band @ 73.8		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0623A

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **4** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
10	NQ	73.9	83.9		10.0		75			**HARD N6 MEDIUM LIGHT GRAY SHALE** w/ coal band @ 74.4, angle fracture @ 75.7		
							80			**SOFT N4 MEDIUM DARK GRAY SHALE**		
										HARD N2 GRAYISH BLACK SHALE		
										COAL		
										HARD 5B 5/1 MEDIUM BLUISH GRAY SHALE		
11	NQ	83.9	93.9		10.0		85			**HARD N5 MEDIUM GRAY SHALE**		
							90			**HARD 5B 7/1 LIGHT BLUISH GRAY MIXED w/ N6 MEDIUM LIGHT GRAY SHALE** w/ limestone nodules		
12	NQ	93.9	103.9		10.0		95			**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0623A

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **5** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										HARD 5B 7/1 LIGHT BLUISH GRAY SHALE w/ sandstone streaks, angle fracture @ 98.5		
							100					
13	NQ	103.9	113.9		10.0					**HARD N6 MEDIUM LIGHT GRAY SHALE** w/ sandstone streaks, bottom 0.5 carbonious		
							105					
							110					
										N8 VERY LIGHT GRAY LIMESTONE		
										HARD N3 DARK GRAY SHALE		
										N7 LIGHT GRAY LIMESTONE w/ 0.2 5B 5/1 medium bluish gray shale band @ 111.6		
14	NQ	113.9	123.9		10.0					**N7 LIGHT GRAY LIMESTONE**		
							115			**HARD 5GY 4/1 DARK GREENISH GRAY SHALE**		
										5GY 4/1 DARK GREENISH GRAY SHALE		
							120			**HARD N6 MEDIUM LIGHT GRAY SHALE** w/ sandstone streaks		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0623A

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **6** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
15	NQ	123.9	133.9		10.0		125			**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALE** bottom 0.8 N3 dark gray carbonious		
							130			**N5 MEDIUM GRAY FINE GRAIN SANDSTONE** w/ shale band		
16	NQ	133.9	143.9		10.0		135			**HARD N5 MEDIUM GRAY SHALE**		
							140			**COAL** w/ hard shale bands		
										N4 MEDIUM DARK GRAY SHALE w/ 0.5 of carbonious shale at 142.0, bottom 1.9 hard		
17	NQ	143.9	153.9		10.0					**HARD N6 MEDIUM LIGHT GRAY SHALE**		
							145			**N8 VERY LIGHT GRAY LIMESTONE**		
										HARD N6 MEDIUM LIGHT GRAY SHALE		
										N8 VERY LIGHT GRAY LIMESTONE w/ 0.3 shale bands @ 147.8 & 152.4		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0623A

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **7** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
18	NQ	153.9	163.9		6.2	68				**HARD N6 MEDIUM LIGHT GRAY LIMESTONE**		**SWL 21.4' on 04/17/06 w/ NQ HOLE TO 153.9'. USED ±4,000 GALS. WATER TO THIS POINT**
							155					
										HARD N6 MEDIUM LIGHT GRAY FRACTURED LIMESTONE		
										HARD N5 MEDIUM GRAY SHALE/LIMESTONE		
										SOFT N5 MEDIUM GRAY SHALE/LIMESTONE		**LOST ALL WATER RETURN AT 157.8'. HYD. PUSH - NO ROTATION FROM 163.9' - 165.9' (VOID)**
										HARD N5 MEDIUM GRAY SHALE/LIMESTONE		
							160					
19	NQ	163.9	168.9		1.9	84				**VOID**		
							165					
										SOFT 5B 5/1 MEDIUM BLUISH GRAY SHALE		
20	NQ	168.9	170.9		1.3	0				**SOFT N5 MEDIUM GRAY SHALE** wet		
							170					**Stopped after going through mine void. Started drilling HW casing and cleaning inside of casing w/ 4" roller bit. At 155', roller bit broke off inside casing. It was decided to abandon and grout this boring. Moved east +/- 5" and started drilling new boring w/ 6" air**
21	NQ	170.9	178.9		7.9	67				**HARD N6 MEDIUM LIGHT GRAY SHALE**		
										SOFT N4 MEDIUM DARK GRAY SHALE fractures throughout		
										HARD N6 MEDIUM LIGHT GRAY SHALE fractured		
							175					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0623A

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **8** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										HARD N7 LIGHT GRAY SHALE		**hammer and inserted HW casing to bottom old mine floor @ 173.3'. This boring was drilled through mine piller; no camera work done on this boring. Coal seam estimated @ +/- 165.0'-17**
22	NQ	178.9	186.9		6.6	56				**SOFT N7 LIGHT GRAY SHALE** w/ fracture		
							180			**SOFT N6 MEDIUM LIGHT GRAY SHALE**		
										SOFT N6 MEDIUM LIGHT GRAY SHALE w/ fracture, wet		
										HARD N7 LIGHT GRAY SHALE dry		
										N7 LIGHT GRAY CLAY SHALE dry		
										HARD N7 LIGHT GRAY CLAY SHALE		
							185			**N4 MEDIUM DARK GRAY SHALE**		
23	NQ	186.9	189.4		2.5	88				**VERY HARD N6 MEDIUM LIGHT GRAY SHALE** w/ trace of fine limestone		**Resumed coring and logging core @ 186.9'**
24	NQ	189.4	194.4		5.0	40				**N5 MEDIUM GRAY SHALE** fracture, wet		
							190			**N6 MEDIUM LIGHT GRAY SHALE/LIMESTONE**		
										SOFT MEDIUM GRAY SHALE wet		
										MEDIUM LIGHT GRAY SHALE		
										SOFT N5 MEDIUM GRAY SHALE moist		
25	NQ	194.4	204.4		10.0	83				**5B 5/1 MEDIUM BLUISH GRAY SHALE**		
							195			**HARD N5 MEDIUM GRAY SHALE** fracture		
										HARD N5 MEDIUM GRAY SHALE		
							200					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

Monitoring Well: CA-0623A

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **9** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										N5 MEDIUM GRAY SHALE fracture, wet		
										HARD N5 MEDIUM GRAY SHALE		
26	NQ	204.4	214.4		8.7	64				**HARD N4 MEDIUM DARK GRAY SHALE**		
							205			**5G 6/1 GREENISH GRAY SHALE** w/trace of fine imestone, wet		
										N2 GRAYISH BLACK SHALE fractured		
										SOFT N4 MEDIUM DARK GRAY SHALE		
										N2 GRAYISH BLACK SHALE fracture		
										N5 MEDIUM GRAY SHALE fracture, wet		
							210					
										5G 6/1 GREENISH GRAY SHALE		
										5G 6/1 GREENISH GRAY SHALE wet		
27	NQ	214.4	219.4		5.0	66				**5GY 6/1 GREENISH GRAY SHALE/LIMESTONE**		
							215					
										N5 MEDIUM GRAY SHALE		
										SOFT 5YR 6/1 LIGHT BROWNISH GRAY SANDY SHALE		
28	NQ	219.4	229.4		9.9	81				**HARD 5B 5/1 MEDIUM BLUISH GRAY SHALE** w/limestone fractures		
							220					
										5B 5/1 MEDIUM BLUISH GRAY SHALE w/limestone		
							225					
										N4 MEDIUM DARK GRAY SHALE fractured, wet		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0623A

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **10** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
29	NQ	229.4	238.8				230			**5B 5/1 MEDIUM BLUISH GRAY SHALE/ LIMESTONE** fracture		
										N4 MEDIUM DARK GRAY SHALE fractured		
										HARD MEDIUM DARK GRAY SHALE w/limestone		
							235			**MEDIUM DARK GRAY LIMESTONE** shale fractures		
										HARD DARK GRAY LIMESTONE		
30	NQ	238.8	244.4							**HARD N4 MEDIUM DARK GRAY SHALE**		
							240					
										N2 GRAYISH BLACK COAL fracture		
										SOFT N4 MEDIUM DARK GRAY SHALE		
										HARD N4 MEDIUM DARK GRAY SHALE/LIMESTONE		
31	NQ	244.4	254.4							**5B 5/1 MEDIUM BLUISH GRAY SHALE**		
							245					
										5B 5/1 MEDIUM BLUISH GRAY SHALE w/limestone fractures		
										SOFT 5GY 6/1 GREENISH GRAY SHALE w/limestone, wet		
							250			**N5 MEDIUM GRAY & 5YR 4/1 BROWNISH GRAY SHALE**		
										5B 5/1 MEDIUM BLUISH GRAY SHALE		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0623A

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **11** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
32	NQ	254.4	264.4				255			**SOFT MEDIUM BLUISH GRAY SHALE**		
							260			**HARD 5GY 6/1 GREENISH GRAY SHALE** w/fractures of limestone		
										5YR 4/1 BROWNISH GRAY RED SHALE		
										MEDIUM BLUISH GRAY SHALE w/fractures of limestone		
33	NQ	264.4	274.4				265			**N4 MEDIUM DARK GRAY SHALE**		
							270			**SOFT N4 MEDIUM DARK GRAY SHALE** wet		
34	NQ	274.4	284.4				275			**SOFT N4 MEDIUM DARK GRAY SHALE**		
										N7 LIGHT GRAY & N4 MEDIUM DARK GRAY SHALE w/trace of limestone		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: CA-0623A

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **12** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										N4 MEDIUM DARK GRAY SHALE/LIMESTONE		
										HARD SHALE		
35	NQ	284.4	294.4				285			**N4 MEDIUM DARK GRAY SHALE** w/fractures of limestone		
										HARD N3 DARK GRAY SHALE		
							290					
36	NQ	294.4	304.4							**HARD N4 MEDIUM DARK GRAY SHALE**		
							295					
							300					
37	NQ	304.4	314.4		10.0	100						
							305					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

Monitoring Well: CA-0623A

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **13** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							310					
38	NQ	314.4	324.4		10.0		315			**N4 MEDIUM DARK GRAY SHALE**		
										N4 MEDIUM DARK GRAY & N6 MEDIUM LIGHT GRAY SHALE w/fine sandstone		
							320			**N4 MEDIUM DARK GRAY SHALE** w/traces of fine standstone lens		
										N5 MEDIUM GRAY SHALE w/trace of fine sandstone		
39	NQ	324.4	334.4		10.0		325			**HARD MEDIUM GRAY & MEDIUM DARK GRAY SHALE** w/trace of coarse sandstone		
							330			**N5 MEDIUM GRAY COARSE GRAIN SANDSTONE**		
										HARD N3 DARK GRAY SHALE w/trace of sandstone		
										N5 MEDIUM GRAY COARSE GRAIN		**MORGANTOWN**

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

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JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **14** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										SANDSTONE Morgantown sandstone starts @ 331.5'		**SANDSTONE STARTS @ 331.5'**
40	NQ	334.4	344.4		10.0		335			**N6 MEDIUM LIGHT GRAY SANSDSTONE**		
										HARD N3 DARK GRAY SHALE w/trace of fine sandstone		
										N2 GRAYISH BLACK SHALE		
							340					
										N5 MEDIUM GRAY COARSE GRAIN SANDSTONE		
										HARD N2 GRAYISH BLACK SHALE w/trace of fine sandstone		
41	NQ	344.4	354.4		9.8	92	345			**N5 MEDIUM GRAY COARSE GRAIN SANDSTONE** w/trace of dark shale		
										HARD N4 MEDIUM DARK GRAY SHALE w/trace of fine sandstone		
							350					
										MEDIUM GRAY SANDSTONE w/dark shale fractures		
42	NQ	354.4	364.4		9.7	91	355			**N6 MEDIUM LIGHT GRAY COARSE GRAIN SANDSTONE**		
										GRAYISH BLACK COAL fracture		

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AEP CIVIL ENGINEERING LABORATORY

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JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **15** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										N6 MEDIUM LIGHT GRAY COARSE GRAIN SANDSTONE		
							360			**N5 MEDIUM GRAY SHALE**		
43	NQ	364.4	373.4		10.0	90	365			**N6 MEDIUM LIGHT GRAY SILTSTONE**		
							370					
										HARD N5 MEDIUM GRAY SHALE		
44	NQ	373.4	383.4		10.0	81				**HARD N3 DARK GRAY CLAY SHALE**		
							375					
										N2 GRAYISH BLACK CLAY SHALE SEAM		
										N1 BLACK COAL SEAM		
										HARD N5 MEDIUM GRAY CLAY SHALE		
							380					
												STOPPED BORING

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

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JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0622** DATE **7/17/15** SHEET **16** OF **16**

PROJECT **CARDINAL LANDFILL** BORING START **4/10/06** BORING FINISH **6/1/06**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
												@ 383.4'. SET 1" GEOMON WELL

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-17

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 833,612.2 E 2,512,715.1**

GROUND ELEVATION **1195.6** SYSTEM

Water Level, ft			
TIME			
DATE			

BORING NO. **CA-0601** DATE **7/17/15** SHEET **1** OF **17**

BORING START **6/5/07** BORING FINISH **6/12/07**

PIEZOMETER TYPE **N/A** WELL TYPE **OW**

HGT. RISER ABOVE GROUND **2.369** DIA **2"**

DEPTH TO TOP OF WELL SCREEN **190.3** BOTTOM **199.8**

WELL DEVELOPMENT **YES** BACKFILL **QUICK GROUT**

FIELD PARTY **MCR / MWJ** RIG **D-120**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
												GROUNDING PROCEDURES NOT IN USE ON THIS BORING; WATER FOR DECONNING AND DRILLING FROM CARDINAL FIRE PROTECTION SYSTEM; DECONED RIG & TOOLS 05/05/07; BLIND DRILLED HW 4" CASING TO START CORING @ 14.0'; MOVED +/- 6' NORTH WHERE TOM DICK HAD THE BORING STAKED.
							5					
							10					
1	NQ	14.0	15.5							**SOFT 5Y 6/1 LIGHT OLIVE GRAY CLAY**		
							15					
2	NQ	15.5	25.5		3.6	42				**SOFT CLAYEY LIMESTONE** **HARD 10YR 7/4 GRAYISH ORANGE LIMESTONE**		LOST ALL WATER RETURN @ 19.0'

TYPE OF CASING USED

	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
X	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-17

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **2** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							25					
3	NQ	25.5	35.5		2.1	48				**5YR 6/4 LIGHT BROWN SANDY SHALE**		
										HARD N8 VERY LIGHT GRAY LIMESTONE		
										HARD N8 VERY LIGHT GRAY LIMESTONE w/iron staining		
							30			**SOFT 5YR 4/1 BROWNISH GRAY SHALE**		
										HARD N6 MEDIUM LIGHT GRAY LIMESTONE		
							35			**5YR 5/6 LIGHT BROWN SAND**		
4	NQ	35.5	45.5							**SOFT 5B 5/1 MEDIUM BLUISH GRAY SHALE**		
							40			**HARD N6 MEDIUM GRAY SHALE**		
										HARD N6 MEDIUM GRAY SHALE w/iron staining		
										HARD N7 MEDIUM LIGHT GRAY LIMESTONE		
							45					
5	NQ	45.5	52.5		6.5	42				**5YR 7/2 GRAYISH ORANGE PINK**		

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COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **3** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										LIMESTONE vertical fracture w/iron staining		
										SOFT 5G 6/1 GREENISH GRAY SHALE		
										SOFT 5G 6/1 GREENISH GRAY SHALE w/iron staining		
							50			**SOFT 5B 5/1 MEDIUM BLUISH GRAY SHALE**		
6	NQ	52.5	58.5		6	52				**HARD 5B 5/1 MEDIUM BLUISH GRAY LIMESTONE** w/ vertical fracture		SWL DRY; NQ HOLE TO 52.5
										5YR 4/4 MODERATE BROWN SANDY SHALE w/iron staining		
										N5 MEDIUM GRAY SHALE		
							55			**MEDIUM LIGHT GRAY LIMESTONE**		
										VERY SOFT MEDIUM GRAY SHALE		
										HARD MEDIUM GRAY SHALE		
7	NQ	58.5	60.5		2	25				**HARD MEDIUM LIGHT GRAY SHALE**		
							60					
8	NQ	60.5	70.5		10	70				**N5 MEDIUM GRAY SHALE**		
										N5 MEDIUM GRAY SHALE w/ vertical fracture		
										LIMESTONE		
							65					
							70					
9	NQ	70.5	76.5		6	47				**HARD N5 MEDIUM GRAY SHALE**		

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COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **4** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										N5 MEDIUM GRAY LIMESTONE w/ vertical fracture		
							75					
10	NQ	76.5	85.5		9	44				**N4 MEDIUM DARK GRAY SHALE** w/iron staining		
										N7 LIGHT GRAY LIMESTONE		
										HARD N4 MEDIUM GRAY CLAY SHALE		
							80					
										N4 MEDIUM GRAY CLAY SHALE w/ broken areas		
							85					
11	NQ	85.5	95.5		9	82				**HARD N6 MEDIUM LIGHT GRAY CLAY SHALE**		
										BROKEN CLAY SHALE		
							90					
										HARD N6 BROKEN CLAY SHALE		
										BROKEN CLAY SHALE		
							95			**HARD N6 BROKEN CLAY SHALE** w/vertical fracture		
12	NQ	95.5	105.5		10	60				**HARD N5 MEDIUM GRAY SHALE**		
										N5 MEDIUM GRAY BROKEN CLAY SHALE		
										HARD 5YR 4/1 BROWNISH GRAY CLAY SHALE		

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COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **5** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							100					
										5YR 4/1 BROWNISH GRAY LIMEY CLAY SHALE		
							105					
13	NQ	105.5	111.5		5.6	54				SOFT N4 MEDIUM DARK GRAY CLAY SHALE		
										N1 BLACK COAL		
							110					
										N2 GRAYISH BLACK CLAY SHALE		
14	NQ	111.5	120.5		9					SOFT N4 MEDIUM DARK GRAY CLAY SHALE		
							115					
										N2 GRAYISH BLACK CLAY SHALE		
										N4 MEDIUM DARK GRAY CLAY SHALE		
							120			HARD N6 MEDIUM LIGHT GRAY CLAY SHALE		
15	NQ	120.5	130.5		10.3	51				N6 LIGHT GRAY LIMESTONE		
										N4 MEDIUM DARK GRAY CLAY SHALE		
										N6 LIGHT GRAY LIMESTONE		

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PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							125			**SOFT N5 MEDIUM DARK GRAY CLAY SHALE**		
										N6 FINE GRAIN SANDSTONE		
										N6 FINE GRAIN SANDSTONE & CLAY SHALE		
							130					
16	NQ	130.5	140.5		10	37				**MEDIUM DARK GRAY SILTY CLAY SHALE**		
							135					
							140			**N7 LIGHT GRAY LIMESTONE**		
17	NQ	140.5	150.5		10	60				**HARD N6 MEDIUM LIGHT GRAY CLAY SHALE**		
										SOFT N6 MEDIUM LIGHT GRAY CLAY SHALE		
							145					
										HARD N6 MEDIUM LIGHT GRAY CLAY SHALE		

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PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
18	NQ	150.5	160.5		10	80				**HARD N5 MEDIUM GRAY CLAY SHALE**		
							155					
										N4 MEDIUM DARK GRAY SILTY CLAY SHALE		
							160					
19	NQ	160.5	170.5		10	11				**N4 MEDIUM DARK GRAY SILTY CLAY SHALE**		
										SOFT N4 MEDIUM DARK GRAY SHALE		
										N5 MEDIUM GRAY SILTY CLAY SHALE		
							165					
										N1 BLACK COAL		
							170			**N2 GRAYISH BLACK DARK CLAY SHALE**		
										N1 BLACK COAL		
20	NQ	170.5	180.5		10	71				**N2 GRAYISH BLACK CLAY SHALE**		
										SOFT N2 GRAYISH BLACK CLAY SHALE		
										HARD N4 MEDIUM DARK GRAY CLAY SHALE		
										SOFT N4 MEDIUM DARK GRAY CLAY SHALE		
										HARD N6 MEDIUM LIGHT GRAY LIMESTONE		
							175					
										SOFT N5 MEDIUM GRAY CLAY SHALE		

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PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										N7 LIGHT GRAY LIMESTONE		
							180					
21	NQ	180.5	190.5		10	70				**N5 MEDIUM LIGHT GRAY LIMESTONE**		
										HARD N5 MEDIUM GRAY CLAY SHALE		
										N7 LIGHT GRAY LIMESTONE		
							185			**N6 MEDIUM LIGHT GRAY LIMEY CLAY SHALE**		
										HARD N5 MEDIUM GRAY CLAY SHALE		
										SOFT N5 MEDIUM GRAY LIMEY CLAY SHALE		
							190					
22	NQ	190.5	200.5		10	18				**SOFT N5 MEDIUM GRAY LIMEY CLAY SHALE**		
										N4 MEDIUM DARK GRAY to BLACK CLAY SHALE		
										SOFT N6 MEDIUM LIGHT GRAY LIMEY CLAY SHALE		
										N4 MEDIUM DARK GRAY to BLACK CLAY SHALE		
							195			**N1 BLACK COAL**		
							200			**N2 GRAYISH BLACK CLAY SHALE**		
23	NQ	200.5	210.5		10	80				**N5 MEDIUM GRAY LIMEY CLAY SHALE**		

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PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										N6 MEDIUM LIGHT GRAY LIMESTONE		
							205			**SOFT N5 MEDIUM GRAY CLAY SHALE**		
										N7 LIGHT GRAY CLAYEY LIMESTONE w/pyrite		
							210					
24	NQ	210.5	220.5		10	83				**N6 MEDIUM LIGHT GRAY LIMESTONE**		
							215			**N4 MEDIUM DARK GRAY CLAY SHALE**		
										N7 LIGHT GRAY FINE GRAIN SILTSTONE		
										N7 LIGHT GRAY CLAY SHALE/SILTSTONE		
							220					
25	NQ	220.5	230.5		10	79				**SOFT N4 MEDIUM DARK GRAY CLAY SHALE**		
										N6 MEDIUM LIGHT GRAY SILTY CLAY SHALE		
										N6 LIGHT GRAY CLAY SHALE/SILTSTONE		
							225			**N6 MEDIUM LIGHT GRAY SILTY CLAY SHALE**		

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COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **10** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							230					
26	NQ	230.5	240.5		10	47				**N6 MEDIUM LIGHT GRAY CLAY SHALE/ SILTSTONE**		
										N4 MEDIUM DARK GRAY CLAY SHALE		
							235			**N6 MEDIUM LIGHT GRAY CLAY SHALE** w/ siltstone		
										SOFT N4 MEDIUM DARK GRAY CLAY SHALE		
										N4 MEDIUM DARK CLAY SHALE		
										SOFT N4 MEDIUM DARK GRAY CLAY SHALE		
							240					
27	NQ	240.5	249.5		9	44				**N6 MEDIUM LIGHT GRAY SILTSTONE**		
										N7 LIGHT GRAY LIMEY CLAY SHALE		
							245			**SOFT N5 MEDIUM GRAY CLAY SHALE**		
										N5 MEDIUM GRAY LIMEY CLAY SHALE		
										HARD N5 MEDIUM GRAY CLAY SHALE		
28	NQ	249.5	255.5		6	55	250			**N5 MEDIUM GRAY LIMEY CLAY SHALE**		
										5RP 4/2 GRAYISH RED PURPLE CLAY SHALE		

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COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **11** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							255			**N5 MEDIUM GRAY CLAY SHALE**		
29	NQ	255.5	265.5		10	90				**5G 6/1 GREENISH GRAY LIMEY SILTSTONE** w/clay shale		SWL 187.4'; NQ HOLE TO 255.5'
							260			**5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE** w/ siltstone		
							265					
30	NQ	265.5	275.5		10	68				**N6 MEDIUM LIGHT GRAY SILTY FINE GRAIN SANDSTONE**		
							270			**SOFT BROWNISH GRAY SANDY CLAY SHALE**		
										MEDIUM GRAY LIMEY CLAY SHALE		
										VERY SOFT 5YR 4/1 BROWNISH GRAY CLAY SHALE		
							275			**5GY 6/1 GREENISH GRAY LIMEY CLAY SHALE**		
31	NQ	275.5	285.5		10	53				**5RP 4/2 GRAYISH RED PURPLE RED CLAY SHALE**		
										N5 MEDIUM GRAY SHALE		

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PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										5RP 4/2 GRAYISH RED PURPLE CLAY SHALE		
										N6 MEDIUM LIGHT GRAY CLAY SHALE		
							285					
32	NQ	285.5	295.5		10	72				**VERY SOFT 5YR 3/2 GRAYISH BROWN CLAY SHALE**		
										HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE		
							290					
							295					
33	NQ	295.5	305.5		10	84				**N5 MEDIUM GRAY CLAY SHALE**		
										SOFT N5 MEDIUM GRAY CLAY SHALE		
							300					
										5YR 4/1 BROWNISH GRAY CLAY SHALE		
										SOFT N5 MEDIUM GRAY CLAY SHALE		
										N7 LIGHT GRAY LIMESTONE		
										HARD N5 MEDIUM GRAY CLAY SHALE		
							305					
34	NQ	305.5	310.5		5	58						

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PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										HARD 5YR 3/2 GRAYISH BROWN CLAY SHALE		
							310					
35	NQ	310.5	315.5		5	58				**5R 4/2 GRAYISH RED RED CLAY SHALE**		SWL 185.3'; NQ HOLE TO 310.5'; 50 hr reading
										N4 MEDIUM DARK GRAY CLAY SHALE		
							315					
36	NQ	315.5	325.5		10	95						
										N6 MEDIUM LIGHT GRAY SILTSTONE w/limestone nodules		
							320					
							325					
37	NQ	325.5	335.5		10	100				**HARD N6 MEDIUM LIGHT GRAY SILTSTONE** w/limestone nodules		
							330					

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PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										HARD N7 LIGHT GRAY FINE GRAIN SANDSTONE		
										HARD N5 MEDIUM GRAY SILTSTONE		
38	NQ	335.5	345.5		10	97	335					
							340			**MEDIUM LIGHT GRAY FINE GRAIN SANDSTONE** w/crossbedding throughout		
							345					
39	NQ	345.5	355.5		10	97				**HARD N4 MEDIUM GRAY MEDIUM GRAIN SANDSTONE**		
							350					
							355			**N2 COAL PARTING GRAYISH BLACK**		
40	NQ	355.5	365.5		10	94				**HARD N4 MEDIUM GRAY MEDIUM GRAIN SANDSTONE**		
										N2 GRAYISH BLACK COAL PARTING		

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COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **15** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										HARD N5 MEDIUM GRAY MEDIUM GRAIN STANDSTONE		
							360					
										HARD N6 MEDIUM LIGHT GRAY FINE GRAIN SANDSTONE		
										HARD N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE w/coal partings		
							365					
41	NQ	365.5	375.5		10	92				**HARD N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE**		
										GRAYISH BLACK COAL PARTING		
							370			**HARD N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE** w/coal partings throughout		
										HARD N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE		
							375					
42	NQ	375.5	385.5		10	92				**N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE** w/crossbeddings throughout		SWL 190.7'; NQ HOLE TO 375.5
										N5 MEDIUM GRAY MEDIUM GRAIN SANDSTONE		
							380					
										N4 MEDIUM DARK GRAY MEDIUM GRAIN SANDSTONE w/crossbeddings throughout		

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COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **16** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							385			**N6 MEDIUM LIGHT GRAY LIMESTONE**		
43	NQ	385.5	395.5		10	91				**N5 MEDIUM GRAY FINE GRAIN SILTY SANDSTONE**		
							390					
							395			**HARD N6 MEDIUM LIGHT GRAY FINE GRAIN SANDSTONE**		
44	NQ	395.5	405.5		10	94				**HARD N6 MEDIUM LIGHT GRAY FINE GRAIN SANDSTONE**		
							400					
							405					
45	NQ	405.5	415.5		10	70				**HARD MEDIUM LIGHT GRAY FINE GRAIN SANDSTONE**		
										N4 MEDIUM DARK GRAY CLAY SHALE		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

Monitoring Well: S-17

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0601** DATE **7/17/15** SHEET **17** OF **17**

PROJECT **CARDINAL LANDFILL** BORING START **6/5/07** BORING FINISH **6/12/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							415					STOPPED BORING @ 415.5'; FLUSHED W/~700 GALS WATER; GEO PHYSICAL LOGGED; INSTALLED 1" GEOMON TYPE WELL

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-10

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 831,867.6 E 2,516,495.5**

GROUND ELEVATION **1002.5** SYSTEM

Water Level, ft			
TIME			
DATE			

BORING NO. **CA-0607** DATE **7/17/15** SHEET **1** OF **5**

BORING START **1/9/07** BORING FINISH **1/9/07**

PIEZOMETER TYPE WELL TYPE

HGT. RISER ABOVE GROUND **2.704** DIA **2**

DEPTH TO TOP OF WELL SCREEN **39.7** BOTTOM **58.7**

WELL DEVELOPMENT BACKFILL

FIELD PARTY **MCR / ZLR** RIG **D-120**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
	AUGER	0.0	14.0							Grounding procedures not in use on this boring. Deconned rig & tools 01/03/07. Decon & drilling water used from cardinal plant fire protection system. Blind drilled 3.25" HSA's from 0' to 14.0'; started coring @ 14.0'		
							5					
							10					
1	NQ	14.0	19.0		1.8	72				**MEDIUM HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
							15					
2	NQ	19.0	24.8		5.8	17				**HARD MEDIUM LIGHT GRAY LIMESTONE** w/iron staining and fractures		

TYPE OF CASING USED

	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
X	AIR HAMMER	8"

Continued Next Page

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **MCR**

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-10

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0607** DATE **7/17/15** SHEET **2** OF **5**

PROJECT **CARDINAL LANDFILL** BORING START **1/9/07** BORING FINISH **1/9/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										MEDIUM HARD N5 MEDIUM GRAY CLAY SHALE		
3	NQ	24.8	34.8		9.9	51	25			**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE** w/high angle fracture, iron staining throughout		
										HARD 5B 5/1 MEDIUM BLUISH GRAY SANDSTONE w/high angle fracture, iron staining throughout		
										HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE w/high angle fracture, iron staining throughout		
							30					
										HARD 5B 5/1 MEDIUM BLUISH GRAY SANDSTONE w/high angle fracture, iron staining throughout		
4	NQ	34.8	44.8		4.8	33	35			**MEDIUM TO SOFT N5 MEDIUM GRAY CLAY SHALE**		
										HARD N6 MEDIUM LIGHT GRAY LIMESTONE		
										MEDIUM TO SOFT N5 MEDIUM GRAY CLAY SHALE		
							40					
												Lost all water return @ 43.7'
5	NQ	44.8	54.8		9.8	54	45			**HARD 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-10

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0607** DATE **7/17/15** SHEET **3** OF **5**

PROJECT **CARDINAL LANDFILL** BORING START **1/9/07** BORING FINISH **1/9/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										w/iron staining		
							50			**HARD FINE 5B 7/1 LIGHT BLUISH GRAY WELL SEAMED SANDSTONE** w/iron staining		
6	NQ	54.8	64.8		10.0	20	55			**HARD 5GY 6/1 GREENISH GRAY SHALE**		
										HARD 56 5/1 MEDIUM BLUISH GRAY FINE SANDY SHALE		
							60					
										SOFT 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE		
7	NQ	64.8	74.8		10.0	55	65			**SOFT 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
										HARD N5 MEDIUM GRAY SILTY CLAY SHALE w/fractures		
							70					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-10

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0607** DATE **7/17/15** SHEET **4** OF **5**

PROJECT **CARDINAL LANDFILL** BORING START **1/9/07** BORING FINISH **1/9/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
8	NQ	74.8	84.8		9.7	41	75			**HARD 5B 5/1 MEDIUM BLUISH GRAY SILTY CLAY SHALE** w/fractures throughout		
							80			**SOFT CLAY SHALE AREA**		
										HARD 5B 5/1 MEDIUM BLUISH GRAY SILTY CLAY SHALE w/fractures throughout		
9	NQ	84.8	90.3		5.5	42	85			**HARD 5B 5/1 MEDIUM BLUISH GRAY SILTY CLAY SHALE** w/fractures		
							90			**HARD N7 LIGHT GRAY LIMESTONE**		
10	NQ	90.3	99.8		8.3					**SOFT 5B 5/1 MEDIUM BLUISH GRAY CLAY SHALE**		
										HARD 5B 5/1 MEDIUM BLUISH GRAY SILTY CLAY SHALE		
							95					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

Monitoring Well: S-10

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **CA-0607** DATE **7/17/15** SHEET **5** OF **5**

PROJECT **CARDINAL LANDFILL** BORING START **1/9/07** BORING FINISH **1/9/07**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
												Stopped boring @ 99.8' on 01/04/07. Plugged NQ hole from 99.8' to 61.0' w/ bentonite pellets. Built 2" well.

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-1

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL PLANT**

COORDINATES **N 831,399.8 E 2,515,207.8**

GROUND ELEVATION **999.6** SYSTEM **STATE PLANE**

Water Level, ft			
TIME			
DATE			

BORING NO. **8502** DATE **7/17/15** SHEET **1** OF **3**

BORING START **12/9/85** BORING FINISH **12/12/85**

PIEZOMETER TYPE WELL TYPE **GM**

HGT. RISER ABOVE GROUND **1.64** DIA **.75**

DEPTH TO TOP OF WELL SCREEN **64.5** BOTTOM **68.5**

WELL DEVELOPMENT BACKFILL **GROUT**

FIELD PARTY **MCR-ML** RIG **B-61**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							5					
							10					
							15					

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-1

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **8502** DATE **7/17/15** SHEET **2** OF **3**

PROJECT **CARDINAL PLANT** BORING START **12/9/85** BORING FINISH **12/12/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							25					
												28.8 TOP OF SEAL.
							30					
												34.0 TOP OF SAND.
							35					
							40					
							45					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-1

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **8502** DATE **7/17/15** SHEET **3** OF **3**

PROJECT **CARDINAL PLANT** BORING START **12/9/85** BORING FINISH **12/12/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
1	NQ	50.0	60.0		9.5	69	50			**LIGHT GREEN GRAY MEDIUM GRAY DARK GRAY SOME RED CLAY SHALE** Calcareous, fissile, soft, fresh, partings sandy.		
							55					
2	NQ	60.0	61.0		.6	33	60			**MEDIUM TO DARK GRAY CLAYEY LIMESTONE** Hard, fresh except oxidized orange on joints at 66.2.		
3	NQ	61.0	70.0		8.5	78				**MEDIUM GREEN GRAY CLAY SHALE** Fissile, calcareous with sand size limestone nodules, poorly cemented, soft, fresh.		63.9 CHECK VALVE. 64.5 TOP OF SCREEN.
							65					68.5 BOTTOM OF SCREEN.
							70					

AEP CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-2

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL PLANT**

COORDINATES **N 831,038.2 E 2,514,714.2**

GROUND ELEVATION **1038.6** SYSTEM **STATE PLANE**

Water Level, ft			
TIME			
DATE			

BORING NO. **8503** DATE **7/17/15** SHEET **1** OF **4**

BORING START **12/12/85** BORING FINISH **12/17/85**

PIEZOMETER TYPE WELL TYPE **GM**

HGT. RISER ABOVE GROUND **1.29** DIA **.75**

DEPTH TO TOP OF WELL SCREEN **80.5** BOTTOM **84.5**

WELL DEVELOPMENT BACKFILL **GROUT**

FIELD PARTY **MCR-ML** RIG **B-61**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							5					
							10					
							15					

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-2

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **8503** DATE **7/17/15** SHEET **2** OF **4**

PROJECT **CARDINAL PLANT** BORING START **12/12/85** BORING FINISH **12/17/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							25					
							30					
							35					
							40					40.5 TOP OF SEAL.
1	NQ	44.3	50.0		2.9	38	45			**MEDIUM BLUE GRAY CLAY SHALE** Calcareous , portions sandy with laminations fine grain light gray sand to 47.1. limestone nodules and streaks limestone, most		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-2

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **8503** DATE **7/17/15** SHEET **3** OF **4**

PROJECT **CARDINAL PLANT** BORING START **12/12/85** BORING FINISH **12/17/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										soft, sandy portions moderately hard. 55'-60' very calcareous, moderately hard, fresh.		46.5 TOP OF SAND.
2	NQ	50.0	60.0		10.0	92	50					
							55					
3	NQ	60.0	70.0		10.0	100	60			**MEDIUM TO DARK BLUE GRAY SHALE** Fissile, lenses and laminations of very fine grain light gray quartZ sandstone, portions calcareous, all fresh no joints visible, all core portions appears to be machine breaks. shale grades down to carbonaceous shale to 69', easily separates, sandy portions hard.		
							65					
										LIGHT GRAY CLAYEY LIMESTONE Hard, fresh.		
4	NQ	70.0	71.5		1.3	87	70			**DARK BLUE GRAY SHALE** Blocky, calcareous , streaks and nodules, limestone, siderite portions of shale with >50% limestone, fresh		
5	NQ	71.5	80.0		8.3					**MEDIUM BLUE GRAY SHALE** CALCAREOUS		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-2

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **8503** DATE **7/17/15** SHEET **4** OF **4**

PROJECT **CARDINAL PLANT** BORING START **12/12/85** BORING FINISH **12/17/85**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										WITH LAMINATIONS, FINE GRAIN WHITE SAND, FRESH MODERATELY HARD.		
										DARK GRAY LIMESTONE Microcrystalline, fresh, hard.		
							75			**MOSTLY LIGHT BLUE GRAY TO LIGHT GREEN GRAY CLAY SHALE** Calcareous blocky, portions dark gray at 75' and 75.7', all soft, fresh , fresh slickenslided surfaces at various orientations. all calcareous with fine sand size to gravel size limestone nodules lenses shaley limestone at 75.-76.3 and 84.5-85.0.		
6	NQ	80.0	90.0		10.0		80					79.9 CHECK VALVE. 80.5 TOP OF SCREEN.
							85			**LIGHT BLUE GRAY SANDY SHALE** Fissile with laminations light gray fine grain quartz sand portions calcareous with streaks and nodules limestone, fresh. moderately hard.		84.5 BOTTOM OF SCREEN
							90					

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-4

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL PLANT**

COORDINATES **N 834,352.3 E 2,513,052.2**

GROUND ELEVATION **1010.9** SYSTEM **STATE PLANE**

Water Level, ft	20.3	20.0	
TIME	7:20	7:15	
DATE	8-16-88	8-17-88	

BORING NO. **88-5-6** DATE **7/17/15** SHEET **1** OF **9**

BORING START **8/11/88** BORING FINISH **8/16/88**

PIEZOMETER TYPE WELL TYPE **GM**

HGT. RISER ABOVE GROUND **SEE NOTE** DIA **1.0**

DEPTH TO TOP OF WELL SCREEN **SEE NOTE** BOTTOM **SEE NOTE**

WELL DEVELOPMENT BACKFILL **GROUT**

FIELD PARTY **MCR-TJH** RIG **B-61**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
												WATER IN CREEK pH 7.3 TESTED BY CARDINAL PLANT LAB PERSONAL.
1	SS	2.5	4.0	5-7-6	.5					**GRAY CLAY** With limestone and coal fragments (fill).		
							5					
2	SS	7.5	9.0	7-6-5	.4							7.8 LOST WATER IN CASING.
							10					
3	SS	12.5	12.5	50/.5	0							
							15					
4	SS	18.3	19.8	7-7-6	.2					**YELLOW CLAY** With coal and limestone fragments.		17.1 DRILLED 2 15/16" ROLLER BIT FROM 17.1 TO 18.3 THROUGH LIMESTONE BOLDERS.

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
X	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **TJH**

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-4

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-5-6** DATE **7/17/15** SHEET **2** OF **9**

PROJECT **CARDINAL PLANT** BORING START **8/11/88** BORING FINISH **8/16/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
5	SS	22.2	23.4	19-27-50/.2	.4					**GRAY LIMESTONE FRAGMENTS**		
							25					
6	SS	27.5	29.0	8-11-15	.5					**GRAY CLAY** With clay shale and limestone fragments.		27.0 TOP OF SEAL.
							30					
7	SS	32.5	34.0	5-12-13	.7							32.0 TOP OF SAND.
							35					
8	SS	37.5	39.0	6-9-13	.2					**SANDSTONE FRAGMENTS**		
							40					
9	SS	42.5	42.9	50/.4	.4					**.2 YELLOW SANDSTONE .2 LIMESTONE**		
							45					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-4

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-5-6** DATE **7/17/15** SHEET **3** OF **9**

PROJECT **CARDINAL PLANT** BORING START **8/11/88** BORING FINISH **8/16/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
10	SS	47.5	49.0	20-15-16	0		50					
11	SS	52.5	53.3	27-50/.3	.2		55			**GREEN AND GRAY SANDY SHALE** Partially cemented.		
12	SS	57.5	57.8	50/.3	.2					**RED CLAY SHALE**		
13	NQ	58.0	61.6		.8		60			**RED AND GRAY CLAYSTONE** Soft.		58.0 SET CASING
14	NQ	61.6	65.0		3.4	88				**GRAY CLAYEY SANDSTONE** Hard, calcareous, grading to fine grain hard sandstone.		
15	NQ	65.0	71.7		6.6	89	65			**GRAY SANDSTONE** Fine, hard.		
										67.0-67.6 LIGHT BROWN		
										68.5-70.0 LIGHT BROWN		
							70			**71.9-73.0 LIGHT BROWN**		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-4

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-5-6** DATE **7/17/15** SHEET **4** OF **9**

PROJECT **CARDINAL PLANT** BORING START **8/11/88** BORING FINISH **8/16/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
16	NQ	71.7	75.0		3.3	67						1.7-75.0 LOST 50% DRILL WATER.
17	NQ	75.0	85.0		9.7	60	75			**77.2-77.6 LIGHT BROWN**		
							80			**79.3-79.7 BROKEN WITH IRON STAIN ON SOFT.**		79.4 CHECK VALVE. 80.0 TOP OF SCREEN.
										GRAY CLAYSTONE Calcareous, soft.		
										GRAY , LIGHT BROWN LIMESTONE Hard.		82.0 BOTTOM OF SCREEN.
										GRAY CLAYSTONE Calcareous, soft.		84.0 BOTTOM OF SAND.
18	NQ	85.0	95.0		9.8	46	85					
							90			**GRAY LIMESTONE** Hard.		
										GRAY CLAYSTONE Calcareous, soft.		
19	NQ	95.0	105.0		9.8	62	95					
										GRAY LIMESTONE Hard.		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-4

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-5-6** DATE **7/17/15** SHEET **5** OF **9**

PROJECT **CARDINAL PLANT** BORING START **8/11/88** BORING FINISH **8/16/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							100			**GRAY CLAYSTONE** Soft, calcareous, with calcite seams.		
							105			**GRAY CLAY SHALE** Soft with some red and gray layers.		
20	NQ	105.0	115.0		10.0	68						
							110			**GRAY CLAYSTONE** Soft.		
										GRAY LIMESTONE Changing to brown at 114.6.		
										SOFT CLAYSTONE LAYERS AT 112.1-112.3 AND 112.7-112.09		
21	NQ	115.0	125.0		5.2	33	115					
										RED CLAYSTONE Calcareous, soft.		
							120					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-4

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-5-6** DATE **7/17/15** SHEET **6** OF **9**

PROJECT **CARDINAL PLANT** BORING START **8/11/88** BORING FINISH **8/16/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
22	NQ	125.0	135.0		9.5	36	125			**GRAY CLAYSTONE** Soft, calcareous, with gray clay shale layers from 126.4-128.1		
							130			**GRAY SHALEY LIMESTONE** Hard.		
23	NQ	135.0	145.0		9.9	73	135			**GRAY CLAYSTONE** Soft with limestone nodules.		
							140			**GRAY SHALEY SANDSTONE** Soft, calcite seams.		
										GRAY SANDSTONE Fine grain.		
24	NQ	145.0	155.0		10.0	100	145					146.5 TOP OF SAND.

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-4

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-5-6** DATE **7/17/15** SHEET **7** OF **9**

PROJECT **CARDINAL PLANT** BORING START **8/11/88** BORING FINISH **8/16/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
25	NQ	155.0	165.0		10.0	98	155					
							160					
26	NQ	165.0	175.0		10.0	98	165					
							170					
27	NQ	175.0	185.0		10.0	98	175					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-4

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-5-6** DATE **7/17/15** SHEET **8** OF **9**

PROJECT **CARDINAL PLANT** BORING START **8/11/88** BORING FINISH **8/16/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							180					
							185					
28	NQ	185.0	195.0		10.0	100						
							190					191.9 CHECK VALVE. 192.5 TOP OF SCREEN.
							195			**GRAY SHALEY SANDSTONE** Soft.		194.5 BOTTOM OF SCREEN.
29	NQ	195.0	205.0		9.9	95						196.5 BOTTOM OF SAND.
							200					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-4

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-5-6** DATE **7/17/15** SHEET **9** OF **9**

PROJECT **CARDINAL PLANT** BORING START **8/11/88** BORING FINISH **8/16/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							205					

AEP CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-5

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL PLANT**

COORDINATES **N 834,917.6 E 2,513,916.2**

GROUND ELEVATION **1000.2** SYSTEM **STATE PLANE**

Water Level, ft	6.4	10.2	22.0
TIME	7:10	7:20	3:00
DATE	8-9-88	8-10-88	8-11-88

BORING NO. **88-7-8** DATE **7/17/15** SHEET **1** OF **8**

BORING START **8/8/88** BORING FINISH **8/10/88**

PIEZOMETER TYPE WELL TYPE **GM**

HGT. RISER ABOVE GROUND **SEE NOTE** DIA **1.0**

DEPTH TO TOP OF WELL SCREEN **SEE NOTE** BOTTOM **SEE NOTE**

WELL DEVELOPMENT BACKFILL **GROUT**

FIELD PARTY **MCR=TJH** RIG **B-61**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
1	SS	2.7	4.2	10-12-14	.9					**GRAY FLY ASH BROWN CLAY**		
							5					
2	SS	7.7	9.2	14-3-5	.5					**GRAY FLY ASH AND ASPHALT FRAGMENT**		
							10					
3	SS	12.7	14.2	13-9-9	.5					**LIMESTONE AND GRAVEL FRAGMENTS**		
							15					
4	SS	17.7	19.2	9-11-11	.1					**LIMESTONE FRAGMENTS**		

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
X	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **TJH**

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-5

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-7-8** DATE **7/17/15** SHEET **2** OF **8**

PROJECT **CARDINAL PLANT** BORING START **8/8/88** BORING FINISH **8/10/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
5	SS	22.7	24.2	11-6-9	.3					**LIMESTONE FRAGMENTS**		20.0 TOP OF SEAL.
							25					24.6 TOP OF SAND.
6	SS	27.7	29.2	10-10-13	.5					**LIMESTONE FRAGMENTS**		
							30					
7	SS	32.7	32.7	50/0	0							
							35					
8	SS	37.7	39.2	8-12-9	.1					**LIMESTONE FRAGMENTS**		
		39.2	67.5									39.2 No samples were taken from 39.2' to 67.5'. material consisted of bolderss and soil. NQ core barrel was used to cut bolders and advanced casing.
							40					
							45					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-5

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-7-8** DATE **7/17/15** SHEET **3** OF **8**

PROJECT **CARDINAL PLANT** BORING START **8/8/88** BORING FINISH **8/10/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							50					
							55					
							60					
							65					
10	NQ	67.5	69.8		2.3	0				**LIGHT GREEN SANDSTONE** Fine grain changing to gray at 69.8'.		
11	NQ	69.8	73.2		1.7	0	70			**GRAY CLAYSTONE** Soft.		70.0 CHECK VALVE. 70.6 TOP OF SCREEN.

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-5

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-7-8** DATE **7/17/15** SHEET **4** OF **8**

PROJECT **CARDINAL PLANT** BORING START **8/8/88** BORING FINISH **8/10/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
12	NQ	73.2	74.8		1.5	0				**LIGHT BROWN SILTY LIMESTONE** Hard.		72.6 BOTTOM OF SCREEN.
13	NQ	74.8	77.0		.7		75			**GRAY CLAYSTONE** Soft.		74.6 BOTTOM OF SAND.
14	NQ	77.0	79.8		2.4					**GRAY CLAYSTONE** Soft with limestone nodules.		
15	NQ	79.8	82.0		2.1	0	80					
16	NQ	82.0	83.2		1.0	0						
17	NQ	83.2	84.8		1.3	0				**RED AND GRAY CLAYSTONE** Soft, with calcite seams 90.0-93.0.		
18	NQ	84.8	87.2		2.1	0	85					
19	NQ	87.2	89.8		2.6	0						
20	NQ	89.8	94.8		4.9	92	90					
										GRAY CLAY SHALE Soft.		
21	NQ	94.8	99.8		4.7	78	95					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-5

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-7-8** DATE **7/17/15** SHEET **5** OF **8**

PROJECT **CARDINAL PLANT** BORING START **8/8/88** BORING FINISH **8/10/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
22	NQ	99.8	101.9		2.1	0	100			**GRAY CLAYSTONE** Soft.		
23	NQ	101.9	102.5		.5	0				**GRAY LIMESTONE** Hard.		
24	NQ	102.5	104.8		2.1	51						
25	NQ	104.8	109.8		5.0	76	105			**GRAY CLAYSTONE** Soft, calcareous, changing to red at 105.1.		
26	NQ	109.8	114.8		4.6	46	110					
27	NQ	114.8	124.8		10.0	48	115			**GRAY CLAYSTONE** Soft with calcite seams.		
										GRAY SANDY SILTSTONE Hard.		
										GRAY CLAYSTONE Soft, with limestone nodules 121.3-124.1.		
							120					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-5

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-7-8** DATE **7/17/15** SHEET **6** OF **8**

PROJECT **CARDINAL PLANT** BORING START **8/8/88** BORING FINISH **8/10/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
28	NQ	124.8	134.8		9.8	83	125					
										GRAY SANDY CLAYSTONE Calcareous grading to light fine grain sandstone at 143.7.		
							130					
29	NQ	134.8	144.8		10.0	100	135					134.7 TOP OF SAND.
							140					
										GRAY SANDSTONE Hard, fine grain, well cemented.		
30	NQ	144.8	154.8		10.0	89	145					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-5

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-7-8** DATE **7/17/15** SHEET **7** OF **8**

PROJECT **CARDINAL PLANT** BORING START **8/8/88** BORING FINISH **8/10/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
31	NQ	154.8	164.8		10.0	90	155					
							160					
32	NQ	164.8	174.8		10.0	98	165					
							170					
33	NQ	174.8	184.8		10.0	84	175					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-5

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-7-8** DATE **7/17/15** SHEET **8** OF **8**

PROJECT **CARDINAL PLANT** BORING START **8/8/88** BORING FINISH **8/10/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							180					180.1 CHECK VALVE. 180.7 TOP OF SCREEN.
										GRAY CLAYSTONE Soft, calcareous.		182.7 BOTTOM OF SCREEN
34	NQ	184.8	194.8		10.0	79	185			**GRAY CLAYEY LIMESTONE**		184.7 BOTTOM OF SAND.
										GRAY CLAYSTONE Calcareous, soft.		
										GRAY SHALEY SANDSTONE Calcareous.		
							190					

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-6

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

PROJECT **CARDINAL PLANT**

COORDINATES **N 834,577.4 E 2,513,679.4**

GROUND ELEVATION **1010.9** SYSTEM **STATE PLANE**

Water Level, ft	22.0	22.8	26.4
TIME	1:15	7:10	7:05
DATE	8-1-88	8-2-88	8-3-88

BORING NO. **88-9-10** DATE **7/17/15** SHEET **1** OF **10**

BORING START **7/28/88** BORING FINISH **8/4/88**

PIEZOMETER TYPE WELL TYPE **GM**

HGT. RISER ABOVE GROUND **SEE NOTE** DIA **1.0**

DEPTH TO TOP OF WELL SCREEN **SEE NOTE** BOTTOM **SEE NOTE**

WELL DEVELOPMENT BACKFILL **GROUT**

FIELD PARTY **MCR-TJH** RIG **B-61**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							5					DRILLED NW CASING TO 53.2'. DRILL WATER IN POND 7.36 TESTED BY CARDINAL PLANT PERSONAL.
							10					
							15					

TYPE OF CASING USED

X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
	NW CASING	3"
	SW CASING	6"
	AIR HAMMER	8"

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PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER **TJH**

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

JOB NUMBER

Monitoring Well: S-6

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-9-10** DATE **7/17/15** SHEET **2** OF **10**

PROJECT **CARDINAL PLANT** BORING START **7/28/88** BORING FINISH **8/4/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							25					
							30					
							35					
							40					39.7 TOP OF SEAL.
							45					44.7 TOP OF SAND.

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-6

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-9-10** DATE **7/17/15** SHEET **3** OF **10**

PROJECT **CARDINAL PLANT** BORING START **7/28/88** BORING FINISH **8/4/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							50					
1	NQ	53.2	54.8		0	0						
2	NQ	54.8	59.8		1.6	0	55			**GRAY CLAYSTONE** Soft,broken, iron stain and calcareous at end of run.		
3	NQ	59.8	65.0		4.9	67	60			**GRAY SILTSTONE** Hard with calcite seams.		61.2 LOST DRILL WATER.
										GRAY SANDSTONE Hard, v-fine grain, well cemented.		
4	NQ	65.0	75.0		10.0	91	65			**68.4-69.4 BROWN**		
							70					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-6

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-9-10** DATE **7/17/15** SHEET **4** OF **10**

PROJECT **CARDINAL PLANT** BORING START **7/28/88** BORING FINISH **8/4/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
5	NQ	75.0	85.0		9.8	49	75			**GRAY SANDY SILTSTONE** Hard.		
										RED AND BROWN CLAYSTONE Soft.		
										LIGHT GRAY LIMESTONE Hard.		
							80			**GRAY AND RED CLAYSTONE** Limestone nodules, calcite seams.		
6	NQ	85.0	95.0		9.8	34	85					
							90					91.1 CHECK VALVE. 91.4 WASH WATER RETURNED. 91.7 TOP OF SCREEN. 93.7 BOTTOM OF SCREEN.
7	NQ	95.0	105.0		9.8	83	95					94.7 BOTTOM OF SAND.

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-6

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-9-10** DATE **7/17/15** SHEET **5** OF **10**

PROJECT **CARDINAL PLANT** BORING START **7/28/88** BORING FINISH **8/4/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										GRAY CLAYSHALE Soft, changing to red and gray at 103.3.		
							100					
										GRAY CLAYSTONE ? Soft.		
8	NQ	105.0	108.0		1.9	0	105					
9	NQ	108.0	115.0		1.6	0				**1.3' of GRAY LIMESTONE** Hard.		108 PULLED NQ RODS TO REPAIR LANDING RING IN CORE BARREL. REASON FOR LOST CORE.
							110					
10	NQ	115.0	125.0		10.0	68	115			**GRAY AND RED CLAYSTONE** Soft, calcareous.		
										GRAY SILTY SANDSTONE Hard.		
							120					
										RED AND GRAY CLAYSTONE Hard.		
										GRAY CLAYSTONE Soft, limestone nodules,		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-6

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-9-10** DATE **7/17/15** SHEET **6** OF **10**

PROJECT **CARDINAL PLANT** BORING START **7/28/88** BORING FINISH **8/4/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
										grading to fine grain clayey sandstone at133.4.		
11	NQ	125.0	135.0		8.2	57	125					
							130					
										GRAY CLAYEY SANDSTONE Hard, fine grain.		
12	NQ	135.0	145.0		9.9	90	135					
										GRAY SANDSTONE Hard, fine grain, well cemented.		
							140					
13	NQ	145.0	155.0		10.0	90	145					145.6 BOTTOM OF SEAL.

Continued Next Page

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-6

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-9-10** DATE **7/17/15** SHEET **7** OF **10**

PROJECT **CARDINAL PLANT** BORING START **7/28/88** BORING FINISH **8/4/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
14	NQ	155.0	165.0		10.0	87	155			**158.0-158.6 DARK GRAY FINE GRAIN**		
							160					
15	NQ	165.0	175.0		10.0	90	165					
							170					
16	NQ	175.0	180.0		4.9	70	175					

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-6

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-9-10** DATE **7/17/15** SHEET **8** OF **10**

PROJECT **CARDINAL PLANT** BORING START **7/28/88** BORING FINISH **8/4/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
17	NQ	180.0	185.0		5.0	98	180					
18	NQ	185.0	189.1		4.1	76	185					
19	NQ	189.1	195.0		5.9	81						
							190			**GRAY SANDY CLAYSTONE** Soft, calcite seams.		191.0 CHECK VALVE. 191.6 TOP OF SCREEN. 193.6 BOTTOM OF SCREEN.
										DARK GRAY SANDSTONE Hard, v-fine grain.		
20	NQ	195.0	195.2		.2	0	195					
21	NQ	195.2	195.4		.2	0						195.6 BOTTOM OF SAND.
22	NQ	195.4	196.4		.9	0						
23	NQ	196.4	205.0		8.5	96				**GRAY SANDSTONE** Fine grain, calcareous.		
							200			**GRAY SANDY SILTSTONE** Hard, calcareous.		

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AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-6

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-9-10** DATE **7/17/15** SHEET **9** OF **10**

PROJECT **CARDINAL PLANT** BORING START **7/28/88** BORING FINISH **8/4/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
24	NQ	205.0	210.0		8.0	76	205					
25	NQ	210.0	215.0		5.0	86	210					
26	NQ	215.0	220.0		5.0	100	215					
27	NQ	220.0	230.0		10.0	70	220			**GRAY SILTSTONE** Hard.		
							225			**GRAY CLAYSTONE** Soft, calcareous.		

Continued Next Page

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-6

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER** BORING NO. **88-9-10** DATE **7/17/15** SHEET **10** OF **10**

PROJECT **CARDINAL PLANT** BORING START **7/28/88** BORING FINISH **8/4/88**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPHIC LOG	U S C S	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							230					

AEP CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING

Monitoring Well: S-7

JOB NUMBER

COMPANY OHIO POWER COMPANY

PROJECT TIDD ASH POND SITE INVESTIGATION

COORDINATES N 831,920.2 E 2,516,676.4

GROUND ELEVATION 1008.5 SYSTEM STATE PLANE

WATER LEVEL	▽ 52.7	▼	▼
TIME			
DATE			

BORING NO. 90CA22-S DATE SHEET 1 OF 2

BORING START 08/13/90 BORING FINISH 08/14/90

PIEZOMETER TYPE WELL TYPE GM

HGT. RISER ABOVE GROUND 1.94 DIA 1.0

DEPTH TO TOP OF WELL SCREEN 66.2 BOTTOM 68.2

WELL DEVELOPMENT BACKFILL BENSEAL

FIELD PARTY MCR-JF RIG B-61

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
							5, 10, 15			NO SPT SAMPLES TAKEN SEATED CASING AT 18.1. LOST WATER DRILL NW CASING AT 9.7. NO WATER RETURN DURING DRILLING. NOT A GOOD SEAL AT CASING ROCK INTERFACE.		
1	NQ	18.1	25.6		5.0		20			GRAY SILTY CLAYSHALE Calcareous, vertical cracks 20.8-21.1, 21.6-21.8		
							25			GRAY SHALEY LIMESTONE Hard.		
2	NQ	25.6	28.6		2.6	0				GRAY SILTY SANDSTONE V-fine grain.		
3	NQ	28.6	35.6		7.0	80	30			GRAY LIMESTONE Hard, stain on joints and vertical cracks.		
										GRAY TO BLACK CLAYSHALE		
							35			GRAY SILTY SANDSTONE F-fine grain.		33.1 TOP OF SEAL.
4	NQ	35.6	45.6		?					vertical cracks		
							40			GRAY LIGHT GRAY CLAYSHALE Slightly sandy, calcareous.		38.6 TOP OF SAND.
										LIGHT GRAY SANDSTONE Silt crossbedding throughout, thin bedding at 43.1		
							45			GRAY TO LIGHT TO DARK GRAY CLAYSHALE Broken slightly calcareous.		
5	NQ	45.6	50.6		?					LIGHT GRAY LIMESTONE Vertical fracture from 46.0-46.9, calcite filled.		
										GRAY SANDY CLAYSHALE Broken, silty,		

TYPE OF CASING USED		
X	NQ-2 ROCK CORE	
	6" x 3.25 HSA	
	9" x 6.25 HSA	
	HW CASING ADVANCER	4"
X	NW CASING	3"
	SW CASING	6"

Continued Next Page

PIEZOMETER TYPE: PT = OPEN TUBE POROUS TIP, SS = OPEN TUBE SLOTTED SCREEN, G = GEONOR, P = PNEUMATIC

WELL TYPE: OW = OPEN TUBE SLOTTED SCREEN, GM = GEOMON

RECORDER JD

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

LOG OF BORING Monitoring Well: S-7

JOB NUMBER

COMPANY **OHIO POWER COMPANY** BORING NO. **90CA22-S** DATE SHEET **2** OF **2**

PROJECT **TIDD ASH POND SITE INVESTIGATION** BORING START **08/13/90** BORING FINISH **08/14/90**

SAMPLE NUMBER	SAMPLE	SAMPLE DEPTH IN FEET FROM	TO	STANDARD PENETRATION RESISTANCE BLOWS / 6"	TOTAL LENGTH RECOVERY	RQD %	DEPTH IN FEET	GRAPH LOG	USCS	SOIL / ROCK IDENTIFICATION	WELL	DRILLER'S NOTES
6	NQ	50.6	52.0		1.1	31				slightly calcareous.		
7	NQ	52.0	57.0		4.6	58				**DEEP MAROON PURPLE CLAYSHALE** Blocky, slightly calcareous, slightly weathered.		PLUGGED OFF.
							55			**LIGHT GREEN TO LIGHT GRAY CLAYSHALE** Slightly broken.		
8	NQ	57.0	65.6		8.6	100				**LIGHT TAN TO LIGHT GRAY SANDSTONE** Fine grain, silt bedding throughout.		PLUGGED OFF. AFTER PULLING NQ RODS SWL 52.7.
							60					
										RUST BROWN CLAYSHALE Iron precipitate staining throughout, broken, slightly sandy to very sandy, fine grained sand.		
							65					
9	NQ	65.6	70.6		5.0	43				**LIGHT GRAY SANDSTONE** Very fine grain,silt partings and cross bedding throughout.		66.0 CHECK VALVE. 66.6 TOP OF SCREEN. 68.6 BOTTOM OF SCREEN
							70					

GeoSyntec Consultants	Project: AEP - Cardinal Plant: FAR1, FAR2 & RWL	Log of Boring: M-20 Sheet 1 of 8
Project No:	Date: 8/15/06	Initial GWL at:
Location: Brilliant, Ohio	Total Borehole Depth: 281 ft.	Drilling Company: Pennsylvania Drilling Co.
Logged by: Scott Hayder	Surface Elevation:	Driller: Earl Dye
Drilling Method: HSA, RC	N: E:	Drilling Machine:
Sampling Comments:		

Depth, ft.	SOIL DESCRIPTION	Strata Plot	Sample No.	Recovery, in.	Blows / 6 in.	Standard Penetration Resistance Blows/ft N-Value (20 40 60 80)	RQD (%)	Plastic Index	Comments
	Brown, silty **SAND** (SM); dry; with some fine to coarse gravel; poorly sorted.		SS-1	12/24	5 4 6 7	10			
2	Loose, black **COAL ASH**; dry; medium grained.		SS-2	13/24	32 29 34 50/4	63			
5			SS-3	10/24	25 30 34 26	64			
6	Light brown, **SILT to SAND** (ML/SP); dry; coal above bedrock.		SS-4	16/24	6 46 21 50/3	67			
8	Soft, green brown to orange brown, **SANDSTONE**; medium grained; approx. 6 horizontal fractures; iron staining along fractures.		SS-5	10/24	50/5 50/2	50			
10			RC-1	74/84			31		
14	Hard, light gray, **LIMESTONE**; vertical fracture at 15.5 ft.; iron staining in fractures.								
15									
15.5	Green brown to orange brown, **SANDSTONE**; medium grained; 7 vertical and horizontal fractures; iron staining along fractures.		RC-2	59/84			35		
20									
20.5	Soft, gray, **CLAYSHALE**; with high sand content.								
22	Green brown to orange brown, **SANDSTONE**; iron staining.								
25									
25	Hard, light gray, **LIMESTONE**; vertical and horizontal fractures; iron staining along fractures.		RC-3	94/120			35		
27	Hard, green gray, **LIMESTONE**.								
30									
	Horizontal fracture at 32.5 ft.; iron staining.								
	Orange brown secondary mineral at 34.0 ft								
35	35 Iron staining at 34.5 to 35.0 ft.								
	Hard, gray, **SANDSTONE**; fine grained; vertical fracture at 36 ft.; iron staining at fracture; massive.		RC-4	116/120			60		
38	Soft to moderately hard, greenish gray, **CLAYSHALE**; high sand content; iron staining.								

GEOSYNTEC AEP CARDINAL FAR1FAR2RWL GEOSYNTECAEPCARDINALFAR1FAR2RWL.GPJ 10/17/2006 LBL

GEOSYNTEC CONSULTANTS	Project: AEP - Cardinal Plant: FAR1, FAR2 & RWL	Log of Boring: M-20 Sheet 2 of 8
Project No:	Date: 8/15/06	Initial GWL at:
Location: Brilliant, Ohio	Total Borehole Depth: 281 ft.	Drilling Company: Pennsylvania Drilling Co.
Logged by: Scott Hayder	Surface Elevation:	Driller: Earl Dye
Drilling Method: HSA, RC	N: E:	Drilling Machine:
Sampling Comments:		

Depth, ft.		SOIL DESCRIPTION	Strata Plot	Sample No.	Recovery, in.	Blows / 6 in.	Standard Penetration Resistance Blows/ft N-Value (20 40 60 80)	RQD (%)	Plastic Index	Comments
		Soft to moderately hard, greenish gray, **CLAYSHALE**; high sand content; iron staining.								
	43	Soft, gray, **CLAYSHALE**; massive.								
45				RC-5	116/120			68		
		Vertical fracture with iron staining at 47.5 ft.								
50										
	52.5	Hard, light gray, **LIMESTONE**.								
55		Vertical fracture at 55.0 ft.		RC-6	113/120			61		
	57	Vertical fracture at 56.5 ft.								
		Soft, dark greenish gray, **CLAYSHALE**; broken limestone in upper 1 ft; massive.								
60										S-20 screen from 60.0 - 85.0 ft.
	62	Hard, gray, **SANDSTONE**; fine grained.								
65		Hard, gray, **SANDSTONE**; fine grained.		RC-7	113/120			99		
	67	Soft to moderately hard, dark greenish gray. **CLAYSHALE**; massive.								
70										
75	75	Hard, gray, **LIMESTONE**; broken; gradational contacts								
	76	Soft to moderately hard, dark greenish gray to gray to black, (GLEY1-5G), **CLAYSHALE**; massive.		RC-8	119/120			54		
		Gray, medium to fine sandstone at 78.5 to 80.0 ft.								
		Vertical fracture at 79.0 ft.								

GEOSYNTEC AEP CARDINAL FAR1FAR2RWL GEOSYNTECAEPCARDINALFAR1FAR2RWL.GPJ 10/17/2006 LBL

GEOSYNTEC CONSULTANTS	Project: AEP - Cardinal Plant: FAR1, FAR2 & RWL	Log of Boring: M-20 Sheet 3 of 8
Project No:	Date: 8/15/06	Initial GWL at:
Location: Brilliant, Ohio	Total Borehole Depth: 281 ft.	Drilling Company: Pennsylvania Drilling Co.
Logged by: Scott Hayder	Surface Elevation:	Driller: Earl Dye
Drilling Method: HSA, RC	N: E:	Drilling Machine:
Sampling Comments:		

Depth, ft.		SOIL DESCRIPTION	Strata Plot	Sample No.	Recovery, in.	Blows / 6 in.	Standard Penetration Resistance Blows/ft N-Value (20 40 60 80)	RQD (%)	Plastic Index	Comments
		Soft to moderately hard, dark greenish gray to gray to black, (GLEY1-5G), **CLAYSHALE**; massive.								S-20 screen from 60.0 - 85.0 ft.
85				RC-9	120/120			48		
90										
95				RC-10	120/120			92		
	99	Light gray, **LIMESTONE**; vertical fracture through 2 ft. unit.								
100	101	Soft to moderately hard, dark greenish gray, **CLAYSHALE**; massive.								
105				RC-11	120/120			87		
110										
115				RC-12	110/120			55		

GEOSYNTEC AEP CARDINAL FAR1FAR2RWL GEOSYNTECAEPCARDINALFAR1FAR2RWL.GPJ 10/17/2006 LBL

GeoSyntec Consultants	Project: AEP - Cardinal Plant: FAR1, FAR2 & RWL	Log of Boring: M-20 Sheet 4 of 8
Project No:	Date: 8/15/06	Initial GWL at:
Location: Brilliant, Ohio	Total Borehole Depth: 281 ft.	Drilling Company: Pennsylvania Drilling Co.
Logged by: Scott Hayder	Surface Elevation:	Driller: Earl Dye
Drilling Method: HSA, RC	N: E:	Drilling Machine:
Sampling Comments:		

Depth, ft.		SOIL DESCRIPTION	Strata Plot	Sample No.	Recovery, in.	Blows / 6 in.	Standard Penetration Resistance Blows/ft N-Value (20 40 60 80)	RQD (%)	Plastic Index	Comments
		Soft to moderately hard, dark greenish gray, **CLAYSHALE**; massive.								
	123	Soft to moderately hard, indian red, (10R 3/2), **CLAYSHALE**.								
125				RC-13	120/120			74		
		Black between 129.0 and 131.5 ft.								
130										
	131 / 131.5	Coal at 131 ft.; pyrite crystals at 131 ft.								
		Light gray, **LIMESTONE**.								
135	134.5	Light gray to dark gray, **SANDSTONE**; fine grained; horizontal bedding in sandstone; pyrite crystals at 134.5 ft.		RC-14	120/120			92		
140		Light gray to dark gray, **SANDSTONE**; fine grained; horizontal bedding in sandstone.								
145		Horizontal fracture at 145.0 ft.		RC-15	116/120			94		
150										
155	154.5	Light gray to dark gray, **SANDSTONE**; medium grained; laminar bedding; minor coal streaks throughout; coal streaks between 154.5 to 156.5 ft.		RC-16	118/120			100		

GEOSYNTEC AEP CARDINAL FAR1-FAR2RWL GEOSYNTECAEPCARDINALFAR1FAR2RWL.GPJ 10/17/2006 LBL

GEOSYNTEC CONSULTANTS	Project: AEP - Cardinal Plant: FAR1, FAR2 & RWL	Log of Boring: M-20 Sheet 5 of 8
Project No:	Date: 8/15/06	Initial GWL at:
Location: Brilliant, Ohio	Total Borehole Depth: 281 ft.	Drilling Company: Pennsylvania Drilling Co.
Logged by: Scott Hayder	Surface Elevation:	Driller: Earl Dye
Drilling Method: HSA, RC	N: E:	Drilling Machine:
Sampling Comments:		

Depth, ft.		SOIL DESCRIPTION	Strata Plot	Sample No.	Recovery, in.	Blows / 6 in.	Standard Penetration Resistance Blows/ft N-Value 20 40 60 80	RQD (%)	Plastic Index	Comments
		Light gray to dark gray, **SANDSTONE**; medium grained; laminar bedding; minor coal streaks throughout; coal streaks between 154.5 to 156.5 ft. Fractures at 161.5 ft.								M-20 screen from 220.0 - 160.0 ft.
165				RC-17	120/120			93		
170										
	171	Coal streaks between 171.0 to 174.0 ft.								
175				RC-18	120/120			98		
180										
185				RC-19	120/120			76		
		Coal streaks at 188.5 ft								
190										
	191	Coal streaks at 191.0 ft. Fractures at 191.5 ft.								
195				RC-20	120/120			97		

GEOSYNTEC AEP CARDINAL FAR1FAR2RWL GEOSYNTECAEPCARDINALFAR1FAR2RWL.GPJ 10/17/2006 LBL

GEOSYNTEC CONSULTANTS	Project: AEP - Cardinal Plant: FAR1, FAR2 & RWL	Log of Boring: M-20 Sheet 6 of 8
Project No:	Date: 8/15/06	Initial GWL at:
Location: Brilliant, Ohio	Total Borehole Depth: 281 ft.	Drilling Company: Pennsylvania Drilling Co.
Logged by: Scott Hayder	Surface Elevation:	Driller: Earl Dye
Drilling Method: HSA, RC	N: E:	Drilling Machine:
Sampling Comments:		

Depth, ft.	SOIL DESCRIPTION	Strata Plot	Sample No.	Recovery, in.	Blows / 6 in.	Standard Penetration Resistance Blows/ft N-Value (20 40 60 80)	RQD (%)	Plastic Index	Comments
	Light gray to dark gray, **SANDSTONE**; medium grained; laminar bedding; minor coal streaks throughout; coal streaks between 154.5 to 156.5 ft. 1" coal at 200.0 ft.								M-20 screen from 220.0 - 160.0 ft.
205			RC-21	120/120			61		
210	Coal streaks at 210.5 ft.								
	Sandstone conglomerate from 212.5 to 213.0 ft. Coal streaks at 213.0 ft.								
215	Light gray to dark gray, **SANDSTONE**; medium grained; laminar bedding; minor coal streaks throughout.		RC-22	120/120			87		
217	Coal streaks at 216 ft.								
	Hard, dark gray, **CLAYSHALE**; massive.								
220									
	Slicken slides at 222.0 ft.								
225	Horizontal fracture at 225.0 ft.		RC-23	104/120			86		
	Plant fossils at 228.0 ft.								
230									
235			RC-24	120/120			87		
	Slicken slides at 237.0 ft. Slicken slides at 237.5 ft. Slicken slides at 238.0 ft.								

GEOSYNTEC AEP CARDINAL FAR1FAR2RWL GEOSYNTECAEPCARDINALFAR1FAR2RWL.GPJ 10/17/2006 LBL

GEOSYNTEC CONSULTANTS	Project: AEP - Cardinal Plant: FAR1, FAR2 & RWL	Log of Boring: M-20 Sheet 7 of 8
Project No:	Date: 8/15/06	Initial GWL at:
Location: Brilliant, Ohio	Total Borehole Depth: 281 ft.	Drilling Company: Pennsylvania Drilling Co.
Logged by: Scott Hayder	Surface Elevation:	Driller: Earl Dye
Drilling Method: HSA, RC	N: E:	Drilling Machine:
Sampling Comments:		

Depth, ft.		SOIL DESCRIPTION	Strata Plot	Sample No.	Recovery, in.	Blows / 6 in.	Standard Penetration Resistance Blows/ft N-Value (20 40 60 80)	RQD (%)	Plastic Index	Comments
		Hard, dark gray, **CLAYSHALE**; massive.								
245		Horizontal fracture at 246.0 ft.; slicken slides at 246.0 ft. Horizontal fracture at 246.5 ft. Slicken slides at 248.0 ft.		RC-25	120/120			59		
250										
	251.5	Gray, coarse to fine **SANDSTONE** from 251.5 to 252.0 ft.								
	252									
	252.5	Hard, dark gray, **CLAYSHALE** from 252.0 to 252.5 ft.; massive.								
	254.5	Gray, medium to fine **SANDSTONE** from 252.5 to 254.5 ft.		RC-26	119/120			95		
255		Hard, dark gray, **CLAYSHALE**; massive.								
260		Vertical fracture at 260.0 ft.								
265				RC-27	119/120			96		
270										
	271	Gray, **SANDSTONE**; medium to fine.								
	272.5	Hard, dark gray, **CLAYSHALE**; massive.								
	274	**COAL**.								
275				RC-28	120/120			58		
	276	Hard, dark gray, **CLAYSHALE**.								

GEOSYNTEC AEP CARDINAL FAR1FAR2RWL GEOSYNTECAEPCARDINALFAR1FAR2RWL.GPJ 10/17/2006 LBL

GEOSYNTEC CONSULTANTS	Project: AEP - Cardinal Plant: FAR1, FAR2 & RWL	Log of Boring: M-20 Sheet 8 of 8
Project No:	Date: 8/15/06	Initial GWL at:
Location: Brilliant, Ohio	Total Borehole Depth: 281 ft.	Drilling Company: Pennsylvania Drilling Co.
Logged by: Scott Hayder	Surface Elevation:	Driller: Earl Dye
Drilling Method: HSA, RC	N: E:	Drilling Machine:
Sampling Comments:		

Depth, ft.	SOIL DESCRIPTION	Strata Plot	Sample No.	Recovery, in.	Blows / 6 in.	Standard Penetration Resistance Blows/ft N-Value 20 40 60 80	RQD (%)	Plastic Index	Comments
	Hard, dark gray, **CLAYSHALE**.								
	End of Boring at 281.0 ft.								
285									
290									
295									
300									
305									
310									
315									

GEOSYNTEC AEP CARDINAL FAR FAR2RWL GEOSYNTECAEPCARDINALFAR1FAR2RWL.GPJ 10/17/2006 LBL

Geosyntec consultants engineers | scientists | innovators	**Client:** AEP-Cardinal **Project:** CHE8126L **Address:** 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No.** S-GS-1 **Page:** 1 of 6

Drilling Start Date:	**03/08/2016 16:15**	Boring Depth (ft):	**102**	Well Depth (ft):	**78**
Drilling End Date:	**03/09/2016 10:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,012.81**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,014.57**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 833,647.7 E 2,514,525.6**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
0									Overburden: No sample recovered with coring wireline rig.		0
5											5
10											10
15											15
20											20

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. S-GS-1** **Page: 2 of 6**

Drilling Start Date:	**03/08/2016 16:15**	Boring Depth (ft):	**102**	Well Depth (ft):	**78**
Drilling End Date:	**03/09/2016 10:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,012.81**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,014.57**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 833,647.7 E 2,514,525.6**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
20											20
25				Run 1			78/96	48	(25') SANDSTONE: strong to very strong, medium gray (N5), fine grained, fresh, competent, slightly fractured, locally silty, massive.	RQD and recovery incorrect in box pictures.	25
									(27') Sandy SHALE: moderately strong, light olive gray (5Y 5/2), moderately decomposed, intensely fractured.		
30											30
				Run 2			102/ 180	31	(33') SILTSTONE: strong, medium light gray (N6), massive, limestone nodules, fresh, competent, slightly to moderately fractured.		
35									(34.7') Silty SANDSTONE: strong, medium light gray (N6), massive, micaceous, fresh to slightly decomposed, slightly disintegrated, moderately fractured.		35
									(38.2') SILTSTONE to CLAYSTONE: moderately strong, medium light gray (N6), calcite nodules, massive, locally fissile, moderately decomposed, moderately to		
40											40

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	BORING LOG Boring/Well No. S-GS-1 Page: 3 of 6

engineers | scientists | innovators

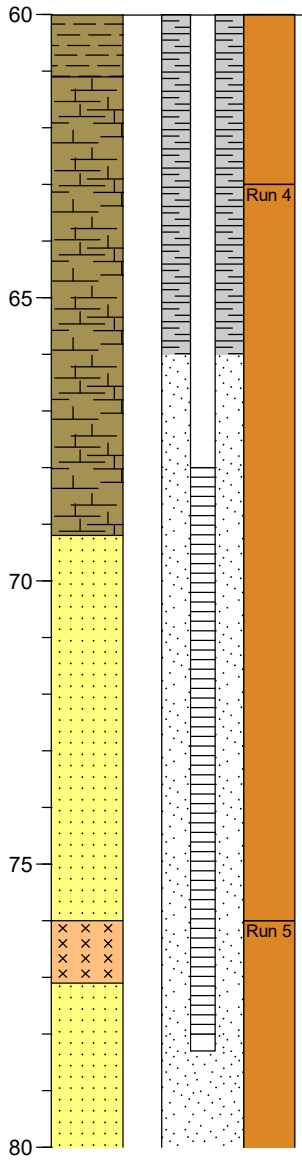
Drilling Start Date:	03/08/2016 16:15	Boring Depth (ft):	102	Well Depth (ft):	78
Drilling End Date:	03/09/2016 10:30	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,012.81	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,014.57	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 833,647.7 E 2,514,525.6	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
40									intensely fractured, at top of unit heavy clay infillings in fractures.		40
45				Run 3			175/ 180	41			45
50									(49') CLAYSTONE: strong, light gray to greenish gray, massive, fresh to slightly decomposed, slightly disintegrated, moderately fractured.		50
55											55
60											60

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	**Client:** AEP-Cardinal **Project:** CHE8126L **Address:** 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No.** S-GS-1 **Page:** 4 of 6

Drilling Start Date:	03/08/2016 16:15	Boring Depth (ft):	102	Well Depth (ft):	78
Drilling End Date:	03/09/2016 10:30	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,012.81	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,014.57	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 833,647.7 E 2,514,525.6	Filter Pack:	#5 Medium Coarse Sand



DEPTH (ft)	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS
60						(59.7') MUDSTONE: very weak, greenish gray, massive, highly decomposed, highly disintegrated.	
						(61.1') CLAYSTONE: strong, light gray to greenish gray, massive, fresh to slightly decomposed, slightly disintegrated, moderately fractured.	
	Run 4			144/ 156	64	(63') CLAYSTONE: strong, light gray to greenish gray, massive, fresh to slightly decomposed, slightly disintegrated, moderately fractured, medium dark gray calcareous veining lasts for 0.5 ft.	
65						(65.2') 0.5 ft of highly decomposed, intensely fractured.	
70						(69.2') SANDSTONE: strong, medium bluish gray (5B 5/1), massive, fine grained, limestone nodules, locally silty, fresh to slightly decomposed, competent, slightly to moderately fractured.	
75						(74.2') 0.5 ft of moderately disintegrated, very intensely fractured.	
	Run 5			162/ 180	47	(76') SILTSTONE: strong, medium gray, massive, slickensides, very intensely fractured, slightly decomposed, slightly disintegrated.	
						(77.1') SANDSTONE: strong, medium bluish gray (5B 5/1), massive, fine to medium grained, limestone nodules for 1.6 ft from top of sandstone, fresh, competent, slightly fractured, micaceous.	
80							

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. S-GS-1** **Page: 5 of 6**

Drilling Start Date:	**03/08/2016 16:15**	Boring Depth (ft):	**102**	Well Depth (ft):	**78**
Drilling End Date:	**03/09/2016 10:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,012.81**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,014.57**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 833,647.7 E 2,514,525.6**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
80									(78.1') Cross-bedding appears for rest of unit. (80.6') 0.8 ft vertical fracture, grades to medium yellowish brown for 1.5 ft.		80
85									(82.9') SILTSTONE: strong, medium light gray (N6), massive, slightly to moderately decomposed, slightly disintegrated, moderately fractured, at top of unit 1.3 ft vertical fracture.		85
90				Run 6			99/ 132	24	(91') SILTSTONE: strong to very strong, light gray (N6), large limestone nodules, massive, local slickensides, fresh to slightly decomposed, slightly disintegrated, moderately fractured.		90
95									(95.8') Becomes intensely fractured.		95
									(97.8') MUDSTONE: weak, medium light gray (N6) and grayish brown (5YR 3/2), highly decomposed, highly disintegrated. [CLARKSBURGH RED BEDS]		
100											100

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	**Client:** AEP-Cardinal **Project:** CHE8126L **Address:** 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No.** S-GS-1 **Page:** 6 of 6

Drilling Start Date:	**03/08/2016 16:15**	Boring Depth (ft):	**102**	Well Depth (ft):	**78**
Drilling End Date:	**03/09/2016 10:30**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,012.81**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,014.57**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 833,647.7 E 2,514,525.6**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
100											100
									End of borehole at 102 ft bgs. Well installed on 04/12/2016		
105											105

NOTES:

Geosyntec consultants engineers | scientists | innovators	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. S-GS-2** **Page: 1 of 5**

Drilling Start Date:	**03/09/2016 13:20**	Boring Depth (ft):	**89**	Well Depth (ft):	**84**
Drilling End Date:	**03/09/2016 18:00**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,009.07**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,011.75**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**Doug Mateas**	Location (X,Y):	**N 832,448.3 E 2,515,777.5**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
0									Overburden: No sample recovered with coring wireline rig.		0
5											5
10											10
15											15
20											20

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	**Client:** AEP-Cardinal **Project:** CHE8126L **Address:** 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No.** S-GS-2 **Page:** 2 of 5

Drilling Start Date:	03/09/2016 13:20	Boring Depth (ft):	89	Well Depth (ft):	84
Drilling End Date:	03/09/2016 18:00	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,009.07	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,011.75	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 832,448.3 E 2,515,777.5	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
20											20
25				Run 1			72/72	13	(25') SANDSTONE: strong to very strong, medium light gray (N6), fine grained, massive, micaceous, slightly decomposed, slightly disintegrated, moderately fractured, redox staining in fractures. (27.2') 0.9 ft vertical fracture, becomes shaly.		25
30									(28.1') Sandy CLAYSTONE: moderately strong, medium dark gray (N4) and grayish black (N2), locally sandy, micaceous, intensely fractured, moderately decomposed, moderately disintegrated.		30
				Run 2			156/156	63	(31') SILTSTONE: strong, medium gray (N5), massive, some limestone nodules, fresh to slightly decomposed, competent, slightly fractured.		
35									(34.8') Silty SANDSTONE: strong, medium gray (N5), fine grained, micaceous, cross bedding, slightly fractured, fresh, competent, mica content grades to more down unit.		35
									(37.4') MUDSTONE: dark greenish gray (5GY 4/1), highly decomposed.		
40									(37.9') Sandy SILTSTONE: strong, medium light gray (N6), locally sandy, slightly fractured, slightly to moderately decomposed,		40

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	BORING LOG Boring/Well No. S-GS-2 Page: 3 of 5

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Drilling Start Date:	03/09/2016 13:20	Boring Depth (ft):	89	Well Depth (ft):	84
Drilling End Date:	03/09/2016 18:00	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,009.07	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,011.75	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 832,448.3 E 2,515,777.5	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
40									slightly to moderately disintegrated, massive.		40
									(42.5') Vertical fracture with calcite infillings for rest of unit, dusky yellow to light brown color change.		
				Run 3			180/ 180	69	(43.8') Silty SANDSTONE: strong, medium light gray (N6), fine grained, cross bedding, fresh, competent, slightly fractured.		
45									(44') SILTSTONE: strong, greenish gray (5G 6/1), massive, limestone nodules/veining in fractures, fresh to slightly decomposed, competent, slightly fractured.		45
									(48.3') Sandy SILTSTONE: strong, greenish gray (5G 6/1), locally sandy, minor cross bedding in sandy sectors, massive, limestone nodules/veining in fractures, fresh to slightly decomposed, competent, slightly fractured.		
50											50
									(52.1') CLAYSHALE to CLAYSTONE: strong, greenish gray (5G 6/1), fissile, limestone nodules/veining in fractures, fresh to slightly decomposed, competent, slightly fractured.		
									(53.6') CLAYSHALE to CLAYSTONE: weak, dark greenish gray (5G 4/1), fissile, limestone nodules/veining in fractures, moderately to highly decomposed, moderately to highly disintegrated, intensely fractured.		
55											55
									(56.4') SILTSTONE: strong to very strong, light gray (N7) to medium dark gray (N4), massive, moderately fractured, slightly decomposed, slightly disintegrated, minor quartz inclusions.		
				Run 4			153/ 180	37	(59') SILTSTONE: moderately strong, greenish gray (5G 6/1), massive, moderately		
60											60

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	BORING LOG Boring/Well No. S-GS-2 Page: 4 of 5

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Drilling Start Date:	03/09/2016 13:20	Boring Depth (ft):	89	Well Depth (ft):	84
Drilling End Date:	03/09/2016 18:00	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,009.07	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,011.75	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 832,448.3 E 2,515,777.5	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
60									to intensely fractured, slightly decomposed, prominent calcareous nodules, clay infillings in fractures.		60
65											65
									(66.7') MUDSTONE: dark reddish brown (10R 3/4), highly decomposed.		
									(67.1') SILTSTONE to CLAYSTONE: moderately strong, greenish gray (5G 6/1), massive, moderately to intensely fractured, slightly decomposed, prominent calcareous veining and some local nodules.		
70									(68.6') Veining grades out.		70
									(69.1') Grades to grayish red purple (5RP 4/2), moderately decomposed, locally fissile.		
									(70.1') Changes to slightly decomposed, medium light gray (N6).		
75				Run 5			180/ 180	64	(74') SILTSTONE: moderately strong, greenish gray (5G 6/1), massive, moderately to intensely fractured, moderately decomposed, moderately disintegrated, clay infillings in fractures.		75
									(77') SANDSTONE: strong, medium gray (N5), massive, cross-bedding starts 2.2 ft down sandstone unit, limestone nodules for first 2.2 ft of unit, becomes micaceous after 2.2 ft of unit, unfractured, fresh, competent, fine grained.		
80											80

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** Boring/Well No. S-GS-2 Page: 5 of 5

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Drilling Start Date:	03/09/2016 13:20	Boring Depth (ft):	89	Well Depth (ft):	84
Drilling End Date:	03/09/2016 18:00	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,009.07	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,011.75	Seal Material(s):	Bentonite Pellets
Logged By:	Doug Mateas	Location (X,Y):	N 832,448.3 E 2,515,777.5	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
80											80
									(80.7') SILTSTONE: moderately strong, greenish gray (5G 6/1), massive, unfractured to slightly fractured, fresh, competent, clay infillings in fractures, minor limestone nodules.		
85									(84.2') SANDSTONE: strong, medium gray (N5), massive, unfractured, fresh, competent, fine grained. (84.7') CLAYSTONE to CLAYSHALE: greenish gray, slightly decomposed, moderately to highly fractured, 0.5 ft LIMESTONE unit at 3.1 ft into unit.		85
90									End of borehole at 89 ft bgs. Well installed on 04/12/2016		90
95											95
100											100

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	**Client:** AEP-Cardinal **Project:** CHE8126L **Address:** 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No.** S-GS-3 **Page:** 1 of 8

Drilling Start Date:	**03/16/2016 10:45**	Boring Depth (ft):	**143**	Well Depth (ft):	**140**
Drilling End Date:	**03/21/2016 16:15**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,036.93**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,039.42**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**D. Mateas & C. Gregory**	Location (X,Y):	**N 835,737.2 E 2,511,639.3**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
0									Overburden: No sample recovered with wireline coring rig.		0
5											5
10											10
15											15
20											20

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** Boring/Well No. S-GS-3 Page: 2 of 8

Drilling Start Date:	03/16/2016 10:45	Boring Depth (ft):	143	Well Depth (ft):	140
Drilling End Date:	03/21/2016 16:15	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,036.93	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,039.42	Seal Material(s):	Bentonite Pellets
Logged By:	D. Mateas & C. Gregory	Location (X,Y):	N 835,737.2 E 2,511,639.3	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
20											20
25											25
30											30
35											35
40											40

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	**Client:** AEP-Cardinal **Project:** CHE8126L **Address:** 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No.** S-GS-3 **Page:** 3 of 8

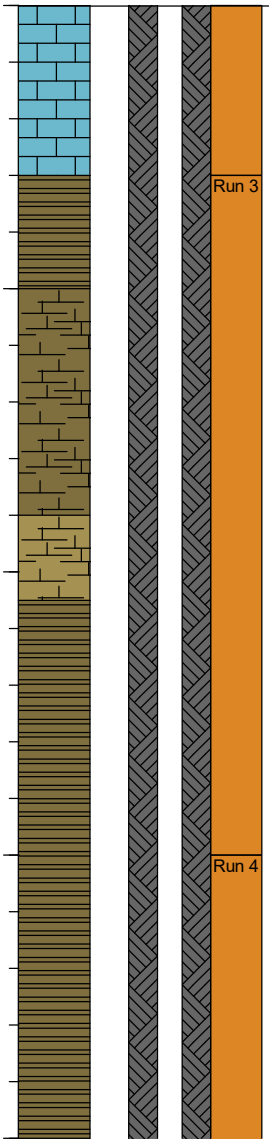
Drilling Start Date:	03/16/2016 10:45	Boring Depth (ft):	143	Well Depth (ft):	140
Drilling End Date:	03/21/2016 16:15	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,036.93	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,039.42	Seal Material(s):	Bentonite Pellets
Logged By:	D. Mateas & C. Gregory	Location (X,Y):	N 835,737.2 E 2,511,639.3	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
40				Run 1			42/ 120	28	Overburden: See remarks.	Began coring at 40 ft bgs due to boulders in overburden that roller bit could not drill through.	40
									(42.3') LIMESTONE: strong, greenish black (5GY 2/2), microcrystalline, moderately fractured, slightly decomposed, slightly disintegrated, clay in fractures.	Bedrock begins @ 42.3 ft.	
45									(46.3') Weak, highly decomposed, intensely fractured.		45
									(49.2') Vertical fracture (0.8 ft long).		
50				Run 2			133/ 156	64			50
									(51.1') CLAYSTONE: moderately strong, medium dark gray (N4), massive, moderately decomposed, intensely fractured.		
									(51.6') Changes to very weak, highly decomposed.		
55									(52.2') Sandy silty SHALE: strong, medium light gray (N6), massive, becomes laminated 0.5 ft from top of unit, competent, fresh, slightly fractured, micaceous, sand lenses increase at bottom of unit.		55
									(57.8') CLAYSHALE: strong, medium dark gray (N4), massive, slightly decomposed, competent, moderately fractured.		
60									(58.7') LIMESTONE: strong, medium dark		60

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. S-GS-3** **Page: 4 of 8**

Drilling Start Date:	**03/16/2016 10:45**	Boring Depth (ft):	**143**	Well Depth (ft):	**140**
Drilling End Date:	**03/21/2016 16:15**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,036.93**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,039.42**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**D. Mateas & C. Gregory**	Location (X,Y):	**N 835,737.2 E 2,511,639.3**	Filter Pack:	**#5 Medium Coarse Sand**



DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
60									gray (N3), microcrystalline, massive, fresh, competent, moderately fractured, limestone nodules.	Begin logging by C. Gregory.	60
				Run 3			131/ 144	44	(63') Sandy silty SHALE: strong, medium to dark gray (N3 to N4), moderately fractured, some fine sandy laminations, minor cross bedding.		
65									(65') CLAYSHALE: moderately strong, medium dark gray to dark greenish gray (5G 4/1), intensely fractured, moderately decomposed, calcareous nodules/lenses.		65
									(69') CLAYSTONE: weak, dark greenish gray (5G 4/1).		
70									(70.5') Sandy silty SHALE: strong, medium to dark gray (N3 to N4), moderately fractured, some fine sandy laminations, minor cross bedding.		70
75				Run 4			156/ 156	73			75
80											80

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** Boring/Well No. S-GS-3 Page: 5 of 8

Drilling Start Date:	03/16/2016 10:45	Boring Depth (ft):	143	Well Depth (ft):	140
Drilling End Date:	03/21/2016 16:15	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,036.93	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,039.42	Seal Material(s):	Bentonite Pellets
Logged By:	D. Mateas & C. Gregory	Location (X,Y):	N 835,737.2 E 2,511,639.3	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
80									(80') Silty SANDSTONE: strong, light gray (N7), moderately fractured, fresh, cross-bedded, thinly bedded, very fine grained.		80
									(81') SILTSTONE: strong, medium dark gray (N4).		
									(82') CLAYSHALE: medium dark gray (N4), silty slightly pyritic, with dark greenish gray claystone lenses.		
									(84-85') Very intensely fractured.		
85											85
									(86') Silty SHALE: strong, medium dark gray, moderately fractured.		
									(87-88') Calcareous.		
				Run 5			58/60	55	(88') LIMESTONE: strong, greenish gray (5G 6/1), massive, intensely fractured, slightly decomposed.		
90											90
									(90.5') Silty CLAYSTONE: moderately strong, medium dark gray to dark greenish gray, moderately decomposed.		
				Run 6			168/ 180	79	(93') CLAYSTONE and CLAYSHALE: moderately strong, medium dark gray to dark greenish gray, moderately decomposed, moderately fractured, quartz veins (yellowish gray 5Y 8/1).		
95											95
100											100

NOTES:

Geosyntec consultants	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No. S-GS-3** **Page: 6 of 8**

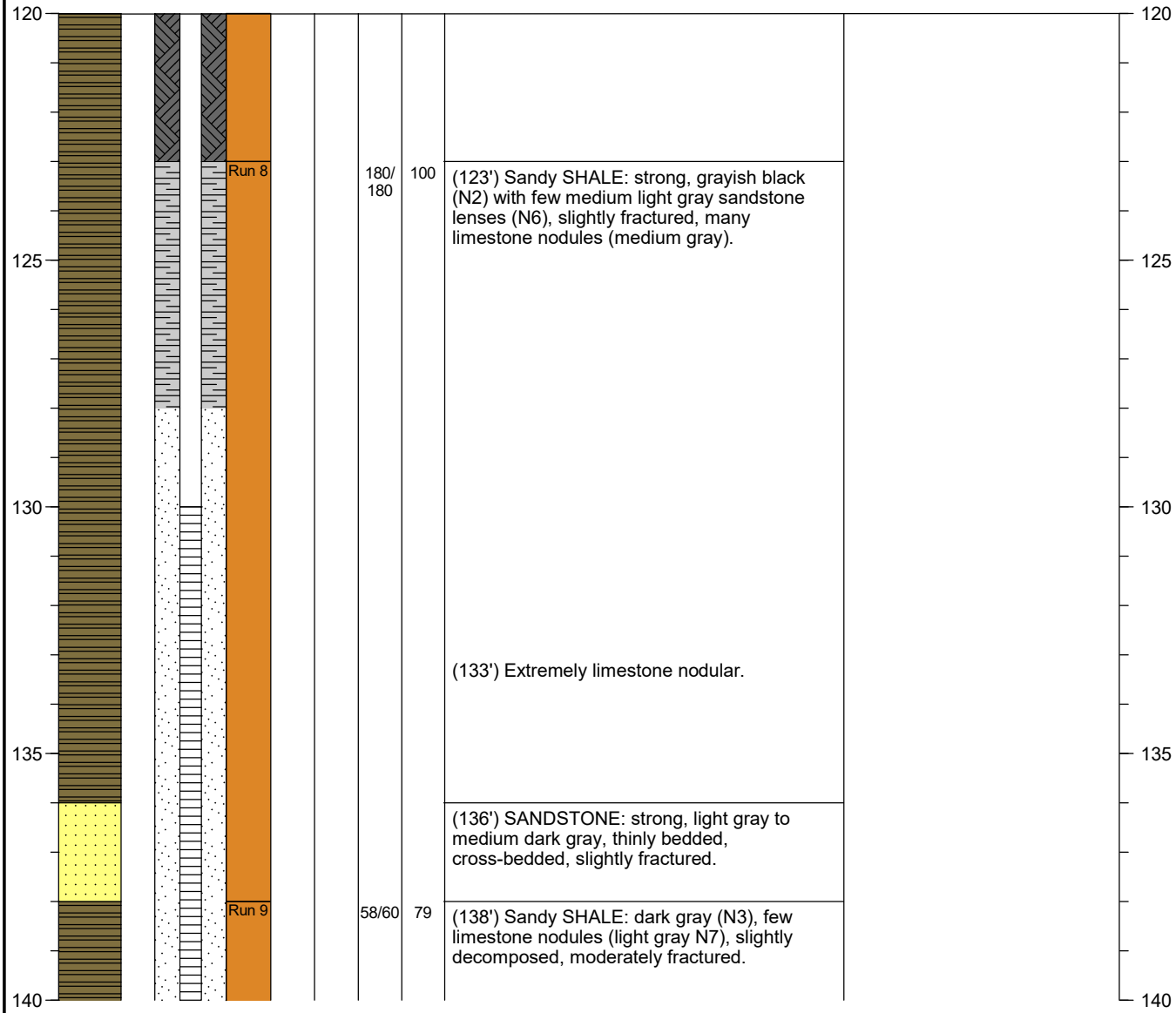
Drilling Start Date:	**03/16/2016 10:45**	Boring Depth (ft):	**143**	Well Depth (ft):	**140**
Drilling End Date:	**03/21/2016 16:15**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,036.93**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,039.42**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**D. Mateas & C. Gregory**	Location (X,Y):	**N 835,737.2 E 2,511,639.3**	Filter Pack:	**#5 Medium Coarse Sand**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
100											100
									(101-101.5') Intensely fractured.		
									(102.5-103') Intensely fractured, soft claystone seams.		
									(103') Silty SHALE: strong, medium dark gray (N4), few claystone lenses, moderately fractured, slightly decomposed.		
105											105
				Run 7			176/ 180	99	(108') Silty sandy SHALE: strong, medium dark gray, few yellowish gray areas, slightly fractured.		
110											110
115									(114.5') Silty SANDSTONE: strong, medium light gray (N6), few dark gray (N3) lenses, thinly bedded, cross-bedded, slightly micaceous, slightly fractured.		115
									(118') Sandy SHALE: strong, grayish black (N2) with few medium light gray sandstone lenses (N6), slightly fractured.		
120											120

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	**Client:** AEP-Cardinal **Project:** CHE8126L **Address:** 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** **Boring/Well No.** S-GS-3 **Page:** 7 of 8

Drilling Start Date:	**03/16/2016 10:45**	Boring Depth (ft):	**143**	Well Depth (ft):	**140**
Drilling End Date:	**03/21/2016 16:15**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Layne Drilling**	Sampling Method(s):	**Rock Core**	Screen Slot (in):	**0.010**
Drilling Method:	**Rock Core**	DTW During Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**CS1500 Wireline Rig**	Ground Surface Elev. (ft):	**1,036.93**	Screen Material:	**Pre-packed Sch 40 PVC**
Driller:	**Bill Womack**	Top of Casing Elev. (ft):	**1,039.42**	Seal Material(s):	**Bentonite Pellets**
Logged By:	**D. Mateas & C. Gregory**	Location (X,Y):	**N 835,737.2 E 2,511,639.3**	Filter Pack:	**#5 Medium Coarse Sand**



DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Date & Time	Blow Counts	Recovery (in)	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
120–125				Run 8			180/180	100	(123') Sandy SHALE: strong, grayish black (N2) with few medium light gray sandstone lenses (N6), slightly fractured, many limestone nodules (medium gray).		120–125
125–135									(133') Extremely limestone nodular.		125–135
135–136									(136') SANDSTONE: strong, light gray to medium dark gray, thinly bedded, cross-bedded, slightly fractured.		135–136
136–140				Run 9			58/60	79	(138') Sandy SHALE: dark gray (N3), few limestone nodules (light gray N7), slightly decomposed, moderately fractured.		136–140

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: AEP-Cardinal Project: CHE8126L Address: 3202 Twp Rd 163, Brilliant, OH	**BORING LOG** Boring/Well No. S-GS-3 Page: 8 of 8

Drilling Start Date:	03/16/2016 10:45	Boring Depth (ft):	143	Well Depth (ft):	140
Drilling End Date:	03/21/2016 16:15	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Layne Drilling	Sampling Method(s):	Rock Core	Screen Slot (in):	0.010
Drilling Method:	Rock Core	DTW During Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	CS1500 Wireline Rig	Ground Surface Elev. (ft):	1,036.93	Screen Material:	Pre-packed Sch 40 PVC
Driller:	Bill Womack	Top of Casing Elev. (ft):	1,039.42	Seal Material(s):	Bentonite Pellets
Logged By:	D. Mateas & C. Gregory	Location (X,Y):	N 835,737.2 E 2,511,639.3	Filter Pack:	#5 Medium Coarse Sand

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Date & Time	COLLECT: Blow Counts	COLLECT: Recovery (in)	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	REMARKS	DEPTH (ft)
140									(140.5') Silty SHALE: grayish black (N2), intensely fractured, moderately decomposed. (141-143') Medium gray, calcareous, massive.		140
									End of borehole at 143 ft bgs. Well installed on 04/05/2016		
145											145
150											150

NOTES:

APPENDIX D

WELL CONSTRUCTION LOGS

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

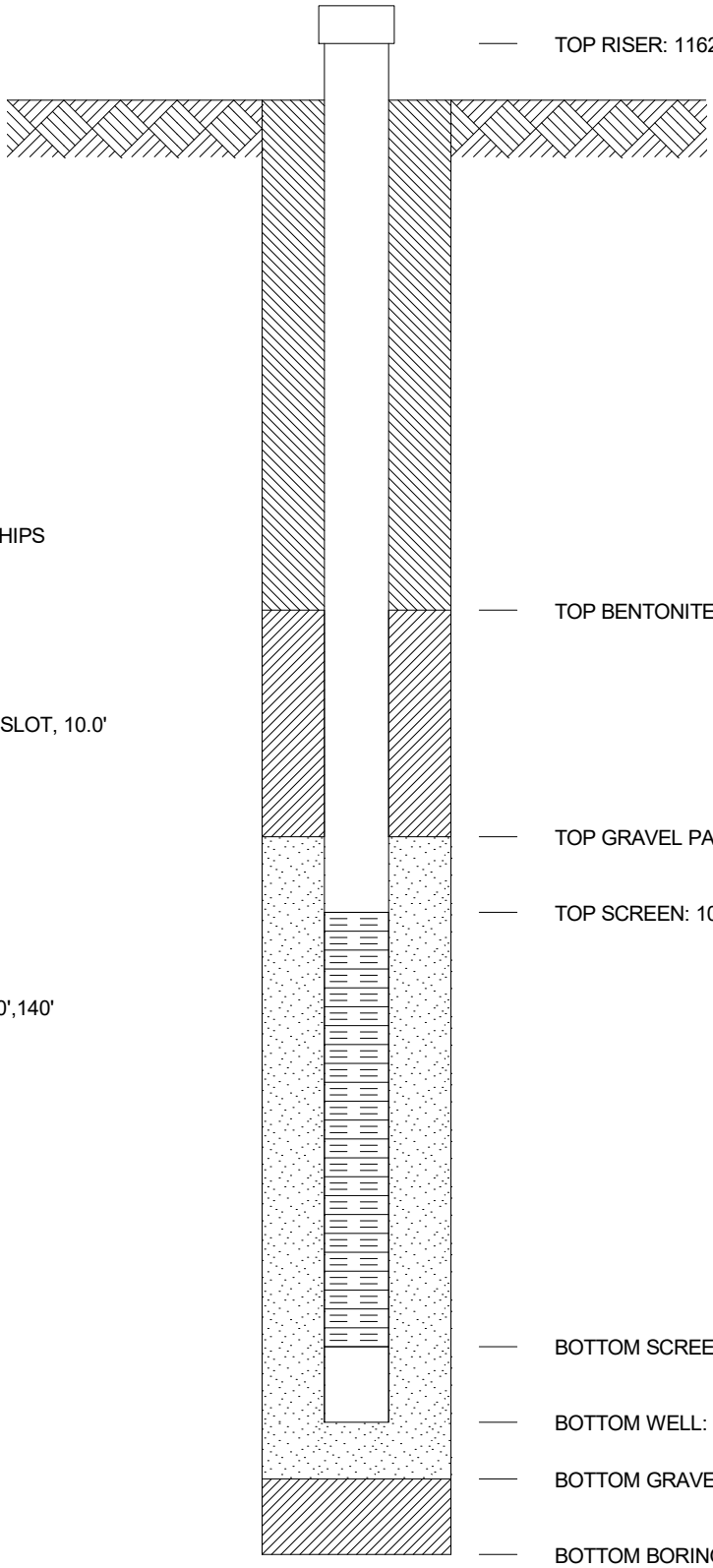
WELL No. **CA-0623A** BORING No. **CA-0623A** INSTALLED **8/16/16**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 836,300.1 E 2,514,227.5**

SYSTEM **State Plane using NAD27/29**

GROUND ELEVATION 1159.62 FT.



TOP RISER: 1162.72 FT.

TOP BENTONITE SEAL: 1012.62 FT.

TOP GRAVEL PACK: 1005.62 FT.

TOP SCREEN: 1005.62 FT.

BOTTOM SCREEN: 995.62 FT.

BOTTOM WELL: 995.62 FT.

BOTTOM GRAVEL PACK: 995.62 FT.

BOTTOM BORING: 995.62 FT.

GROUT SEAL: BENTONITE CHIPS

BENTONITE SEAL: PELLETS

SCREEN: 2" dia., U-PACK .10 SLOT, 10.0'

GRAVEL PACK:

RISER PIPE: 2", dia., PVC

SPACERS, DEPTH: 20',60',100',140'

GEOMCNST CD_FGD_LANDFILL BORINGS & WELLS.GPJ AEP.GDT 8/22/16

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

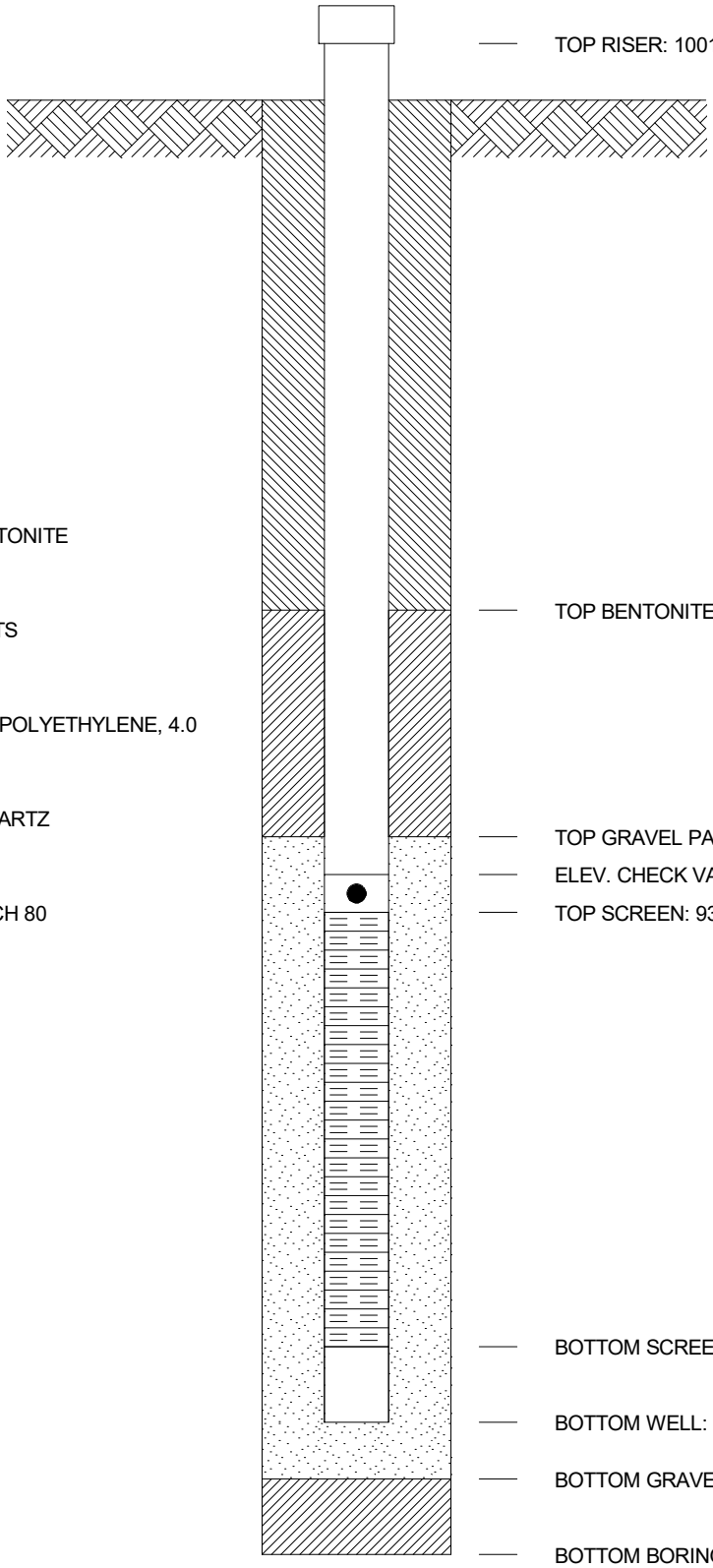
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-1** BORING No. **8502** INSTALLED **12/12/85**

PROJECT **CARDINAL PLANT**

COORDINATES **N 831,399.8 E 2,515,207.8**

SYSTEM **STATE PLANE**

GROUND ELEVATION 999.59 FT.



TOP RISER: 1001.23 FT.

TOP BENTONITE SEAL: 970.70 FT.

TOP GRAVEL PACK: 965.50 FT.

ELEV. CHECK VALVE: 935.69 FT.

TOP SCREEN: 935.09 FT.

BOTTOM SCREEN: 931.09 FT.

BOTTOM WELL: 931.00 FT.

BOTTOM GRAVEL PACK: 929.50 FT.

BOTTOM BORING: 929.50 FT.

GROUT SEAL: CEMENT\BENTONITE

BENTONITE SEAL: PI PELLETS

SCREEN: 1.25 dia., POROUS POLYETHYLENE, 4.0

GRAVEL PACK: # 4 OHIO QUARTZ

RISER PIPE: 0.8, dia., PVC SCH 80

SPACERS, DEPTH:

4' GEOMON

GEOMCNST CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

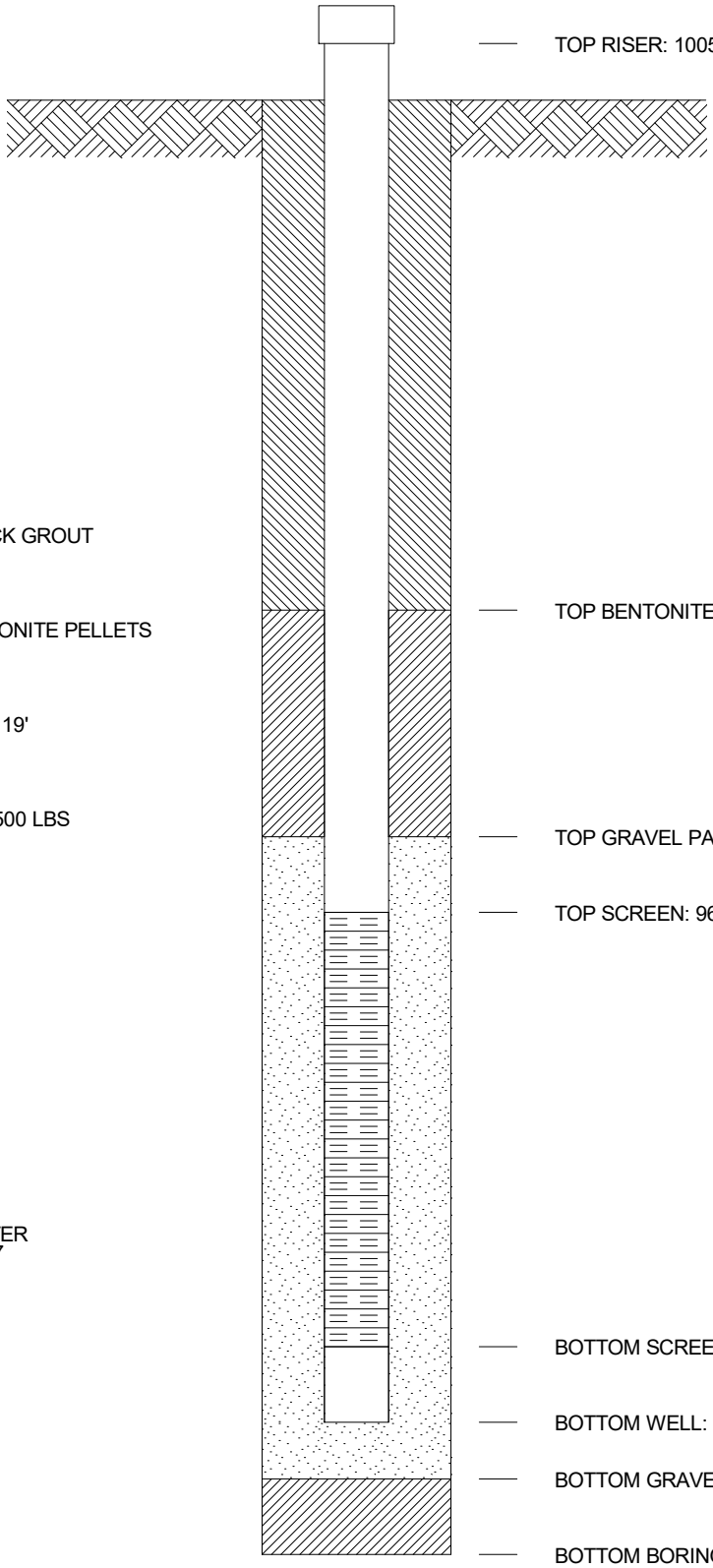
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-10** BORING No. **CA-0607** INSTALLED **1/9/07**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 831,867.6 E 2,516,495.5**

SYSTEM

GROUND ELEVATION 1002.48 FT.



TOP RISER: 1005.19 FT.

TOP BENTONITE SEAL: 980.38 FT.

TOP GRAVEL PACK: 973.68 FT.

TOP SCREEN: 962.78 FT.

BOTTOM SCREEN: 943.78 FT.

BOTTOM WELL: 943.38 FT.

BOTTOM GRAVEL PACK: 941.08 FT.

BOTTOM BORING: 902.68 FT.

GROUT SEAL: 75 GALS QUICK GROUT

BENTONITE SEAL: 100# BENONITE PELLETS

SCREEN: 2' dia., 0.20 SLOT, 19'

GRAVEL PACK: #4 QUARTZ 500 LBS

RISER PIPE: 1", dia., PVC

SPACERS, DEPTH: 51', 21'

-SWL @ INSTALL 44.8'
-DRILLED W/6" AIR HAMMER
-FLUSHED W/700 GALS WATER
-DECONNED TOOLS 01/08/07

-3' SS Pump Type
-Pump intake @ 56.1'

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

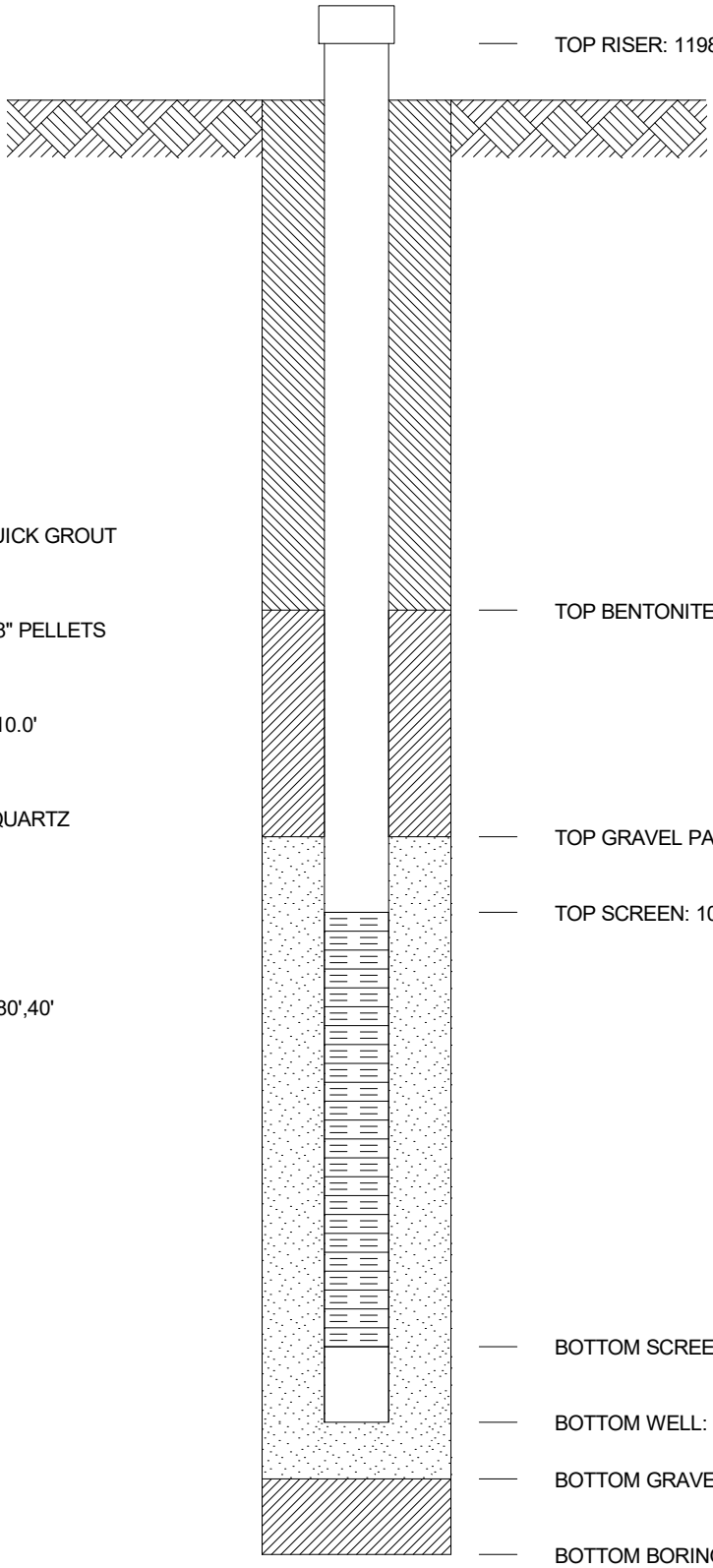
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-17** BORING No. **CA-0601** INSTALLED **6/12/07**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 833,612.2 E 2,512,715.1**

SYSTEM

GROUND ELEVATION 1195.63 FT.



TOP RISER: 1198.00 FT.

TOP BENTONITE SEAL: 1013.83 FT.

TOP GRAVEL PACK: 1008.43 FT.

TOP SCREEN: 1005.33 FT.

BOTTOM SCREEN: 995.83 FT.

BOTTOM WELL: 995.13 FT.

BOTTOM GRAVEL PACK: 993.33 FT.

BOTTOM BORING: 780.13 FT.

GROUT SEAL: ~200 GALS QUICK GROUT

BENTONITE SEAL: 75 LBS 3/8" PELLETS

SCREEN: 2" dia., .020 SLOT, 10.0'

GRAVEL PACK: 300 LBS #4 QUARTZ

RISER PIPE: 2", dia., PVC

SPACERS, DEPTH: 170',120',80',40'

NOTES:
-Decon 07/11/07
-Drilled w/6" Air Hammer
-SWL @ Install 193.4'
-Hydrated Pellets

-3' SS Pump Type
-Pump intake @ 199.5'

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

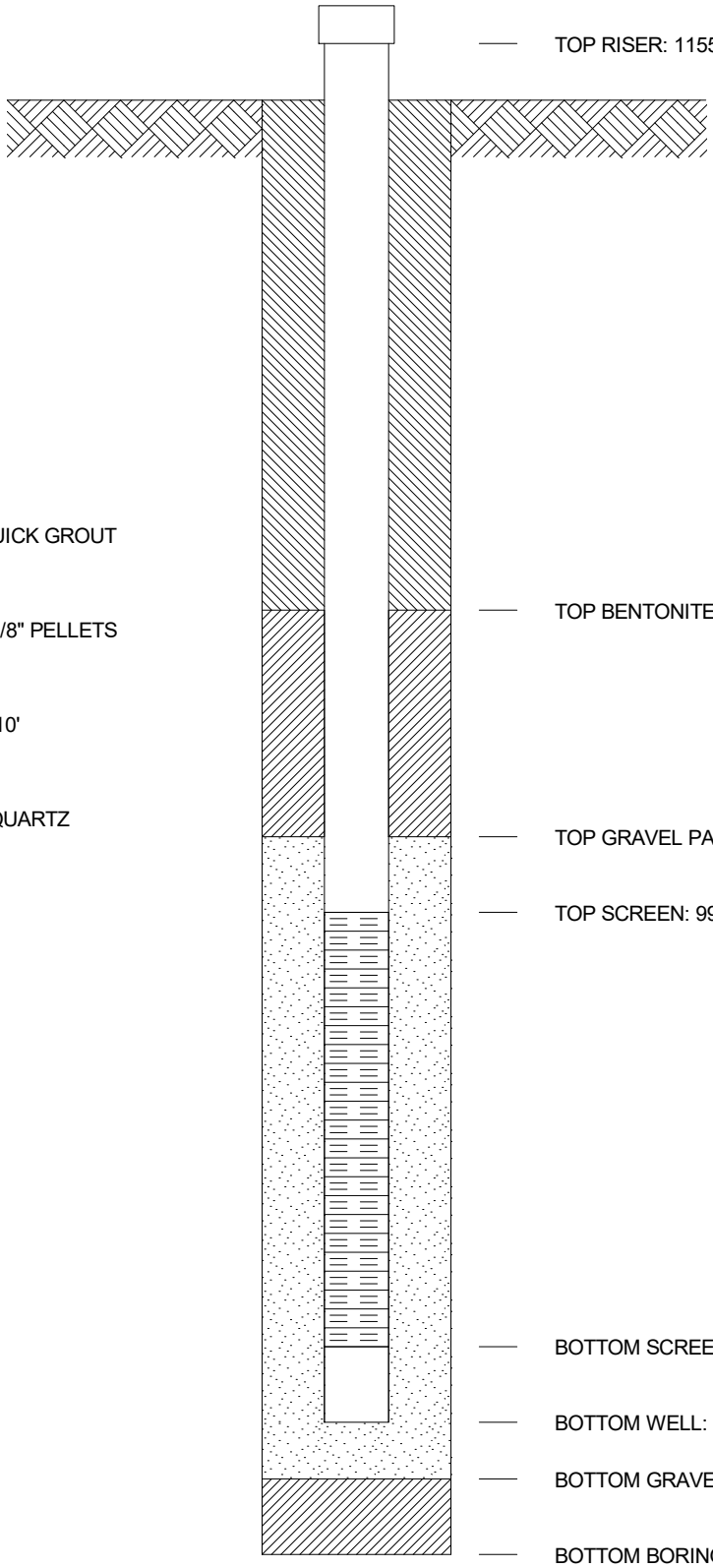
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-18** BORING No. **CA-0603** INSTALLED **8/22/07**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 832,194.6 E 2,513,596.2**

SYSTEM

GROUND ELEVATION 1153.26 FT.



TOP RISER: 1155.37 FT.

TOP BENTONITE SEAL: 1012.86 FT.

TOP GRAVEL PACK: 1003.26 FT.

TOP SCREEN: 999.46 FT.

BOTTOM SCREEN: 989.96 FT.

BOTTOM WELL: 989.26 FT.

BOTTOM GRAVEL PACK: 987.86 FT.

BOTTOM BORING: 987.86 FT.

GROUT SEAL: ~250 GALS QUICK GROUT

BENTONITE SEAL: 100 LBS 3/8" PELLETS

SCREEN: 2" dia., .020 SLOT, 10'

GRAVEL PACK: 250 LBS #4 QUARTZ

RISER PIPE: 2", dia., PVC

SPACERS, DEPTH: 110', 30'

NOTES:
-Decon 07/09/07
-Drilled w/6" Air Hammer
-SWL @ Install 155.2'
-Hydrated Pellets

-3' SS Pump Type
-Pump intake @ 163'

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

COMPANY **AMERICAN ELECTRIC POWER**

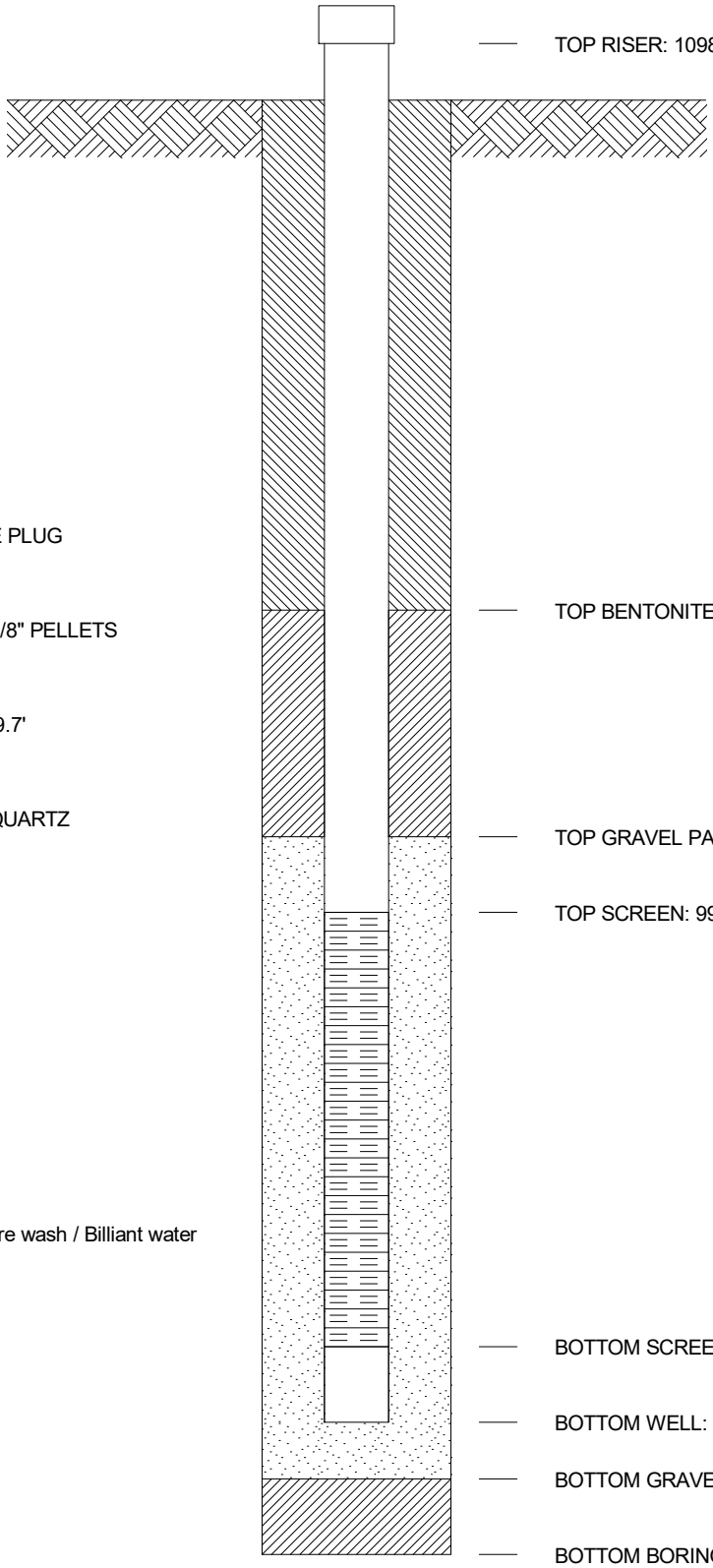
WELL No. **S-19A** BORING No. **CA-0606A** INSTALLED **7/28/11**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 830,793.8 E 2,514,074.6**

SYSTEM

GROUND ELEVATION 1095.98 FT.



TOP RISER: 1098.60 FT.

TOP BENTONITE SEAL: 1015.98 FT.

TOP GRAVEL PACK: 1001.08 FT.

TOP SCREEN: 995.98 FT.

BOTTOM SCREEN: 985.98 FT.

BOTTOM WELL: 985.28 FT.

BOTTOM GRAVEL PACK: 984.98 FT.

BOTTOM BORING: 986.28 FT.

GROUT SEAL: 750 LBS HOLE PLUG

BENTONITE SEAL: 200 LBS 3/8" PELLETS

SCREEN: 2" dia., .020 SLOT, 9.7'

GRAVEL PACK: 600 LBS #4 QUARTZ

RISER PIPE: 2", dia.,

SPACERS, DEPTH: N/A

NOTES:
-Replacement well for S-19
-Decon 07/27/11 / High-pressure wash / Billiant water system
-Drilled w/6" air hammer
-SWL @ install 109.0'
-Hole would not grout up

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

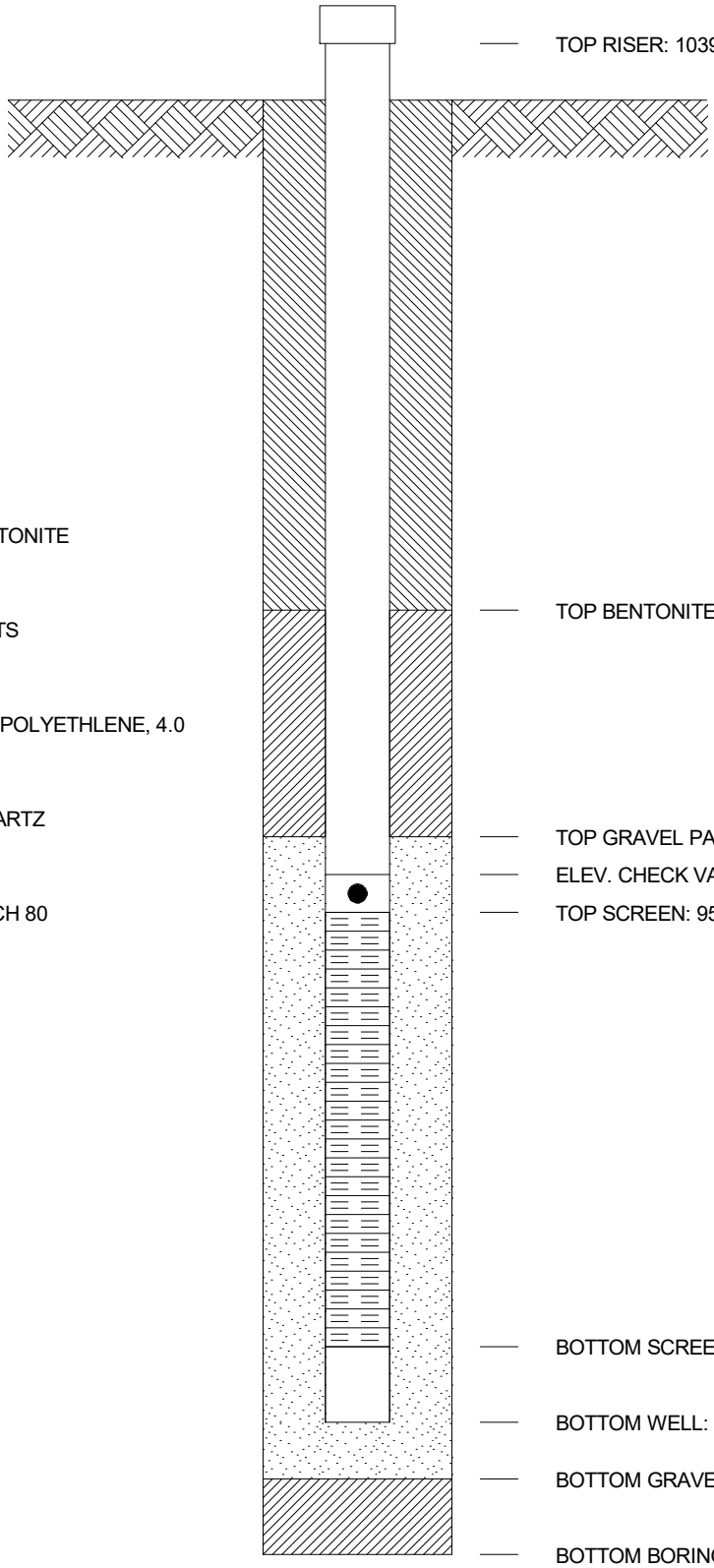
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-2** BORING No. **8503** INSTALLED **12/17/85**

PROJECT **CARDINAL PLANT**

COORDINATES **N 831,038.2 E 2,514,714.2**

SYSTEM **STATE PLANE**

GROUND ELEVATION 1038.60 FT.



TOP RISER: 1039.89 FT.

TOP BENTONITE SEAL: 998.10 FT.

TOP GRAVEL PACK: 992.10 FT.

ELEV. CHECK VALVE: 958.70 FT.

TOP SCREEN: 958.10 FT.

BOTTOM SCREEN: 954.10 FT.

BOTTOM WELL: 954.10 FT.

BOTTOM GRAVEL PACK: 948.60 FT.

BOTTOM BORING: 948.60 FT.

GROUT SEAL: CEMENT\BENTONITE

BENTONITE SEAL: PI PELLETS

SCREEN: 1.25 dia., POROUS POLYETHLENE, 4.0

GRAVEL PACK: #4 OHIO QUARTZ

RISER PIPE: 0.8, dia., PVC SCH 80

SPACERS, DEPTH:

4' GEOMON

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

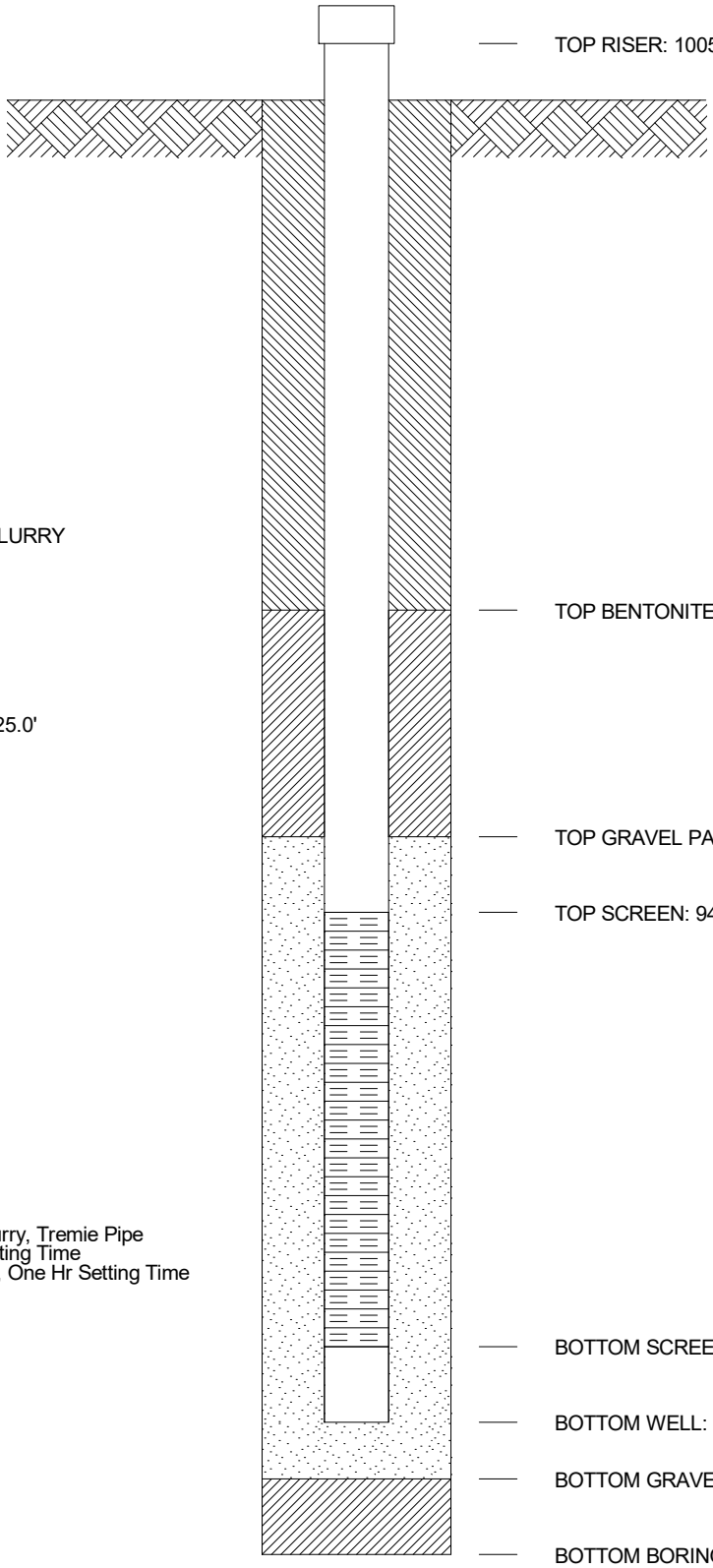
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-20** BORING No. **CA-0619** INSTALLED **8/24/06**

PROJECT **CARDINAL LANDFILL**

COORDINATES **N 830,850.2 E 2,515,582.3**

SYSTEM

GROUND ELEVATION 1003.43 FT.



TOP RISER: 1005.88 FT.

TOP BENTONITE SEAL: 963.13 FT.

TOP GRAVEL PACK: 957.93 FT.

TOP SCREEN: 943.43 FT.

BOTTOM SCREEN: 918.43 FT.

BOTTOM WELL: 918.43 FT.

BOTTOM GRAVEL PACK: 916.43 FT.

BOTTOM BORING: 916.43 FT.

GROUT SEAL: BENTONITE SLURRY

BENTONITE SEAL: PELLETS

SCREEN: 1" dia., .020 SLOT, 25.0'

GRAVEL PACK: FILTER PRO

RISER PIPE: 2", dia., PVC

SPACERS, DEPTH:

NOTES:
-Surface Seal: Cement
-Annular Sealant: Bentonite Slurry, Tremie Pipe Installation, Overnight Setting Time
-Bentonite Seal: Poured Slowly, One Hr Setting Time
-Sand Pack: Poured Slowly

-3' PVC Pump Type
-Pump intake @ 84.5'

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

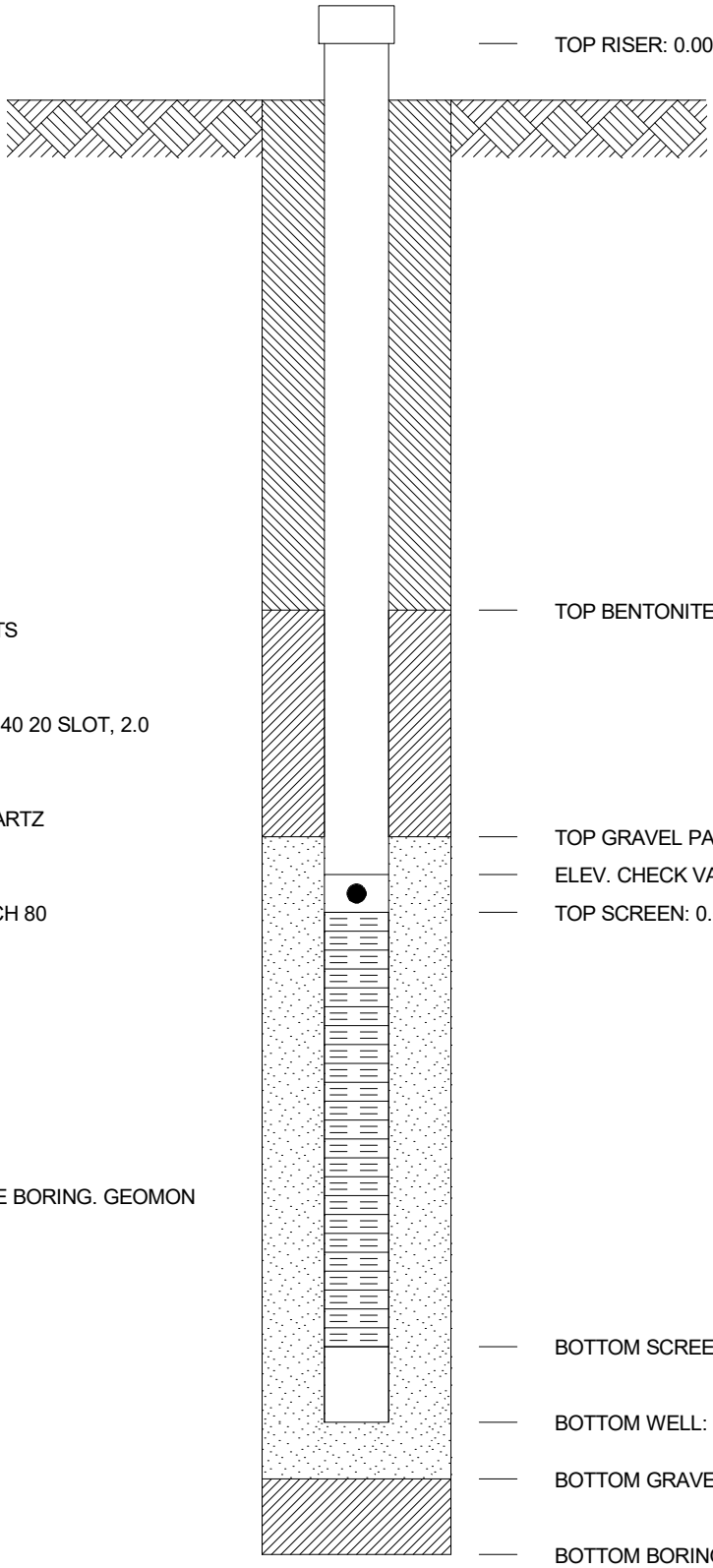
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-4** BORING No. **88-5-6** INSTALLED **8/16/88**

PROJECT **CARDINAL PLANT**

COORDINATES **N 834,352.3 E 2,513,052.2**

SYSTEM **STATE PLANE**

GROUND ELEVATION 1010.90 FT.



TOP RISER: 0.00 FT.

TOP BENTONITE SEAL: 983.90 FT.

TOP GRAVEL PACK: 978.90 FT.

ELEV. CHECK VALVE: 931.90 FT.

TOP SCREEN: 0.00 FT.

BOTTOM SCREEN: 0.00 FT.

BOTTOM WELL: 928.90 FT.

BOTTOM GRAVEL PACK: 926.90 FT.

BOTTOM BORING: 805.90 FT.

GROUT SEAL: BENTONITE

BENTONITE SEAL: PI PELLETS

SCREEN: 1.25 dia., PVC SCH 40 20 SLOT, 2.0

GRAVEL PACK: #4 OHIO QUARTZ

RISER PIPE: 0.8, dia., PVC SCH 80

SPACERS, DEPTH:

WELLS S-4 AND M-2 IN SAME BORING. GEOMON

GEOMCNST CD SI.GPJ AEP.GDT 7/17/15

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

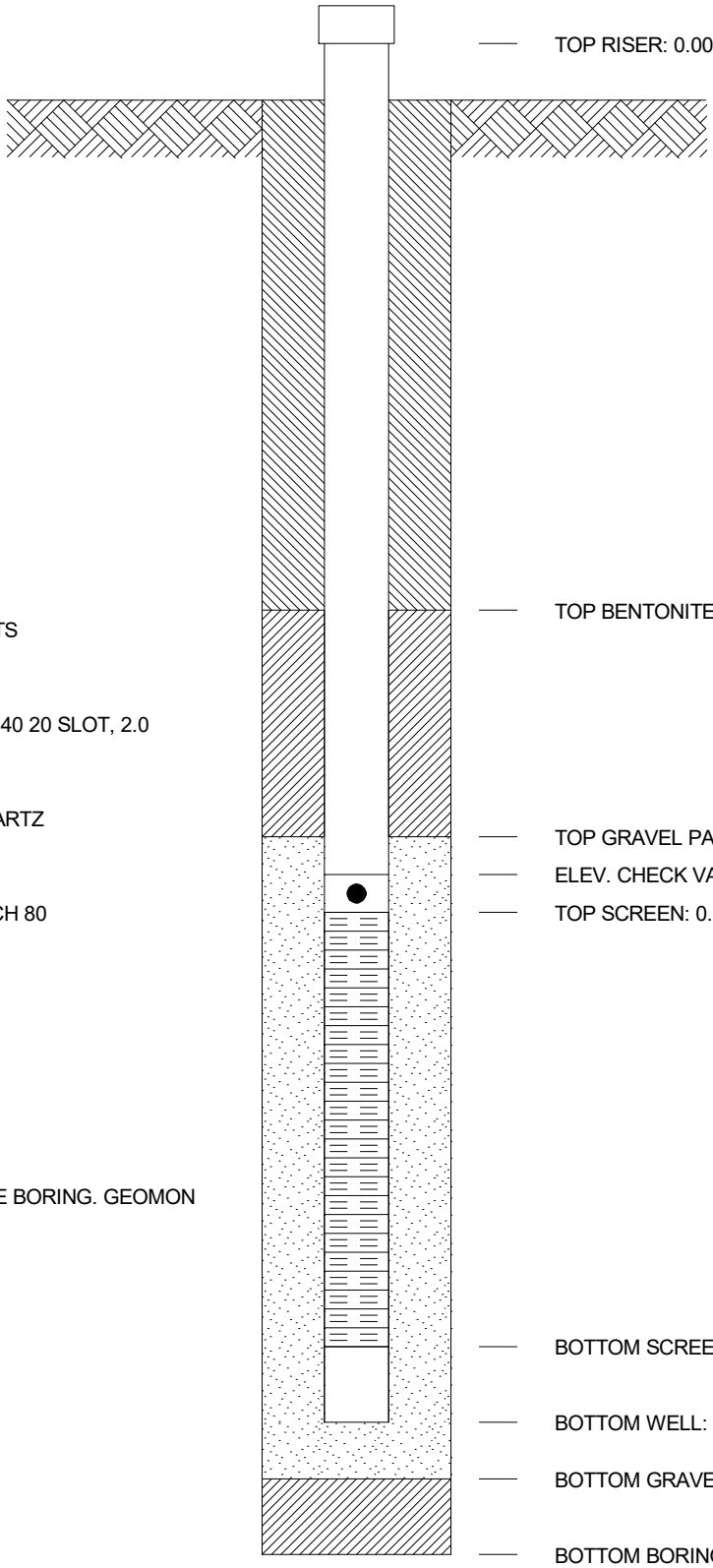
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-5** BORING No. **88-7-8** INSTALLED **8/10/88**

PROJECT **CARDINAL PLANT**

COORDINATES **N 834,917.6 E 2,513,916.2**

SYSTEM **STATE PLANE**

GROUND ELEVATION 1000.20 FT.



TOP RISER: 0.00 FT.

TOP BENTONITE SEAL: 980.60 FT.

TOP GRAVEL PACK: 975.60 FT.

ELEV. CHECK VALVE: 930.60 FT.

TOP SCREEN: 0.00 FT.

BOTTOM SCREEN: 0.00 FT.

BOTTOM WELL: 927.60 FT.

BOTTOM GRAVEL PACK: 925.60 FT.

BOTTOM BORING: 805.40 FT.

GROUT SEAL: BENTONITE

BENTONITE SEAL: PI PELLETS

SCREEN: 1.25 dia., PVC SCH 40 20 SLOT, 2.0

GRAVEL PACK: #4 OHIO QUARTZ

RISER PIPE: 0.8, dia., PVC SCH 80

SPACERS, DEPTH:

WELLS S-5 AND M-3 IN SAME BORING. GEOMON

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

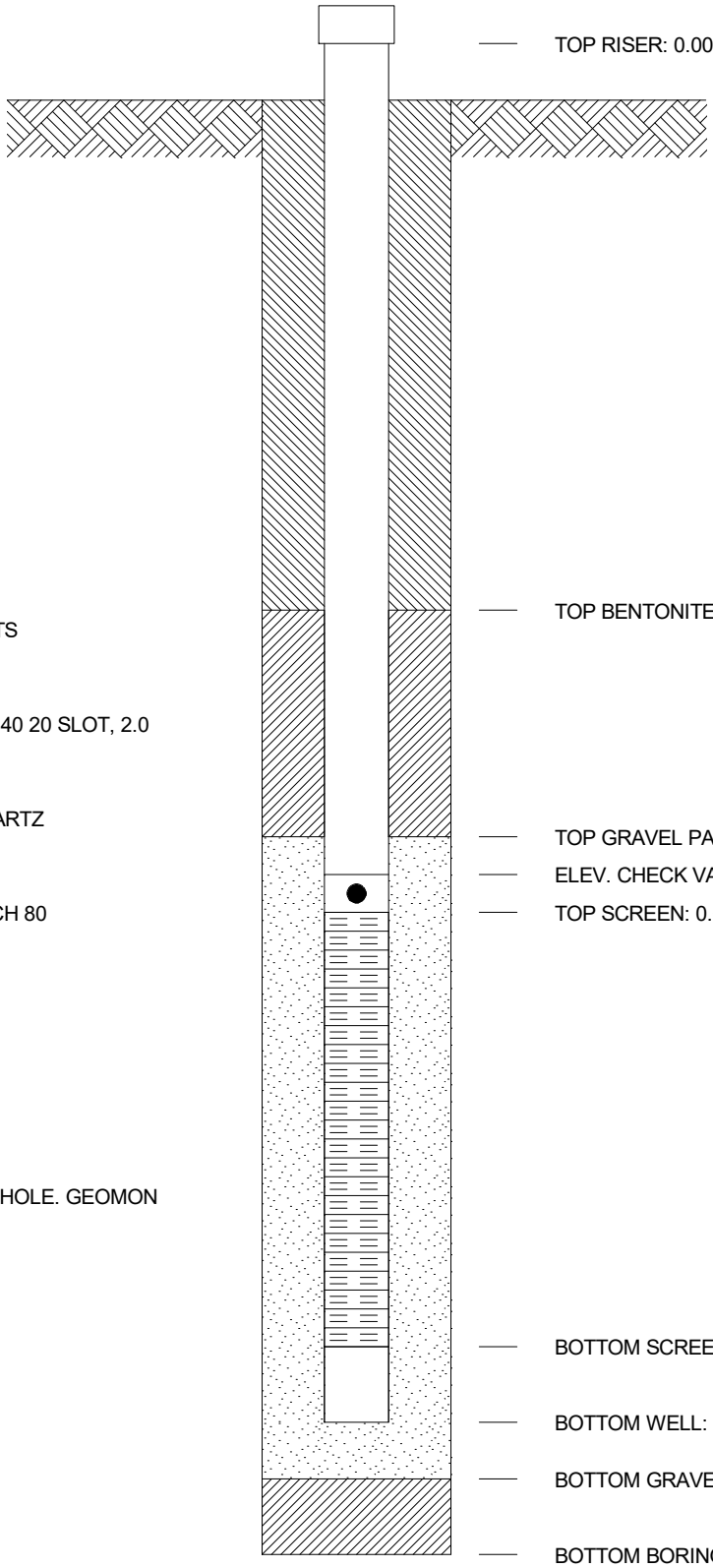
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-6** BORING No. **88-9-10** INSTALLED **8/4/88**

PROJECT **CARDINAL PLANT**

COORDINATES **N 834,577.4 E 2,513,679.4**

SYSTEM **STATE PLANE**

GROUND ELEVATION 1010.90 FT.



TOP RISER: 0.00 FT.

TOP BENTONITE SEAL: 971.20 FT.

TOP GRAVEL PACK: 966.20 FT.

ELEV. CHECK VALVE: 920.20 FT.

TOP SCREEN: 0.00 FT.

BOTTOM SCREEN: 0.00 FT.

BOTTOM WELL: 917.20 FT.

BOTTOM GRAVEL PACK: 916.20 FT.

BOTTOM BORING: 780.90 FT.

GROUT SEAL: BENTONITE

BENTONITE SEAL: PI PELLETS

SCREEN: 1.25 dia., PVC SCH 40 20 SLOT, 2.0

GRAVEL PACK: #4 OHIO QUARTZ

RISER PIPE: 0.8, dia., PVC SCH 80

SPACERS, DEPTH:

WELL S-6 AND M-4 IN SAME HOLE. GEOMON

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER

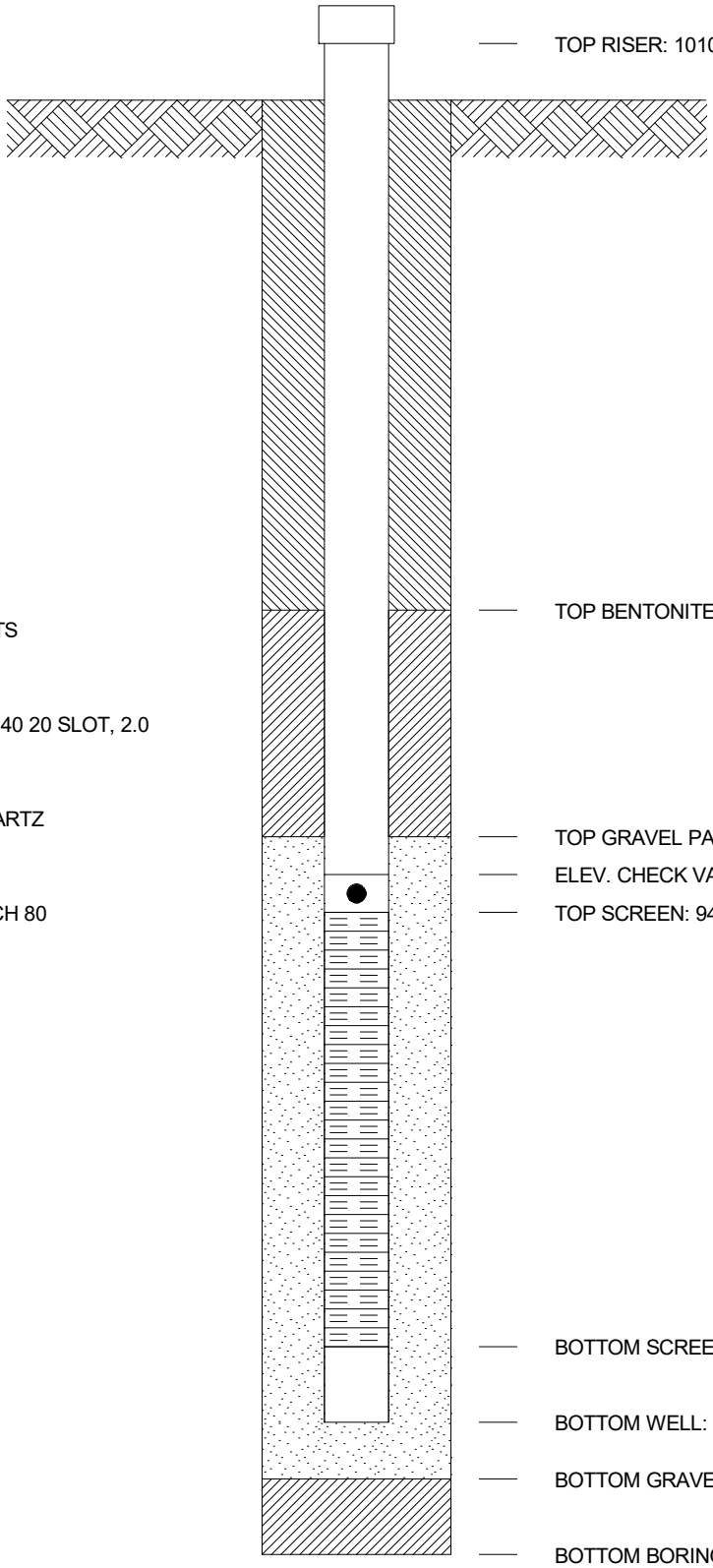
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **S-7** BORING No. **90CA22-S** INSTALLED **8/14/90**

PROJECT **CARDINAL PLANT**

COORDINATES **N 831,920.2 E 2,516,676.4**

SYSTEM **STATE PLANE**

GROUND ELEVATION 1008.52 FT.



TOP RISER: 1010.98 FT.

TOP BENTONITE SEAL: 975.42 FT.

TOP GRAVEL PACK: 969.92 FT.

ELEV. CHECK VALVE: 942.92 FT.

TOP SCREEN: 942.32 FT.

BOTTOM SCREEN: 940.32 FT.

BOTTOM WELL: 939.92 FT.

BOTTOM GRAVEL PACK: 937.92 FT.

BOTTOM BORING: 937.92 FT.

GROUT SEAL: BENSEAL

BENTONITE SEAL: PI PELLETS

SCREEN: 1.25 dia., PVC SCH 40 20 SLOT, 2.0

GRAVEL PACK: #4 OHIO QUARTZ

RISER PIPE: 1.0, dia., PVC SCH 80

SPACERS, DEPTH:

GEOMON

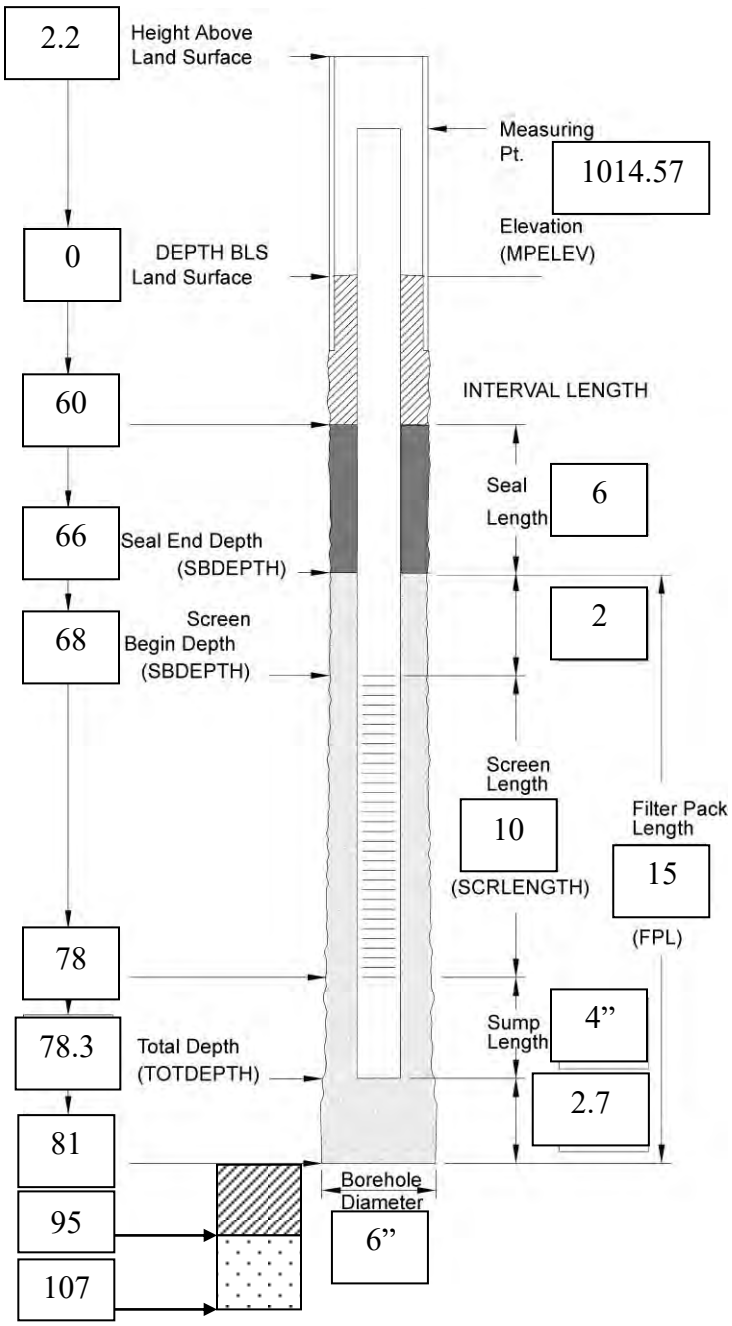
GEOMCNST CD SI.GPJ AEP.GDT 7/17/15

Geosyntec consultants

WELL CONSTRUCTION LOG
ABOVE GROUND COMPLETION

Well I.D. (LOCID): S-GS-1
Drilling Company: Layne
Drillers: Danny Allen
Geologist/Engineer: D. Mateas / M. Muenich
Signature:

Site: AEP – Cardinal Project Number: CHE8126L
Installation Method: HSA
Casing Installation Date (INSDATE): 4/12/16
Well Type (WTCCODE): Monitoring Well
Well Completion Method (WCMCODE): Above Grade
Geologic Completion Zone (GZCODE):



Well Completion
2 Guard Posts (Y / N) Date:
Surface Pad Size: 2 ft x 2 ft x 6"
Protective Casing or Cover
Diameter/Type: 4" locking flip-top
Depth BGS: 2.5 Weep Hole (Y / N)
Grout
Composition/Proportions: 150 lbs Haliburton Bentonite Quick Grout / 100 gal. H_2O; 15 x 50 lb bags
Placement Method: pressure tremie

Seal Date: 4/12/16
Type: 3/8" coated bentonite pellets; 2 x 5 gal buckets
Source: Pel-Plug Western Bentonite
Set-up/Hydration Time: 30 mins
Placement Method: poured gravity
Vol. Fluid Added: N/A - submerged
Filter Pack
Type: #5 filter sand
Source: Flat Rock Bagging, Sparta, MI
Amount Used: 30 x 50 lb bags
Placement Method: Poured gravity
Well Riser Pipe
Casing Material (CMACODE): Sch. 40 PVC
Casing Inside Diameters (CASDIAM): 2.0 in.
Screen
Material: Sch. 40 PVC
Inside Diameter (SCRDIAM): 2.0 in.
Screen Slot Size: (SOUA): 0.010 10-slot in.
Percent Open Area (PCTOPEN):
Sump or Bottom Cap (Y / N)
Type/Length: 4" Sch. 40 PVC
Backfill Plug (Y / N)
Material: 3/8" med. crushed bentonite chips
Placement Method: poured gravity
Set-up/Hydration Time:

Comments
Total drilled depth = 107'; backfilled to 81' with sand and chips.

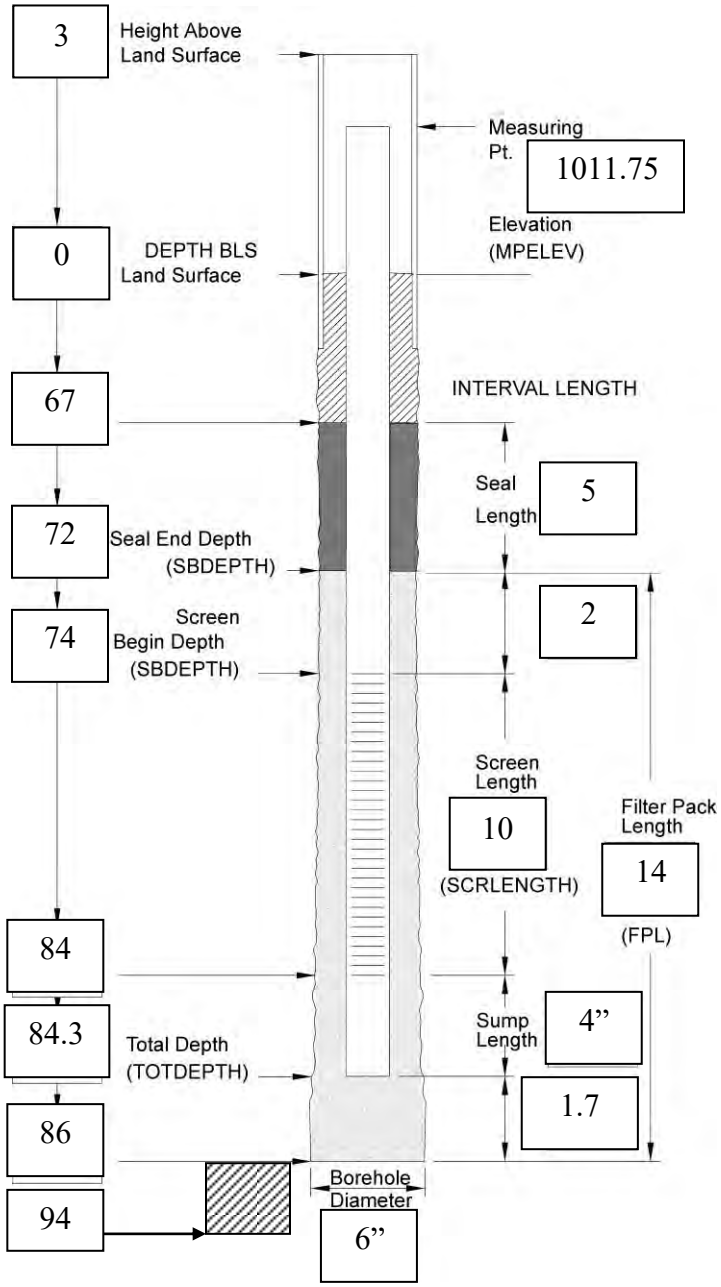
Total Water Volume During Construction
Introduced (Gal): 0 Recovered (Gal): -
Reviewed By: J. Neil Couch Date: 4/22/2016

Geosyntec consultants

WELL CONSTRUCTION LOG
ABOVE GROUND COMPLETION

Well I.D. (LOCID): S-GS-2
Drilling Company: Layne
Drillers: Danny Allen
Geologist/Engineer: D. Mateas / M. Muenich
Signature:

Site: AEP – Cardinal Project Number: CHE8126L
Installation Method: HSA
Casing Installation Date (INSDATE): 4/12/16
Well Type (WTCCODE): Monitoring Well
Well Completion Method (WCMCODE): Above Grade
Geologic Completion Zone (GZCODE):



Well Completion
2 Guard Posts (Y / N) Date:
Surface Pad Size: 2 ft x 2 ft x 6”
Protective Casing or Cover
Diameter/Type: 4” locking flip-top
Depth BGS: 2 Weep Hole (Y / N)
Grout
Composition/Proportions: 150 lbs Haliburton Bentonite Quick Grout / 100 gal. H_2O
Placement Method: pressure tremie

Seal Date: 4/12/16
Type: 3/8” coated bentonite pellets
Source: Pel-Plug Western Bentonite
Set-up/Hydration Time: 30 mins
Placement Method: poured gravity
Vol. Fluid Added: N/A - submerged
Filter Pack
Type: #5 filter pack sand
Source: Flat Rock Bagging, Sparta, MI
Amount Used: 10 x 50 lb bags
Placement Method: poured gravity
Well Riser Pipe
Casing Material (CMACODE): Sch. 40 PVC
Casing Inside Diameters (CASDIAM): 2.0 in.
Screen
Material: Pre-packed Sch. 40 PVC
Inside Diameter (SCRDIAM): 2.0 in.
Screen Slot Size: (SOUA): 0.010 10-slot in.
Percent Open Area (PCTOPEN):
Sump or Bottom Cap (Y / N)
Type/Length: 4” Sch. 40 PVC
Backfill Plug (Y / N)
Material: 3/8” coated bentonite pellets
Placement Method: poured gravity
Set-up/Hydration Time: 45 mins

Comments
Total boring depth = 94 ft; backfilled with chips to 86’.

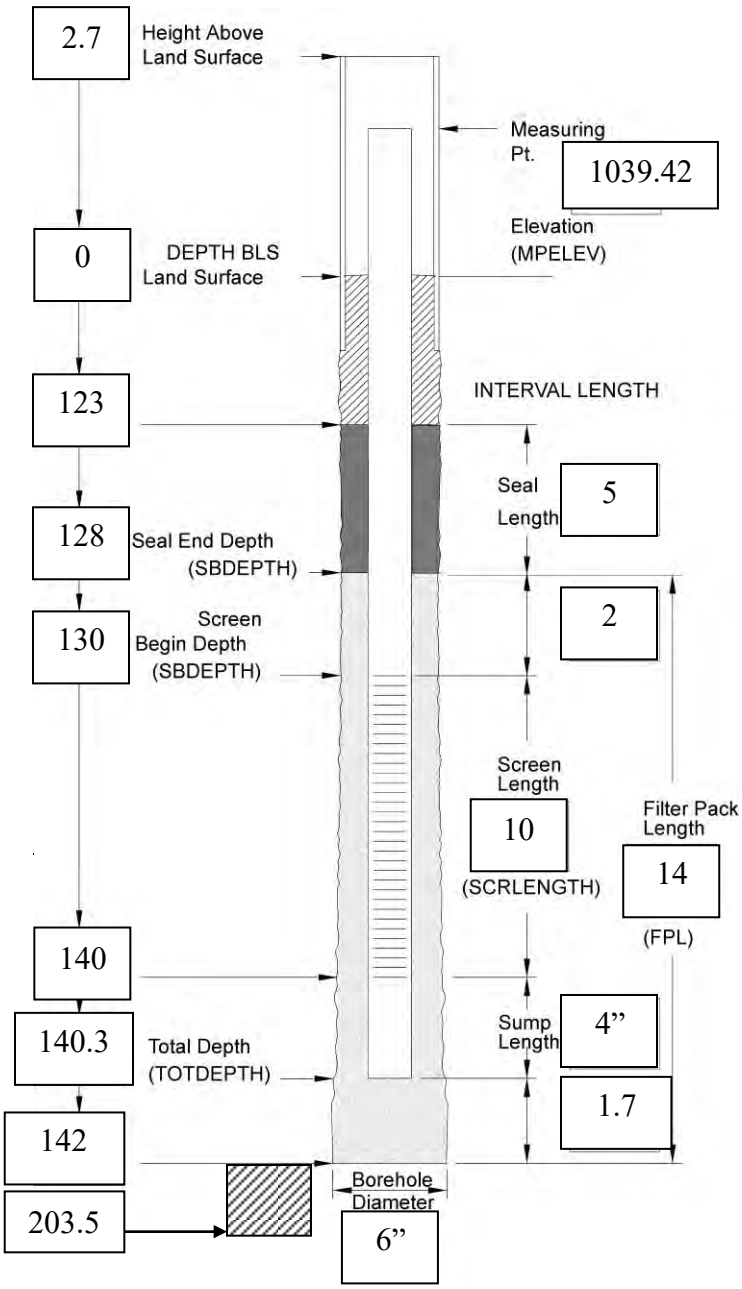
Total Water Volume During Construction
Introduced (Gal): 0 Recovered (Gal): -
Reviewed By: J. Neil Couch Date: 4/22/2016

Geosyntec consultants

WELL CONSTRUCTION LOG
ABOVE GROUND COMPLETION

Well I.D. (LOCID): S-GS-3
Drilling Company: Layne
Drillers: Danny Allen
Geologist/Engineer: J. Bannantine
Signature:

Site: AEP – Cardinal Project Number: CHE8126L
Installation Method: HSA/Rotary
Casing Installation Date (INSDATE): 4/5/16
Well Type (WTCCODE): Monitoring Well
Well Completion Method (WCMCODE): Above Grade
Geologic Completion Zone (GZCODE):



Well Completion
2 Guard Posts (Y / N) Date:
Surface Pad Size: 2 ft x 2 ft x 6”
Protective Casing or Cover
Diameter/Type: 4” locking flip-top
Depth BGS: 2 Weep Hole (Y / N)
Grout
Composition/Proportions: 150 lbs Haliburton Bentonite Quick Grout / 100 gal. H_2O
Placement Method: pressure tremie

Seal Date: 4/5/16
Type: 3/8” coated bentonite pellets
Source: Pel-Plug Western Bentonite
Set-up/Hydration Time: 30 mins
Placement Method: poured gravity
Vol. Fluid Added: N/A - submerged
Filter Pack
Type: #5 med. coarse sand
Source: Flat Rock, Sparta, MI
Amount Used: 8 x 50 lb bags
Placement Method: poured gravity

Well Riser Pipe
Casing Material (CMACODE): Sch. 40 PVC
Casing Inside Diameters (CASDIAM): 2.0 in.
Screen
Material: Pre-packed Sch. 40 PVC
Inside Diameter (SCRDIAM): 2.0 in.
Screen Slot Size: (SOUA): 0.010 10-slot in.
Percent Open Area (PCTOPEN):
Sump or Bottom Cap (Y / N)
Type/Length: 4” Sch. 40 PVC
Backfill Plug (Y / N)
Material: 3/8” med. crushed bentonite chips
Placement Method: poured gravity
Set-up/Hydration Time:
Total Water Volume During Construction
Introduced (Gal): 0 Recovered (Gal): -
Reviewed By: J. Neil Couch Date: 5/3/2016

Comments
Total drilled depth = 203.5’; backfilled with chips to 142’.

AMERICAN ELECTRIC POWER SERVICE CORPORATION

AEP CIVIL ENGINEERING LABORATORY

MONITORING WELL CONSTRUCTION

JOB NUMBER _____

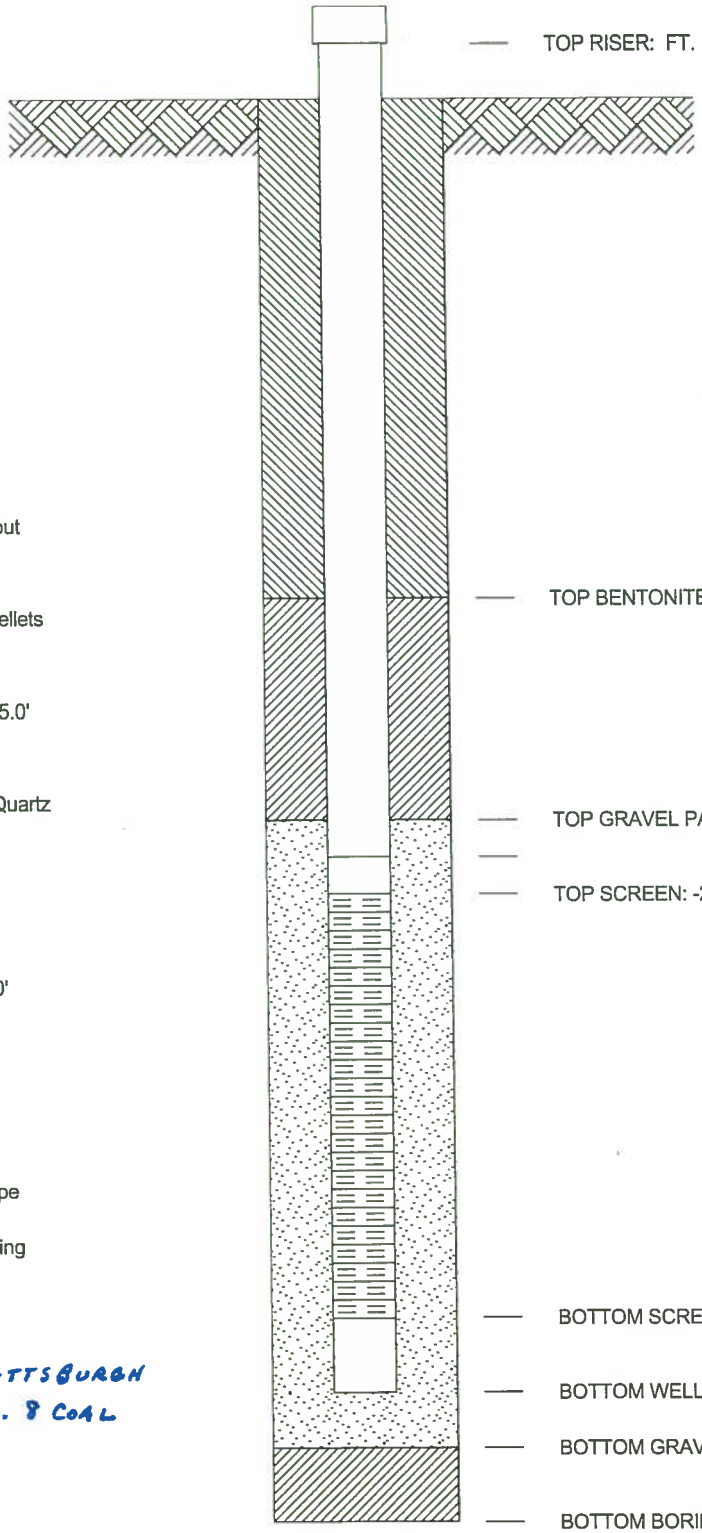
COMPANY **AMERICAN ELECTRIC POWER** WELL No. **OAE 0610-C** BORING No. _____ INSTALLED **2/16/06**

PROJECT **CARDINAL FLY ASH DAM** WELL No. OAE 2005 10C

COORDINATES N 833,417.3 E 2,511,621.5

SYSTEM _____

GROUND ELEVATION 0.00 FT. 1237.93



TOP RISER: FT. 1240.85

TOP BENTONITE SEAL: -224.10 FT. 1013.83

TOP GRAVEL PACK: -229.70 FT. 1008.23

TOP SCREEN: -235.40 FT. 1002.53

BOTTOM SCREEN: -240.40 FT. 997.53

BOTTOM WELL: -240.50 FT. 997.43

BOTTOM GRAVEL PACK: -241.10 FT. 996.83

BOTTOM BORING: -241.10 FT. 996.83

GROUT SEAL: ~350 Gals Grout

BENTONITE SEAL: 110 lbs Pellets

SCREEN: 1" dia., GEOMON, 5.0'

GRAVEL PACK: 150 lbs. #4 Quartz

RISER PIPE: 2", dia., PVC

SPACERS, DEPTH: 200', 100'

NOTES:
-Set 1" Geomon on 2" riser pipe
-SWL @ 52.4'
-Drilled w/6" air hammer
-Deconned 02/13/06 / No bailing
-Flushed w/1,000 gals water
-Set protector / poured pad

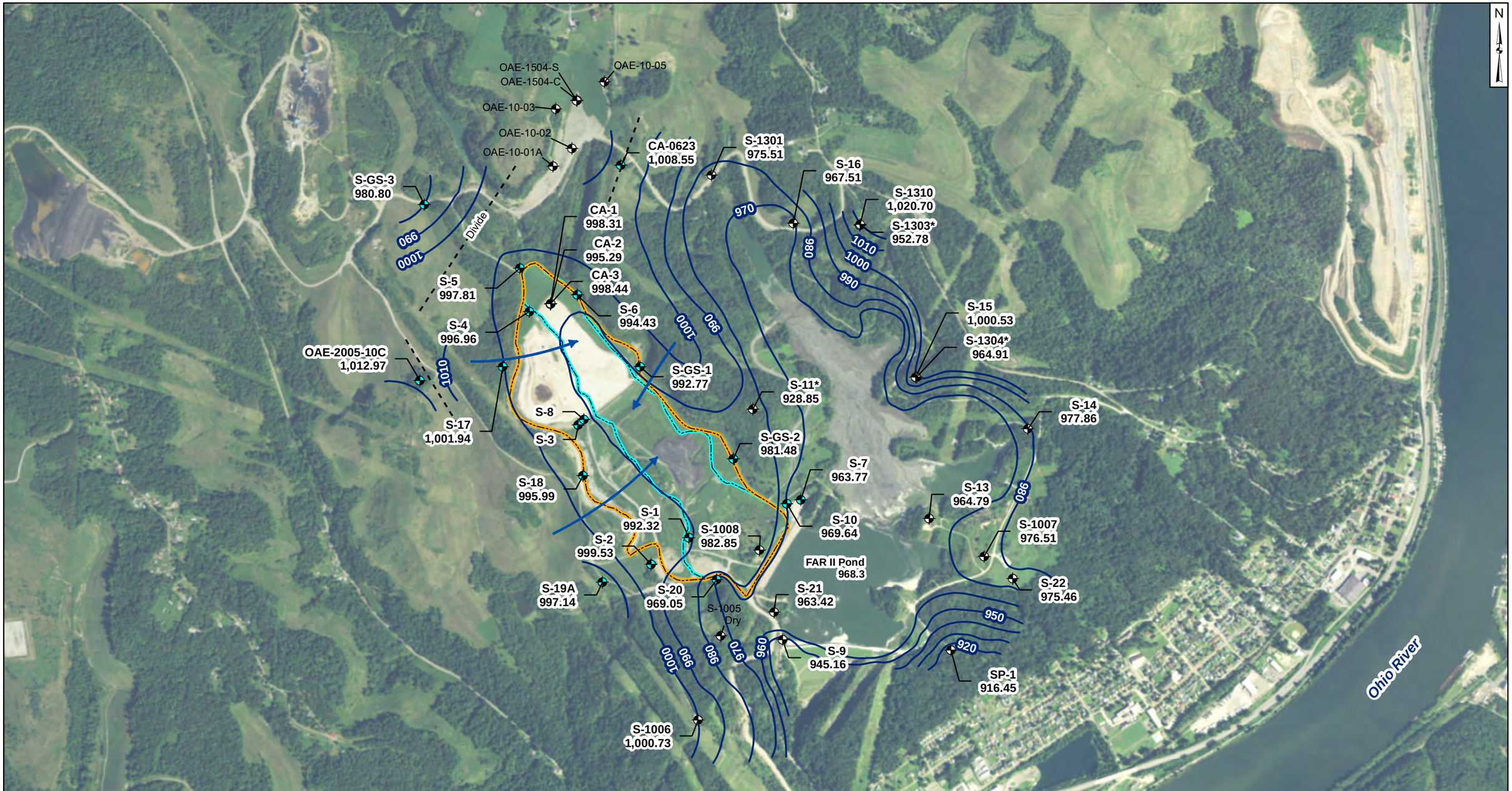
MONITORS PITTSBURGH No. 8 COAL

WELL LOG CARD_FA_DAM.GPJ AEP.GDT 6/12/08

FAR I RSW Landfill

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

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



Legend

- base_layer_point
- FAR I Network Monitoring Well
- State/Other Program Monitoring Well
- Approximate Groundwater Flow Direction
- Groundwater Elevation Contour
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected between June 21 and June 22, 2016) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
- CA-1, CA-2, CA-3, and S-1008 are screened in CCR material.
* Wells not used for contouring due to inconsistent and/or anamolous readings.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
June 2016

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/08/24

Figure 1

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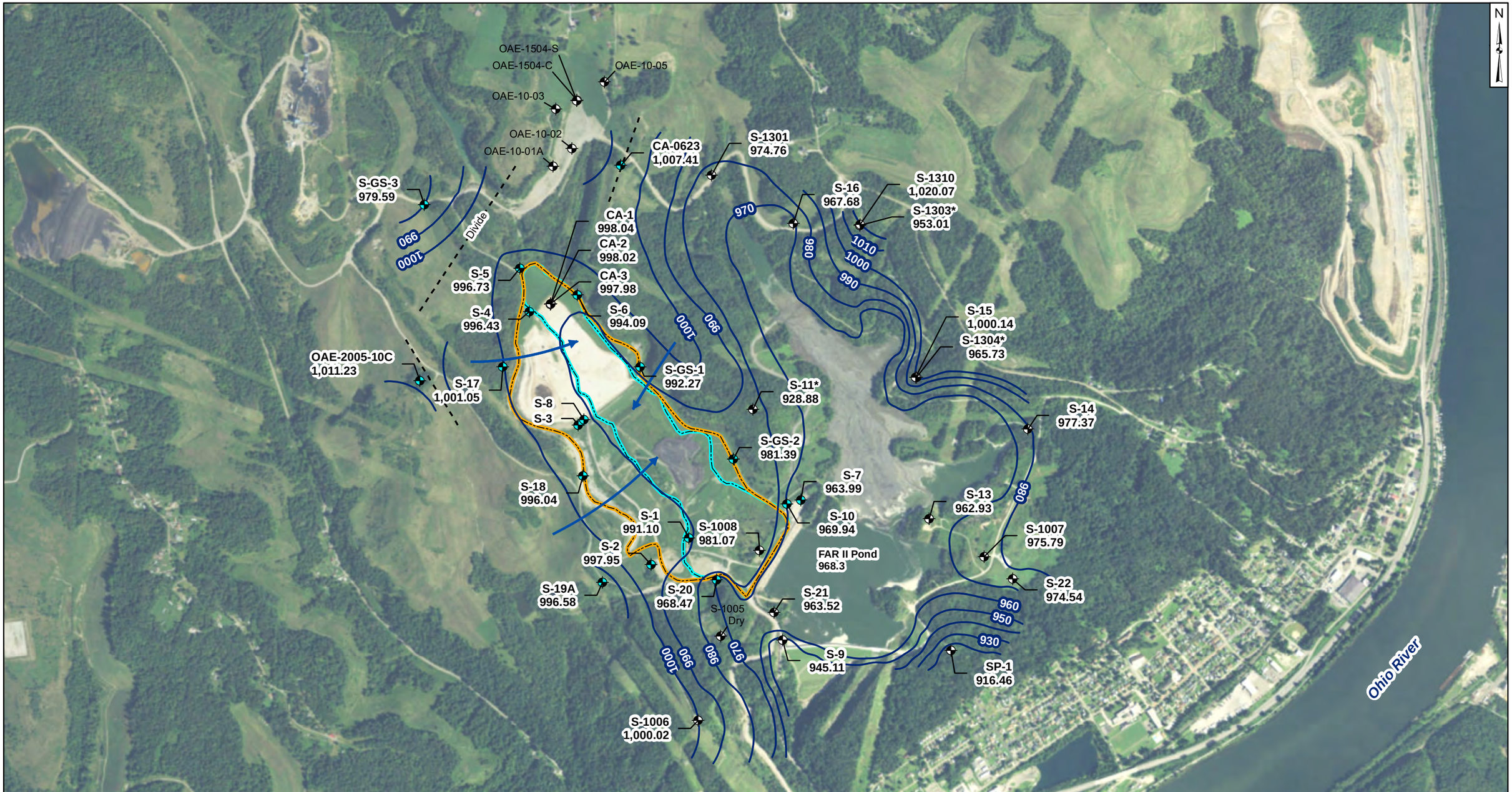

Legend

- FAR I Network Monitoring Well
- State/Other Program Monitoring Well
- Approximate Groundwater Flow Direction
- Groundwater Elevation Contour
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected between August 1 and August 2, 2016) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
- CA-1, CA-2, CA-3, and S-1008 are screened in CCR material.
* Wells not used for contouring due to inconsistent and/or anamolous readings.

1,000 500 0 1,000
Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
August 2016

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/08/18

Figure 2

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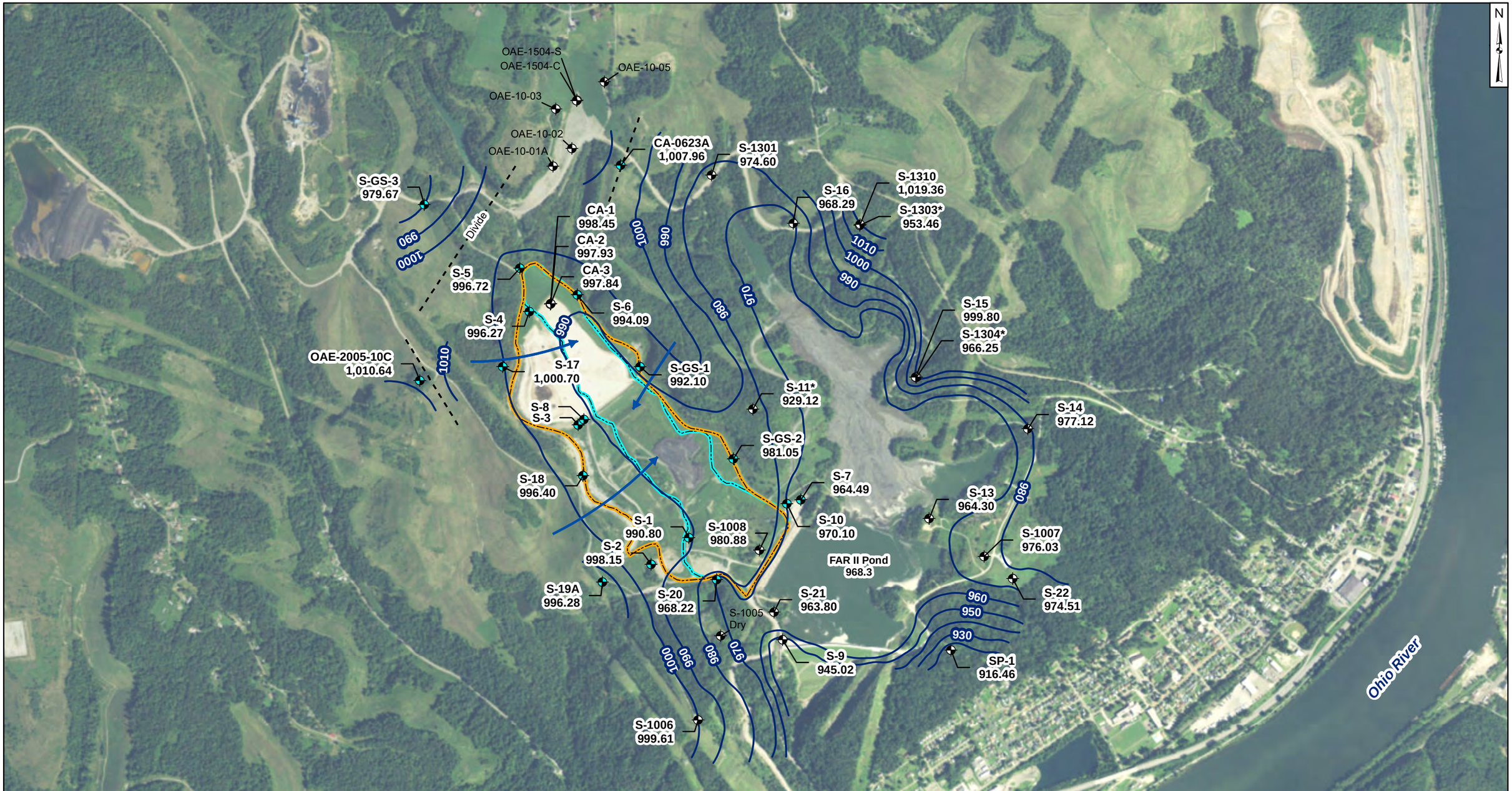

Legend

- FAR I Network Monitoring Well
- State/Other Program Monitoring Well
- Approximate Groundwater Flow Direction
- Groundwater Elevation Contour
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected between October 3 and October 4, 2016) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
- CA-1, CA-2, CA-3, and S-1008 are screened in CCR material.
* Wells not used for contouring due to inconsistent and/or anamolous readings.
- CA-0623 was replaced by CA-0623A on 8/16/2016

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
October 2016

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/08/24

Figure 3

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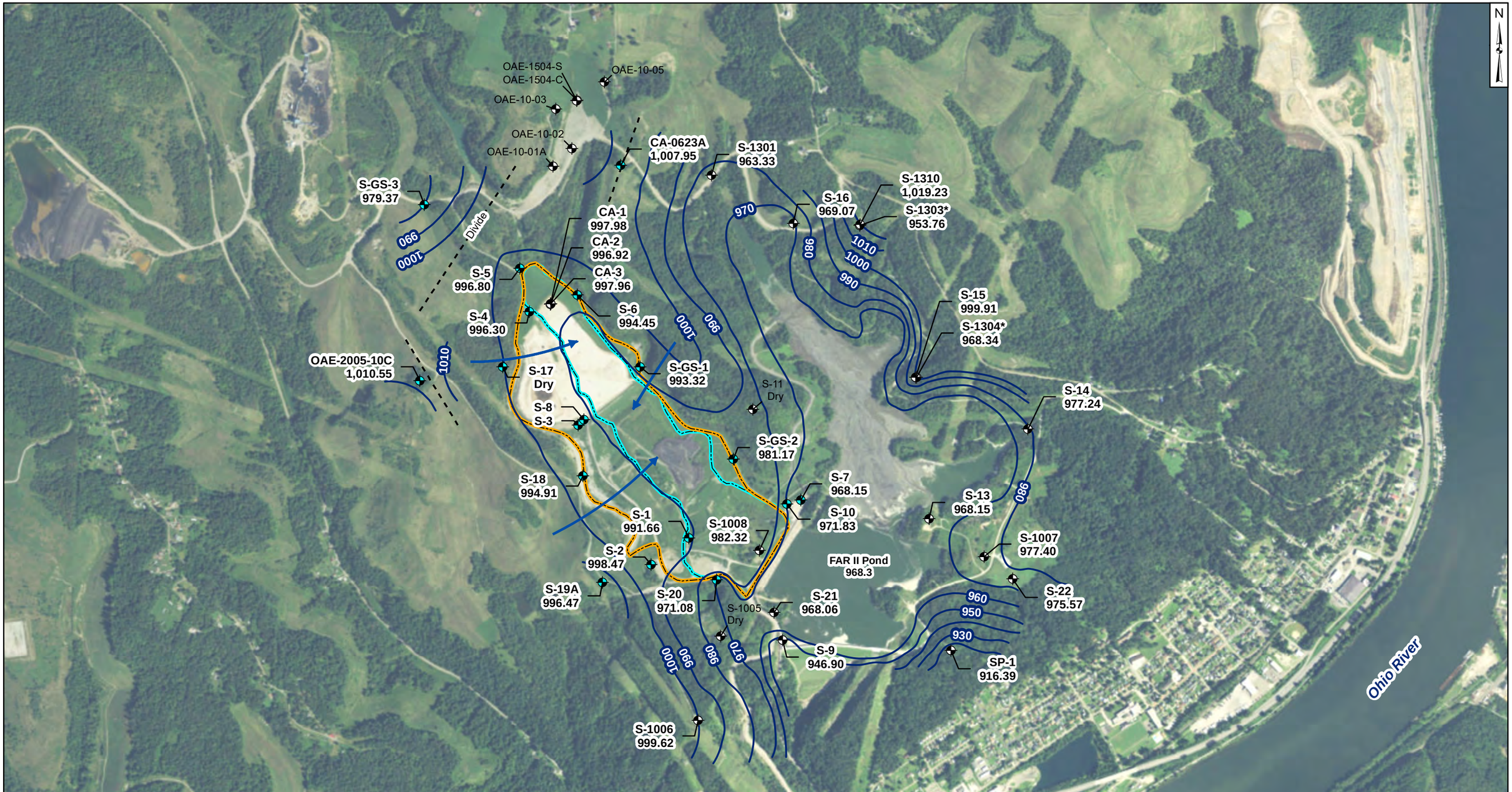

Legend

- FAR I Network Monitoring Well
- State/Other Program Monitoring Well
- Approximate Groundwater Flow Direction
- Groundwater Elevation Contour
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

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 - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
- CA-1, CA-2, CA-3, and S-1008 are screened in CCR material.
* Wells not used for contouring due to inconsistent and/or anamolous readings.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
November 2016

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/08/24

Figure 4

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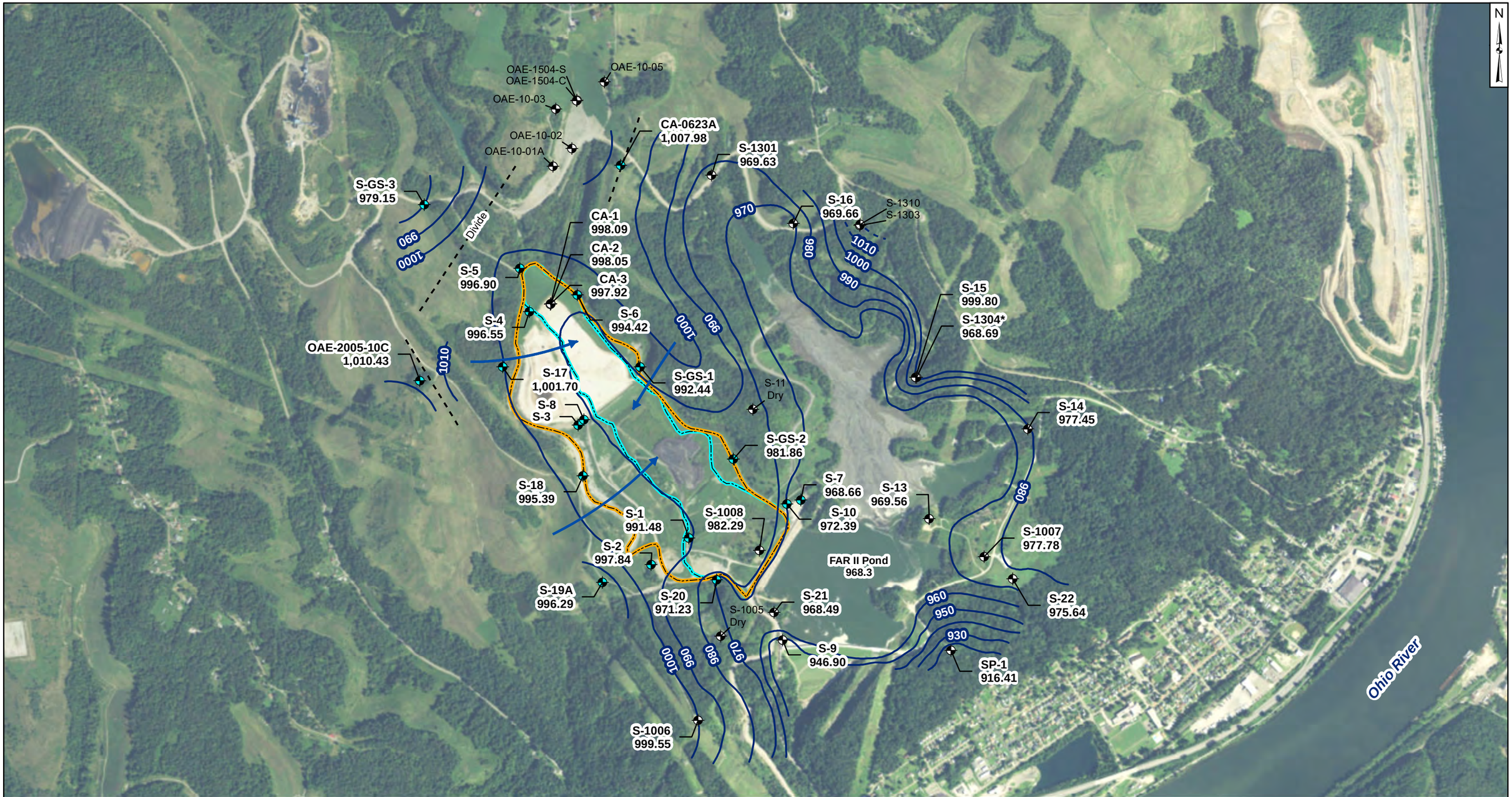

Legend

- FAR I Network Monitoring Well
- State/Other Program Monitoring Well
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour
- Approximate Groundwater Flow Direction
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected on December 12, 2016) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
- CA-1, CA-2, CA-3, and S-1008 are screened in CCR material.
* Wells not used for contouring due to inconsistent and/or anamolous readings.
- S-1310 not measured; contours inferred from previous events.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
December 2016

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/08/24

Figure 5

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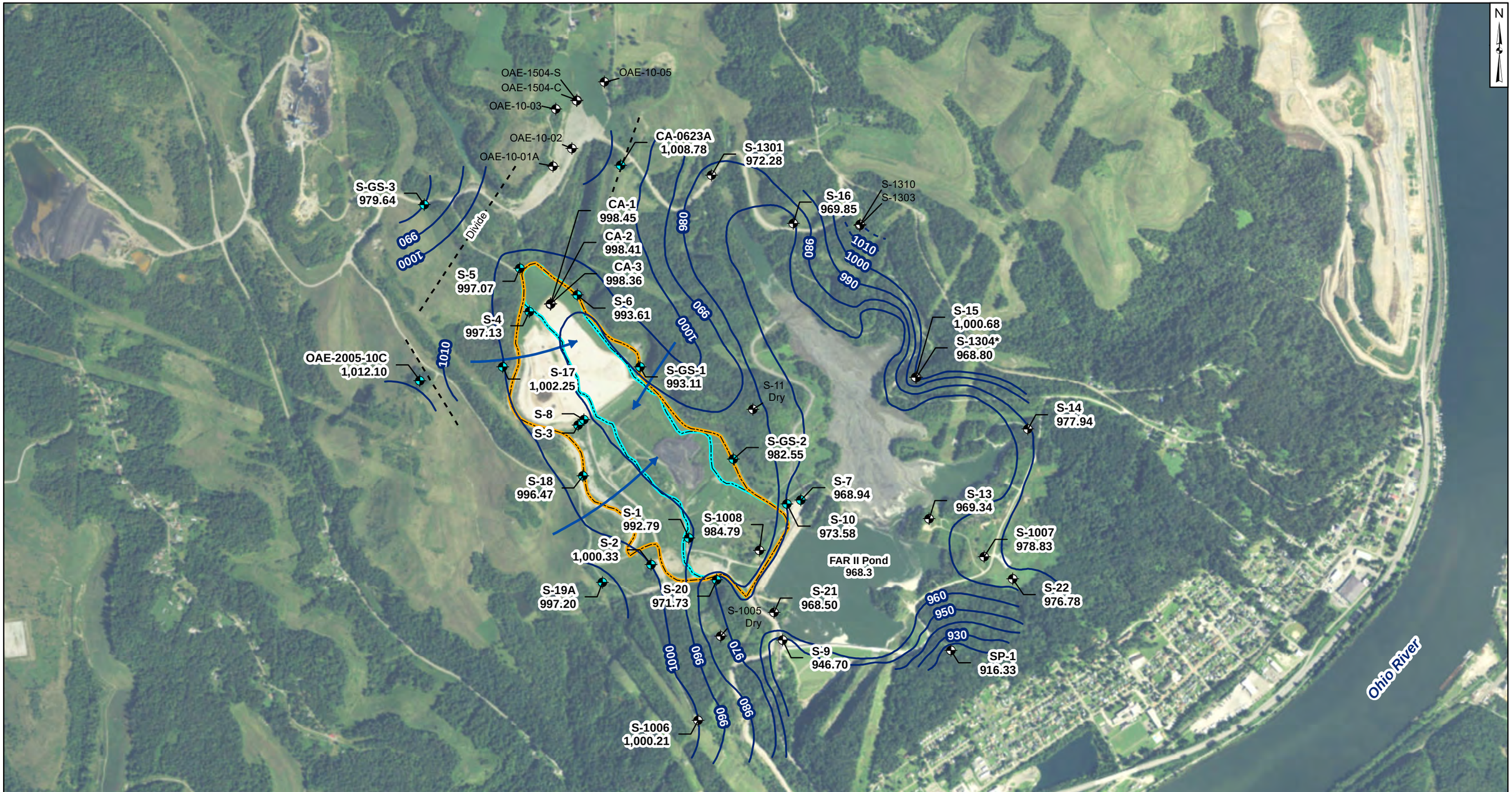

Legend

- FAR I Network Monitoring Well
- State/Other Program Monitoring Well
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour
- Approximate Groundwater Flow Direction
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

Notes

- Monitoring well coordinates and water level data (collected on January 9, 2017) provided by AEP.
-Site features based on information available in Groundwater Monitoring Network Evaluation - Cardinal Site - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
- CA-1, CA-2, CA-3, and S-1008 are screened in CCR material.
* Wells not used for contouring due to inconsistent and/or anamolous readings.
- S-1310 not measured; contours inferred from previous events.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
January 2017

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

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Figure 6

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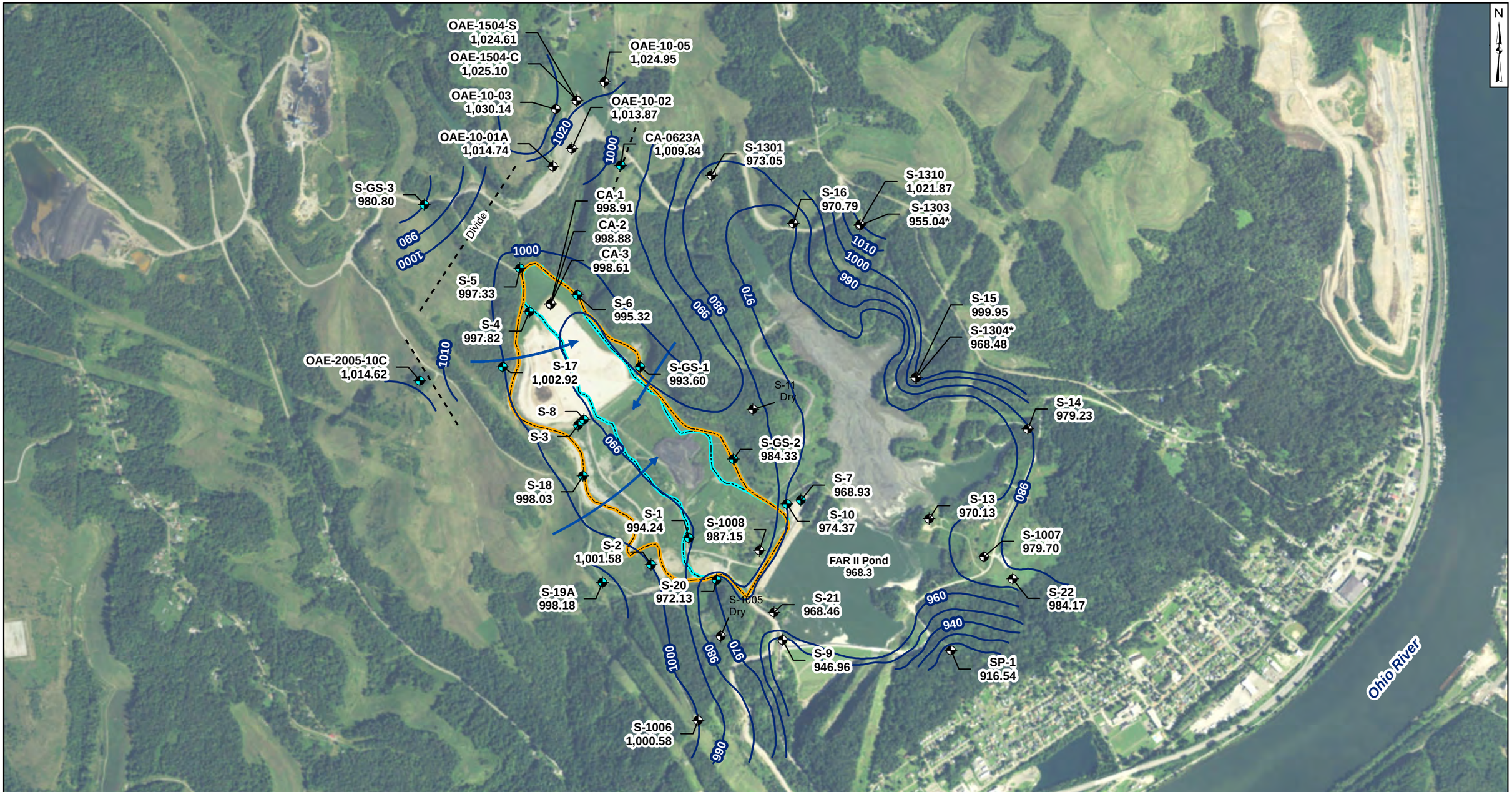

Legend

- FAR I Network Monitoring Well
- State/Other Program Monitoring Well
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour
- Approximate Groundwater Flow Direction
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

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 - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
- CA-1, CA-2, CA-3, and S-1008 are screened in CCR material.
* Wells not used for contouring due to inconsistent and/or anamolous readings.

1,000 500 0 1,000 Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
April 2017

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/08/24

Figure 7

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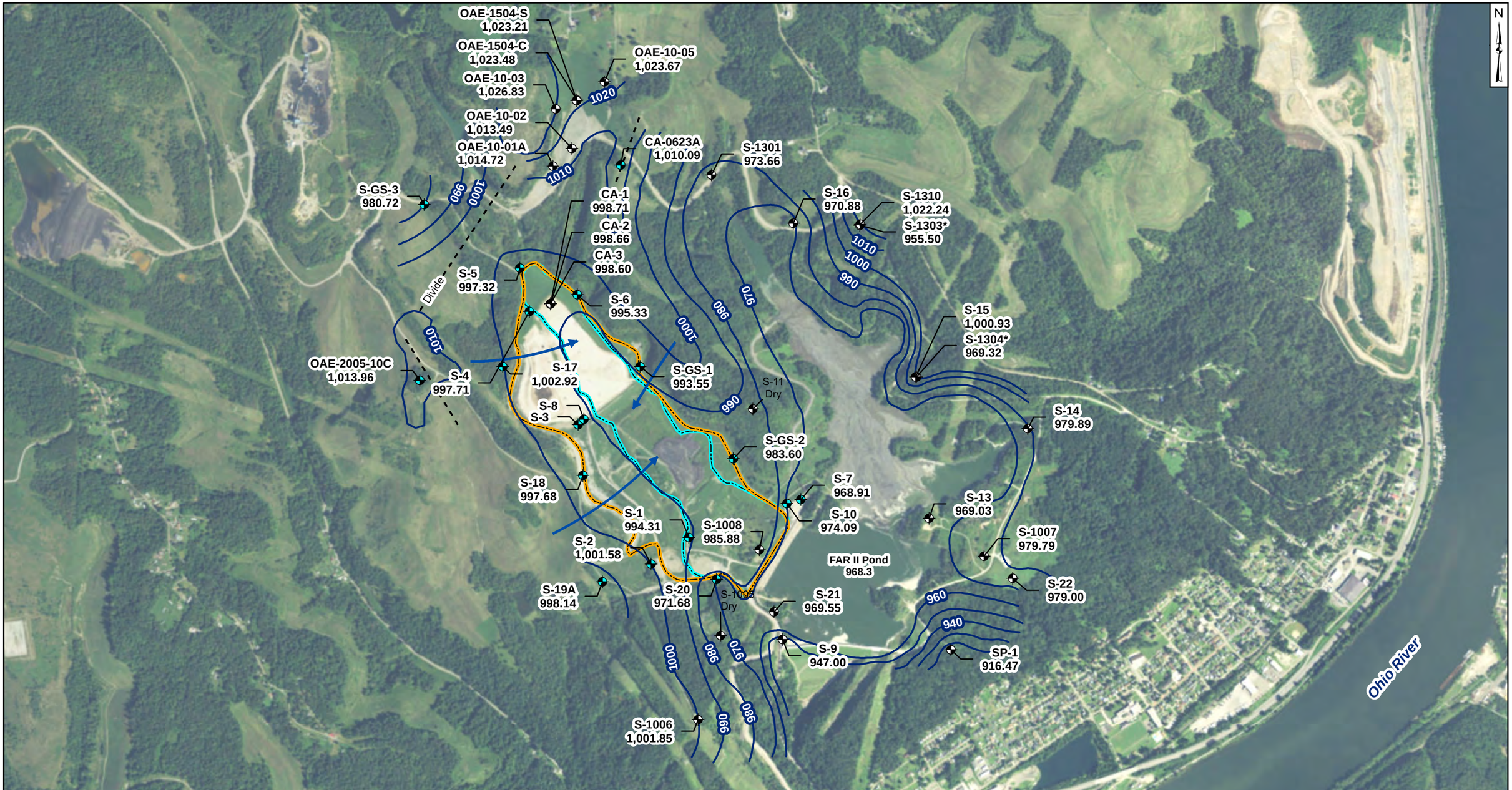

Legend

- FAR I Network Monitoring Well
- State/Other Program Monitoring Well
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour
- Approximate Groundwater Flow Direction
- Residual Solid Waste (RSW) Landfill
- Former Fly Ash Reservoir (FAR) I

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 - Former Fly Ash Reservoir I - Residual Solid Waste Landfill (Geosyntec, 2016) provided by AEP.
- Groundwater elevation units are feet above mean sea level.
- CA-1, CA-2, CA-3, and S-1008 are screened in CCR material.
* Wells not used for contouring due to inconsistent and/or anamolous readings.

1,000 500 0 1,000
Feet

Potentiometric Surface Map - Shallow Water Table
Former FAR I & RSW Landfill
May 2017

AEP Cardinal Generating Plant
Brilliant, Ohio

Geosyntec consultants

Columbus, Ohio | 2017/08/24

Figure 8

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FAR I RSW Landfill

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 - Landfill

Parameter	Unit	CA-0623A									OAE-2005-10-C									
		10/13/2016	11/15/2016	12/14/2016	1/10/2017	4/18/2017	5/25/2017	6/21/2017	7/27/2017	9/27/2017	6/29/2016	8/9/2016	12/14/2016	1/12/2017	2/9/2017	4/17/2017	5/31/2017	6/22/2017	7/27/2017	10/3/2017
		Background								Detection	Background									Detection
Antimony	µg/L	0.02J	0.01J	0.01J	0.05U	0.02J	0.05U	0.05U	0.01J	-	0.29	-	0.36	0.07	0.03J	0.04J	0.03J	0.05J	0.28	-
Arsenic	µg/L	0.54	0.34	0.36	0.27	0.4	0.26	0.24	0.26	-	0.92	-	7.87	0.97	0.85	0.67	0.52	0.63	0.96	-
Barium	µg/L	20.1	21.1	21.5	21.2	23	22.5	20.6	21	-	26.6	-	209	45.3	29.5	31.9	32	27.6	41.1	-
Beryllium	µg/L	0.009J	0.006J	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U	-	0.02U	-	0.588	0.041	0.008J	0.007J	0.01J	0.02U	0.04J	-
Boron	mg/L	0.442	0.487	0.388	0.434	0.418	0.474	0.454	0.422	0.488	0.332	-	0.343	0.389	0.451	0.422	0.438	0.437	0.486	0.425
Cadmium	µg/L	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U	0.03	-	0.04	-	0.5	0.04	0.01J	0.02J	0.01J	0.007J	0.04J	-
Calcium	mg/L	1.55	1.37	1.22	1.16	1.12	1.15	1.14	1.14	1.11	8.18	-	142	12.4	7.55	7.16	6.19	5.99	10.5	5.52
Chloride	mg/L	24.8	25.4	25.7	24	16.4	14.6	16.2	23.1	24.5	35.9	-	12.2	10.5	10.5	11.4	11.1	11.2	12.3	12.3
Chromium	µg/L	4.1	0.548	0.829	0.12	0.112	0.515	0.062	0.143	-	0.6	-	36.3	3.86	0.824	0.86	0.737	0.244	2.95	-
Cobalt	µg/L	0.116	0.045	0.047	0.026	0.022	0.02	0.022	0.02J	-	0.162	-	12.8	0.852	0.167	0.207	0.151	0.06	0.801	-
Combined Radium	pCi/L	0.587	0.587	0.6	0.344	0.656	0.855	1.031	0.359	-	0.2248	-	2.3997	0.678	0.168	0.244	1.18	2.708	0.095	-
Fluoride	mg/L	2.12	1.98	1.93	1.88	2.02	2.04	2.09	2.03	1.98	1.01	-	0.72	0.82	0.84	0.88	0.87	0.89	0.9	0.96
Lead	µg/L	0.164	0.056	0.064	0.031	0.047	0.024	0.032	0.118	-	0.412	-	475	20.3	4.87	6.84	6.5	3.96	29.3	-
Lithium	mg/L	0.02	0.02	0.02	0.024	0.02	0.025	0.026	0.021	-	0.042	-	0.052	0.039	0.036	0.029	0.025	0.032	0.035	-
Mercury	µg/L	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	-	0.005U	-	0.006	0.004J	0.005U	0.003J	0.005U	0.005U	0.005U	-
Molybdenum	µg/L	0.99	0.73	0.6	1.61	0.72	0.81	0.43	0.53	-	10.9	-	3.05	1.27	1.06	1.97	3.99	1.79	2.72	-
Selenium	µg/L	0.06J	0.1U	0.03J	0.1U	0.1U	0.1U	0.1U	0.1U	-	0.1	-	3.1	0.1	0.04J	0.04J	0.1U	0.1U	0.06J	-
Total Dissolved Solids	mg/L	600	666	642	658	666	651	657	644	669	1660	-	1780	1490	1650	1470	1500	1430	1540	1350
Sulfate	mg/L	37.7	44.3	47.9	51.7	43.4	40.3	41.6	36.3	35.6	681	-	482	248	421	442	437	430	403	393
Thallium	µg/L	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.02J	-	0.03J	-	0.124	0.02J	0.01J	0.05U	0.01J	0.05U	0.02J	-
pH	SU	8.92	8.7	8.71	8.72	8.93	7.89	8.31	8.5	8.55	8.15	8.12	8.49	8.07	7.66	8.21	8.21	8.01	7.93	8.35

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 - Landfill

Parameter	Unit	S-1										S-2								
		6/30/2016	8/4/2016	10/11/2016	1/11/2017	4/11/2017	4/20/2017	5/24/2017	6/21/2017	7/26/2017	10/4/2017	6/24/2016	8/4/2016	10/6/2016	1/17/2017	4/19/2017	5/24/2017	6/21/2017	7/26/2017	10/4/2017
		Background									Detection	Background								Detection
Antimony	µg/L	0.02J	0.02J	0.04J	0.02J	0.04J	-	0.03J	0.03J	0.1U	-	4.23	3.6	1.01	0.66	0.53	0.23	0.29	3.57	-
Arsenic	µg/L	0.44	0.35	0.46	0.48	0.4	-	0.42	0.42	0.41	-	13.6	10.9	5.57	5.78	5.99	2.7	3.93	5.87	-
Barium	µg/L	24.8	24.6	23.1	23.6	23.2	-	23.4	22.9	22.6	-	19.5	18.4	18.1	20.3	17.3	16.8	17.4	16.8	-
Beryllium	µg/L	0.02U	0.02U	0.02U	0.02U	0.02U	-	0.02U	0.04U	0.04U	-	0.04J	0.02J	0.03J	0.044	0.03J	0.02J	0.03J	0.02J	-
Boron	mg/L	0.924	0.937	0.921	0.856	0.874	-	0.897	0.895	0.855	0.834	1.66	1.91	2.74	2.32	1.8	1.9	1.77	2.09	2.73
Cadmium	µg/L	0.01J	0.04	0.04	0.04	0.1	-	0.06	0.06	0.05	-	0.62	1.04	0.29	0.27	0.04J	0.04U	0.03J	0.24	-
Calcium	mg/L	335	291	296	293	279	-	314	320	319	305	424	386	421	463	403	420	353	391	395
Chloride	mg/L	6.36	6.1	6.13	6.03	5.69	-	5.77	5.73	5.65	5.39	7.91	6.7	5.76	7.56	6.88	7.62	6.82	6.35	4.98
Chromium	µg/L	0.3	0.1	0.3	0.193	0.02J	-	0.05J	0.1J	0.405	-	1.1	0.3	0.9	1.03	0.2J	0.05J	0.385	0.526	-
Cobalt	µg/L	0.824	0.771	0.623	0.811	0.919	-	0.622	1.17	1.04	-	3.87	4.97	4.21	5.29	4.8	3.67	3.96	5.21	-
Combined Radium	pCi/L	1.418	1.345	0.562	1.962	0.244	-	1.345	0.68	1.915	-	0.627	1.237	1.149	2.96	0.166	0.696	2.422	0.982	-
Fluoride	mg/L	0.2	0.19	0.24	0.17	0.16	-	0.17	0.14	0.14	0.16	0.4	0.36	0.35	0.32	0.28	0.3	0.29	0.28	0.31
Lead	µg/L	0.101	0.162	0.089	0.229	0.383	-	0.154	0.145	0.11	-	10.1	8.64	7.53	3.77	0.546	0.2	1.02	5	-
Lithium	mg/L	0.05	0.033	0.033	0.039	0.036	-	0.047	0.039	0.042	-	0.074	0.067	0.066	0.092	0.088	0.09	0.079	0.083	-
Mercury	µg/L	0.005U	0.005U	0.005U	0.005U	0.005U	-	0.005U	0.005U	0.005U	-	0.005U	0.005U	0.006	0.005U	0.005	0.005U	0.005U	0.005U	-
Molybdenum	µg/L	2.92	2.23	3.7	2.69	2.25	-	3.06	2.78	3.1	-	20.4	21.2	27.2	24.3	22.4	17.3	19	26.4	-
Selenium	µg/L	0.1	0.1U	0.05J	0.1U	0.1U	-	0.05J	0.2U	0.2U	-	1.3	3	0.09J	0.1	0.1J	0.2U	0.3U	0.7	-
Total Dissolved Solids	mg/L	1750	1760	1670	1820	-	1860	1830	1880	1840	1820	3000	2870	2920	3260	3060	2970	2820	2890	2990
Sulfate	mg/L	947	928	885	996	-	970	954	1050	1080	1000	1880	1800	1820	2020	1880	1820	1800	1910	1880
Thallium	µg/L	0.054	0.02J	0.01J	0.03J	0.01J	-	0.01J	0.1U	0.02J	-	1.06	1.72	0.254	0.505	0.1J	0.199	0.303	1.22	-
pH	SU	7.1	7.1	7.26	7.23	6.81	6.98	6.82	7.05	6.79	7.08	7.55	7.91	7.33	6.92	6.89	6.82	7.05	6.9	7.89

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 - Landfill

Parameter	Unit	S-4										S-5									
		6/28/2016	8/5/2016	10/12/2016	1/11/2017	4/11/2017	4/26/2017	5/24/2017	6/21/2017	7/26/2017	10/4/2017	6/29/2016	10/12/2016	11/15/2016	1/11/2017	4/11/2017	4/26/2017	5/24/2017	6/21/2017	7/26/2017	10/4/2017
		Background									Detection	Background									Detection
Antimony	µg/L	0.41	0.17	0.43	0.31	0.25	-	0.2J	0.16	0.17	-	0.21	0.14	0.13	0.02J	0.03J	-	0.05J	0.13	0.02J	-
Arsenic	µg/L	15.7	6.82	4.84	9.1	5.37	-	12.1	5.9	6.76	-	11.6	11.8	15.8	0.68	0.6	-	1.04	4.29	0.64	-
Barium	µg/L	116	63.3	175	466	255	-	595	521	620	-	97.9	74.1	101	19.5	19.7	-	26.7	50.4	20.1	-
Beryllium	µg/L	3.13	1.24	0.217	0.506	0.192	-	0.691	0.276	0.334	-	0.771	0.7	1.19	0.01J	0.01J	-	0.051	0.221	0.021	-
Boron	mg/L	0.405	0.301	0.196	0.276	0.329	-	0.45	0.381	0.308	0.242	0.009J	0.031	0.026	0.019	0.034	-	0.087	0.032	0.03	0.02
Cadmium	µg/L	15.1	3.61	4.99	4.05	2.55	-	0.91	0.53	0.47	-	0.84	1.18	1.82	0.03	0.03	-	0.1	0.3	0.03	-
Calcium	mg/L	709	508	353	423	383	-	437	471	473	406	297	271	292	251	250	-	273	259	272	243
Chloride	mg/L	8.13	7.73	6.62	5.34	-	5.71	5.91	6.38	6.66	5.98	6.99	6.87	6.95	6.6	-	6.8	6.85	6.82	6.85	6.66
Chromium	µg/L	71.1	28.7	8	19.9	9.49	-	22.2	10.8	13.2	-	6.1	4.8	7.04	0.298	0.166	-	0.444	1.95	0.298	-
Cobalt	µg/L	116	37.1	34.9	26	18.7	-	18.1	14.1	14.2	-	7.77	6.76	9.5	0.27	0.229	-	0.718	2.76	0.296	-
Combined Radium	pCi/L	2.587	1.455	1.901	14.144	4.021	-	0.957	1.798	1.33	-	2.47	0.78	1.143	0.629	0.941	-	0.924	0.64	0.961	-
Fluoride	mg/L	0.26	0.23	0.22	0.23	-	0.26	0.24	0.21	0.21	0.2	0.11	0.1J	0.1	0.1	-	0.1	0.1	0.08	0.08	0.09
Lead	µg/L	128	29.8	5.64	13.5	7.85	-	19.1	7.7	10.2	-	24.8	28.9	39.8	0.444	0.499	-	1.91	8.38	0.769	-
Lithium	mg/L	0.14	0.072	0.047	0.076	0.064	-	0.088	0.077	0.078	-	0.014	0.011	0.023	0.014	0.011	-	0.013	0.01	0.017	-
Mercury	µg/L	0.03	1.01	0.022	0.059	0.03	-	0.003J	0.023	0.006	-	0.005U	0.005U	0.172	0.005U	0.005U	-	0.005U	0.002J	0.005U	-
Molybdenum	µg/L	9.15	3.65	6.29	5.06	3.85	-	4.04	3.62	3.72	-	1.22	0.97	1.23	0.43	0.18	-	0.32	0.67	0.31	-
Selenium	µg/L	10	4.8	1	2.1	1.1	-	2.7	1.1	0.5	-	4.7	4.8	7.6	0.06J	0.08J	-	0.3	1.6	0.08J	-
Total Dissolved Solids	mg/L	2870	3010	2280	2930	-	2690	3390	2780	2710	2310	1250	1250	1270	1240	-	1280	1310	1330	1300	1280
Sulfate	mg/L	1680	1580	1210	1400	-	1510	1500	1700	1640	1380	697	662	678	670	-	685	675	726	713	691
Thallium	µg/L	2.02	0.692	0.505	0.658	0.431	-	0.36	0.208	0.224	-	0.247	0.216	0.325	0.02J	0.05U	-	0.02J	0.096	0.02J	-
pH	SU	7.19	6.96	6.71	7.19	7.31	7.02	6.92	6.75	6.7	7.71	7.1	7.39	7.28	7.54	7.15	7.63	7.12	7.2	7.2	8.11

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 - Landfill

Parameter	Unit	S-6										S-7									
		6/28/2016	8/5/2016	10/12/2016	1/11/2017	4/11/2017	4/20/2017	5/24/2017	6/21/2017	7/26/2017	10/4/2017	6/30/2016	8/4/2016	10/11/2016	1/11/2017	4/11/2017	4/20/2017	5/24/2017	6/21/2017	7/26/2017	10/4/2017
		Background									Detection	Background									Detection
Antimony	µg/L	0.07	0.08J	0.05J	0.05J	0.1U	-	2U	0.01J	0.1U	-	0.07	0.1	0.09	0.08	0.1	-	0.06J	0.06J	0.06J	-
Arsenic	µg/L	0.54	0.72	0.75	0.81	0.6	-	0.8J	0.59	0.51	-	0.52	0.49	0.71	0.56	0.59	-	0.5	0.76	0.51	-
Barium	µg/L	15.4	23.7	26.5	15	13.6	-	14.3	12.7	15.1	-	13.7	13.2	14	13.3	13.3	-	14.1	12.8	13.5	-
Beryllium	µg/L	0.005J	0.04U	0.01J	0.04U	0.04U	-	0.3J	0.02U	0.04U	-	0.01J	0.008J	0.01J	0.007J	0.01J	-	0.008J	0.04U	0.009J	-
Boron	mg/L	1.65	1.97	2.06	2.15	1.69	-	1.72	1.54	1.44	1.67	1.77	1.78	1.81	1.75	1.84	-	1.82	1.74	1.79	1.88
Cadmium	µg/L	0.6	0.4	0.52	0.14	0.13	-	0.6U	0.08	0.14	-	0.03	0.07	0.09	1.16	0.43	-	0.03J	0.02J	0.02J	-
Calcium	mg/L	241	308	352	393	254	-	263	219	203	251	271	247	255	245	240	-	251	239	259	244
Chloride	mg/L	32	37.4	41.1	39	-	40.6	35.7	32.2	29.3	37	34.1	33.9	35.7	33.7	-	32.6	34.7	35.2	35.2	36.5
Chromium	µg/L	0.1	0.4	0.3	0.226	0.03J	-	0.3J	0.065	0.318	-	0.3	0.1	0.1	0.086	0.069	-	0.132	0.05J	0.329	-
Cobalt	µg/L	0.268	0.383	0.437	0.404	0.279	-	0.3J	0.226	0.208	-	0.132	0.142	0.14	0.144	0.147	-	0.14	0.149	0.159	-
Combined Radium	pCi/L	0.752	2.328	0.936	0.981	0.075	-	0.811	1.416	1.5629	-	0.996	1.149	0.235	0.824	0.437	-	1.05	0.71	1.071	-
Fluoride	mg/L	0.28	0.22	0.21	0.14	-	0.16	0.23	0.23	0.23	0.2	0.18	0.16	0.17	0.16	-	0.16	0.16	0.14	0.13	0.1
Lead	µg/L	0.737	0.862	0.717	1.4	0.211	-	0.2J	0.158	0.344	-	1.36	3.58	4.23	5.03	6.17	-	1.34	0.617	0.928	-
Lithium	mg/L	0.042	0.029	0.03	0.033	0.03	-	0.032	0.027	0.031	-	0.09	0.081	0.087	0.093	0.084	-	0.09	0.087	0.092	-
Mercury	µg/L	0.003J	0.005U	0.002J	0.005U	0.005U	-	0.005U	0.005U	0.005U	-	0.005U	0.005U	0.005U	0.005	0.005U	-	0.005U	0.005U	0.005U	-
Molybdenum	µg/L	0.5	0.53	0.32	1.04	0.54	-	3.08	0.62	1.08	-	5.45	7.53	7.95	8.1	6.19	-	7.6	7.7	7.61	-
Selenium	µg/L	0.1U	0.2U	0.2U	0.06J	0.2U	-	3U	0.1U	0.2U	-	0.3	0.1	0.2	0.1	0.3	-	0.2	0.2J	0.1J	-
Total Dissolved Solids	mg/L	1040	2270	2260	2520	-	2470	22100	766	1890	2200	1850	1820	1760	1820	-	1850	1900	1890	1900	1860
Sulfate	mg/L	1110	1340	1350	1440	-	1420	1200	1220	1070	1250	1040	1020	988	1060	-	961	1010	1140	1090	1020
Thallium	µg/L	0.04J	0.04J	0.04J	0.04J	0.1U	-	2U	0.05U	0.03J	-	0.02J	0.02J	0.02J	0.03J	0.02J	-	0.02J	0.02J	0.03J	-
pH	SU	7.44	7.19	7.69	7.08	7.38	7.55	6.95	7.46	7.2	7.89	7.25	7.69	7.22	7.23	7.51	7.44	7	6.98	6.93	7.41

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 - Landfill

Parameter	Unit	S-10									S-17									
		6/23/2016	8/3/2016	10/20/2016	1/17/2017	5/2/2017	5/25/2017	6/27/2017	7/26/2017	9/26/2017	6/29/2016	8/9/2016	10/12/2016	2/9/2017	3/9/2017	4/17/2017	5/31/2017	6/22/2017	8/1/2017	10/3/2017
		Background								Detection	Background									Detection
Antimony	µg/L	0.05	0.05J	0.06	0.05J	0.05J	0.06	0.07J	0.06J	-	0.02J	0.12	-	0.07	0.02J	0.02J	0.06	0.01J	0.07	-
Arsenic	µg/L	0.65	0.4	0.66	0.74	0.72	0.88	1.11	0.94	-	5.23	9.37	-	10.1	9.28	9.41	11.6	9.62	10.7	-
Barium	µg/L	20.2	13.1	12.9	20.6	19.9	25.6	19.4	20	-	37.7	41.2	-	31.3	31	33.7	43.3	23.7	43	-
Beryllium	µg/L	0.02J	0.04U	0.01J	0.01J	0.01J	0.02J	0.02J	0.02J	-	0.01J	0.157	-	0.042	0.01J	0.006J	0.043	0.006J	0.057	-
Boron	mg/L	1.27	0.853	0.896	1.22	1.33	1.5	1.4	1.29	0.825	0.127	0.151	-	0.173	0.157	0.153	0.175	0.221	0.165	0.168
Cadmium	µg/L	0.02J	0.01J	0.01J	0.01J	0.04U	0.03	0.04U	0.06	-	0.07	0.91	-	0.09	0.02	0.02U	0.11	0.02	0.12	-
Calcium	mg/L	246	303	285	252	251	238	264	249	295	235	237	-	254	203	201	195	138	190	212
Chloride	mg/L	25.7	25	24.3	26.4	29.3	27.8	25.3	25.1	24.6	3.52	3.98	-	3.02	2.55	2.98	3.22	2.36	2.68	4.71
Chromium	µg/L	0.2	0.02J	0.077	0.106	0.06J	0.04J	0.09J	0.372	-	0.6	4.3	-	1.17	0.479	0.03J	1	0.139	1.55	-
Cobalt	µg/L	0.111	0.043	0.079	0.077	0.068	0.311	0.292	0.26	-	0.518	1.69	-	3.43	1.27	0.769	1.17	1.1	1.11	-
Combined Radium	pCi/L	0.996	0.573	1.816	1.759	0.729	1.274	1.806	1.046	-	0.568	1.192	-	1.267	0.691	2.75	1.094	1.159	0.807	-
Fluoride	mg/L	0.17	0.21	0.23	0.16	0.16	0.15	0.15	0.13	0.17	0.24	0.22	-	0.16	0.19	0.19	0.2	0.2	0.22	0.22
Lead	µg/L	0.06	0.01J	0.034	0.067	0.048	0.056	0.047	0.057	-	0.393	6.43	-	1.79	0.471	0.008J	1.96	0.182	2.88	-
Lithium	mg/L	0.093	0.061	0.065	0.089	0.102	0.11	0.084	0.095	-	0.04	0.033	-	0.044	0.033	0.032	0.032	0.034	0.032	-
Mercury	µg/L	0.004J	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	-	0.005U	0.015	-	0.006	0.005U	0.003J	0.002J	0.005U	0.005U	-
Molybdenum	µg/L	15.2	6.91	5.12	14.5	18.9	21.6	18.1	20.7	-	0.81	0.96	-	2.4	1.86	1.84	1.91	1.6	2.01	-
Selenium	µg/L	0.4	0.3	0.5	0.5	0.7	0.6	0.6	0.4	-	0.1	0.8	-	0.4	0.1	0.05J	0.3	0.04J	0.4	-
Total Dissolved Solids	mg/L	1670	1700	1690	1600	1640	1570	1660	1640	1730	1460	1410	-	1720	1370	1470	1440	1170	1420	1460
Sulfate	mg/L	967	998	970	897	889	867	979	989	1060	813	797	-	1180	740	823	821	643	850	784
Thallium	µg/L	0.05U	0.1U	0.116	0.02J	0.1U	0.05U	0.1U	0.03J	-	0.094	0.369	-	0.131	0.05J	0.03J	0.091	0.01J	0.116	-
pH	SU	6.88	6.88	6.99	6.97	7	7.12	7.13	6.92	7.74	7.04	6.97	8	6.39	-	6.8	6.73	6.84	8.08	7.14

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 - Landfill

Parameter	Unit	S-18									S-19A								
		6/29/2016	8/9/2016	10/6/2016	1/12/2017	4/17/2017	5/31/2017	6/22/2017	7/27/2017	10/3/2017	6/24/2016	8/8/2016	10/5/2016	1/12/2017	4/17/2017	5/31/2017	6/22/2017	7/27/2017	10/3/2017
		Background								Detection	Background								Detection
Antimony	µg/L	0.03J	0.05	0.06	0.03J	0.09J	0.03J	0.02J	0.1U	-	0.1U	0.1U	0.1U	0.1U	0.05J	0.2U	0.2U	0.2U	-
Arsenic	µg/L	1.4	2.29	2.24	0.9	0.98	1.41	0.8	0.74	-	1.84	2.46	2.78	2.3	2.15	2.63	2.07	2.19	-
Barium	µg/L	20.9	68.9	64.5	22.1	21.7	25.9	18.3	18.3	-	18.2	18.6	15.2	15.7	20.7	19.6	18.7	19.6	-
Beryllium	µg/L	0.009J	0.092	0.103	0.008J	0.01J	0.02	0.04U	0.04U	-	0.01J	0.01J	0.01J	0.04U	0.03J	0.02J	0.06U	0.02J	-
Boron	mg/L	0.611	0.658	0.568	0.561	0.558	0.538	0.573	0.517	0.556	0.33	0.34	0.378	0.335	0.364	0.331	0.348	0.311	0.388
Cadmium	µg/L	0.06	0.04	0.04	0.02J	0.01J	0.14	0.02J	0.05	-	0.01J	0.04U	0.04U	0.04U	0.02J	0.1U	0.06U	0.06U	-
Calcium	mg/L	218	207	179	202	142	189	154	156	178	419	405	338	373	413	401	407	388	388
Chloride	mg/L	2.2	1.77	1.82	1.23	2.36	1.36	1.5	1.55	1.18	3.64	4.01	6.9	6.32	4.68	4.02	3.97	3.84	3.47
Chromium	µg/L	0.5	1.9	1.8	0.184	0.143	0.371	0.09J	0.421	-	0.1	0.1	0.1J	0.162	0.06J	0.2J	0.502	0.485	-
Cobalt	µg/L	0.248	0.606	0.834	0.35	0.334	0.215	0.151	0.227	-	0.095	0.087	0.463	0.182	0.099	0.127	0.05J	0.071	-
Combined Radium	pCi/L	1.036	2.05	2.108	1.173	0.522	1.351	2.577	0.434	-	1.769	1.239	1.759	1.821	0.572	1.565	0.948	2.26	-
Fluoride	mg/L	0.36	0.33	0.35	0.36	0.35	0.32	0.31	0.3	0.29	0.35	0.36	0.39	0.32	0.33	0.32	0.36	0.29	0.32
Lead	µg/L	0.329	1.87	2.48	0.236	0.175	0.877	0.07	0.116	-	0.041	0.01J	0.089	0.03J	0.06J	0.106	0.066	0.05J	-
Lithium	mg/L	0.074	0.063	0.057	0.073	0.057	0.056	0.06	0.057	-	0.061	0.058	0.061	0.065	0.062	0.06	0.066	0.061	-
Mercury	µg/L	0.002J	0.009	0.005U	0.002J	0.003J	0.006	0.005U	0.005U	-	0.005U	0.005U	0.005U	0.005U	0.003J	0.005U	0.005U	0.005U	-
Molybdenum	µg/L	11.5	12.1	13.7	10.7	7.63	10.9	7.92	8.4	-	3.49	4.83	7.8	6.77	5.12	6.89	5.35	5.31	-
Selenium	µg/L	0.1	0.3	0.4	0.06J	0.3	0.07J	0.2U	0.2U	-	0.2U	0.09J	0.1J	0.2U	0.4U	0.5U	0.3U	0.3U	-
Total Dissolved Solids	mg/L	1540	1520	1600	1760	1610	1490	1530	1510	1520	3290	3190	2780	2910	3230	6730	3330	3080	3050
Sulfate	mg/L	910	859	928	1040	908	872	899	842	799	2070	1980	1700	1730	2040	2090	2130	2120	1930
Thallium	µg/L	0.095	0.02J	0.03J	0.069	0.02J	0.03J	0.1U	0.02J	-	0.1U	0.1U	0.1U	0.1U	0.05J	0.2U	0.2U	0.03J	-
pH	SU	6.98	7.01	7.35	6.87	6.97	6.76	6.93	6.98	7.12	6.83	6.85	6.85	6.83	6.89	6.64	6.8	6.96	6.97

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 - Landfill

Parameter	Unit	S-20											SGS-1								
		6/29/2016	8/3/2016	10/6/2016	1/17/2017	4/12/2017	4/19/2017	5/2/2017	5/30/2017	6/21/2017	8/1/2017	9/26/2017	6/23/2016	8/5/2016	10/20/2016	1/16/2017	5/2/2017	5/24/2017	6/22/2017	7/27/2017	10/4/2017
		Background										Detection	Background								Detection
Antimony	µg/L	0.13	0.09J	0.06J	0.04J	0.22	-	-	0.05J	0.04J	0.1U	-	0.05J	0.04J	0.03J	0.07J	0.03J	0.02J	0.03J	0.02J	-
Arsenic	µg/L	4.91	4.55	3.11	2.67	2.35	-	-	2.42	2.16	2.06	-	1.42	1.71	2.47	3.17	2.22	2.16	2.18	2.73	-
Barium	µg/L	16.5	16.3	16.6	16.1	16.4	-	-	16.1	15.4	14.6	-	34	32.3	31.7	38.4	32.9	34.7	33.1	35.1	-
Beryllium	µg/L	0.03	0.03J	0.01J	0.01J	0.01J	-	-	0.01J	0.01J	0.01J	-	0.04U	0.02U	0.02U	0.08U	0.04U	0.04U	0.04U	0.04U	-
Boron	mg/L	0.172	0.2	0.22	0.22	0.254	-	-	0.214	0.273	0.294	0.293	0.989	0.948	1.12	0.853	0.831	0.912	0.877	0.866	0.934
Cadmium	µg/L	0.02U	0.04U	0.05	0.02U	0.02U	-	-	0.04U	0.04U	0.04U	-	0.04U	0.005J	0.02U	0.02J	0.04U	0.04U	0.04U	0.04U	-
Calcium	mg/L	345	342	386	344	323	-	-	305	326	322	339	189	170	156	129	118	126	119	115	110
Chloride	mg/L	3.04	2.62	2.72	2.59	-	2.76	2.81	2.84	2.72	2.59	2.53	28.6	25.5	24.1	23.6	24.3	24	24	23.8	23.4
Chromium	µg/L	5.5	1	0.3	0.212	3.5	-	-	2.32	0.508	0.384	-	0.2	0.1	0.245	0.2J	0.1J	0.223	0.13	0.355	-
Cobalt	µg/L	4.51	5.58	6.7	5.77	5.14	-	-	5.4	5.17	5.21	-	1.91	1.04	0.885	0.872	0.61	0.516	0.544	0.555	-
Combined Radium	pCi/L	0.504	1.89	1.005	2.0464	0.43	-	-	0.861	1.32	4.988	-	0.778	1.893	1.792	4.035	0.259	1.207	1.043	1.273	-
Fluoride	mg/L	0.22	0.26	0.25	0.25		0.25	0.26	0.23	0.24	0.26	0.26	0.42	0.47	0.51	0.57	0.59	0.58	0.57	0.56	0.55
Lead	µg/L	0.462	0.348	0.375	0.164	0.128	-	-	0.145	0.089	0.02J	-	0.041	0.02J	0.009J	0.05J	0.01J	0.03J	0.02J	0.02J	-
Lithium	mg/L	0.054	0.033	0.034	0.036	0.038	-	-	0.03	0.037	0.039	-	0.026	0.027	0.031	0.027	0.026	0.031	0.024	0.029	-
Mercury	µg/L	0.005U	0.005U	0.005U	0.005U	0.003J	-	-	0.005U	0.005U	0.005U	-	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	-
Molybdenum	µg/L	0.91	0.47	1.67	0.5	0.72	-	-	0.9	4	1.92	-	10.2	3.16	30.1	15.5	2.07	1.93	2.18	2.11	-
Selenium	µg/L	0.2	0.2U	0.06J	0.04J	0.08J	-	-	0.2J	0.2U	0.2U	-	0.09J	0.07J	0.05J	0.2J	0.2U	0.06J	0.2U	0.2U	-
Total Dissolved Solids	mg/L	1740	2030	2060	2010	-	1920	1940	1840	1960	1900	1950	1970	1890	1920	1820	1820	1810	1810	1810	1800
Sulfate	mg/L	1030	1140	1170	1070	-	1040	1030	1030	1070	1230	1180	1030	1010	947	918	916	891	947	959	922
Thallium	µg/L	0.03J	0.1U	0.1U	0.02J	0.01J	-	-	0.1U	0.04J	0.1U	-	0.1U	0.04J	0.03J	0.585	0.02J	0.1U	0.1U	0.1U	-
pH	SU	6.57	6.58	6.97	6.64	6.7	7.26	6.64	6.57	6.3	7.94	7.74	6.86	6.98	6.72	7.08	7.44	7.05	7.62	8.86	7.99

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 - Landfill

Parameter	Unit	SGS-2									SGS-3								
		6/23/2016	8/4/2016	10/20/2016	1/16/2017	5/2/2017	5/24/2017	6/21/2017	7/27/2017	10/4/2017	6/27/2016	8/3/2016	10/7/2016	1/10/2017	4/17/2017	5/30/2017	6/22/2017	7/27/2017	10/3/2017
		Background								Detection	Background								Detection
Antimony	µg/L	0.74	0.31	0.13	0.2J	0.23	0.22	0.15	0.11	-	0.63	0.32	0.31	0.53	0.24	0.74	0.1J	0.11	-
Arsenic	µg/L	2.65	4.36	8.13	16.5	16.7	26.8	17.1	17.8	-	1.11	1.27	2.04	3.61	2.69	3.48	3.14	3.11	-
Barium	µg/L	50.5	49.3	50.9	67.5	63.7	82.7	71.6	78.4	-	74.3	104	189	253	156	208	155	152	-
Beryllium	µg/L	0.04U	0.02U	0.006J	0.08U	0.04U	0.04U	0.04U	0.04U	-	0.02J	0.01J	0.072	0.204	0.008J	0.09	0.06U	0.04U	-
Boron	mg/L	0.87	0.869	0.851	0.612	0.655	0.59	0.587	0.612	0.67	0.209	0.236	0.452	0.29	0.283	0.299	0.306	0.283	0.302
Cadmium	µg/L	0.14	0.04	0.009J	0.08U	0.04U	0.04U	0.04U	0.04U	-	0.008J	0.008J	0.007J	0.04	0.006J	0.11	0.06U	0.01J	-
Calcium	mg/L	104	70.3	44.8	23.2	26	12.1	16.1	15.1	13	16.4	15	9.98	24.6	6.04	12.2	4.98	4.96	4.82
Chloride	mg/L	80.9	77.5	63.3	102	70.5	97.7	68	111	62.2	149	248	279	297	313	346	311	298	314
Chromium	µg/L	0.3	0.6	0.544	0.423	0.281	0.279	0.264	0.505	-	0.8	1.5	1	6.64	0.293	3.23	0.223	0.4	-
Cobalt	µg/L	1.04	0.788	0.218	0.155	0.142	0.097	0.105	0.11	-	0.702	1.09	0.644	3.06	0.4	1.95	0.325	0.335	-
Combined Radium	pCi/L	0.799	1.316	1.087	1.34	0.988	1.115	0.563	0.552	-	0.237	1.659	1.673	0.448	0.506	1.293	0.563	0.672	-
Fluoride	mg/L	1.6	1.74	2.1	2.01	2.24	2.36	2.42	2.61	2.33	1.18	0.73	2.02	1.74	1.81	1.92	2.04	1.91	2.04
Lead	µg/L	0.131	0.192	0.13	0.164	0.266	0.19	0.184	0.15	-	0.358	0.382	0.71	5.13	0.279	3.43	0.15	0.184	-
Lithium	mg/L	0.044	0.035	0.039	0.034	0.032	0.034	0.03	0.034	-	0.047	0.022	1.96	0.032	0.02	0.02	0.027	0.025	-
Mercury	µg/L	0.005U	0.005U	0.005U	0.005U	0.002J	0.004J	0.003J	0.003J	-	0.005U	0.005U	0.005U	0.005U	0.002J	0.005U	0.005U	0.005U	-
Molybdenum	µg/L	31.1	22.8	15.5	3.82	5.31	1.82	7.18	7.28	-	24.2	30.2	12.6	11.6	12.2	13.4	12.6	10.6	-
Selenium	µg/L	0.8	0.2	0.09J	0.4U	0.1J	0.1J	0.08J	0.09J	-	0.3	0.2	0.3	0.7	0.1U	0.2	0.3U	0.2U	-
Total Dissolved Solids	mg/L	2050	1980	1790	1960	1830	1820	1740	1750	1700	1570	1550	1600	1690	-	1730	3390	1700	1630
Sulfate	mg/L	832	799	491	365	344	127	201	73.2	131	494	56.2	100	93.2	63.6	83.4	103	126	118
Thallium	µg/L	0.03J	0.055	0.02J	0.2U	0.1U	0.1U	0.1U	0.1U	-	0.02J	0.066	0.01J	0.06	0.05U	0.05J	0.2U	0.05J	-
pH	SU	7.41	7.91	7.87	7.91	7.89	8.17	8.15	8.84	8.28	7.9	8.21	8.22	8.06	7.94	7.83	7.9	7.86	8.09

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 - Landfill

Geosyntec Consultants, Inc.

Parameter	Unit	CA-0623A		OAE-2005-10-C		S-1			S-2	
		5/15/2018	10/16/2018	5/15/2018	10/16/2018	5/16/2018	10/9/2018	11/19/2018	5/16/2018	10/9/2018
		2018-D1	2018-D2	2018-D1	2018-D2	2018-D1	2018-D2	2018-D2-V1	2018-21	2018-D2
Boron	mg/L	0.546	0.513	0.476	0.502	0.888	0.97	0.961	1.09	2.5
Calcium	mg/L	1.64	1.18	6.3	5.44	315	321	-	271	385
Chloride	mg/L	14.1	20.7	9.69	12	5.42	6.4	-	8.09	5.6
Fluoride	mg/L	2.08	2.3	1.09	1.1	0.19	0.23	-	0.42	0.2
pH	SU	8.59	8.72	8.37	8.55	6.84	7.46	-	7.54	7.53
Total Dissolved Solids	mg/L	609	642	1410	1410	1880	1840	-	2110	3060
Sulfate	mg/L	33.1	30.9	357	377	1030	1020	-	1340	1840

Parameter	Unit	S-4		S-5		S-6		S-7				
		5/16/2018	10/12/2018	5/16/2018	10/12/2018	5/16/2018	10/12/2018	1/24/2018	2/15/2018	5/16/2018	10/9/2018	11/19/2018
		2018-D1	2018-D2	2018-D1	2018-D2	2018-D1	2018-D2	2017-D1-V1	2017-D1-V1	2018-D1	2018-D2	2018-D2-V1
Boron	mg/L	0.255	0.307	0.051	0.0222	1.57	1.73	1.90	2.12	1.93	2.16	-
Calcium	mg/L	593	459	268	258	209	236	-	-	251	263	-
Chloride	mg/L	5.37	6	6.95	8.1	30.9	34.7	-	-	34.7	38.4	31.9
Fluoride	mg/L	0.27	0.27	0.11	0.13	0.28	0.25	-	-	0.18	0.17	-
pH	SU	6.92	7.94	7.37	8.77	7.23	8.02	-	-	7.1	7.61	-
Total Dissolved Solids	mg/L	3260	606	1260	1280	1950	2040	-	-	1870	1890	-
Sulfate	mg/L	1580	1600	704	743	1100	1200	-	-	1090	1080	-

Notes:
mg/L: milligrams per liter
SU: standard unit
J: Estimated value. Parameter was detected in concentrations below the reporting limit
-: Not sampled
2017-D1-V1: Verification sampling for initial detection monitoring event (initial detection event occurred in 2017)
2018-D1: First semi-annual detection monitoring event of 2018
2018-D1-V1: Verification sampling, first semi-annual detection monitoring event
2018-D2: Second semi-annual detection monitoring event of 2018
2018-D2-V1: Verification sampling, second semi-annual detection monitoring event

Table 1: Groundwater Data Summary
Cardinal Plant - Landfill

Geosyntec Consultants, Inc.

Parameter	Unit	S-10					S-17		S-18		
		1/24/2018	5/22/2018	8/7/2018	10/15/2018	11/19/2018	5/15/2018	10/16/2018	5/15/2018	10/8/2018	11/19/2018
		2017-D1-V1	2018-D1	2018-D1-V1	2018-D2	2018-D2-V1	2018-D1	2018-D2	2018-D1	2018-D2	2018-D2-V1
Boron	mg/L	-	1.87	1.37	1.74	1.88	0.229	0.212	0.573	0.586	-
Calcium	mg/L	-	196	-	178	-	143	140	172	164	-
Chloride	mg/L	-	25.1	-	22.8	-	3.21	5.7	1.64	2.9	1.7
Fluoride	mg/L	-	0.100 J	-	0.16	-	0.23	0.28	0.36	0.39	0.36
pH	SU	-	7.27	-	7.18	-	6.87	7.13	7.05	7.05	-
Total Dissolved Solids	mg/L	-	1450	-	1480	-	1210	514	1320	1250	-
Sulfate	mg/L	894	849	-	834	-	671	775	743	772	-

Parameter	Unit	S-19A		S-20				SGS-1			SGS-2		SGS-3	
		5/15/2018	10/16/2018	5/17/2018	8/7/2018	10/8/2018	11/19/2018	5/22/2018	8/7/2018	10/15/2018	5/22/2018	10/15/2018	5/15/2018	10/15/2018
		2018-D1	2018-D2	2018-D1	2018-D1-V1	2018-D2	2018-D2-V1	2018-D1	2018-D1-V1	2018-D2	2018-D1	2018-D2	2018-D1	2018-D2
Boron	mg/L	0.398	0.409	0.34	0.264	0.267	-	0.923	-	0.911	0.556	0.55	0.418	0.319
Calcium	mg/L	419	385	315	-	319	-	118	-	107	9.96	7.94	5.3	5
Chloride	mg/L	3.57	3.6	2.93	-	3.9	2.7	23.8	-	23.2	91.2	99.7	375	401
Fluoride	mg/L	0.40	0.35	0.27	-	0.31	0.22	0.72	0.62	0.64	2.75	2.6	2.08	1.9
pH	SU	6.94	7.26	6.75	-	6.83	-	7.23	-	7.17	7.98	7.98	8.05	8.19
Total Dissolved Solids	mg/L	3210	3100	1480	-	1860	-	1800	-	1820	1700	1700	1750	1900
Sulfate	mg/L	2080	2080	1040	-	1060	-	906	-	935	81.1	73.8	123	126

Notes:
mg/L: milligrams per liter
SU: standard unit
J: Estimated value. Parameter was detected in concentrations below the reporting limit
-: Not sampled
2017-D1-V1: Verification sampling for initial detection monitoring event (initial detection event occurred in 2017)
2018-D1: First semi-annual detection monitoring event of 2018
2018-D1-V1: Verification sampling, first semi-annual detection monitoring event
2018-D2: Second semi-annual detection monitoring event of 2018
2018-D2-V1: Verification sampling, second semi-annual detection monitoring event

Table 1 - Groundwater Data Summary
Cardinal Plant - Landfill and Fly Ash Reservoir I

Parameter	Unit	CA-0623A		OAE-2005-10-C		S-1				S-2		S-4	
		3/26/2019	10/1/2019	4/2/2019	10/7/2019	2/7/2019	3/29/2019	5/1/2019	10/3/2019	3/29/2019	10/3/2019	3/29/2019	10/9/2019
		2019-D1	2019-D2	2019-D1	2019-D2	2018-D2-R2	2019-D1	2019-D1-R1	2019-D2	2019-D1	2019-D2	2019-D1	2019-D2
Boron	µg/L	441	440	468	489	960	938	-	834	1,280	2,590	312	263
Calcium	µg/L	929	1,070	4,850	6,180	-	333,000	-	341,000	318,000	404,000	499,000	478,000
Chloride	mg/L	11.9	19.9	12.6	19.3	-	5.00	-	4.50	6.70	4.50	4.40	4.30
Fluoride	mg/L	2.10	2.00	1.10	1.10	-	0.110	-	0.120	0.370	0.290	0.190	0.240
Total Dissolved Solids	mg/L	632	646	1,440	1,350	-	1,800	-	1,790	2,400	2,930	2,130	2,560
Sulfate	mg/L	32.1	18.7	363	421	-	1,400	940	992	1,290	1,910	1,400	1,440
pH	SU	8.76	8.71	7.80	7.61	7.19	7.19	7.11	7.43	7.05	7.37	7.34	7.60

Parameter	Unit	S-5		S-6		S-7					S-10			
		3/28/2019	10/9/2019	3/28/2019	10/3/2019	1/7/2019	3/28/2019	5/1/2019	5/22/2019	10/3/2019	1/7/2019	3/28/2019	5/1/2019	9/30/2019
		2019-D1	2019-D2	2019-D1	2019-D2	2018-D2-R2	2019-D1	2019-D1-R1	2019-D1-R2	2019-D2	2018-D2-R2	2019-D1	2019-D1-R1	2019-D2
Boron	µg/L	22.2	20.5	1,510	2,190	1,900	1,980	1,940	1,860	2,000	1,600	1,080	-	608
Calcium	µg/L	302,000	287,000	182,000	418,000	-	252,000	-	-	255,000	-	268,000	-	278,000
Chloride	mg/L	6.90	7.20	27.1	37.6	29.9	32.1	-	-	31.4	19.8	23.1	-	19.4
Fluoride	mg/L	0.210	0.110	0.370	0.0720	-	0.260	0.0910	-	0.0880	-	0.290	0.0950	0.200
Total Dissolved Solids	mg/L	1,280	1,240	1,780	2,500	-	1,870	-	-	1,930	-	1,580	-	1,710
Sulfate	mg/L	739	689	973	1,360	-	1,100	-	-	984	-	966	-	946
pH	SU	8.11	7.93	7.59	7.00	7.48	7.72	7.42	7.22	7.68	7.40	7.23	7.16	7.03

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
SU: standard unit
J: Estimated value. Parameter was detected in concentrations below the reporting limit
-: Not sampled
2018-D2-R2: Second verification sampling, second semi-annual detection monitoring event of 2018
2019-D1: First semi-annual detection monitoring event of 2019
2019-D1-R1: Verification sampling, first semi-annual detection monitoring event
2019-D1-R2: Second verification sampling, first semi-annual detection event of 2019
2019-D2: Second semi-annual detection monitoring event of 2019
2019-D2-R1: Verification sampling, second semi-annual detection monitoring event

Table 1 - Groundwater Data Summary
Cardinal Plant - Landfill and Fly Ash Reservoir I

Parameter	Unit	S-17	S-18				S-19A		S-20		
		4/2/2019	4/2/2019	5/9/2019	10/7/2019	11/21/2019	3/28/2019	10/8/2019	3/28/2019	5/1/2019	10/3/2019
		2019-D1	2019-D1	2019-D1-R1	2019-D2	2019-D2-R1	2019-D1	2019-D2	2019-D1	2019-D1-R1	2019-D2
Boron	µg/L	182	558	-	549	-	388	381	253	-	287
Calcium	µg/L	159,000	112,000	-	146,000	-	457,000	452,000	361,000	-	304,000
Chloride	mg/L	4.20	2.60	2.10	1.80	-	3.00	3.30	2.70	-	2.70
Fluoride	mg/L	0.190	0.300	-	0.300	-	0.460	0.270	0.370	0.150	0.220
Total Dissolved Solids	mg/L	1,270	938	-	1,070	-	3,200	3,180	1,830	-	1,750
Sulfate	mg/L	644	444	-	688	-	2,090	2,180	1,130	-	1,120
pH	SU	7.03	7.08	-	6.63	6.99	7.07	6.95	6.65	7.08	6.75

Parameter	Unit	SGS-1			SGS-2		SGS-3	
		3/28/2019	5/9/2019	10/2/2019	3/28/2019	10/2/2019	3/26/2019	10/2/2019
		2019-D1	2019-D1-R1	2019-D2	2019-D1	2019-D2	2019-D1	2019-D2
Boron	µg/L	870	-	855	502	473	302	288
Calcium	µg/L	111,000	-	110,000	6,920	6,380	5,600	5,540
Chloride	mg/L	23.1	-	22.7	90.9	93.2	404	363
Fluoride	mg/L	0.750	0.610	0.620	2.80	2.80	2.10	1.90
Total Dissolved Solids	mg/L	1,760	-	1,780	1,620	1,600	1,880	1,950
Sulfate	mg/L	954	-	991	58.3	38.1	174	184
pH	SU	7.36	-	7.45	8.02	8.02	8.40	8.21

Notes:
µg/L: micrograms per liter
mg/L: milligrams per liter
SU: standard unit
J: Estimated value. Parameter was detected in concentrations below the reporting limit
-: Not sampled
2018-D2-R2: Second verification sampling, second semi-annual detection monitoring event of 2018
2019-D1: First semi-annual detection monitoring event of 2019
2019-D1-R1: Verification sampling, first semi-annual detection monitoring event
2019-D1-R2: Second verification sampling, first semi-annual detection event of 2019
2019-D2: Second semi-annual detection monitoring event of 2019
2019-D2-R1: Verification sampling, second semi-annual detection monitoring event

Table 1: Detection Monitoring Data Evalation
Cardinal Plant - Landfill

Geosyntec Consultants, Inc.

Parameter	Unit	Description	S-1	S-7	S-10	S-18	S-20	SGS-1	SGS-2	SGS-2
			4/16/2020	4/14/2020	4/14/2020	4/14/2020	4/20/2020	4/14/2020	4/13/2020	6/3/2020
Boron	mg/L	Intrawell Background Value (UPL)	1.01	2.15	2.13	0.659	0.360	1.11	0.980	
		Detection Monitoring Result	0.830	1.96	1.55	0.549	0.245	0.794	0.467	--
Calcium	mg/L	Intrawell Background Value (UPL)	353	275	342	246	390	198	32.6	
		Detection Monitoring Result	309	256	190	126	307	104	6.26	--
Chloride	mg/L	Intrawell Background Value (UPL)	6.83	39.2	30.5	3.07	3.90	28.6	125	
		Detection Monitoring Result	4.80	30.9	22.7	2.80	3.50	23.4	103	--
Fluoride	mg/L	Intrawell Background Value (UPL)	0.267	0.258	0.293	0.411	0.362	0.788	3.23	
		Detection Monitoring Result	0.130	0.150	0.130	0.410	0.340	0.660	**3.40**	2.5
pH	SU	Intrawell Background Value (UPL)	7.5	7.9	7.7	7.4	7.9	8.8	8.8	
		Intrawell Background Value (LPL)	6.6	6.7	6.6	6.7	6.3	5.9	7.2	
		Detection Monitoring Result	7.2	7.7	7.2	6.9	6.6	7.1	8.0	--
Total Dissolved Solids (TDS)	mg/L	Intrawell Background Value (UPL)	1960	1960	1830	1980	2250	1980	2130	
		Detection Monitoring Result	1780	1850	1390	921	1720	1750	1530	--
Sulfate	mg/L	Intrawell Background Value (UPL)	1400	1180	1100	1190	1260	1050	488	
		Detection Monitoring Result	899	1010	694	475	1010	848	28.5	--

Notes:
UPL: Upper prediction limit
LPL: Lower prediction limit
Bold values exceed the background value.
Background values are shaded gray.

FAR I RSW Landfill

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

A description of site hydrogeology including stratigraphic cross-sections

May	64.6	2.95
June	70.0	10.69
July	71.4	4.66
August	70.5	2.81
September	69.3	6.70
October	53.2	2.56
November	47.8	1.17
December	46.6	3.24

2.4.2 Regional and Local Geologic Setting

The geology at the former FAR I RSW Landfill and the vicinity consists of nearly horizontal sequences of lower Permian and upper Pennsylvanian sedimentary rock. The Permian-age Dunkard Group occurs only on the tops of some ridges above an elevation of approximately 1,250 feet (ft), northwest and west of landfill and FAR II sites.

The Monongahela Group is up to 230 feet thick in Jefferson County, consisting of shale, sandstone, limestone, coal claystone and siltstone. These rocks form much of the slopes above the current levels of the FAR I RSW Landfill and FAR II sites. Below the Monongahela Group is the Conemaugh Group, which is generally over 500 feet thick in Jefferson County. The Conemaugh Group consists of shale, sandstone, limestone, coal, and claystone, including the Morgantown Sandstone, which is a developed aquifer in the area. Beneath the Morgantown Sandstone is a sequence of the Conemaugh Group including the Elk Lick Limestone, the Skelly Limestone and shale, the Ames Limestone, several thick shale sequences, and the Cow Run Sandstone (AEP, 2005a).

2.4.3 Surface Water and Surface Water-Groundwater Interactions

The intermittent stream of the western branch of Blockhouse Hollow at the northwest end of the FAR I RSW Landfill was historically re-routed during surface mining operations and flows in a constructed stream channel along the bottom of the highwall slope north of the landfill and former FAR I. Blockhouse Hollow then drains into FAR II. Surface water northeast of the landfill flows to, or is collected and drained to, Blockhouse Hollow. Drainage from the highwall adjacent to Cells 1 & 2 of the landfill is collected in an engineered highwall drainage layer and conveyed through the landfill subsurface drainage layer and piping to a perimeter solid wall transmission pipe that discharges into the Blockhouse Hollow channel draining to FAR II (AEP, 2006; AEP, 2007). Perimeter landfill and final cover system surface water will be collected and conveyed in piping to either Blockhouse Hollow or piping that drains directly to FAR II. Landfill contact stormwater is collected and transferred to the landfill leachate collection system. Both surface stormwater and

leachate are transferred to FAR II as FAR II serves as the facilities sedimentation pond and leachate collection pond.

2.4.4 Water Users

According to water well records obtained from the Ohio Department of Natural Resources (ODNR), the nearest water supply well is located approximately 3,000 feet east of the landfill. Additionally, ODNR records indicate a series of water supply wells in the Tidd-Dale Subdivision of Brilliant, Ohio, approximately 4,000 to 5,000 feet southeast of the former FAR I RSW Landfill. These water supply wells are developed in the deeper Buffalo Sandstone, which underlies the uppermost aquifer.

Approximately one mile west of the former FAR I RSW Landfill, a series of water supply wells develop several limestone horizons, apparently the Arnoldsburg and Benwood Limestone units. These well logs report pumping rates ranging from approximately 1.0 gpm to 8.0 gpm with significant drawdown (AEP, 2006).

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 1.25 mile east of the FAR I RSW Landfill. ODNR records indicate these wells are screened within the alluvial deposits of the Ohio River and exhibit pumping rates of up to 700 gpm.

3. MONITORING NETWORK EVALUATION

3.1 Hydrostratigraphic Units

3.1.1 Horizontal and Vertical Position relative to CCR Unit

The hydrogeology at the former FAR I RSW Landfill Facility is characterized by an uppermost aquifer system comprised of sandstone and limestone units, specifically the Connellsville Sandstone, Summerfield Limestone, and Bellaire Sandstone, which lie above the shale aquitard that caps the Morgantown Sandstone. The landfill is situated horizontally and vertically within the upper sandstone and limestone units and above the former FAR I. The landfill is separated from FAR I by a base liner system and five feet of geologic material. The existing monitoring network includes wells located upgradient and downgradient of the landfill facility that are screened within the uppermost aquifer system, referred to as the Shallow Aquifer. Geologic cross-sections illustrating the horizontal and vertical position of FAR II relative to the uppermost aquifer are provided in Appendix B.

3.1.2 Overall Flow Conditions

Based on monitoring well data in the vicinity of the former FAR I RSW Landfill site, the uppermost aquifer system is under water table conditions. This uppermost aquifer includes unconsolidated mine waste, sandstone, and limestone beds with a range of hydraulic conductivity from 1×10^{-1} to 1×10^{-4} centimeters per second (cm/sec) (AEP, 2006). This water table zone generally flows toward the FAR I RSW Landfill from the east and west, while flowing south towards the Ohio River on the south side of the FAR I RSW Landfill. The shale aquitard where present above the Morgantown Sandstone has very low hydraulic conductivity values, in the range of 1×10^{-7} to 1×10^{-9} cm/sec. Contours depicting the groundwater elevations in the Shallow Aquifer are shown in Figure 3-1.

Historical groundwater elevation data for the Shallow Aquifer show water table elevations in the range of 1000 to 1010 ft upgradient and approximately 960 feet on the downgradient side of the FAR I RSW Landfill. The groundwater elevation data indicates a regular seasonal variation, with spring water levels up to several feet higher than fall water levels. Seasonal variation appears somewhat more pronounced on the upgradient side of the FAR I RSW Landfill (AEP, 2006).

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 the 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

The FAR I RSW Landfill overlies the former FAR I reservoir, which had surface elevations from approximately 990 ft. to 1,020 ft. Based upon these elevations and the elevations of the material underlying the original FAR I topography, the uppermost aquifer consists of saturated unconsolidated material, limestone, and sandstone sedimentary units.

Based on ODNR water well logs, the nearest wells with a recorded pumping rate (not including wells screened in the alluvial sediments near the Ohio River) occur approximately one mile west of FAR I RSW Landfill. These wells are screened within limestone and shale units, and at a similar elevation to the upper aquifer system at the FAR I RSW Landfill. These wells have recorded pumping rates ranging from 1.0 to 8.0 gpm.

Based on the information gathered from ODNR, geological and hydrogeologic conditions at the FAR I RSW Landfill, the uppermost aquifer is considered to be the unconsolidated material, limestone, and sandstone sedimentary units (Shallow Aquifer) which lie above the shale aquitard and Morgantown Sandstone.

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

3.3.1 Overview

The groundwater monitoring network is shown in Figure 3-2 and consists of seven (7) wells located upgradient (0AE 2005 10C, CA-0623A, S-GS-3, S-4, S-5, S-6 and S-17) and nine (9) monitoring wells located downgradient (S-GS-1, S-GS-2, S-1, S-2, S-7, S-10, S-18, S-19 and S-20) of the former FAR I RSW Landfill. The network will provide detection monitoring for the uppermost aquifer (Shallow 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 and span the full thickness of the uppermost aquifer system. 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 and Appendix D, respectively.

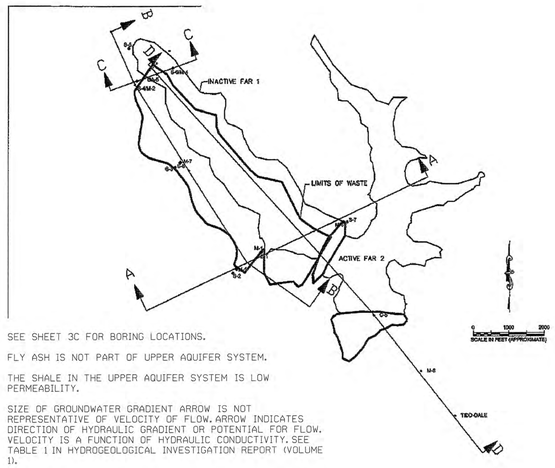
3.3.2 Compliance Assessment

Review of the existing groundwater monitoring well network in relation to the geologic and hydrogeologic conditions in the area of the former FAR I RSW Landfill 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 system that accurately represent the

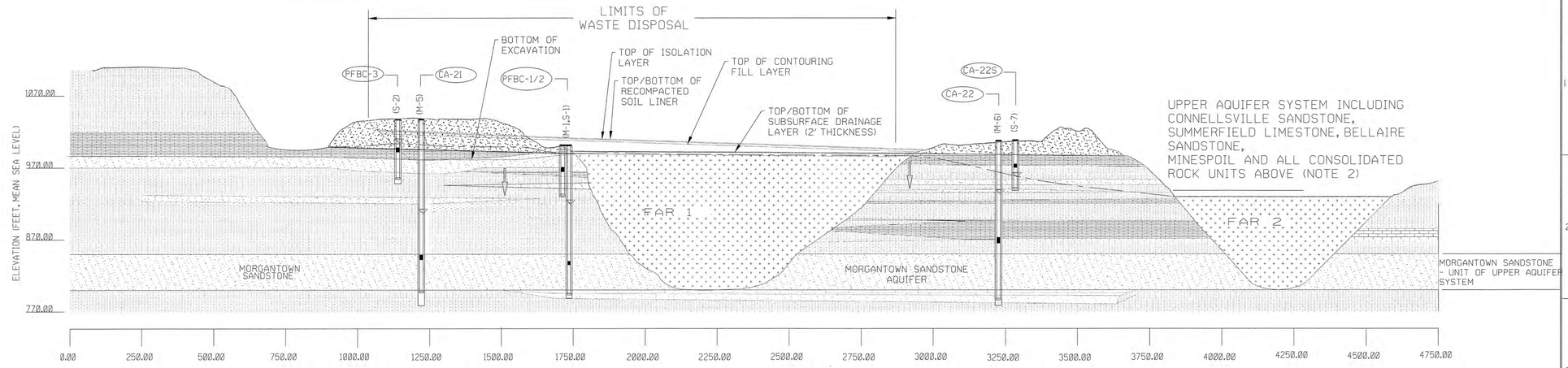
groundwater quality upgradient and downgradient of the former FAR I RSW Landfill. The groundwater monitoring well network is also capable of providing upgradient background groundwater quality and downgradient detection monitoring for a potential contaminant release to the uppermost aquifer (Shallow Aquifer) nearest the waste boundary. Based on the above review, the groundwater monitoring network around the Cardinal former FAR I RSW Landfill meets the requirements of 40 CFR 257.91.

DWG. NO. - 13-30100-5A

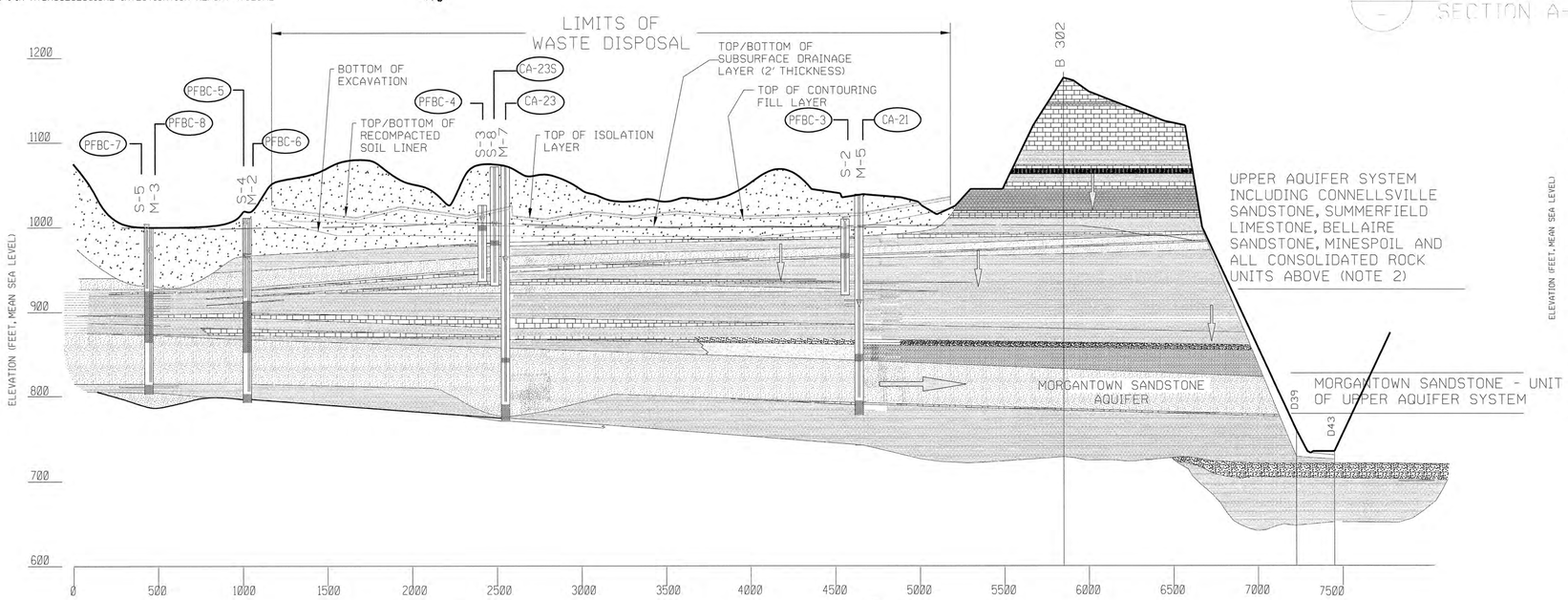
SECTION LOCATION PLAN



1. SEE SHEET 3C FOR BORING LOCATIONS.
2. FLY ASH IS NOT PART OF UPPER AQUIFER SYSTEM.
3. THE SHALE IN THE UPPER AQUIFER SYSTEM IS LOW PERMEABILITY.
4. SIZE OF GROUNDWATER GRADIENT ARROW IS NOT REPRESENTATIVE OF VELOCITY OF FLOW. ARROW INDICATES DIRECTION OF HYDRAULIC GRADIENT OR POTENTIAL FOR FLOW. VELOCITY IS A FUNCTION OF HYDRAULIC CONDUCTIVITY. SEE TABLE 1 IN HYDROGEOLOGICAL INVESTIGATION REPORT (VOLUME 1).

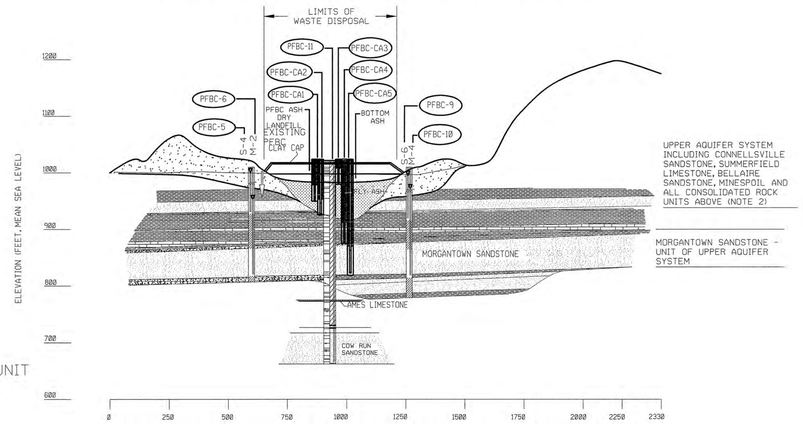


SECTION A-A'

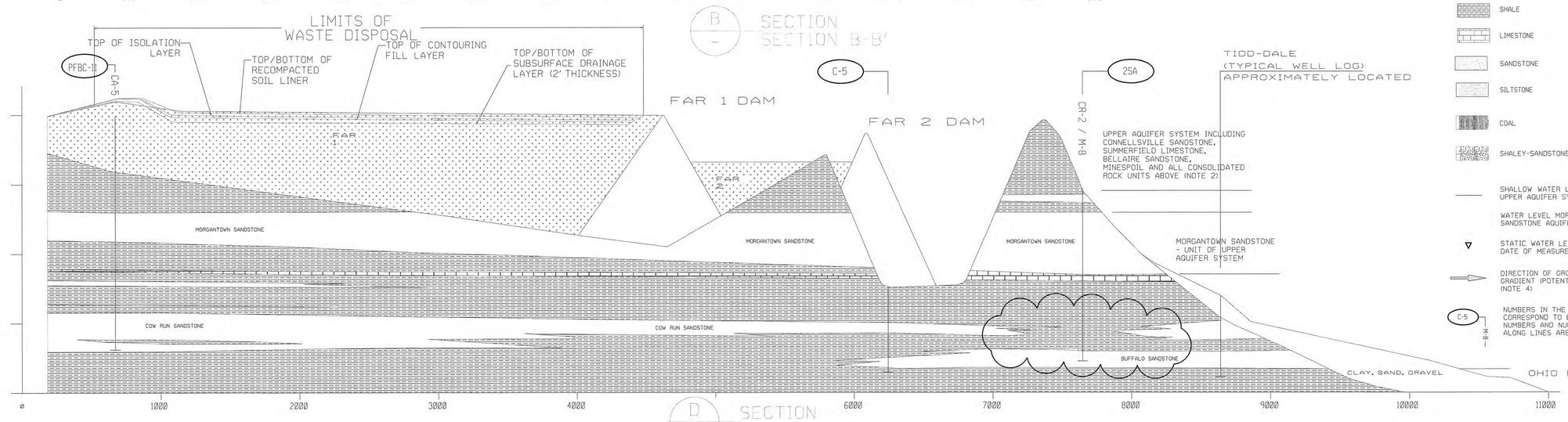


SECTION B-B'

NOTE: SEE DRAWING 13-30560 FOR EXTENSION OF THIS SECTION FROM RIDDLES RUN TO CROTS CREEK.



SECTION C-C'



SECTION D-D'

LEGEND

- FLY ASH
- MINESPOIL
- SHALE
- LIMESTONE
- SANDSTONE
- SILTSTONE
- COAL
- SHALEY-SANDSTONE
- SHALLOW WATER LEVEL UPPER AQUIFER SYSTEM
- WATER LEVEL MORGANTOWN SANDSTONE AQUIFER SYSTEM
- STATIC WATER LEVEL MEASUREMENTS DATE OF MEASUREMENT APR 21, 2004
- DIRECTION OF GROUNDWATER GRADIENT (POTENTIAL FLOW) (NOTE 4)
- C-5 / M-8 — NUMBERS IN THE OVAL CORRESPOND TO BORING NUMBERS AND NUMBERS ALONG LINES ARE WELLS

DATE	NO.	DESCRIPTION	APPD.
3/8/12	D	REVISED BY AEP FOR SECTION D-D TO SHOW SHALE STRATA SEPARATING COW RUN FROM BUFFALO SANDSTONE.	H/FZ
NOV 17 2000	C	REVISED - NOD 2 RESPONSE	DGB
MAY 26 2000	B	REVISED NOD 1 RESPONSE	DGB
OCT 24 2005	A	ISSUED FOR PERMIT	DGB

REVISIONS

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CARDINAL OPERATING COMPANY

BRILLIANT OHIO

TITLE: CARDINAL FAR 1 RESIDUAL WASTE LANDFILL GEOLOGIC/HYDROGEOLOGIC CROSS SECTIONS

DWG. NO. 13-30100-5A-D

CIVIL ENGINEERING DIVISION

APPROVED BY: Pedro J. Amaya

GEOSYNTEC CONSULTANTS
55 WEST WACKER DRIVE, SUITE 1100
CHICAGO, IL 60601 USA
(312) 850-0500

SIGNATURE
DATE

PROJECT NO. CHE8126
FILE NO.
DRAWING 5A OF 39

AEP AMERICAN ELECTRIC POWER
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

SYSTEM DATE:

FAR I RSW Landfill

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

Any corrective measures assessment conducted as required at 40 CFR 257.96

Not applicable. The FAR I RSW Landfill is in Detection Monitoring

FAR I RSW Landfill

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 FAR I RSW Landfill is currently in Detection Monitoring.

FAR I RSW Landfill

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

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

Not applicable to Landfills

FAR I RSW Landfill

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

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

Not Applicable to Landfills